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Great Lakes Hydrilla
Risk Assessment

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Table of Contents

A Hydrilla Occurrence Database

This appendix includes a technical memorandum describing the approach used to develop the Hydrilla occurrence database for this project. The database was used for several purposes, as described in Section 3.1.2 of the risk assessment report.

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Memorandum

Great Lakes Hydrilla Risk Assessment

Description and Methods for Compiling Current and Historical (Hydrilla) *Hydrilla verticillata* Occurrences

Project Database (Subtask 3.3)

Database compilation efforts through February 26, 2016

Ecology and Environment, Inc. (E & E) created the Great Lakes Hydrilla (*Hydrilla verticillata*) Risk Assessment Project Database (Project Database) by combining four datasets exported from different sources and merging them into a single dataset within a set schema. Comparatively, a relatively small number of additional records were added by E & E personnel (see Table 1). The final version of the Project Database provided to Texas Tech University and the University of Toledo for modeling purposes was last updated on February 26, 2016.

After the initial exports, each dataset was appended to the primary dataset (EDDMapS) in a hierarchical manner, based on the amount of ancillary information provided (see Table 2). The dataset hierarchy is structured as follows:

1. EDDMapS 2015. [U.S. OCCURRENCES] Early Detection and Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; original data export on March 23, 2015, and checks for recent additions were conducted on July 7, 2015, December 14, 2015, and February 26, 2016.
2. Global Biodiversity Information Facility (GBIF) 2015. [GLOBAL OCCURRENCES] Available online at www.gbif.org/; original data export occurred on March 17, 2015, and checks for recent additions were conducted on July 7, 2015, December 14, 2015, and February 26, 2016.
3. "Barnes Other". [GLOBAL OCCURRENCES] Barnes et al. (2014)[1] provided coordinate data in his publication's Appendix S2, with 316 records attributed to unpublished data from Zhang, Purcell, and Ding (Hydrilla native range), and one record attributed to Anderson et al. 2005 (South America).

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[1] Barnes, M. A., Jerde, C. L., Wittmann, M. E., Chadderton, W. L., Ding, J., Zhang, J., M. Purcell, et al. 2014. Geographic selection bias of occurrence data influences transferability of invasive *Hydrilla verticillata* distribution models. *Ecology and evolution*, *4*(12), 2584-2593.

4. GBIF 2012. [GLOBAL OCCURRENCES] Barnes et al. (2014) provided coordinate data in his publication's Appendix S2, with the majority of records attributed to data exported from GBIF in March 2012. Because their Appendix S2 lacked ancillary information (e.g., date, biotype, acres infested, rate of spread, control efforts) Barnes provided E & E with the original data export so whatever ancillary information was downloaded from GBIF in 2012 was available for review.

5. E & E. [MOSTLY NORTHERN LATITUDES] Additional individual records were entered by E & E personnel. The additional records represented recent reports of Hydrilla in Great Lakes states acquired through personal communication with stakeholders, smaller-scale, on-line resources such as iMapInvasives (https://www.imapinvasives.org/), and older literature reports of Hydrilla at northern latitudes in Eurasia (e.g., Russia, Latvia, and northern China).

Table 1 Contribution of Each Dataset in Project Database circa February 26, 2016

Dataset	Number of Records
EDDMapS	1,626
GBIF2015	2,395
BarnesOther	317
GBIF2012	2,315
E & E	41
Total	**6,694**

Matthew Barnes and Carl Mach recommended using the Barnes et al. 2014 dataset and to re-query the following databases used for that research: GBIF and U.S. Department of Agriculture (USDA) PLANTS database. In addition to longitude and latitude, the project's technical memorandum specified that E & E also needed to extract the following information from the GBIF, USDA, and other databases for project use, when available: 1) date of record; 2) biotype (monoecious vs. dioecious); 3) growth rate of infestation; 4) indicators of severity of infestation (e.g., size of affected area); and 5) existence of control efforts. Date and biotype information are the most important based on the needs of the modeling.

Table 2 Contribution of Each Parameter in Project Database circa February 26, 2016

Parameter	Number of Records (out of total records)
Total Number of Records	6,694
Latitude/Longitude	5,604
Date or Year	5,360
Biotype	24 (14 in U.S.)
Acres Infested	394
Other Severity Indicators	271
Treatment	197

The GBIF website was re-queried as requested and the search for data through the USDA led to the use of the EDDMapS dataset. The U.S. Geological Survey (USGS) Nonindigenous Aquatic Species (NAS) database curated aquatic plants in the past; during the effort to assemble the Project Database the NAS was going through a transition in their online databases. The USGS NAS website only had invasive aquatic animals available and did not include any invasive plant data. However, many of the records in the other datasets reference USGS NAS, so E & E believes the resource is well-represented. A dataset was found and exported through the Global Invasive Species Information Network (GISIN) that contained records attributed to NAS, but they were virtually all duplicates of existing records in the United States and offered no ancillary data so the GISIN dataset was not incorporated. Once data for invasive plant species such as Hydrilla are available, USGS NAS would be an additional resource to consult for updating the Project Database.

Refining the Project Database

Many of the records in the original Project Database lacked coordinate information (latitude/longitude). However, for many records E & E personnel were able to use available locality information to estimate/assign coordinates to records without coordinate data (see “GBIF 2015” description below). The following steps were taken:

1. E & E GIS personnel added coordinates for all of the United States locations by using data in the locality field or determining the centroid of the county (408 records primarily in southern states), with the exception of four United States records because location information was too vague.
2. E & E personnel added coordinates for 29 records in under-represented global regions, including Central America, Africa, and Oceania, by using data in the locality field. The remaining 23 records in these regions had location information that was too vague.
3. The current Project Database contains 612 records outside the United States that still lack coordinate information and it is unlikely there will be efforts to estimate coordinates. Of the 612 records, 128 contain locality information but are in already well-represented regions, notably Great Britain, Australia, and Japan, or have no country listed. The other 484 records lack any location information beyond country and sometimes state/province.

E & E provided the final assembled Hydrilla occurrence database to Texas Tech University and the University of Toledo for modeling purposes in February 2016. The Project Database is suitable for study at global, national or local geographic scales. Using a geographic information system (GIS) and the Project Database, E & E has assembled maps that depict the global distribution of Hydrilla, Hydrilla locations within in the United States, and locations that are within or proximate to the Great Lakes Basin (see Figures 1 through 3).

Communication with Project Collaborators

The Project Database will be used extensively by Matt Barnes and Jon Bossenbroek during modelling efforts, therefore ongoing communication is essential to ensure the assembled Project Database meets their needs. Regular email correspondence and a conference call on June 26, 2015, provided opportunities for inquiry and feedback with both Project collaborators. The following is a summary of topics that were discussed regarding the Project Database.

1. Barnes provided raw data used in Barnes et al. 2014 along with recommendations and information for potential sources for Hydrilla locations and the level of spatial precision required for his modelling efforts in March 2015.
2. A draft version of the Project Database was sent to Barnes and Bossenbroek on April 9, 2015, for them to review the amount and detail of available information, identify gaps, and provide suggestions for what should be done to best meet their needs.
3. One early suggestion was to create a series of maps demonstrating Hydrilla occurrence in North America over time using GIS. However, after discussions with Barnes and Bossenbroek this mapping effort was determined not to be a project priority.
4. Should the GBIF 2012 records be included (see discussion in "GBIF 2012 section")? Barnes and Bossenbroek agreed that the GBIF 2012 records should be included even though they did not appear in the GBIF 2015 data export. Barnes will compare the distribution of Hydrilla locations including the GBIF 2012 records and excluding the GBIF 2012 records and make an informed decision of which data to incorporate into his models based on the findings.
5. What should be done with records without coordinate information? Barnes agreed with E & E's assessment that no further efforts should be made for remaining 616 records lacking coordinate information.
6. Is it necessary to attempt population of the ancillary data fields? This would require searching for information on individual infestations of interest; this was done for documented infestations in the Great Lakes states to maximize information on these infestations.
    a. Barnes is interested in creating combined and separate models for monoecious and dioecious Hydrilla. However, these data are very limited in the Project Database. Barnes may be able to use Madiera et al. (2000)[2], which presents a distribution map classifying HUC drainages as containing monoecious, dioecious, or both biotypes. Barnes proposes to overlay the known occurrences onto the biotype map, and label known occurrences accordingly to estimate and extrapolate the distributions of monoecious and dioecious Hydrilla. E & E established contact with the authors and Pam Fuller at USGS at the start of July 2015 and are attempting to determine whether the data is available.
    b. Bossenbroek is most interested in using date and year information to understand patterns of spread. These data are available for a sufficiently large number of records in the Project Database. Acreage could potential useful for weighting strength of source, but it would not be worthwhile to exert effort populating the Project Database by researching individual infestations.
7. The number of records does not equal number of unique locations. The Project Database contains duplicate/proximate coordinates or apparent duplicates of records with and without coordinates, such that the number of records overestimates the actual number of infested locations. However, some duplicates have unique information in other fields, such as observation date. Through correspondence with Barnes, it was determined to minimize

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[2] Madeira, P. T., Jacono, C. C., & Van, T. K. 2000. Monitoring hydrilla using two RAPD procedures and the nonindigenous aquatic species database. *Journal of Aquatic Plant Management*, *38*, 33-40.

rarifying the dataset and removing duplicates at this stage of the project; that effort will be undertaken by Barnes and Bossenbroek as suits their modeling needs.

8. Should potential suitability data (e.g., submerged aquatic vegetation mapping, bathymetry) be incorporated into the Project Database or should that effort be kept separate? At this time it seems most logical to keep potential suitability data as distinct spatial layers and datasets separate from the Project Database file.
9. In the June 26 conference call, Barnes and Bossenbroek agreed with E & E that the Project Database can be considered complete with the caveat that records may be added in the future based on stakeholder outreach. Barnes may also add a few more points from west Texas to the Project Database based on his interactions with Texas Parks and Wildlife.

Finding Additional Hydrilla Locations through Outreach Efforts

As part of stakeholder outreach conducted under Task 2, additional locations of Hydrilla infestations were identified through interviews with state agency staff and other management practitioners responsible for management of aquatic invasive species in states with borders on the Great Lakes as well as New England. Outreach efforts have provided approximately 20 additional locations of Hydrilla infestations in Ohio, Pennsylvania, New York, and Massachusetts to the Project Database. The absence of Hydrilla has also been confirmed by contacts in Rhode Island, Vermont, and New Hampshire.

Detailed Methodology and Dataset Information

EDDMapS

The USDA National Invasive Species Information Center website (http://www.invasivespeciesinfo.gov/aquatics/hydrilla.shtml) links to EDDMapS for acquiring the current distribution of *Hydrilla verticillata* within the United States. The EDDMapS exported dataset provided the most complete information regarding ancillary information of interest (e.g., observation date, indicators of extent/severity, control efforts, biotype). Although many irrelevant or empty fields from the original dataset were deleted, the EDDMapS dataset provided the overall schema for the Project Database. Sixty-three fields were retained for use in the E & E dataset. The original export from March 23, 2015, contained 1,407 records with coordinate data (1,694 total records). Later exports from July 7, 2015, December 14, 2015, and February 26, 2016 together added 25 EDDMapS records to the Project Database. Recent records were identified in EDDMapS using the "Date Entered" field.

GBIF 2015

The *Hydrilla verticillata* dataset that was exported on March 17, 2015, provided occurrences from around the world. Some ancillary information was available, primarily date information. Many irrelevant or empty fields from the original dataset were deleted. Twenty-seven fields in the GBIF dataset were mapped to existing fields in the EDDMapS/E & E dataset. Seven unique GBIF 2015 fields were added to the schema of the Project Database. Later exports from July 7, 2015, December 14, 2015, and February 26, 2016 together added 434 GBIF records to the Project Database. Recent records were identified in GBIF using the record identifications numbers.

The original GBIF 2015 export contained 1,247 records with coordinate data (2,917 total records). Some of the records that lacked coordinates did contain locality information, such as the country, town, lake, or river. Using GoogleEarth it is possible to estimate coordinates for some of these records. A field was created to assign a rank of relative importance for researching the record's location. Initially applied to the GBIF 2015 dataset, the ranking was later applied to the entire Project Database:

1 – Priority country/state worthwhile to acquire coordinate data for record primarily pertains to countries/states at northern latitudes: these records have all been assigned (or attempted to assign) coordinates.

2 – Possible country of interest: these records have been assigned (or attempted to assign) coordinates.

3 – Record has country and locality but is near/below equator: these records have been assigned (or attempted) coordinates.

4 – Record has no country but possibly other location information: potentially low-confidence results.

5 – Record has no coordinates but is from a country in which there are numerous existing records with coordinates: Japan, Australia, South Korea, and Great Britain (lower priority but could be done).

Barnes Other

Barnes' Hydrilla dataset (2014) contained records in locations in Asia and one in South America, which were areas largely not represented in the GBIF 2015 dataset. Only coordinate data was available in Barnes et al. 2014 Appendix S2, without any ancillary information. The 317 records were added to the Project Database. A few of these records may be duplicates worth removing from the Project Database.

GBIF 2012

Barnes' Hydrilla dataset (2014) contained 3,983 records with coordinate data attributed to GBIF, which was exported in March 2012. A search completed in March 2015 returned only 1,247 records with coordinate data (out of 2,917 total records). The dramatically lower number of records available in 2015 was unexpected. According to a GBIF newsletter and blog post, in December 2012 the entire GBIF database dropped the total number of records from 389 million to 383 million, which likely accounts for the fewer available records in 2015 compared to 2012. GBIF's explanation for the reductions is that they removed duplicate entries and old versions of records and datasets that are no longer published at the source. It is unknown whether eliminated points represented duplicates, erroneous, or were managed/eradicated populations, which should still be considered occurrences from a modelling perspective. Emails were sent on March 27, 2015, to the blog entry's author (ahahn@gbif.org) and the GBIF's technical help desk (helpdesk@gbif.org) for additional information about the data-cleaning process and the reliability of the 2012 occurrence data but E & E has not received a response.

Barnes' response to the situation: "For our current work, we could probably justify including all the data from 2012 and simply adding to it with supplementary sources (including a new GBIF query), or we could again accept your most recent GBIF search 'as is' even if it has fewer data (assuming the eliminated data were somehow inaccurate or unconfirmed). I actually lean toward the second option- we can be a little more confident in those data if they survived whatever quality checking has occurred between 2012 and today." Barnes will conduct a comparison between GBIF 2012 and GBIF 2015 to determine whether or not the GBIF 2012 records should be incorporated into models.

Barnes provided the raw dataset he exported in March 2012 from GBIF to E & E so the limited ancillary data (date information) could be accessed. The dataset contained 8,575 records with coordinate data (all records without coordinates were deleted). Coordinates were rounded to three decimal places and records with duplicate latitude and longitude within the GBIF 2012 dataset were removed (record with oldest date retained) and the existing E & E dataset (higher ranking datasets retained). After identifying duplicates, 2,316 records from GBIF 2012 were added to the E & E dataset. Barnes will conduct a comparison between GBIF 2012 and GBIF 2015 to determine whether the GBIF 2012 records should remain in the Project Database and incorporated into models.

E & E

Some relatively recent Hydrilla infestations did not appear in any of the researched databases. Recent individual infestations in the vicinity of the Great Lakes have been identified through agency reports, journal publications, news articles, and other resources accessible through Internet searches. Additional infestation locations may be informed by outreach to local stakeholders. For example, as of April 1, 2015, E & E had entered 22 individual records for otherwise unrepresented infestations in the Great Lakes states and occurrences at extremely northern latitudes (e.g., Russia, Latvia, and northern China).

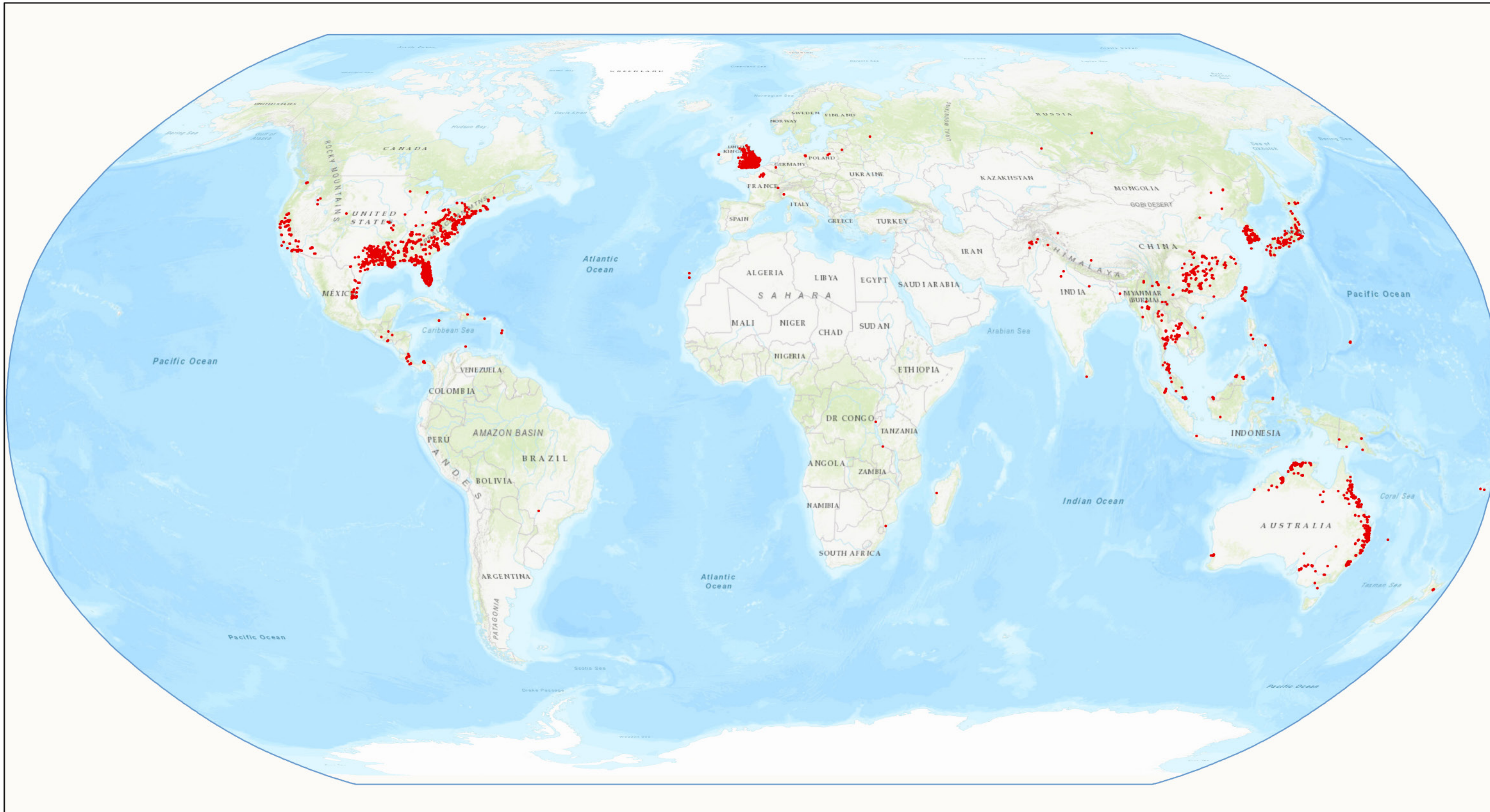
Internet searches were conducted using combinations of the following key words and phrases for each of the Great Lakes states (New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota), New England state (Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine) and the Great Lakes (Ontario, Erie, Huron, Michigan, Superior): Hydrilla, [state name], [state abbreviation], status, distribution, occurrence, locations, lake. E & E searched using the county name or lake/reservoir/river name if there was a lead, but needed additional information. Similar searches were conducted by E & E for evidence of Hydrilla in Canada, Ontario, and British Columbia.

E & E registered for an account with iMap Invasives (http://imapinvasives.org/) to access location data for Pennsylvania (Hydrilla data was not publically available). With this account, four new locations were added for Pennsylvania (two after 2012) and confirmed existing Pennsylvania and New York data.

Other Maps That May Potentially be Useful for Populating Ancillary Fields of the Project Database

BIOTYPE: Publication from USGS (Madiera et al. 2000) with a distribution map of monoecious vs. dioecious by HUC drainages (http://nas.er.usgs.gov/taxgroup/plants/maps/hy_vert_bio.jpg). Note: biotype has not been documented for each drainage, they used historically accepted/reported ranges of monoecious vs. dioecious Hydrilla are for the figure. E & E contacted USGS and received regular updates from them a dataset containing each HUC 8 unit (sub-basin) with documented Hydrilla infestations classified by biotype. Ian Pfingsten with USGS NAS provided E & E the initial biotype dataset on August 12, 2015. The latest update was sent November 3, 2015. Barnes integrated the biotype data with the Project Database and they were used in a subset of Barnes' distributional models (see Section 3.1.3).

TREATMENT EFFORTS: USDA/ APHIS map with 2006-2011 data that documents U.S. counties that have eradication programs for Hydrilla (http://pest.ceris.purdue.edu/map.php?code=PCHAFBA).



KEY:

• Hydrilla - Known Occurrence

N

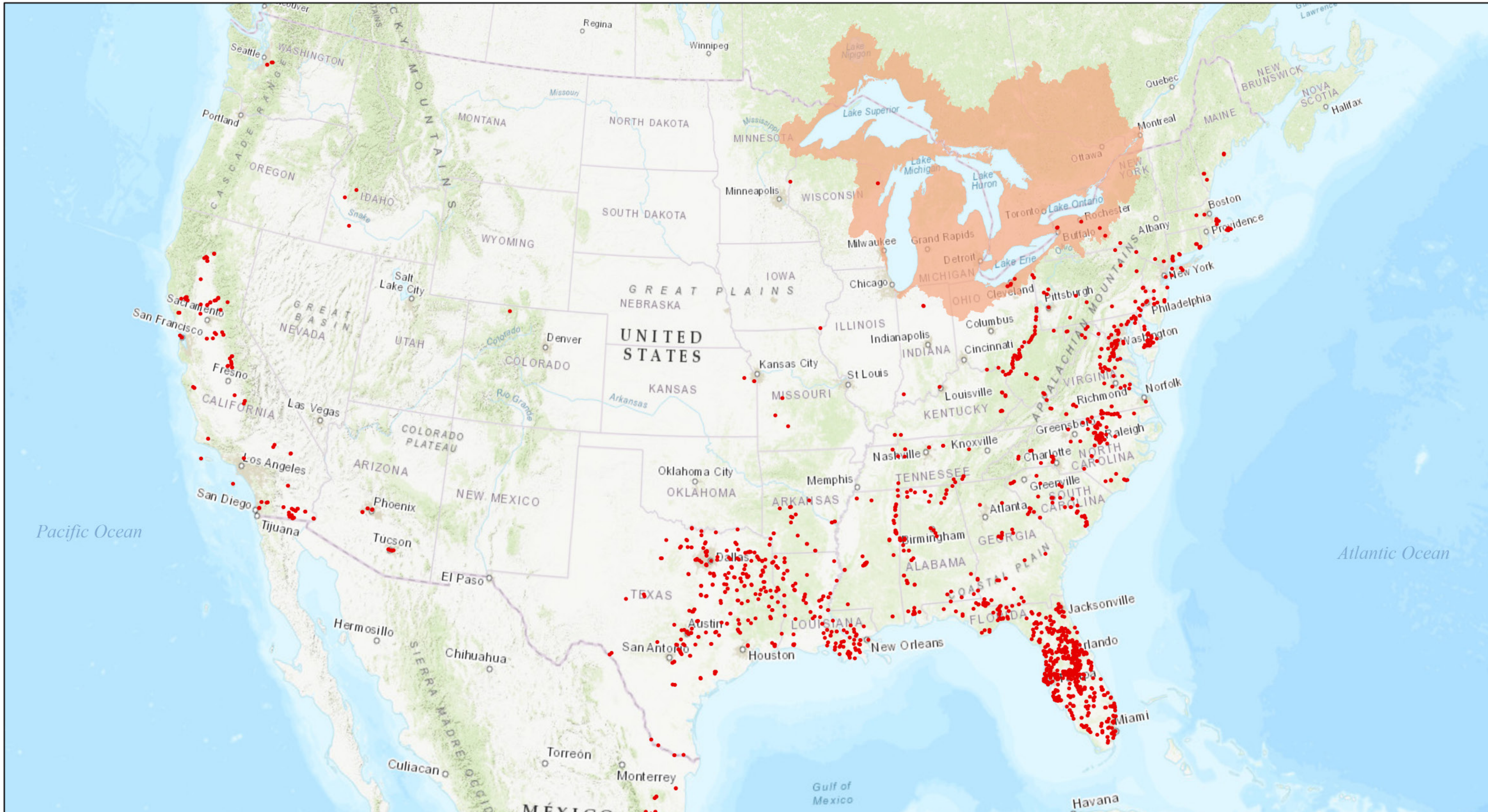
0 1,000 2,000 4,000

Miles

Figure 1
Hydrilla Locations Derived from Ecology and Environment, Inc. Assembled Hydrilla Occurrence Database Worldwide Distribution

Data Source: ESRI 2015; Barnes 2014; EDDMaps 2015; GBIF 2012, 2015; Ecology and Environment, Inc. 2015.

L:\Buffalo\Hydrilla\Maps\MXDs\3_3_Hydrilla_Occurrence\2017_Oct\Hydrilla_Occurrences_US.mxd 10/10/2017



KEY:

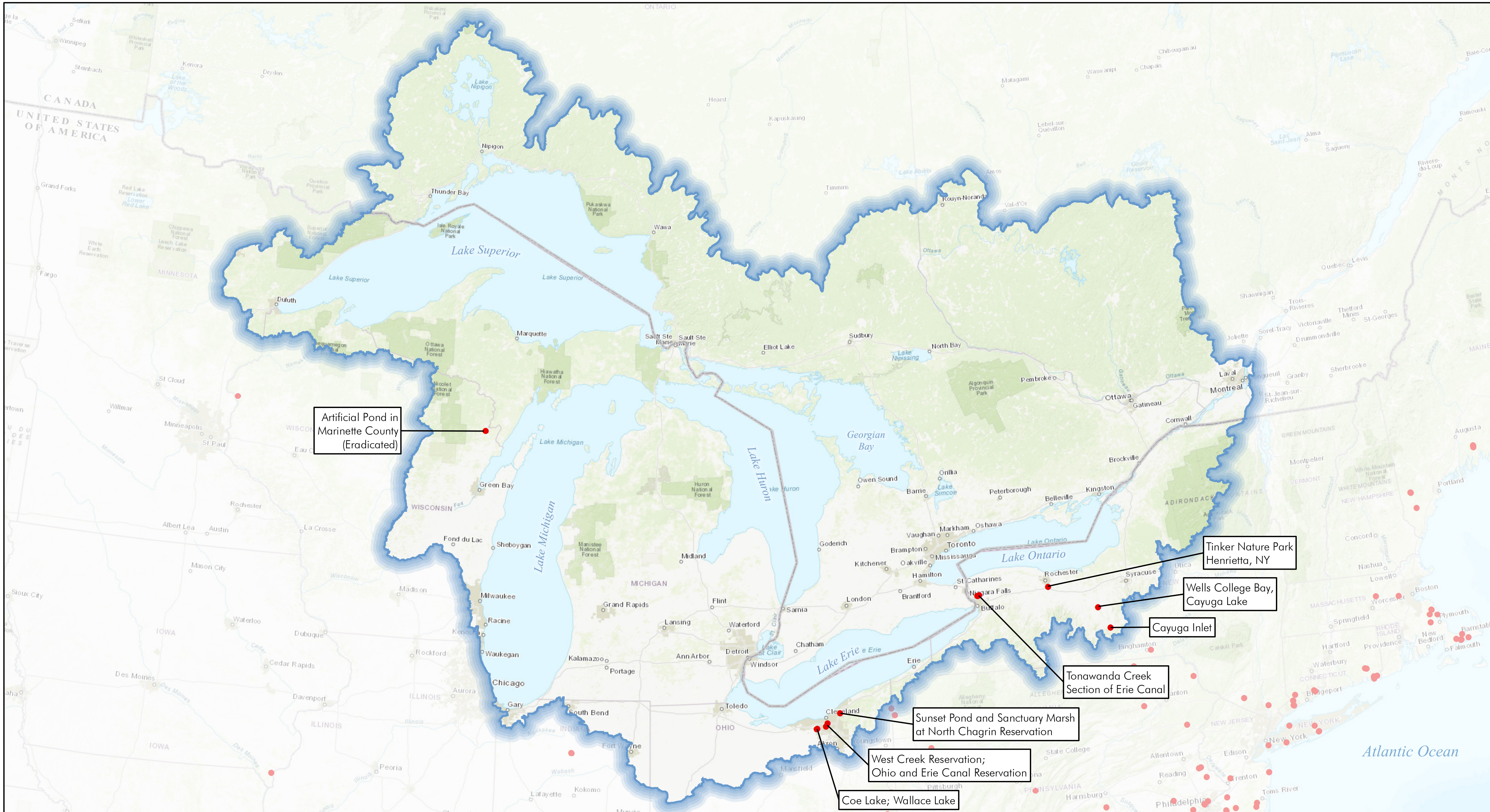
- Hydrilla - Known Occurrence
- Great Lakes Basin

N

0 250 500 1,000
Miles

Figure 2
Hydrilla Locations Derived from
Ecology and Environment, Inc.
Assembled Hydrilla Occurrence Database
United States of America Distribution

Data Source: ESRI 2015; Barnes 2014; EDDMaps 2015; GBIF 2012, 2015; GLIN 2015; Ecology and Environment, Inc. 2015.



KEY:

- Hydrilla – Documented Occurrences
- Great Lakes Basin

Figure 3

Documented Hydrilla Occurrences in the Great Lakes Basin

Great Lakes Basin Distribution

Data Source: ESRI 2015; Barnes 2014; EDDMaps 2015; GBIF 2012, 2015; GLIN 2015; Ecology and Environment, Inc. 2015.

B

Texas Tech Distributional Modeling Papers

This appendix includes a copy of a manuscript entitled *Hydrilla verticillata bio-type alters spatial distribution model prediction* prepared by Sasha Soto (graduate research assistant) and Dr. Mathew Barnes of Texas Tech University, Lubbock, Texas in April 2017 under contract with Ecology and Environment, Inc.

Target Journal: ***Diversity and Distributions***

Hydrilla verticillata biotype alters spatial distribution model prediction

S.D. Soto, K. Erickson, C. Mach, C. Portillo-Quintero, C. Rockwell, and M.A. Barnes

Abstract

Invasive species are expanding beyond their native ranges and causing severe bioeconomic damage globally at an increasing rate. Researchers have urged use of species distribution models to better identify at-risk regions and improve invasive species prevention. Some organisms possess species-specific traits, such as genetic and/or physiological characteristics, which may influence invasion potential. To determine if species-specific traits like biotype influence model predictions, we partitioned known US *Hydrilla verticillata* occurrences into biotype-specific datasets, using all data together and data by biotype, to train models with regional considerations. Each biotype dataset was simulated using modelling programs Maxent and Maxlike. Combined biotype models indicated an influence on hydrilla model predictions when biotype distributions were considered. By modelling each biotype separately and combining the resulting predictions, overall model predictions improved in accuracy; this was tested by assessing the models ability to correctly identify known occurrences. This technique may benefit invasive species prevention by training researchers and managers to focus on local species characteristics and behavior.

Introduction

Understanding invasion ecology and the mechanisms that influence species distributions is imperative to help conserve native biodiversity. Invasive species represent the second leading cause of biodiversity loss because they outcompete native species and negatively affect their surroundings (Pyšek and Richardson 2010). Furthermore, because of their many negative effects, invasive species-caused bioeconomic damage is increasing globally (Pimentel et al. 2005, Lodge et al. 2016). Often, once an invasive species has established it is very difficult and costly to eradicate. Therefore, prevention is the most effective form of defense from invasive species (Leung et al. 2002, Keller et al. 2008). There are many factors that influence a species' ability to survive and successfully establish new populations in new regions, such as individual fitness, tolerance to prolonged stress, biological adaptations, and/or environmental variables that allow the species to quickly adapt, rapidly grow, and be resilient to disturbance (Williamson and Fitter 1996, Lee 2002). It is necessary to increase our understanding of invasive species distributions, so that we may predict where best to allocate available resources and prevent further destruction. Our ability to understand mechanisms that influence a species' invasion potential is our primary defense against invasive species and can potentially help predict future bioeconomic damage.

Species distribution models (SDMs) provide one effective tool for informing prevention efforts by using conditions around known occurrences to identify areas capable of supporting future invasions (Phillips et al. 2006, Elith et al. 2011). By identifying regions that are of most concern, SDMs provide advanced warning, an advantage for management efforts because they can actively monitor the areas and treat infestations early, potentially preventing spread and reducing negative impacts (Liu et al. 2011). There are a variety of environmental, atmospheric, and/or biological factors that influence a species' ability to establish and invade new regions; tools like SDMs, can incorporate theses influences and tailor predictions to detect any habitat alterations that may result (Broennimann et al. 2008, Hellman et al. 2008, Wittman et al. 2016). These influences have been tested by popular SDM methods, including GARP, Maxent, Maxlike, and other programs (Stockwell and Perterson 2002, Evangelista et al. 2008, Kumar et al. 2009). SDMs utilize presence-only or presences absence data to calculate where species occur across a geographic space (Elith et al. 2011). Presence-absence data requires recorded absence data which is rather difficult to gather. Alternatively, presence-only models have more accessible data that can be located in historical collections and/or extensive database searches. A study examining aquatic organisms confirmed, each model generates acceptable and similar recommendations for prevention (Kumar et al. 2009). SDMs can accurately assess species requirements and account for a variety of environmental and species-specific influences, whether based on presence-only or presence absence data. Without tools like SDMs, search missions and management funds would be misguided and ineffective if targeted at the wrong areas; increasing bioeconomic damage (Broennimann et al. 2007).

One influence that has not been considered in modelling strategies is the local genetic structure (biotype) of a species. A biotype is a species-specific description that can be distinguished across taxa. Biotypes are classified as individuals possessing identical genetic structure but different physical structure (Allaby 2006, Saunders 2007). It is unclear if biotypes of varying taxa reside in different regions, conditions, or rely on different mechanisms to survive (Claridge and Hollander 1980); although large behavioral and physiological differences do exist between biotypes of the same taxa (Saxena and Barrion 1985). For example, Jiu et al. (2007) reported over twenty known biotypes for sweetpotato Whitefly (*Bemisia labaci*), but only predicted the B biotype would behave as invasive due to its relatively high fecundity and longevity. Whitefly biotypes have been recorded in different geographic ranges, displaying different tolerance, and presenting different negative impacts (Pan et al. 2011), which may also contribute to invasive differences between biotypes. Further research is needed to determine the influence of biotypes on invasiveness and viability.

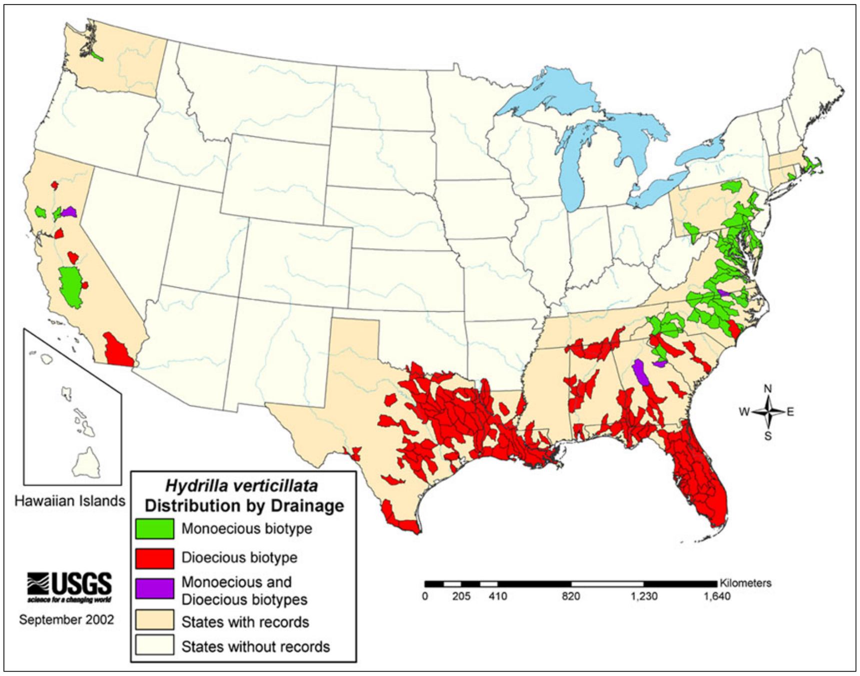
To determine if the incorporation of biotype in modeling frameworks influences species distribution predictions, we developed models using monoecious and dioecious Hydrilla biotypes. We used Maxent and Maxlike to determine if one model type is more accurate at recognizing unique environmental preferences than the other. It is unknown if environmental similarities or differences within biotype preferences will influence distributions in an alternative way; therefore, we examined biotype influences on SDM predictions. Further, we used spatially explicit model outputs to observe influences. Biotype-specific models have potential to improve our knowledge and understanding of species-specific traits regarding invasive species distributions; possibly developing more accurate predictions.

Methods

Study Species. Hydrilla (*Hydrilla verticillata*) represents an alarming aquatic invasive species that is extremely hardy and responsible for the decline of aquatic health in many freshwater reservoirs and waterways globally (Basiony et al. 1978). The aggressive invader has been labeled the "The Perfect Aquatic Weed," due to its resilience and high impact in the United States (Langeland 1996). Hydrilla reproduces through fragmentation; forming thick dense vegetative "mat-like" blockages (Haller 1977). The dense vegetation can reduce native biodiversity, habitat availability, and recreational use (Langeland 1996). Hydrilla arrived during at least two separate introduction events that resulted in populations in the north and south US (Van 1989).

Two distinct hydrilla biotypes (monoecious and dioecious) have been recorded in different regions of the United States (Fig. 2.1). The moneocious biotype remains mostly in the northeastern US where temperatures vary greatly with elevation but are generally much cooler than where dioecious hydrilla occurs, throughout the south with warmer conditions (Langeland 1996). Van and Steward (1990) revealed monoecious and dioecious biotypes utilize different growth strategies for reproduction. Both biotypes prefer to reproduce when environmental conditions are temperate. However, because monoecious and dioecious hydrilla occur in different geographic regions, they are adapted to different environmental and atmospheric conditions (Spencer and Anderson 1986; McFarland and Barko 1999). SDMs can be trained to recognize the variable temperature preferences of hydrilla biotypes and its influence in model distributions.

Fig. 2.1 *Hydrilla verticillata* distribution in the United States as of September 2002 (USGS).



Data Treatment. Hydrilla occurrence data was acquired from public data repositories (EDDMapS and GBIF). Biotype records were restricted to known occurrences in North America, Mexico, and Canada because those data were the full-extent of known biotype records. To reduce bias attributable to uneven sampling efforts, occurrence data points were converted to Raster files with the same cell size as our environmental data layers; then back to a points file (McDowell et al. 2014). Furthermore, points were screened visually and omitted if logged coordinates did not contain both latitude and longitude or if they were located offshore. Data were categorized by biotype as recorded and identified in historic databases. Additionally, occurrences were cross-checked in ArcGIS by viewing geographic locations and comparing them to known biotype distributions. Overall, rarified working occurrences tallied to 751 total hydrilla occurrences: 203 monoecious and 548 dioecious in the United States.

Occurrences were compared to Bioclim environmental layers, global atmospheric data describing temperature trends (Hijmans et al. 2005). We chose to use temperature-based Bioclim layers (1-11) and not precipitation because hydrilla is not dependent on precipitation for source water, only requiring standing water (Barnes et al. 2014).

BIO_1	Annual Mean Temperature
BIO_2	Mean Diurnal Range
BIO_3	Isothermality
BIO_4	Temperature Seasonality
BIO_5	Maximum Temperature of the Warmest Month
BIO_6	Minimum Temperature of the Coldest Month
BIO_7	Temperature Annual Range
BIO_8	Mean Temperature of Wettest Quarter
BIO_9	Mean Temperature of Driest Quarter
BIO_{10}	Mean Temperature of Warmest Quarter
BIO_{11}	Mean Temperature of Coldest Quarter

Table 1. Bioclim environmental and atmospheric variables, layers 1-11 (WorldClim).

Modeling. We chose to test popular species distribution modelling programs Maxent version 3.3.3k (Phillips et al. 2006) and Maxlike package in R (Royle et al. 2012) to determine if biotype had an influence on predictions. Maxent is one of the most widely used SDM programs, consistently outperforming other species distribution modelling options (Elith et al. 2006). Maxent makes predictions using the maximum entropy principle which employs the "Method of Lagrange Multipliers" to calculate the most uniform distribution with the environmental variables and constraints given (Harte 2011). Environmental background data near and away from known occurrences are compared to provide a logistic habitat 'suitability index' that estimates the relative occurrence probability by minimizing the relative entropy between the raw and logistic outputs (Elith et al. 2011). Maxlike was created in response to Maxent's limited predictions by offering a technique capable of estimating probability of occurrence by assuming the average occurrence probability is near the true occurrence probability using the maximum likelihood method (Fitzpatrick et a. 2013, Merow and Silander Jr 2013). Maxent and Maxlike are presence-only SDMs, meaning only occurrence data is needed to calculate model predictions. For Maxent, we chose to use default software settings, with the exception that model iterations increased to 5000. Likewise, we used the standard settings in R to run Maxike model simulations (Chandler and Royle et al. 2012). When implementing both programs, models were replicated 100 times for each approach. With each Maxent run, the program automatically withheld 20% of the occurrence data to test model performance in Maxent (Barnes et al. 2014). For Maxlike runs, we manually selected a random 80% of the data in Excel for each simulation.

We analyzed the US hydrilla data in three different ways: 1. restricting data to monoecious hydrilla ("monoecious-only"); 2. restricting data to dioecious hydrilla ("dioecious-only"); and 3. compiling both monoecious and dioecious occurrences ("all -data"). Additionally, we developed an "additive model" by combining monoecious-only and dioecious-only forecasts using raster math in ArcGIS. The Additive distribution model was formed by displaying the highest assigned raster value between the monoecious-only and dioecious-only raster outputs in a single distribution map. The all-data model and the Additive model are both trained by the same hydrilla presences; however, the data were treated (input) differently; therefore, comparisons between the two enabled us to determine how biotype influenced model predictions. To compare the monoecious-only and dioecious-only models and all-data and Additive models, we calculated "discrepancy models" which display the largest differences between raster outputs. The Biotype Discrepancy model depicted differences between the monoecious-only and dioecious-only forecasts; while the Additive Discrepancy model recognizes differences between the all-data and Additive rasters. Finally, we calculated the standard deviation of the 100 replicate models for both Maxent and Maxlike. All distributions were visualized in ArcGIS 3.0.

Results

For Maxent, the monoecious-only model predicted suitable habitat in the northeastern US but not south to Florida in dioecious territory; regions of concern included the Great Lakes, Virginia, and West Virginia (Fig. 2.2). For the dioecious-only forecast, suitable habitat was identified along the southern US and sparingly along the west coast with hot spots in Florida and Louisiana (Fig. 2.3). Based on all-data projections, regions of suitable habitat were located in Texas, Louisiana, Arkansas, Florida, Ohio, West Virginia, Virginia, and Pennsylvania for hydrilla (Fig. 2.4). The all-data model recognized potential habitat along the southern and eastern United States. Forecasts indicated regions of moderate habitat in yellow, across the southeastern US with two hotspots, one large Florida region in dioecious territory and a much smaller region in monoecious range. The Maxent Additive model warned of high risk regions in Louisiana, Florida, West Virginia, and Virginia (Fig. 2.5). The monoecious-only (Fig. 2.6), dioecious-only (Fig. 2.7), and all-data (Fig. 2.8) Deviation models (standard deviation) indicated the most model agreement occurred within the center of the predicted range, while the most uncertainty occurred along the edge of the current hydrilla distribution.

Similarly, for Maxlike, monoecious-only forecasts identified the Great Lakes as suitable habitat for hydrilla range expansion (Fig. 2.9). Habitat severity risk increased along the northwestern and eastern coasts of North America, as far north as Alaska. The dioecious-only model detected hotspots along the southern most points of the Great Lakes, the US coasts, fragments of Canada, California, Central America, and the southern US (Fig. 2.10). Maxlike all-data, showed severe risks in both monoecious and dioecious ranges; and along much of the North American coasts, including British Columbia, Alaska, and the Yucatan Peninsula (Fig. 2.11). Additionally, the Great Lakes appeared as suitable habitat in for invasive hydrilla. The Great Lakes are listed in order of severity (high-risk to cautionary advisory) based on Maxlike calculations: Lake Michigan, Lake Erie, Lake Ontario, and Lake Huron. Maxlike Additive predictions expanded suitable habitat from Hawaii to Alaska, California to Florida, portions of Canada and the Great Lakes (Fig. 2.12). Dioecious-only standard deviation (Fig. 2.13) showed disagreement along the west coast of North America. This was due to the random variability within the training and test data. Both monoecious-only (Fig. 2.14) and all-data (Fig. 2.15) standard deviations had large disagreements that were to due large variances in the input data and the small sample size.

Further, to visualize disagreements between the individual biotype models, Biotype Discrepancy models produced ranges that failed to identify the opposing biotype distribution: Maxent (Fig. 2.16) and Maxlike (Fig. 2.17). Discrepancy models compared all-data and Additive distributions by calculating the ranges of disagreement between raster outputs. The Maxent Discrepancy model revealed extensive regions of disagreement between the predictions in the northeastern US and around the Great Lakes (Fig. 2.18). The Maxlike Discrepancy model had little disagreement between the all-data and the Additive distributions, bordering the southern US (Fig. 2.19).

Discussion

Biotype influences habitat suitability predictions. In our story, training the model to consider local environmental and atmospheric conditions preferred by local biota individually and then combining (our "Additive Models"), improved predictions by more equally recognizing both monoecious and dioecious hydrilla habitats. The all-data models have no mechanism to consider that the two biotypes may have different habitat requirements. Both Maxent and Maxlike biotype-only models accurately predicted their biotype-dominant regions; however, the models underestimated regional atmospheric preferences and did not predict suitable habitat for the opposing biotype as shown by the Additive model. Both Additive models more accurately reflected hotspots of known hydrilla invasion than their all-data counterparts and improved species distribution forecasts by recognizing and displaying multiple regions at-risk of hydrilla invasion by multiple biotypes. This distinction is the first of its kind, to consider regional biotype distributions and improve model predictions.

When comparing the Additive model to the all-data model, the latter failed to emphasize the less populous biotype (i.e. monoecious) habitats. The all-data model treated the occurrences as belonging to one biotype. The model is not intuitive enough to recognize there were multiple genotypes with variable environmental requirements; therefore, it is up to the modeler to make this distinction and adjust the datasets accordingly. Hence, the predictions favored warm temperate regions where dioecious hydrilla is commonly found. The Additive model fared better than the all-data model by manipulating the data inputs. The Additive model was created by using the highest risk areas from both the monoecious and dioecious regions; thereby providing a more comprehensive representation of hydrilla distribution in the United States. The regions strongly predicted in the Additive model match up with hydrilla occurrences that were missed in the all-data distribution, leading one to infer the Additive model is performing best by estimating a more thorough distribution. The hydrilla invasion in North America is not yet complete and therefore, the current model may underestimate the possible extent of the invasion. Models were trained using current known occurrences, new or undetected infestations could alter model predictions.

Monoecious-only and dioecious-only model simulations more accurately reflected known range of each specific biotype, with the exception of Maxlike monoecious-only. Maxent distributions stay near the vicinity of the local hydrilla range, indicating good model performance. Maxlike dioecious-only predictions occur longitudinally across the country, near temperate coastal regions, and correctly identified known hydrilla habitat. However, the both Maxlike models expand the predictions of suitable habitat to the Pacific coast in British Columbia and southeast Alaska where hydrilla is not currently found. Further, the monoecious-only Maxlike model fails to identify many hydrilla occurrences in the mid-west and further northeast coast, while increasing at-risk habitats along the Pacific coast. Merow and Silander Jr (2014) remind researchers that Maxlike has a more variable response when given smaller datasets. Lastly, the Maxent Biotype Discrepancy (Fig. 2.16) model supports Maxents' Additive Discrepancy (Fig. 2.18) proficiency to accurately predict distributions by indicating areas of large disagreement; whereas the Maxent Additive model performs better against the Maxent all-data model supporting the idea that biotype does influence model predictions. With MaxLike, there is much less difference between the monoecious-only model (Fig. 2.9) and dioecious only model (Fig. 2.10), which is reflected in the MaxLike biotype discrepancy model (Fig. 2.17) and to a lesser extent in the MaxLike additive discrepancy model (Fig. 2.19). Overall, it seems that MaxEnt is better able to distinguish between biotypes than MaxLike, and may therefore be the more informative modeling tool. Hydrilla biotypes occur in different regions where environmental conditions vary and average photoperiods differ; influencing model distributions by presenting multiple environmental preferences. However, both biotypes utilize short photoperiods and reproduce in high temperatures; monoecious hydrilla is adapted to conserving available resources until environmental conditions are best for reproduction and growth (Spencer and Anderson 1986; McFarland and Barko 1999). Van (1989) suggested that monoecious hydrilla is better adapted to harsh conditions than dioecious. In addition, studies have recorded increased tuber growth for monoecious hydrilla, opposed to dioecious tuber growth under similar photoperiods (Steward and Van 1987, Sutton et al. 1992). Furthermore, Soto et al. (in prep) observed greater desiccation tolerance and survival rates in monoecious plant fragments than dioecious fragments. These results support monoecious hydrilla's ability to successfully establish in new locations. While dioecious hydrilla has been more extensively recorded across North America, it does not discredit monecious hydrillas' invasion potential. SDM models that do not consider biotypes can severely underestimate invasion potentials, as demonstrated with monoecious occurrences. It would be beneficial to continue investigating species-specific traits that may influence invasive species management, perhaps considering growing degree days to measure photoperiods necessary for reproduction.

In conclusion, slowing the spread of non-native species can be accomplished by identifying regions most suitable for new invasive populations to establish, and this study supports the hypothesis that incorporating biotype during SDM implementation can improve forecasts. We recommend caution when modelling species with multiple biotypes, they may possess unseen or undetectable advantages that species distribution models may not be able to account for. The incorporation of species-specific traits like biotype into a species distribution modeling will influence model performance and improve ability to predict future habitat invasions. The outcome of comparisons between all-data and biotype-specific models will allow managers to understand the extent regional characteristics or subspecies will affect species distribution predictions. Invasive species management costs and bioeconomic damage can be reduced by targeting resources to specific areas where invasions are most likely to occur, a much more cost-efficient method. It is recommended to continue investigate species-specific traits to continue improving invasive species distributions. By considering all the influences that contribute to distribution of invasive species and monitoring at-risk regions, researchers and managers have the potential to halt future invasions just at the forefront of the destruction and successfully manage invasive species.

Acknowledgements

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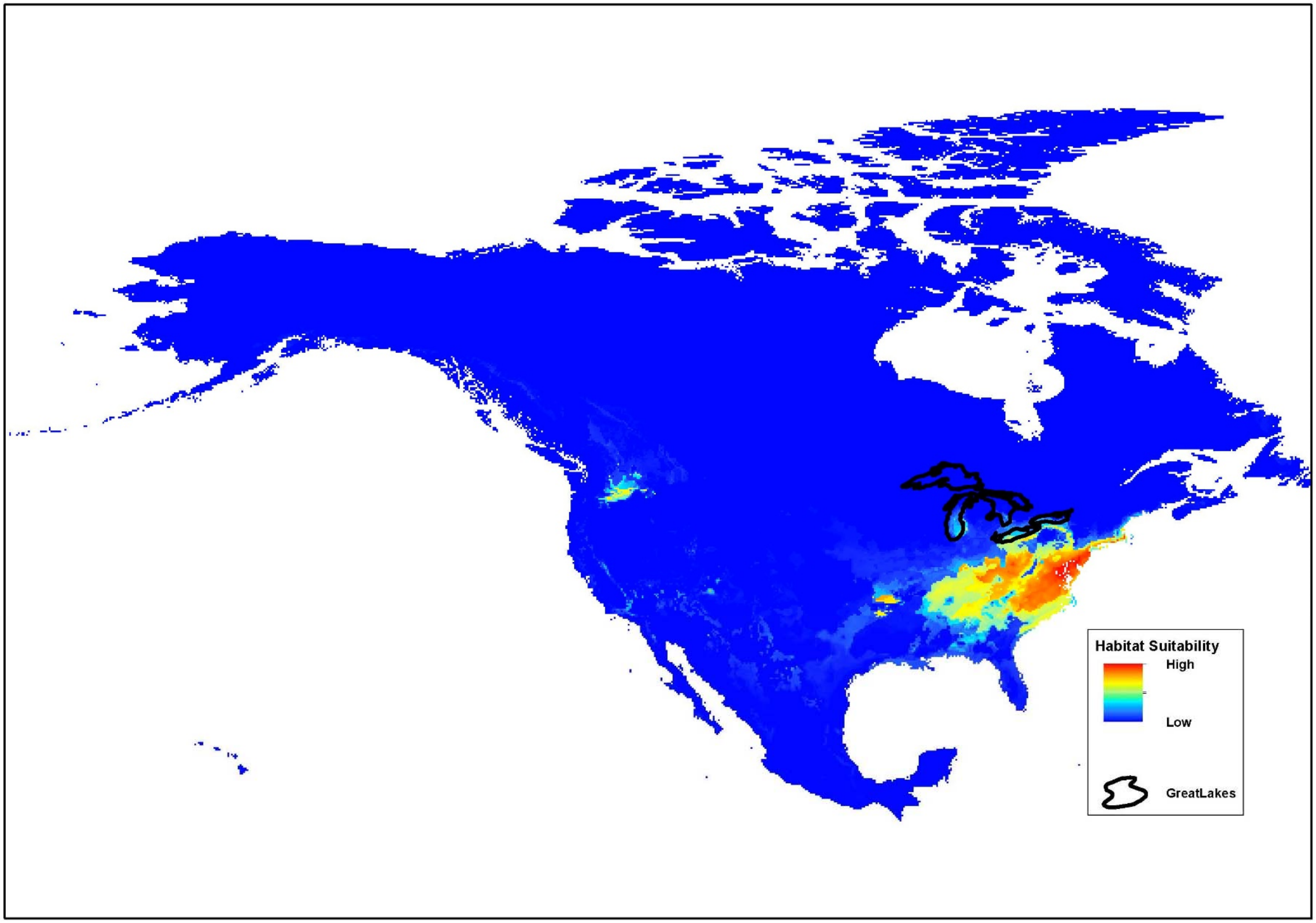

Fig. 2.2 Maxent monoecious-only distribution

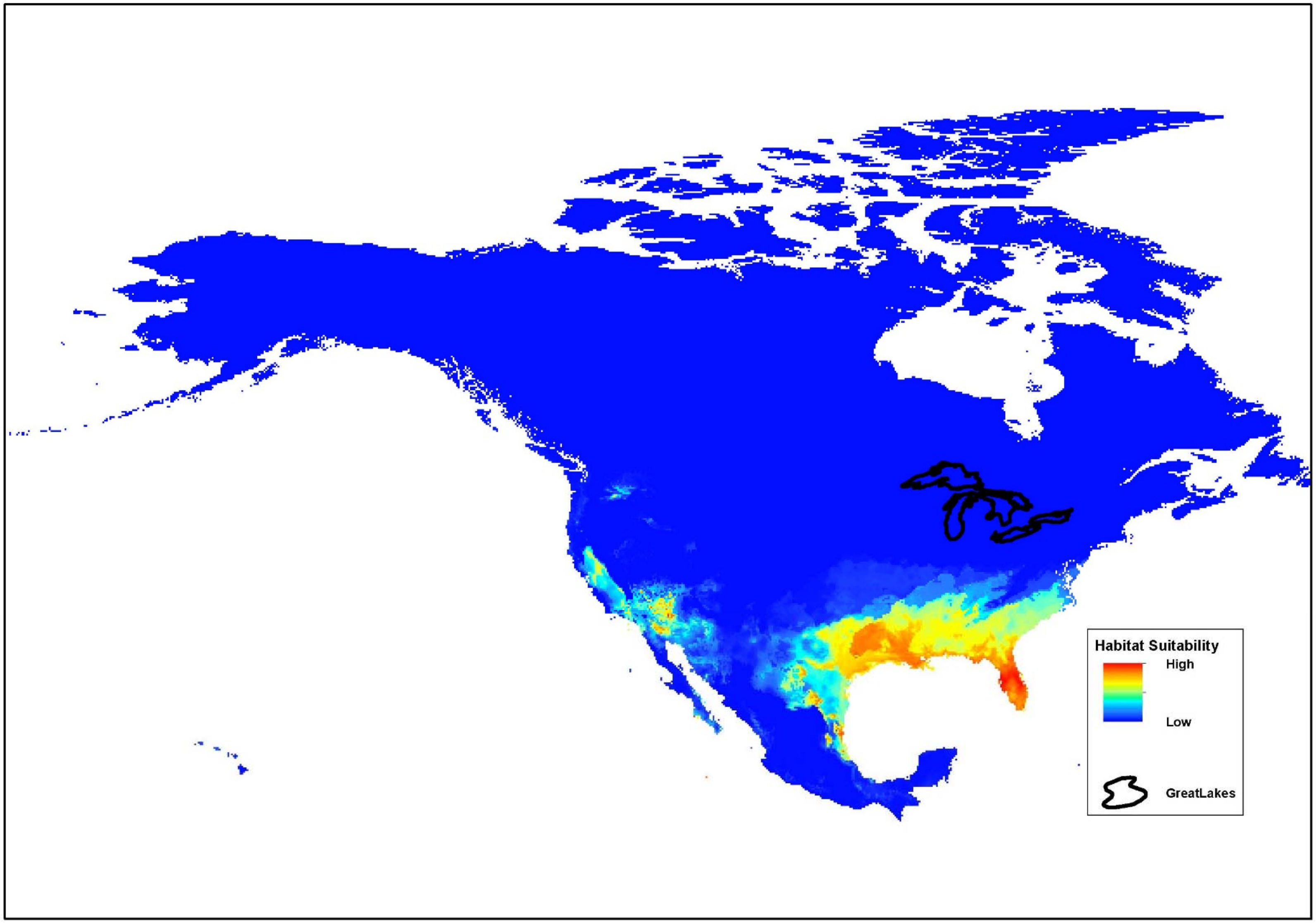

Fig. 2.3 Maxent dioecious-only distribution

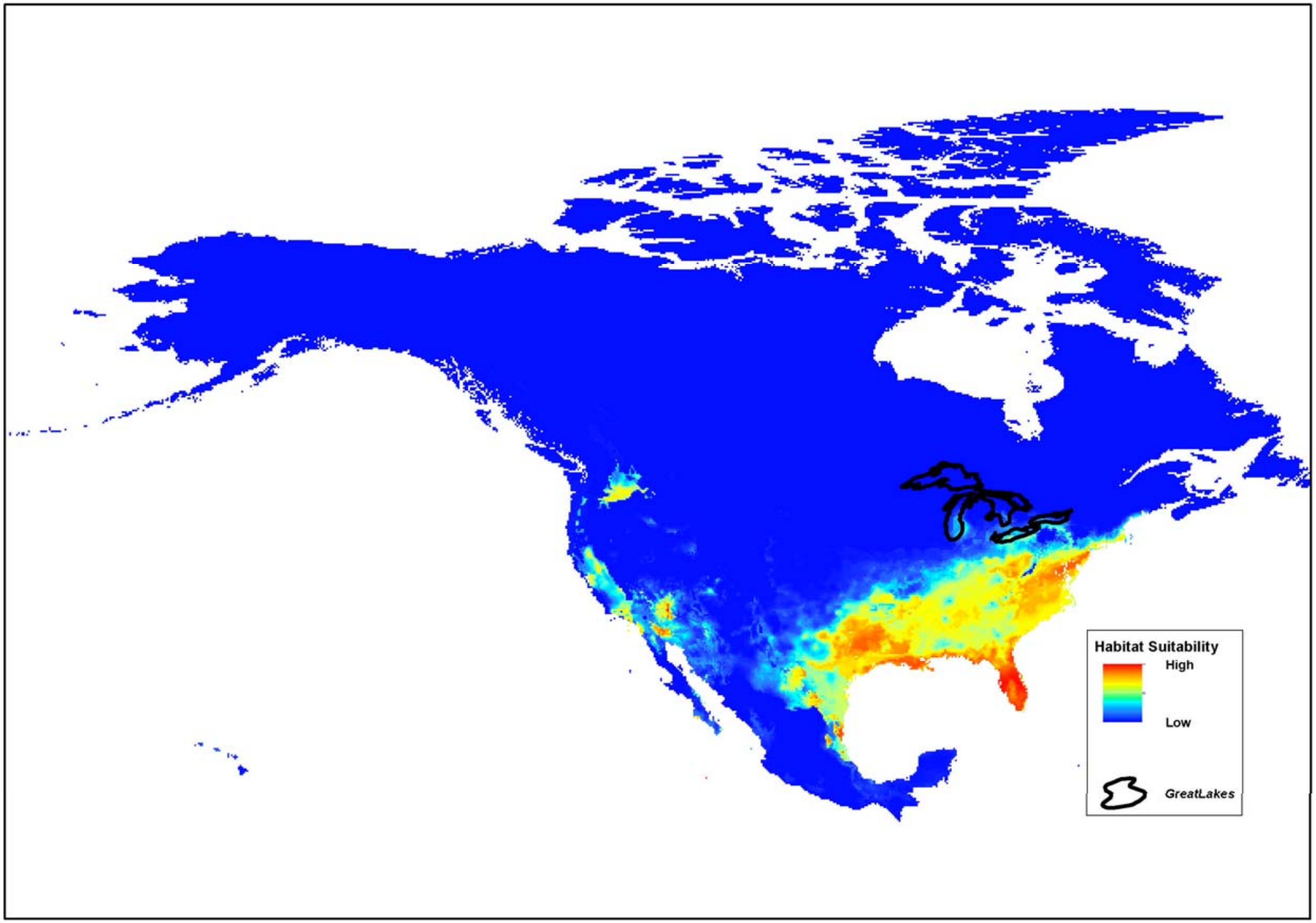

Fig. 2.4 Maxent all-data distribution

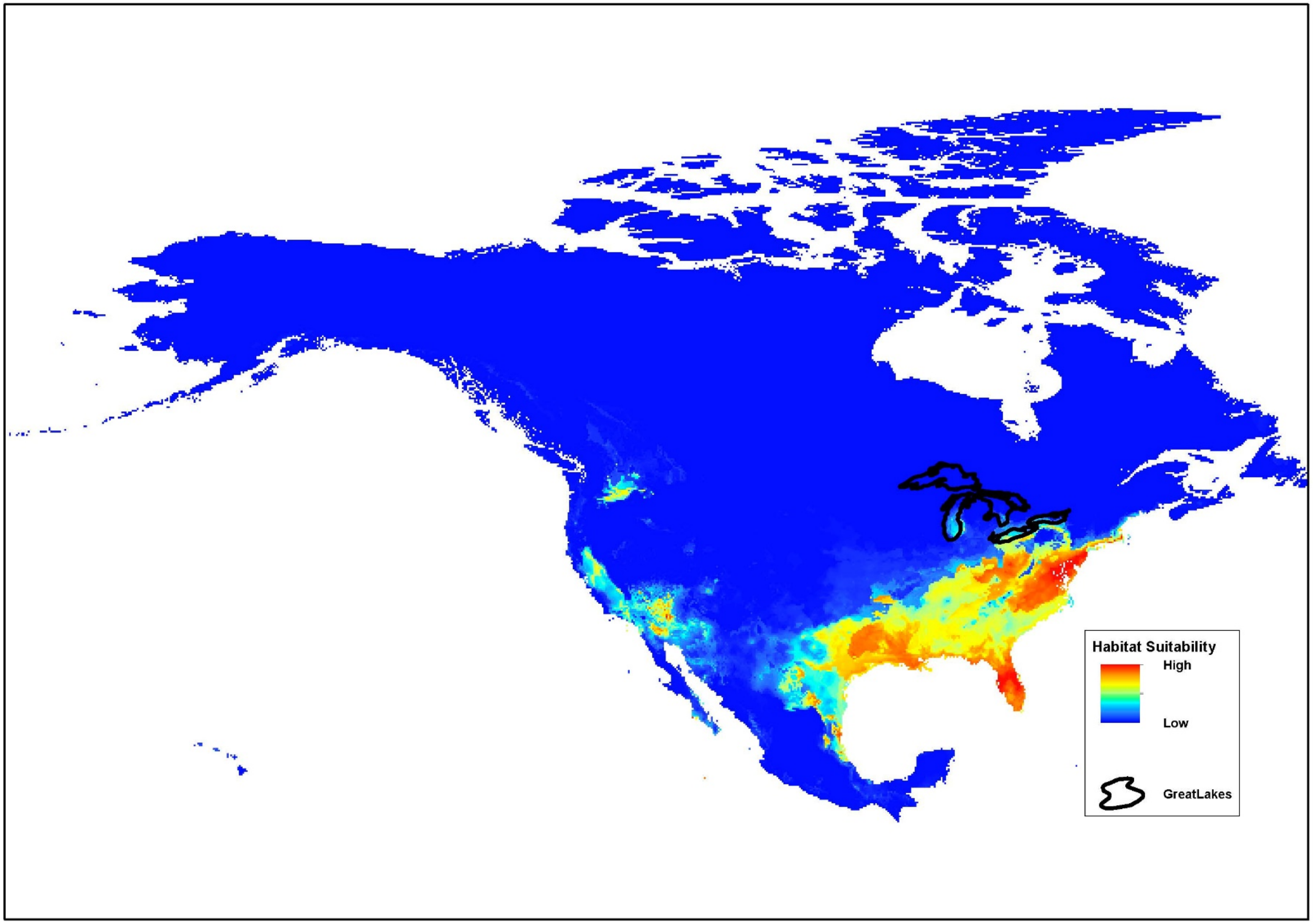

Fig. 2.5 Maxent Additive distribution

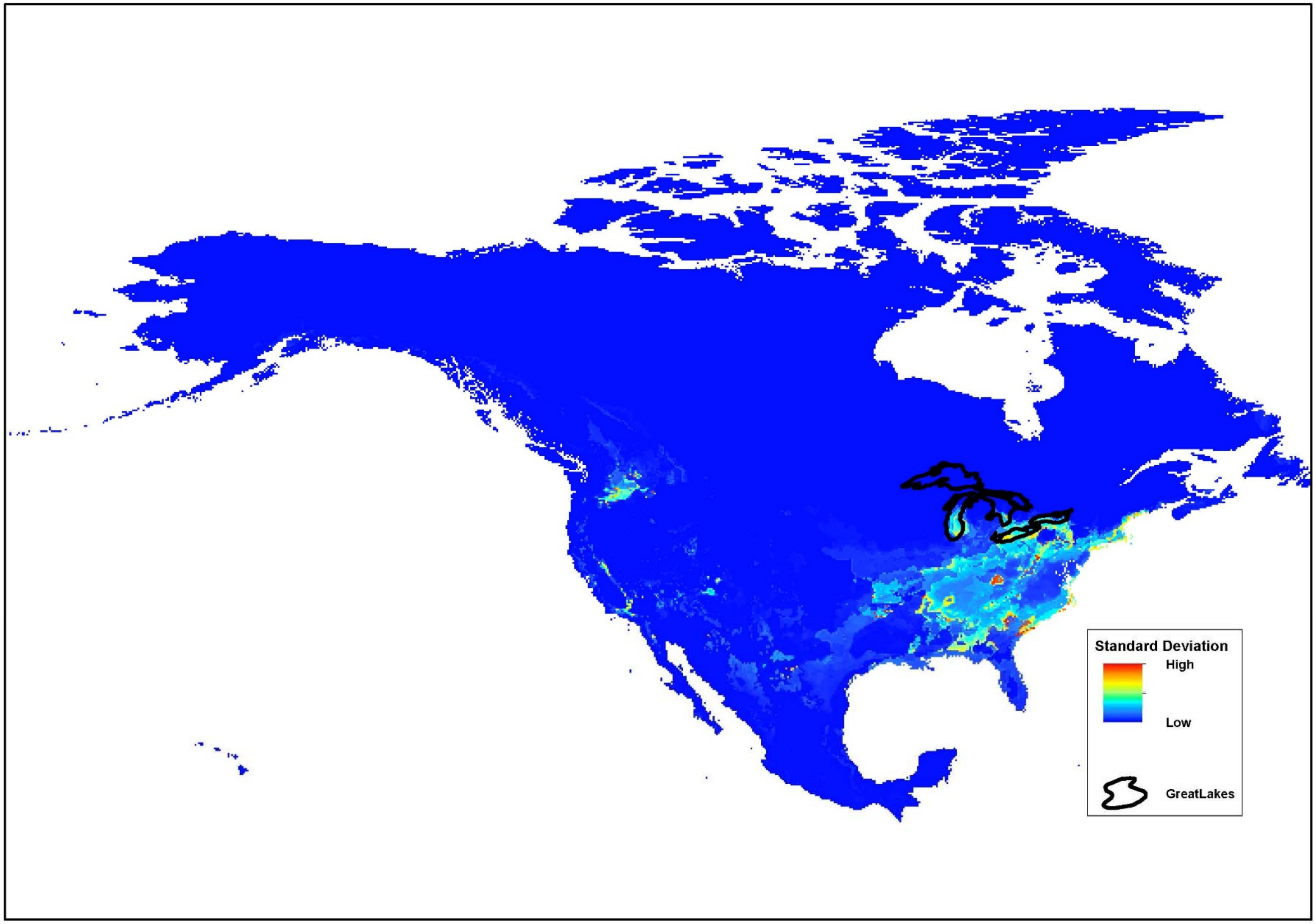

Fig. 2.6 Maxent monoecious-only standard deviation

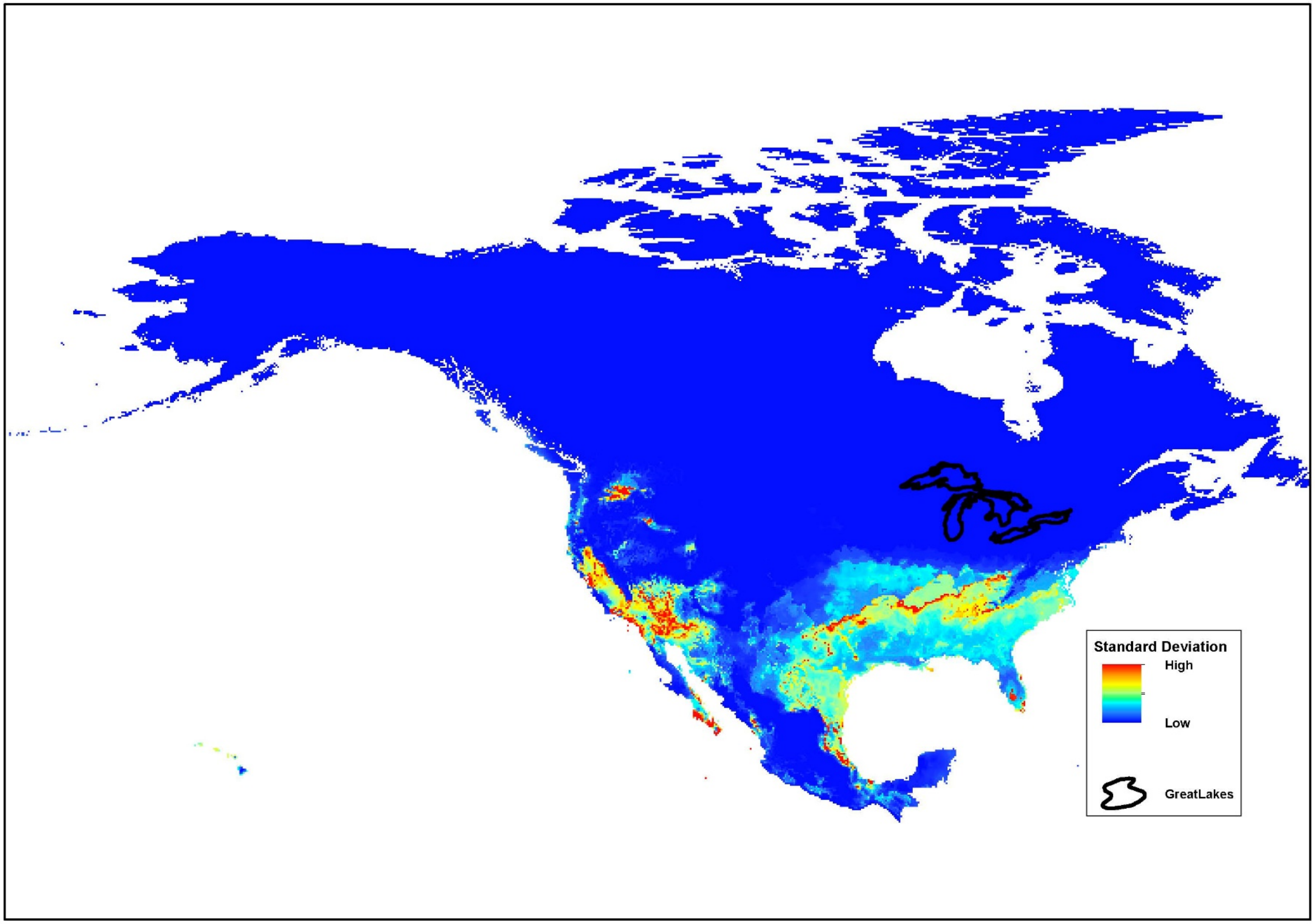

Fig. 2.7 Maxent dioecious-only standard deviation

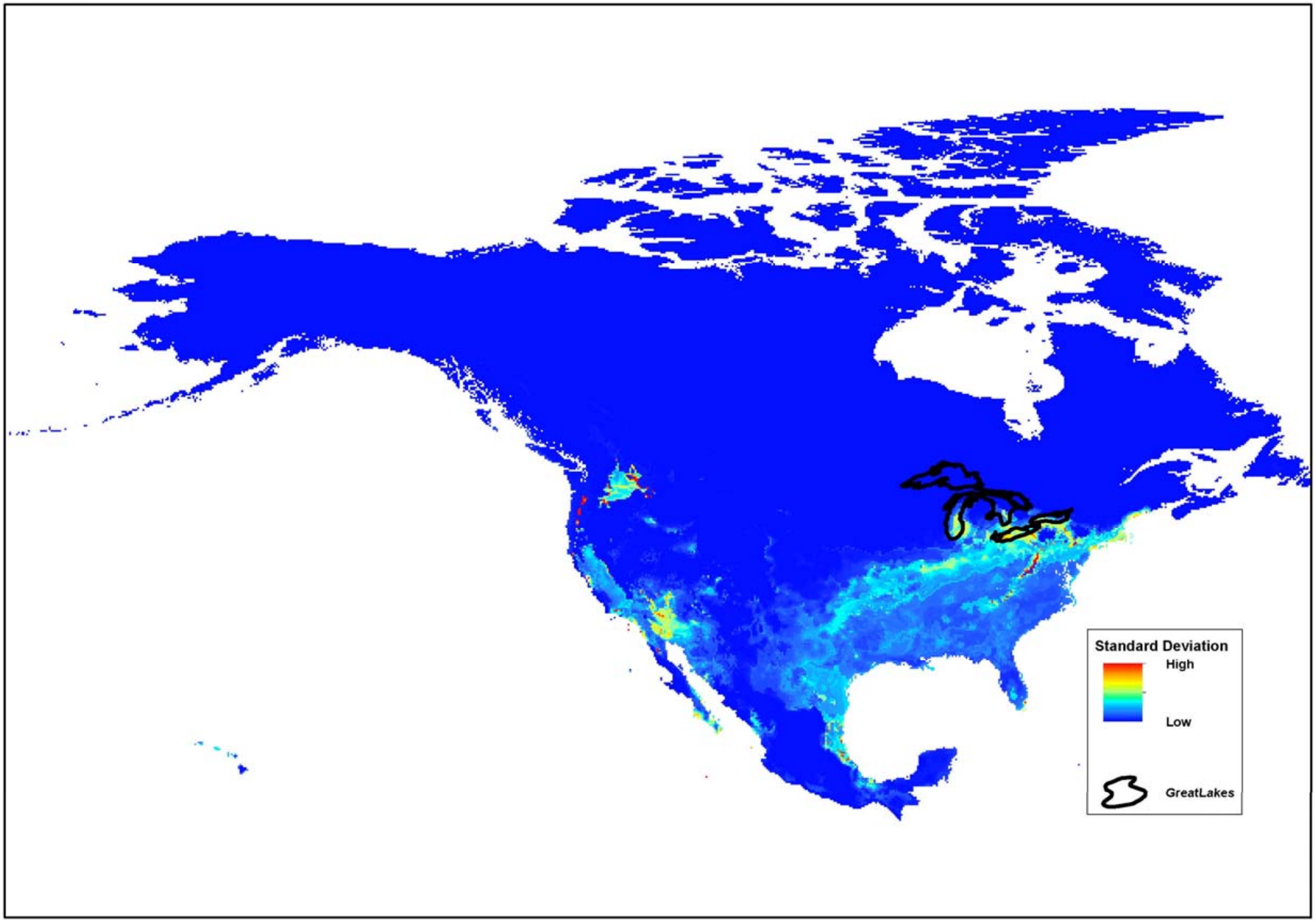

Fig. 2.8 Maxent all-data standard deviation

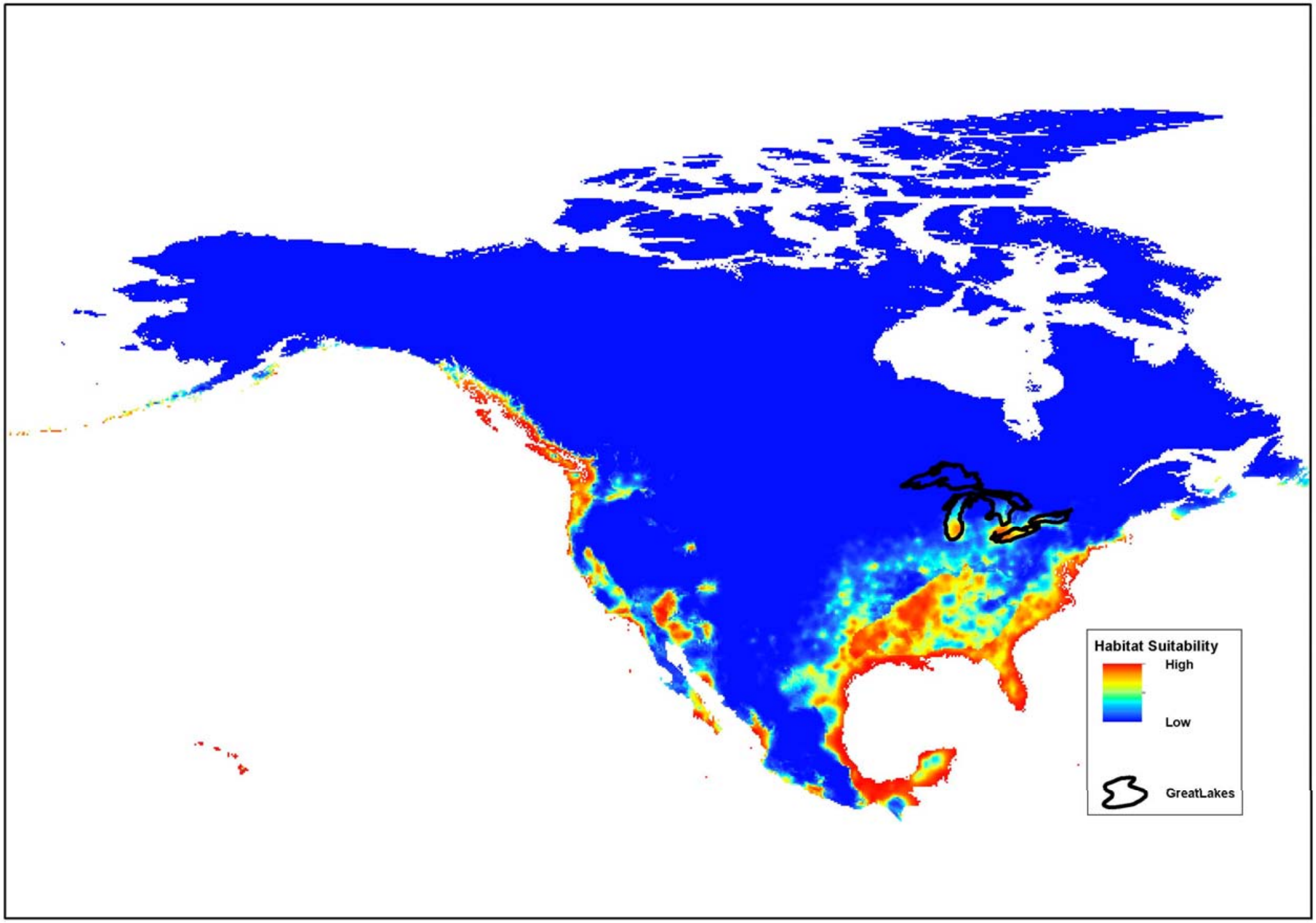

Fig. 2.9 Maxlike monoecious-only distribution

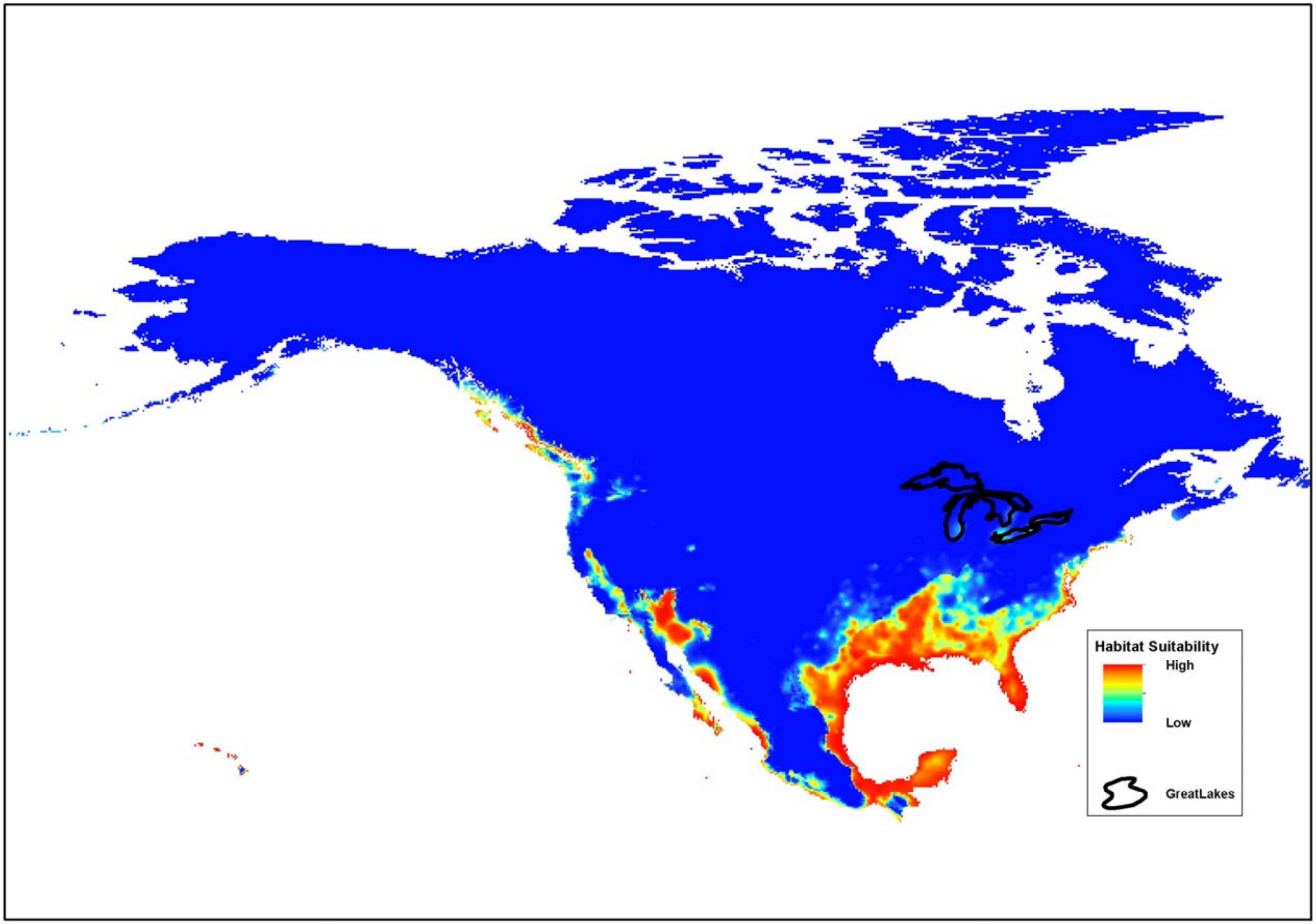

Fig. 2.10 Maxlike dioecious-only distribution

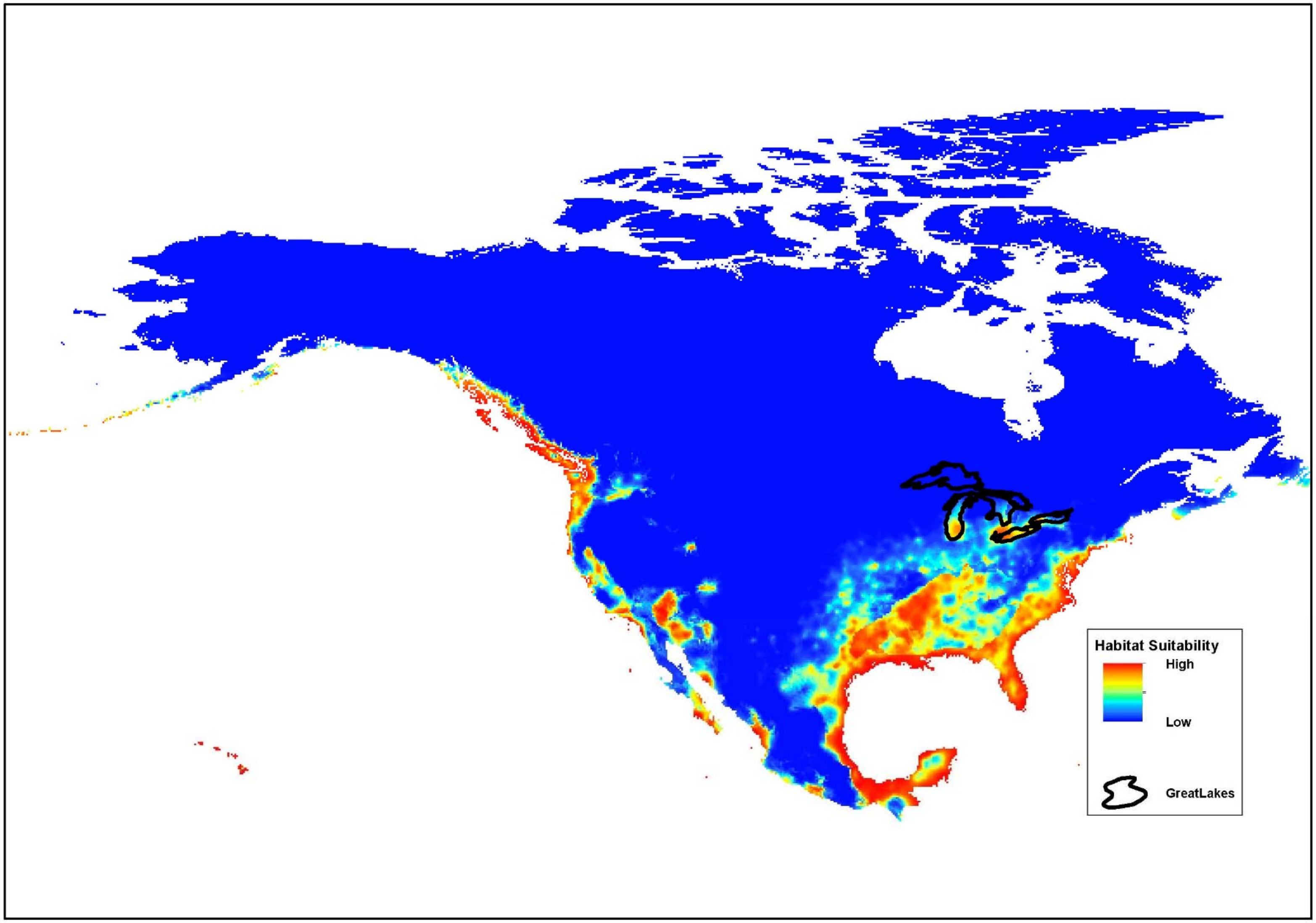

Fig. 2.11 Maxlike all-data distribution

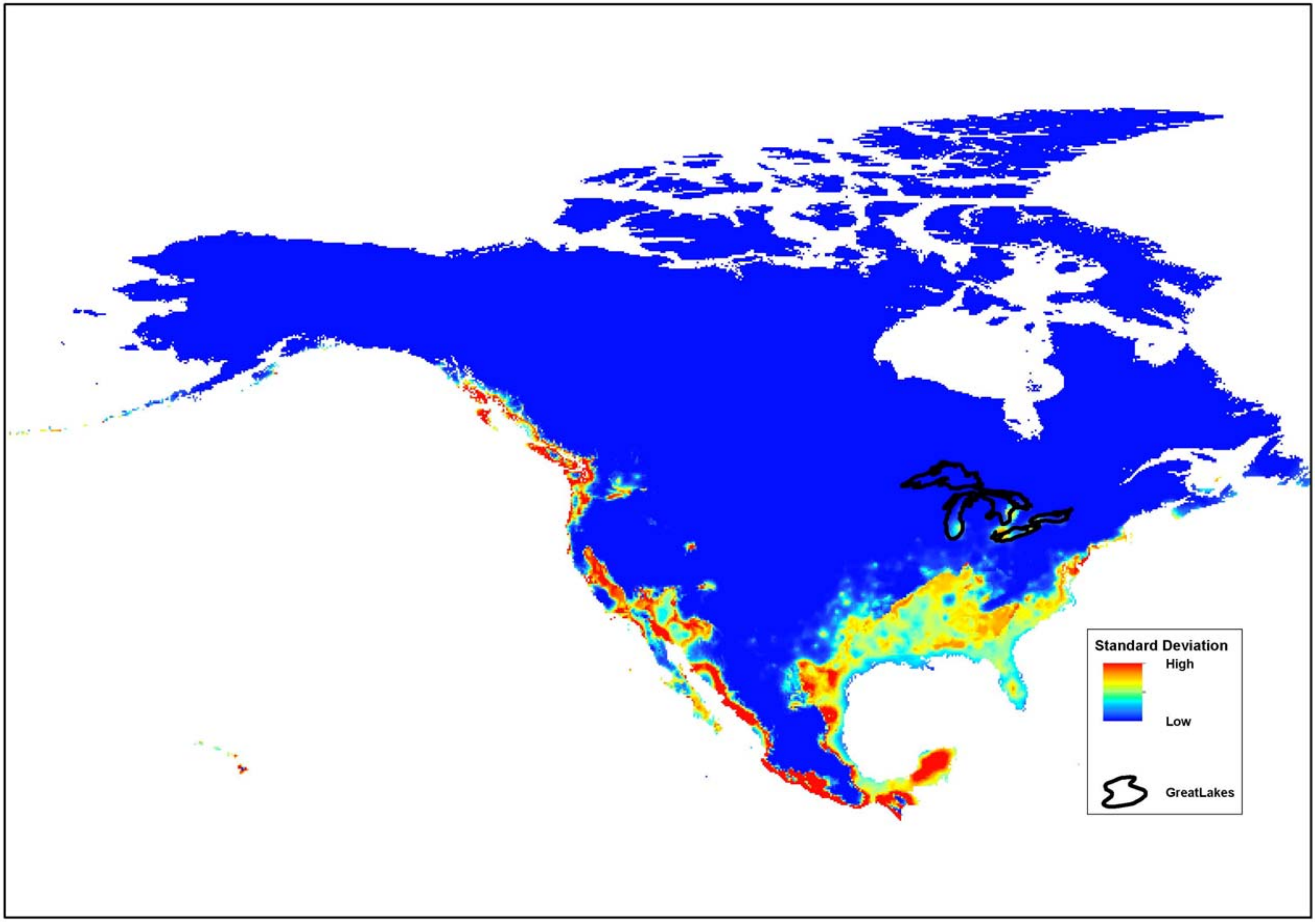

Fig. 2.13 Maxlike dioecious-only standard deviation

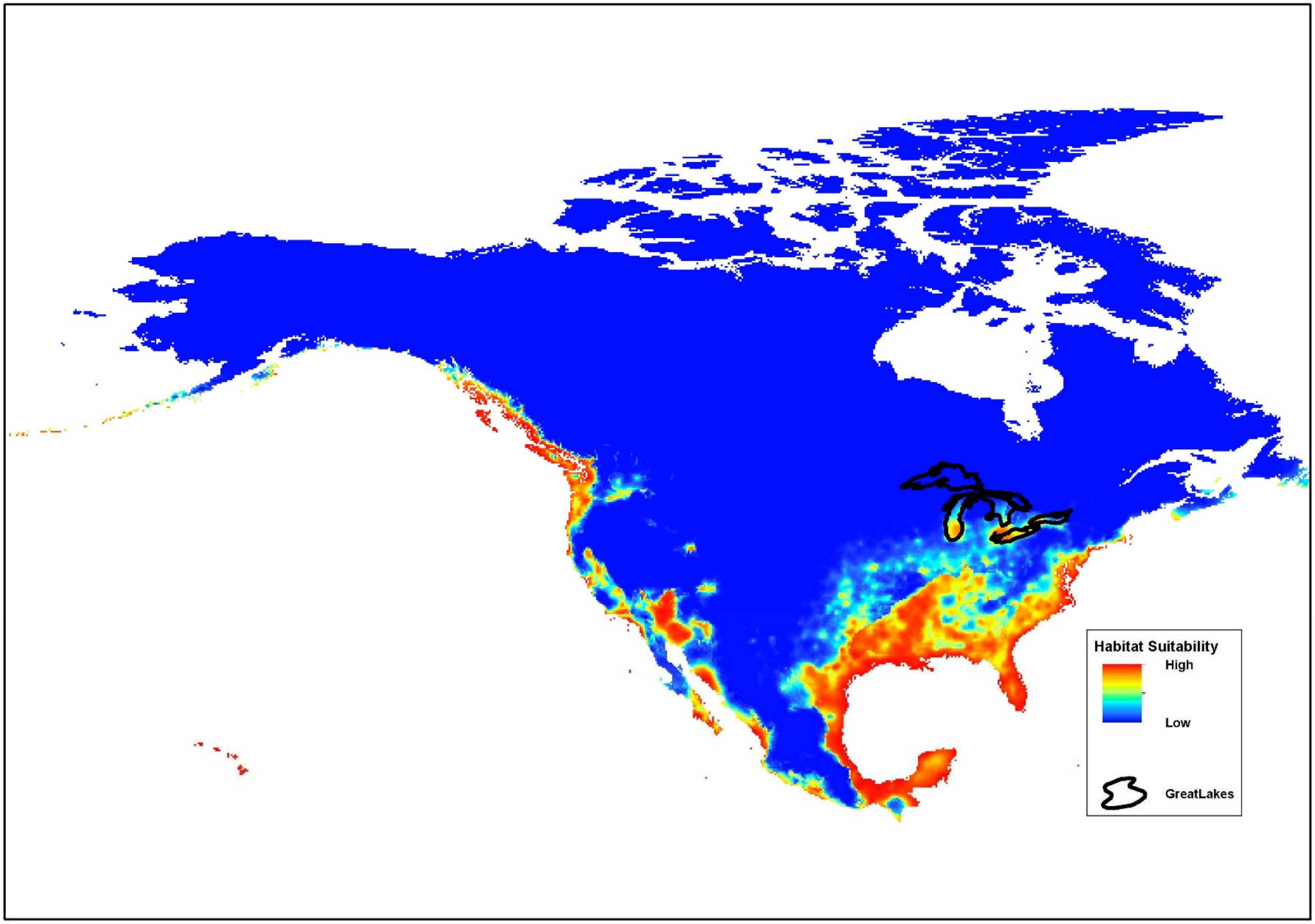

Fig. 2.12 Maxlike Additive distribution

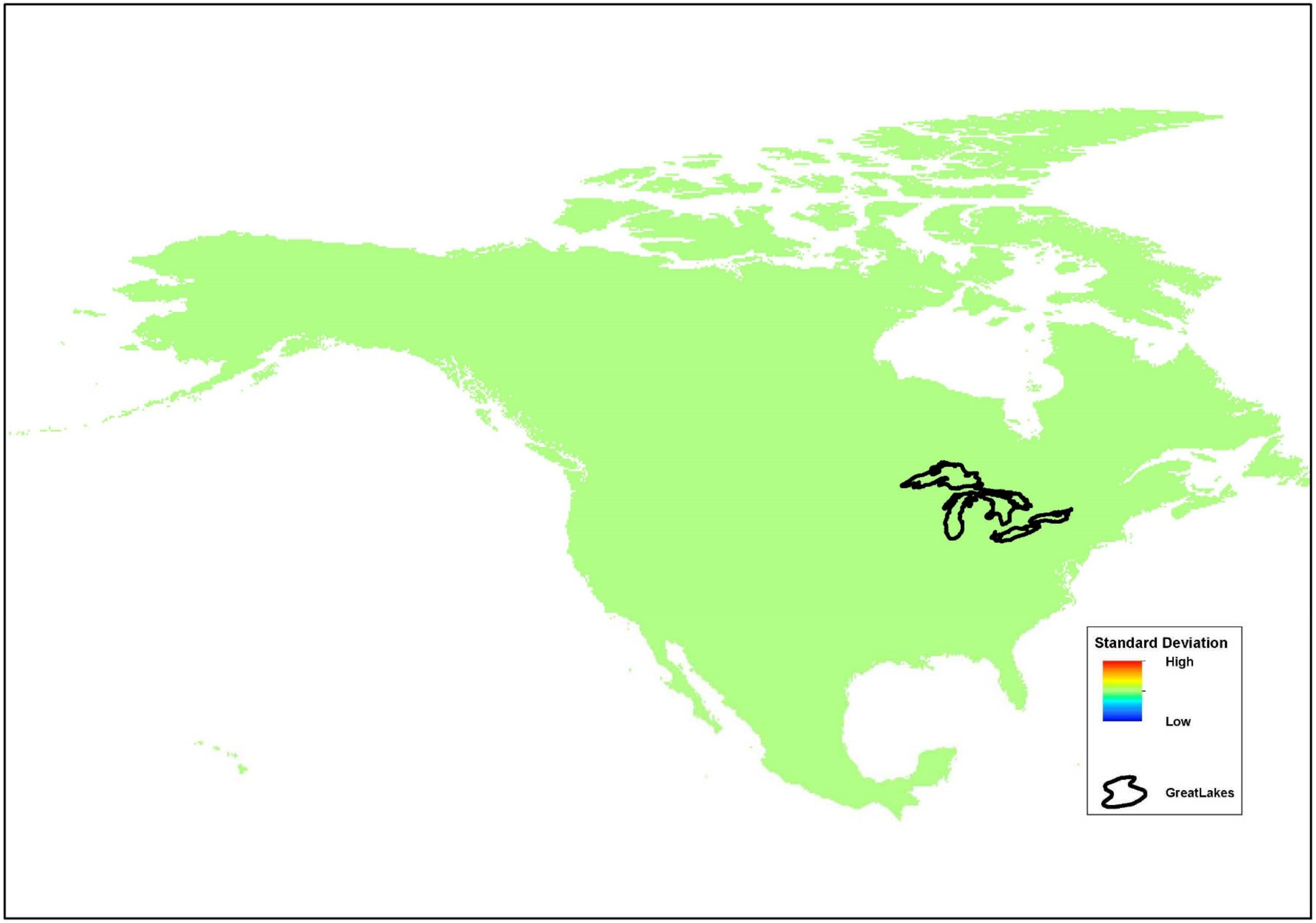

Fig. 2.14 Maxlike monoecious-only standard deviation

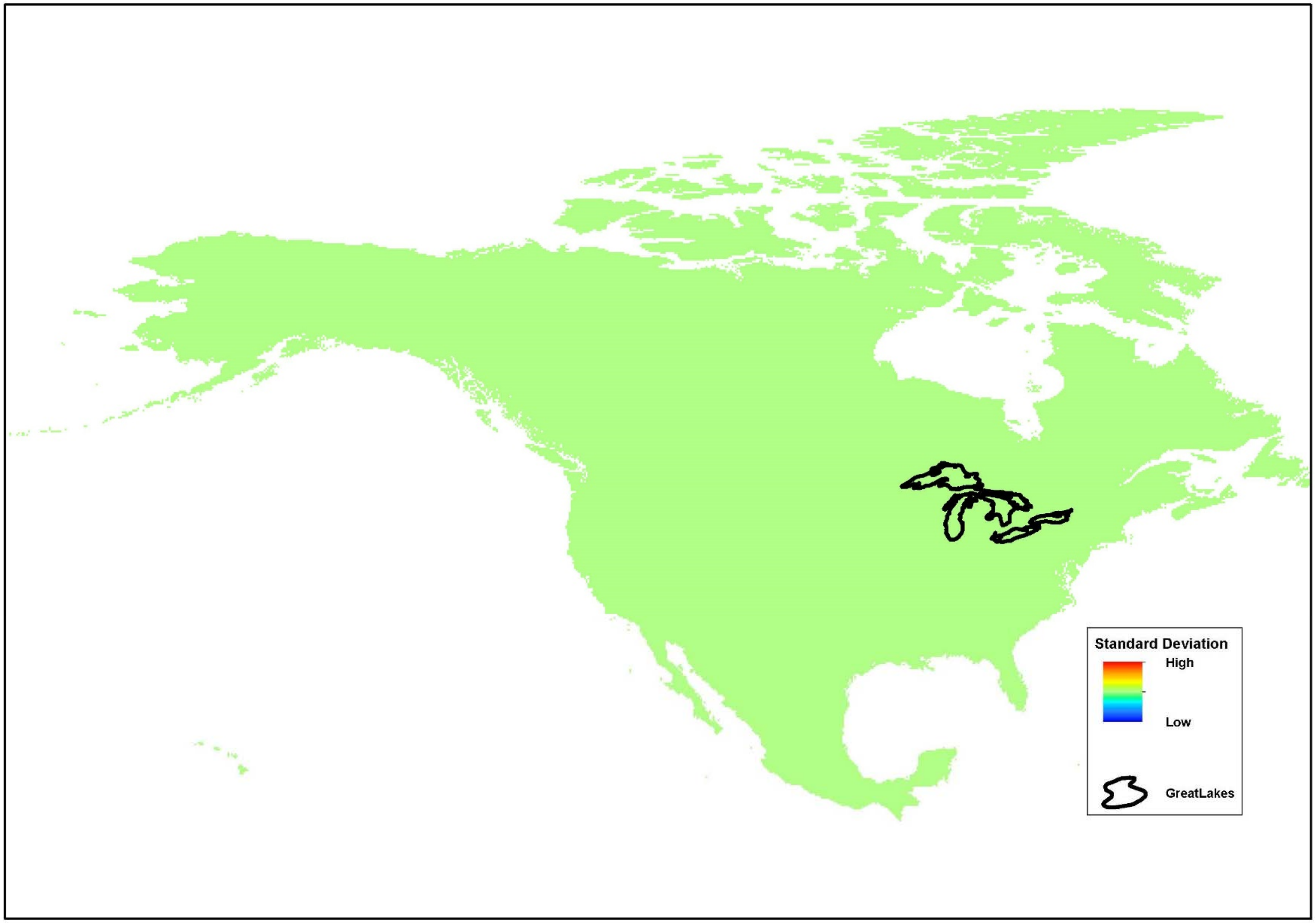

Fig. 2.15 Maxlike all-data standard deviation

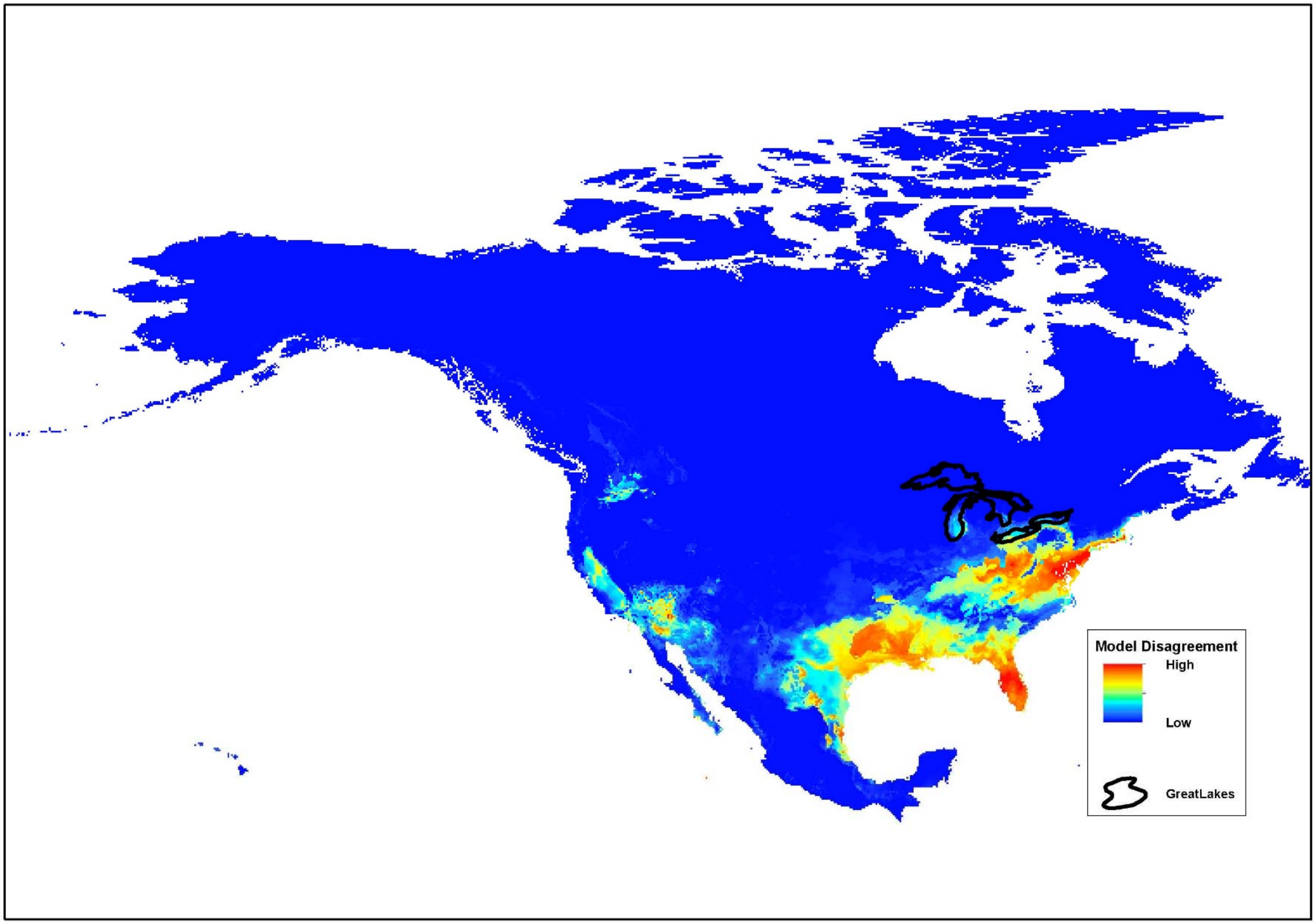

Fig. 2.16 Maxent Biotype Discrepancy model shows there is a difference between hydrilla monoecious and dioecious distributions

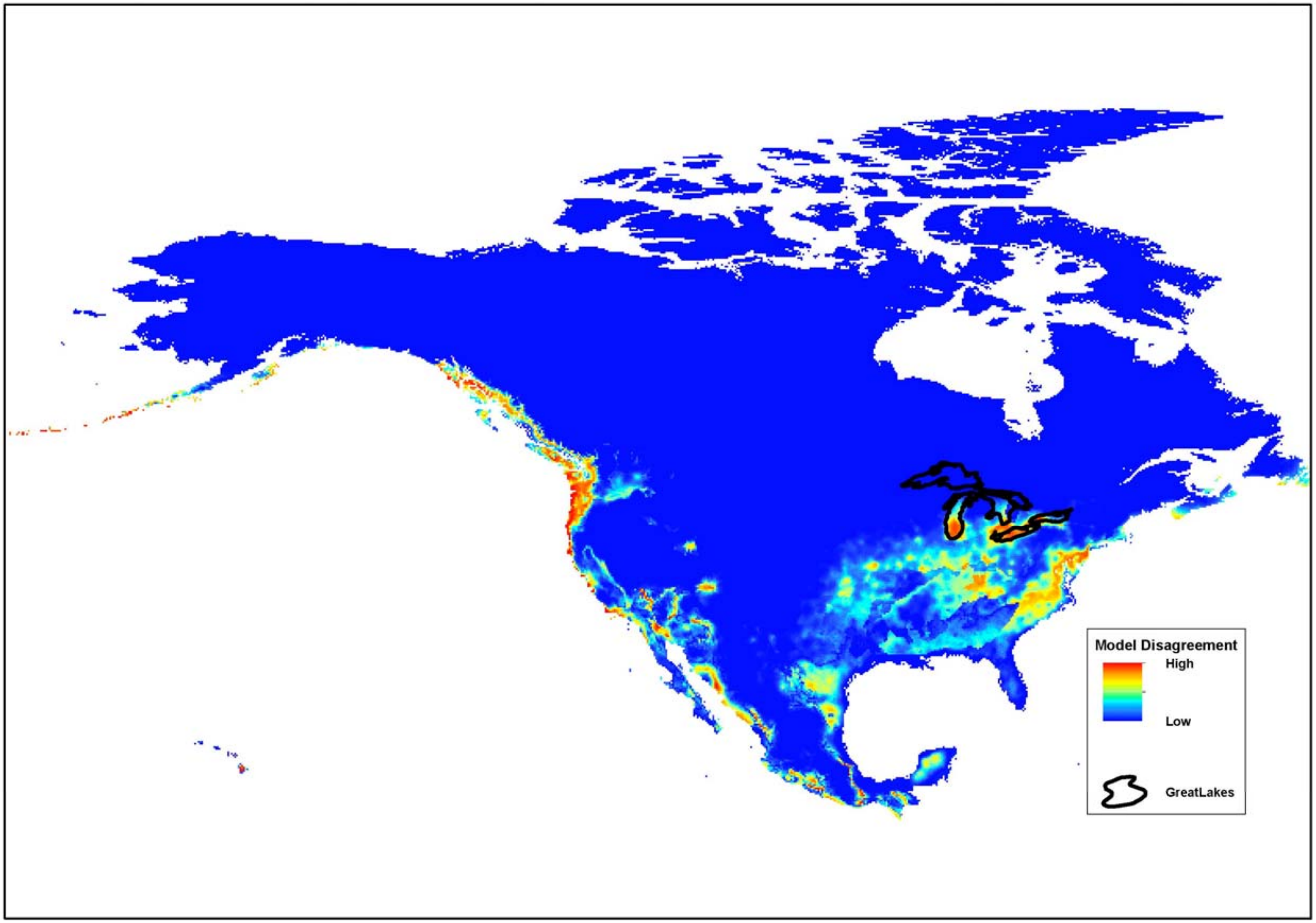

Fig. 2.17 Maxlike Biotype Discrepancy model shows increased model disagreement in the northeastern United States.

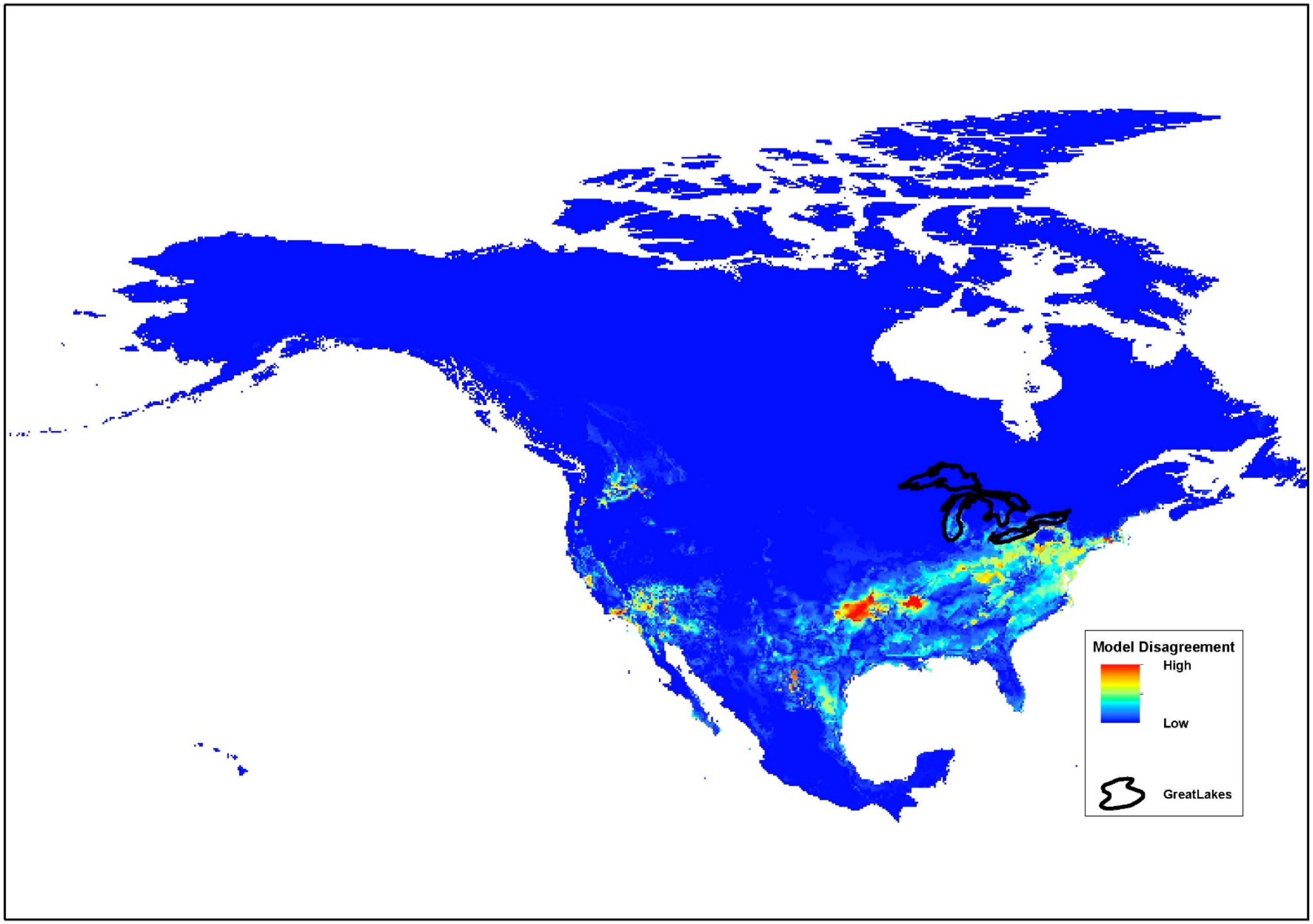

Fig. 2.18 Maxent Additive Discrepancy model shows large disagreements between the all-data and Additive models

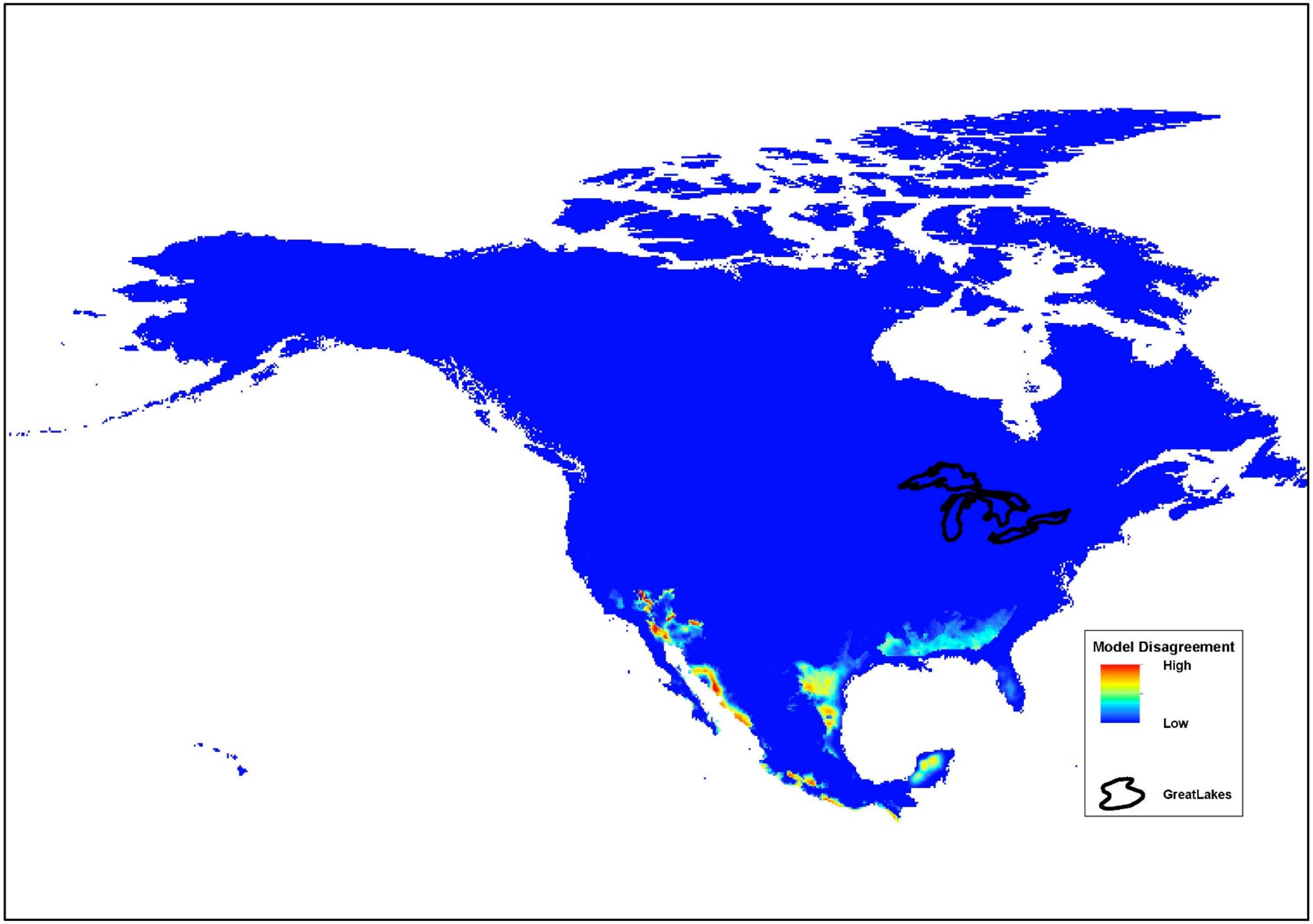

Fig. 2.19 Maxlike Additive Discrepancy model shows large agreements throughout much of the US

C Great Lakes Habitat Features

This appendix includes a technical memorandum describing the approach used to collect and review a variety of Great Lakes habitat features with the potential to influence habitat suitability for Hydrilla in the Great Lakes. The information was used for several purposes, as described in Section 3.1.4 of the risk assessment report.

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Memorandum

Great Lakes Hydrilla Risk Assessment

Identifying Spatial Data for "Inferences of Suitability"

Data Compilation Efforts

The original primary objective was to compile a database of current and historical occurrences of *Hydrilla verticillata* (Hydrilla). The database is intended to provide information for modelling efforts that were used to predict which regions of the Great Lakes may be most susceptible to introduction and invasion of Hydrilla. In response to comments provided by the United States Army Corps of Engineers – Buffalo District (USACE Buffalo) and USACE Engineering Research and Development Center (ERDC) on the Hydrilla Risk Assessment Methodology, Ecology and Environment, Inc. (E & E) has led efforts to locate spatial data that may potentially infer suitability for Hydrilla infestation within the Great Lakes. Specific recommendations provided by USACE Buffalo and ERDC included:

> "…in-lake variables (e.g., light, depth, growing degree days, sediment types, exposure to fetch, history of prior plant growth) will likely be critical in determining where Hydrilla might successfully establish and expand."
>
> "…accessing information on current and historic SAV [submerged aquatic vegetation] communities in the Great Lakes will prove more difficult and time-consuming, but will yield valuable data regarding sites that may be at high risk due to current or prior support of SAV beds. This is the type of data that could be used to help refine models."

Subsequently, online resources have been queried and new project contacts were made in efforts to obtain spatial data for in-lake variables for the Great Lakes that may be useful as "Inferences of Suitability" for potential Hydrilla infestations. Kevin O'Donnell with the U.S. Environmental Protection Agency's (EPA's) Great Lakes National Program Office provided several useful suggestions. Organizations and online resources that have either directly provided spatial data or potential information include:

- Michigan Tech Research Institute (MTRI), contact was made with Colin Brooks;
- U.S. Geological Survey (USGS), contact was made with Dale Robertson and David Saad;
- The Great Lakes Information Network (GLIN);
- Great Lakes Aquatic Habitat Framework (GLAHF);
- Early Detection and Distribution Mapping System (EDDMapS);

- National Oceanic and Atmospheric Administration (NOAA);
- Ontario Ministry of the Environment (OMOE);
- University of Wisconsin–Madison: Center for Sustainability and the Global Environment (UW - SAGE);
- Environmental Protection Agency: Great Lakes Environmental Database (EPA: GLENDA);
- National Geospatial-Intelligence Agency (NGA);
- Conservation Biology Institute: Data Basin;
- Great Lakes Environmental Assessment and Mapping (GLEAM); and
- USACE, Wisconsin (USACE Wis).

Shapefiles have been downloaded and received from sources, and metadata for a number of these "Inferences of Suitability" that are anticipated to inform modelling and prediction efforts, most notably layers for bathymetry, SAV mapping, and the distribution of Eurasian water-milfoil (*Myriophyllum spicatum*), another invasive SAV species. There have been efforts to locate mapping of nutrient loading in nearshore areas (phosphorus and nitrogen), and while some useful data have been discovered the effort is not fully complete. The availability of spatial data for weather-related variables such as surface water temperature and wave action has not been extensively researched to date. Table 1 summarizes the "Inferences of Suitability" variables, including variables for which adequate spatial data have been obtained and those variables still being researched or under consideration.

Communication with Project Collaborators

Collaborator Matthew Barnes has suggested an approach for integrating "Inferences of Suitability" data into the Hydrilla distribution models. To be included in the development of Barnes' global distribution models, the variables of environmental data must be available for the projected range (the Great Lakes) as well as any native or invasive range. For example, climate data is often available at the global level. Yet any data limited to the Great Lakes region are not useful for Barnes' global distribution model development. However, once the global distribution models have been developed, data for relevant environmental factors limited to the extent of the Great Lakes could be overlaid with the global model outputs to refine the predicted distribution of Hydrilla within the Great Lakes Basin.

During the development of the Hydrilla occurrence database, communication with project collaborators Matthew Barnes, Jonathan Bossenbroek, and Rob Richardson was important. They provided knowledgeable feedback regarding environmental factors that are most likely to be valuable for predicting potential Hydrilla habitat in the Great Lakes. Correspondence with these collaborators and Mike Netherland provided specific data classification for areas with suitable or unsuitable conditions for Hydrilla. Regular email correspondence with all three collaborators, and a conference call on June 26, 2015, with Barnes and Bossenbroek, have provided opportunities for inquiry and feedback.

Based on communications with collaborators, the following suitability layers have been determined to be the most valuable for predicting Hydrilla introduction and growth and were used in some capacity to refine global model outputs:

- Depth/light penetration: Richardson considers light penetration one of the most important factors, as it limits where Hydrilla can successfully photosynthesize. The Project Team used a recommendation from Michael Netherland, Ph.D. (Center of Aquatic and Invasive Plants, University of Florida) of a maximum threshold depth of 25 feet, as hydrostatic pressure at greater depths limits Hydrilla growth. Water depth is correlated with light penetration, which is another important factor as light limits where Hydrilla can successfully photosynthesize.
- Water temperature: Richardson, Bossenbroek, and Barnes agree that water temperature is an important factor. Barnes stated that air temperature, which is strongly correlated with local water temperatures, was used as a variable in his global predictive models. However, it was also considered worthwhile to obtain water temperature data within the Great Lakes. Wood (2017) reported in growth chamber studies and mesocosm studies that sprouted monoecious Hydrilla tubers had limited growth after four weeks at temperatures less than 66°F (19°C) but demonstrated significant biomass production when temperatures increased to approximately 68°F (20°C). Regan (2017) reported that shoot lengths of sprouted propagules were significantly reduced in 64°F (17.6˚C), which corroborates the limiting effects of lower temperatures on Hydrilla growth. According to Netherland, problematic growth of Hydrilla requires two months or more of water temperatures of 68°F (20°C) or greater. Great Lake waters that do not reach this temperature for this duration would be unlikely to support dense infestations of Hydrilla.
- Eurasion water-milfoil presence: Richardson and Bossenbroek believe that the distribution of this invasive species in the Great Lakes Basin would be a good indicator of both potential habitat and vectors of introduction. This plant is another highly invasive, rooted, submerged aquatic plant that coexists and competes with Hydrilla where their introduced ranges overlap, which may indicate similar habitat preferences. Eurasian water-milfoil is not expected to be a perfect predictor for Hydrilla, but its preference for higher latitudes makes it a good match for monoecious Hydrilla. In addition, Wood (2017) found that the buoyancy of fragments of monoecious Hydrilla was more similar to Eurasian water-milfoil buoyancy than dioecious Hydrilla. Both Eurasian water-milfoil and monoecious Hydrilla are well-documented in the Mid-Atlantic States and around the Ohio River. There are more infestations of Eurasian water-milfoil within the Great Lakes Basin than Hydrilla, providing examples of potentially suitable habitat (Figure 3).
- Embayments: Exposure to wave action is another useful indicator of potential Hydrilla habitat in the Great Lakes. As a rooted aquatic plant, it would be anticipated that sites protected from wave action, notably embayments along the Great Lakes shoreline, would provide more favorable habitat for Hydrilla growth than exposed shorelines. Thus, embayments received special consideration in the potential socio-cultural and economic impact analyses. While a useful variable, identifying embayments had to be completed manually; while possible for small-scale analyses, it was not practical to apply at the scale of the entire Great Lakes. An alternative resource to assess wave action that was investigated was wave action models for the nearshore areas of the Great Lakes developed by USACE Wave Information Studies (available online through GLAHF). However, the outputs provided by the models were not readily applicable to the impact analyses or large-scale spatial analysis.

Barnes also considers growing-degree days to be a particularly useful factor; it is one of the variables that he has used in past Hydrilla modelling research and incorporated these data at a global scale. Barnes was interested to know which data are available at the global and national levels to potentially apply to model development.

The project collaborators were less confident in the applicability of nutrient information and shipping ports. For nutrient loading, it would be necessary to determine the optimal concentrations for Hydrilla growth and relate these concentrations to nearshore areas. Richardson noted that while high nutrient levels would potentially encourage Hydrilla growth, phosphorus would enable phytoplankton and algae growth far more than Hydrilla. As phytoplankton and algae increase, light penetration decreases and would thus reduce submersed plant growth. Regarding the utility of shipping ports, Barnes observed that small boats are a more likely vector than large boats, although Bossenbroek noted that shipping ports house dredging and construction equipment that is moved between the Great Lakes and other areas. This equipment could be a potential vector for Hydrilla introduction.

Details and Figures of Assembled Suitability Layers for the Great Lakes

Bathymetry: Last updated in 2012, detailed bathymetry layers for Lakes Ontario, Erie, Huron, Michigan, Superior, and St. Clair are readily available for download. The resolution for depth contours is typically 1 to 5 meters (see Figure 1). The compilation of bathymetry for the Great Lakes is carried out cooperatively between NOAA (National Geophysical Data Center and Great Lakes Environmental Research Laboratory), and the Canadian Hydrographic Service. Nearshore mapping could provide potential limits of suitability based upon depth ranges and what is known about water depths and Hydrilla growth requirements.

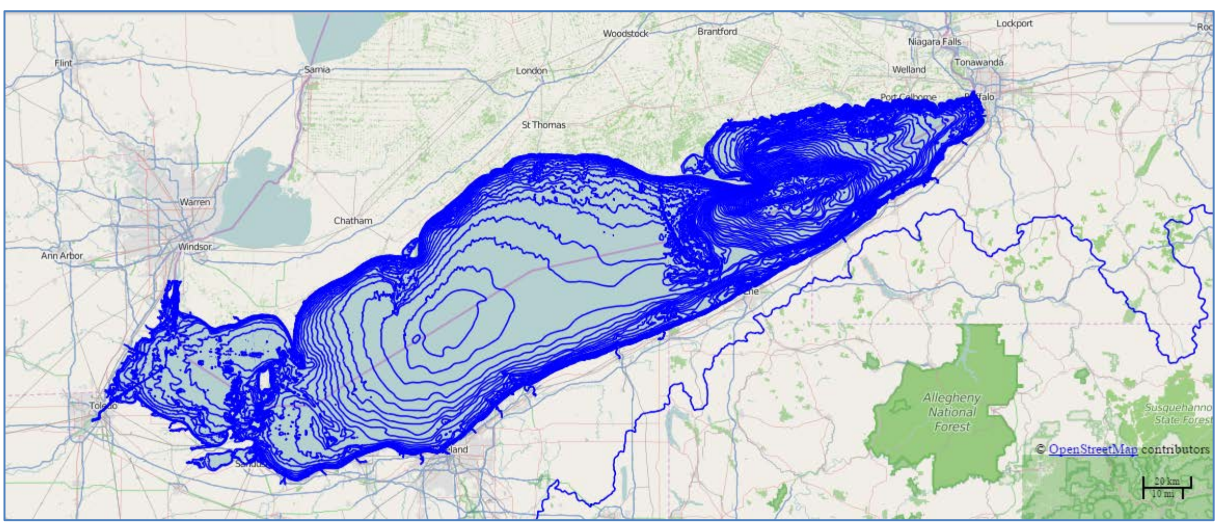

Figure 1 Bathymetry Layer of Lake Erie (last updated in 2012)

SAV/*Cladophora*: The most extensive effort for mapping SAV in the Great Lakes that E & E personnel have come across is the work conducted by MTRI. They used Landsat imagery (2008-2011) for the coastal regions of Lakes Ontario, Erie, Huron, and Michigan in the optically shallow areas where the lake bottom was visible. Each Landsat pixel (1 pixel = 900 square meters [m^2]) was then classified as sand, less dense SAV, and dense SAV (see Figure 2). In same time frame as imagery collections, MTRI conducted field sampling at 20 characterization sites on Lake Michigan at different depths to calibrate dense SAV, un-colonized sand, and mixed sand/SAV. MTRI found the majority of SAV detected was composed of *Cladophora* (a filamentous algae) attached to hard or rocky surfaces. Colin Brooks at MTRI responded to E & E's request for the original shapefiles. While these maps of existing SAV in four of the Great Lakes should be applicable to the project, one consideration is that Hydrilla is rooted to the substrate, while *Cladophora* attaches to hard/rocky substrates. Although substrate preferences and other biological aspects differ, the growth and expansion of Hydrilla is likely to respond to the availability of nutrients and light, which are major factors that facilitate the growth of *Cladophora*. During a conference call with Colin Brooks on June 5, 2015, E & E discussed the application of the *Cladophora* mapping to the Hydrilla risk assessment and to a Eurasian milfoil mapping/treatment project being conducted in Lake Superior. Brooks provided suggestions for additional people to contact regarding nutrient modelling and hydrodynamic modelling.

Light penetration. As described above, the methods MTRI used for mapping Cladophora and other SAV species encompassed coastal regions of Lakes Ontario, Erie, Huron, and Michigan in shallow areas where the lake bottom was visible. Therefore, the full spatial extent MTRI obtained for mapping reflects the depth and extent in which the lake bottom was detectable, with the exception of some areas too turbid to classify. Generally, these data should provide a reasonable predictor of potential growing habitat for SAV species.

Table 1 Summary of "Inferences of Suitability" Spatial Data

Variable	Source	Figure No.	Data Extent (Individual Lakes)	Catchment	Coastal Terrestrial Zone	Coastal Margin Zone	Near-shore Zone	Off-shore Zone	Resolution	Time Period	Download Link
Lakebottom											
Bathymetry	GLIN	1	H,O,M,E,S, St. Clair			x	x	x	1 - 5 m (20 m for Lake Superior)	2012	http://maps.glin.net/content/basic-gis-data-great-lakes/
Substrate/ Sediment	Data Basin	7	M			x	x	x	Composite from previous surveys	1968-1976	http://www.arcgis.com/home/item.html?id=45685914d9d841acb2251ef0d0d17016
Light penetration	MTRI	2	H,O,M,E			x			30 m	2010	ftp://ftp.mtri.org/pub/SAV_Cladophora
Submerged Aquatic Vegetation											
SAV/ Cladophora	MTRI	2	H,O,M,E			x			30 m	2010	ftp://ftp.mtri.org/pub/SAV_Cladophora
Eurasian water-milfoil distribution	EDDMapS	3	United States		x	x	x		Point	1916-2014	http://www.eddmaps.org/distribution/viewmap.cfm?sub=3055
Nutrient Loading											
Total nitrogen and phosphorus	USGS-SPARROW	4	United States	x	x	x			Catchment	2002	http://wi.water.usgs.gov/nutrients/sparrow/index_sparrow_online_tools.html
Total nitrogen and phosphorus	OMOE	5	H,O,E (Canadian side)				x		Point	2003-2010	https://www.ontario.ca/data/great-lakes-nearshore-index-stations
Phosphorus	GLEAM	6	H,O,M,E,S			x	x	x	Unknown	Unknown	Unknown

Table 1 Summary of "Inferences of Suitability" Spatial Data

Variable	Source	Figure No.	Data Extent (Individual Lakes)	Catchment	Coastal Terrestrial Zone	Coastal Margin Zone	Near-shore Zone	Off-shore Zone	Resolution	Time Period	Download Link
Climate											
Growing-degree days	UW - SAGE	-	Global	x	x	x	x	x	0.5 degree	TBD	http://nelson.wisc.edu/sage/data-and-models/atlas/data.php?incdataset=Growing%20Degree%20Days
Water surface temperature	NOAA Great Lakes Coast Watch GLSEA	-	H,O,M,E,S[2]			x	x	x	1.25 kilometers	1994-2013	http://coastwatch.glerl.noaa.gov/
Wave action	USACE Wisconsin	-	H,O,M,E,S[2]			x	x		Point	1979-2012	http://wis.usace.army.mil/
Other											
Shipping ports	NGA	8	H,O,M,E,S, St. Clair		x	x			Point	2012	http://msi.nga.mil/NGAPortal/MSI.portal?_nfpb=true&_pageLabel=msi_portal_page_62&pubCode=0015
Embayments[1]	E & E	-	H,O,M,E Sample watersheds			x			Unknown	2017	None

Notes:
[1] No suitable datasets located. E & E staff identified embayments in six sample watersheds examined in the potential economic and sociocultural impact analyses.
[2] Possible but not verified the extent of data available.

Key:

E	=	Lake Erie
GLSEA	=	Great Lakes Surface Environmental Analysis
GLIN	=	Great Lakes Information Network
H	=	Lake Huron
M	=	meters
M	=	Lake Michigan
MTRI	=	Michigan Tech Research Institute
NGA	=	National Geospatial-Intelligence Agency
NOAA	=	National Oceanic and Atmospheric Administration
O	=	Lake Ontario
S	=	Lake Superior
USACE	=	U.S. Army Corps of Engineers
UW – SAGE	=	University of Wisconsin-Madison – Center for Sustainability and the Global Environment

Eurasian water-milfoil distribution: Existing comprehensive knowledge of SAV beds or large-scale mapping efforts for SAV species that may be similar to Hydrilla appears to be limited. However, the EDDMapS resource developed by the University of Georgia's Center for Invasive Species and Ecosystem Health has extensive records of many invasive plant and animal species. Documentation of invasive species that cause economic and environmental harm may be more thorough than distributions of native SAV species. In efforts to compile the Hydrilla occurrence database, it was evident that the data from EDDMapS offered the most complete Hydrilla dataset for the United States. Therefore, it would be possible to use another invasive SAV species to indicate both potential habitat suitable for rooted SAV and vectors of introduction.

Nitrogen and phosphorus with SPARROW mapper: Several experimental studies have demonstrated a positive relationship between Hydrilla growth and the availability of nutrients, although only a few have focused on monoecious Hydrilla.[1] The growth of Hydrilla could potentially respond to nutrient loading in nearshore waters of the Great Lakes. The USGS Great Lakes Sparrow Mapper uses nutrient models (2002) to estimate total phosphorus and total nitrogen (in kg/km^2) for catchments and watersheds within the United States that empty into the Great Lakes (see Figure 4). Besides the Great Lakes, Spatially Referenced Regressions on Watershed attributes (SPARROW) models were developed to estimate loads and sources of phosphorus and nitrogen from the Upper Mississippi, Ohio, and Red River basins. "Results indicated that recent U.S. loadings to Lakes Michigan and Ontario are similar to those in the 1980s, whereas loadings to Lakes Superior, Huron, and Erie decreased. Highest loads were from tributaries with the largest watersheds, whereas highest yields were from areas with intense agriculture and large point sources of nutrients" (Robertson and Saad 2011). The data are shapefiles in which each polygon represents a tributary outlet within a watershed.

Nitrogen and phosphorus with OMOE: The Great Lakes Nearshore Sampling Stations is a set of approximately 57 nearshore sampling stations along the Canadian side of Lakes Ontario, Erie, and Huron; and the St. Lawrence River (see Figure 5). There are apparently no stations for Lake Superior despite having shoreline within Ontario. Water quality data (including phosphorus and nitrogen concentrations) from 2003-2010 was readily available for download in a single Excel file. Theoretically these data may be used for the Canadian shorelines of the Great Lakes, yet it may be difficult to compare directly with the SPARROW model results.

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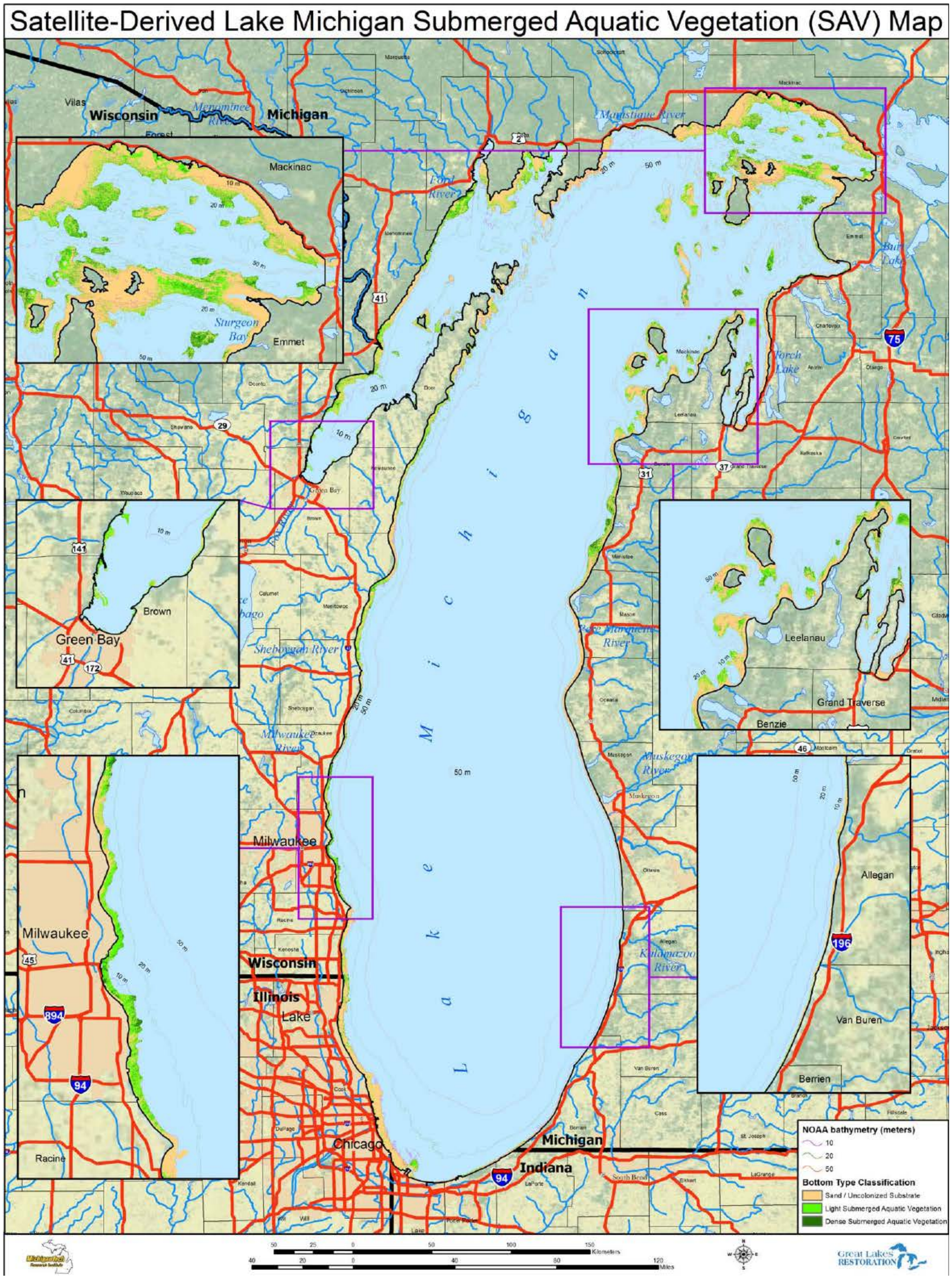
[1] Monoecious references include:
Chadwell, T. B., & Engelhardt, K. A. 2008. Effects of pre-existing submersed vegetation and propagule pressure on the invasion success of *Hydrilla verticillata*. *Journal of Applied Ecology*, *45*(2), 515-523.
Spencer, D. F., Ksander, G. G., & Bissell, S. R. (1992). Growth of monoecious hydrilla on different soils amended with peat or barley straw. *Journal of Aquatic Plant Management*, *10*, 73-78.



Source: Robert Shuchman and Colin Brooks of the Michigan Tech Research Institute

Figure 2 Lake Michigan SAV Map

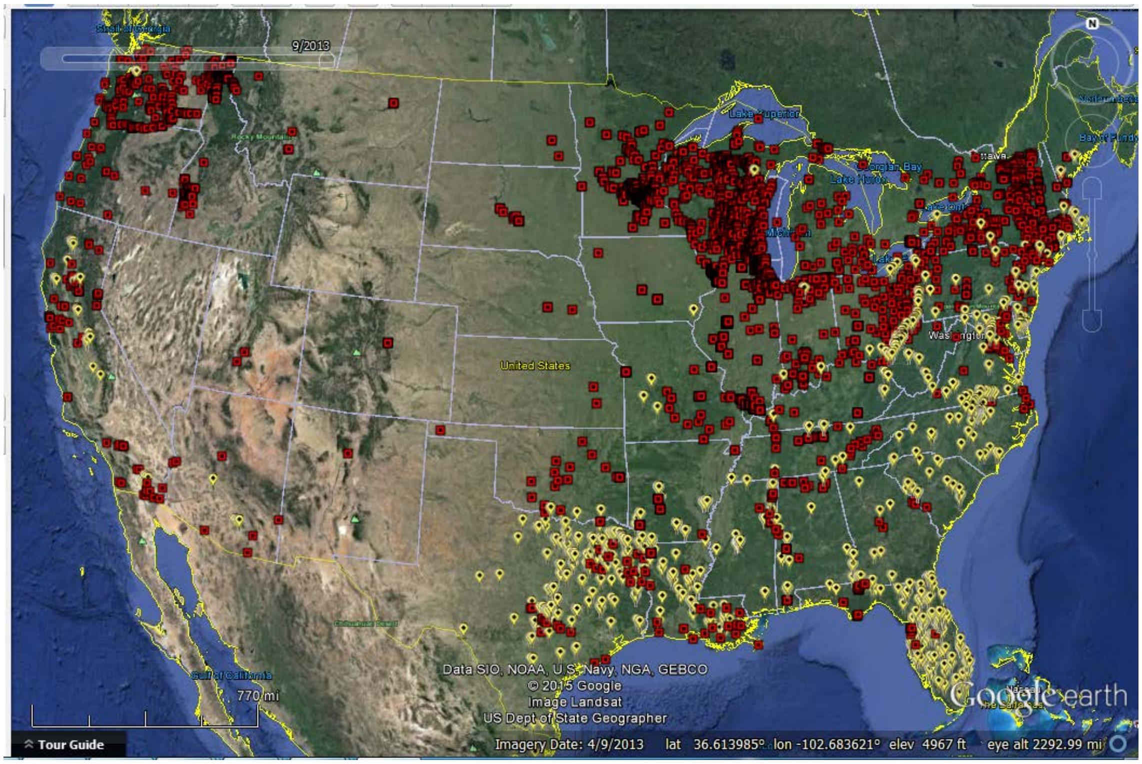
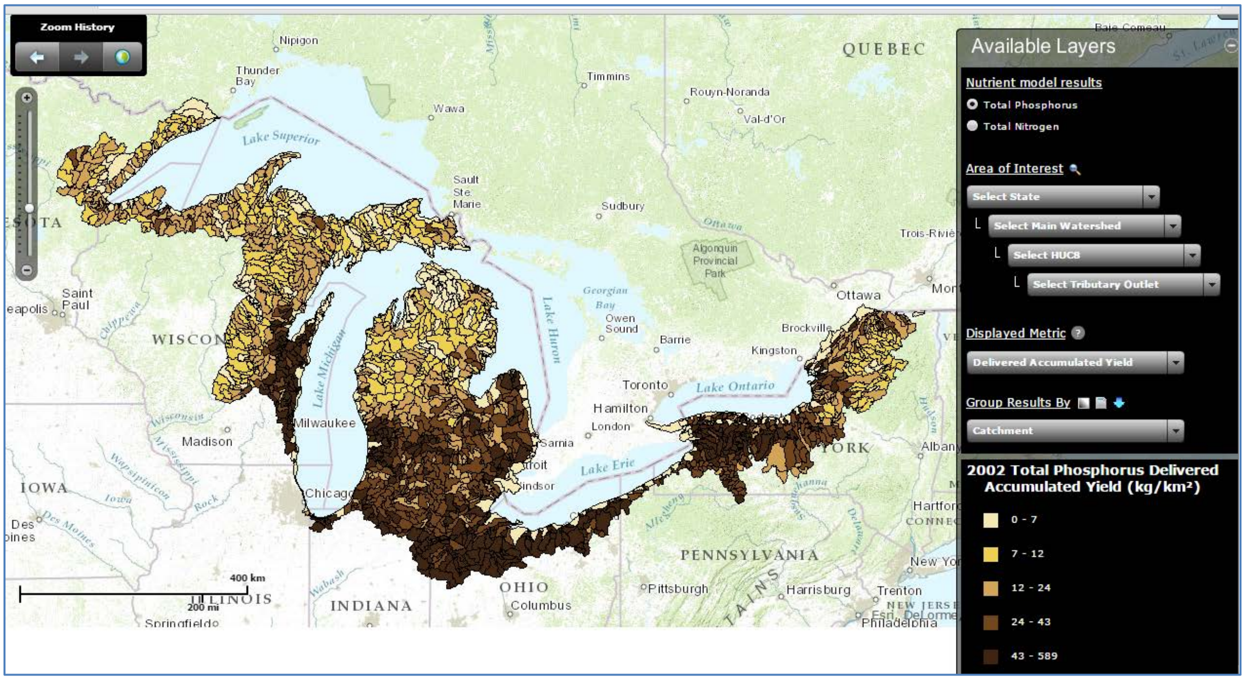


Figure 3 Eurasian Water-milfoil (red points) Distribution in the United States Compared to the Distribution of Hydrilla (yellow points)



Source: Robertson, Dale M. and David A. Saad, 2011. Nutrient Inputs to the Laurentian Great Lakes by Source and Watershed Estimated Using SPARROW Watershed Models. J*ournal of the American Water Resources Association* (JAWRA) 47(5):1011-1033.

Figure 4 Total Phosphorus Output (kg/km^2) for United States Catchments that Empty into the Great Lakes (Using 2002 SPARROW Nutrient Models)

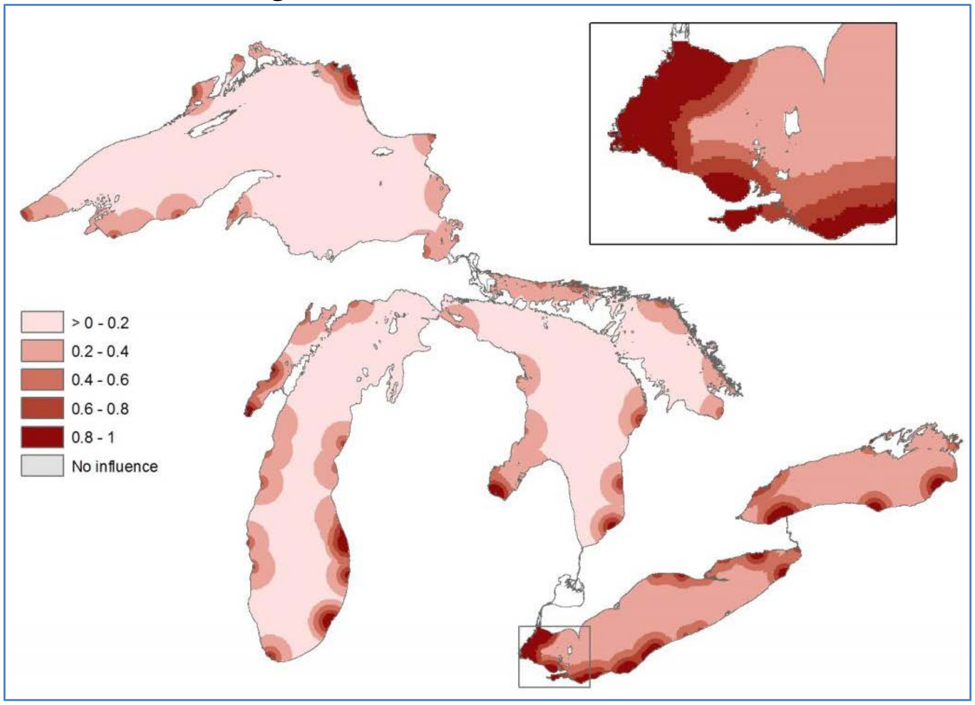
Figure 5 Ontario Water Quality Sampling Stations Visited Bi-annually (based on 2006-2010 station locations)

Nitrogen and Phosphorus - Other Efforts for Locating Nearshore Nutrient Data: The SPARROW data could be useful for the Hydrilla risk assessment, but it is unclear how the concentrations in the source watersheds affect the nutrient levels of nearshore Great Lakes. Dale Robertson and David Saad were contacted for recommendations regarding how to obtain nearshore nutrient modelling. A map created by GLEAM appears to have potential (see Figure 6). However there may be utility for the purposes of the risk assessment (although the units for this map are fairly arbitrary, apparently a stressor scale of 0-1).

As yet another alternative, Kevin O'Donnell (EPA) described that nutrient levels are available for specific areas around the Great Lakes. He mentioned one-time actual measurements and termed the effort the Nutrient Coastal Condition Assessment (summer 2010). After searching, these data were found in the Great Lakes Environmental Database (GLENDA) Query System. Data are available for download for nitrogen, phosphorus, and other water quality variables for all five lakes for many years, but the point sample data was taken from offshore locations. Offshore locations may provide little utility for the project's purposes.

Ultimately, discussions with the Project Team determined there are too many uncertainties regarding the response of Hydrilla to nutrients to make the inclusion of nutrient data practical in the current assessment. This is particularly notable when considering interactions with other plant species. For example, while high phosphorous levels encourage Hydrilla growth, they also encourage phytoplankton growth. As phytoplankton increase, light penetration decreases, thereby reducing growth of submersed plants such as Hydrilla.

Substrate/sediment: Several studies have considered substrate type preferences for monoecious Hydrilla (Spencer et al. 1992; Poovey & Kay 1998). Initial online searches indicated that nearshore substrate mapping efforts are high resolution but highly localized and pertain to specific studies or projects, such as assessing fish habitat. For example, Lake Michigan has a fully mapped substrate bottom that was constructed as a composite map from surveys conducted between 1968 and 1976 (see Figure 7). More extensive Great Lakes sediment data were later made available through GLAHF.



Source: Great Lakes Environmental Assessment and Mapping

Figure 6 Phosphorus Levels in the Great Lakes According to an Environmental Stressor Scale

Although substrate data were available, it was a more conservative approach to assume that Hydrilla could grow at least moderately in all substrates. For example, sand is typically a low-nutrient substrate, but not in all locations, and Hydrilla has been reported to grow in a wide range of substrates, including gaps in hard, rocky substrate. Over time Hydrilla can engineer its own favorable habitat even in unvegetated areas.

Photoperiod: There was not a large enough gradient in photoperiod across the Great Lakes to make some areas more favorable than others for Hydrilla growth and tuber production.

Shipping ports: Although small boats are more likely vectors of Hydrilla introduction in the Great Lakes, Bossenbroek noted that dredging and construction equipment is moved between Great Lakes ports and other areas; the equipment could be a potential vector. The World Port Index was readily available for download from NGA. Great Lakes ports would need to be selected out of the global dataset (see Figure 8). The data are readily accessible online.

Embayments: Hydrilla may be most likely to establish in embayments protected from wave action. E & E is currently investigating options for obtaining or creating a spatial layer representing embayments. However, efforts into obtaining such information may be limited as embayment features would likely overlap with suitable areas predicted by bathymetry and light penetration data.

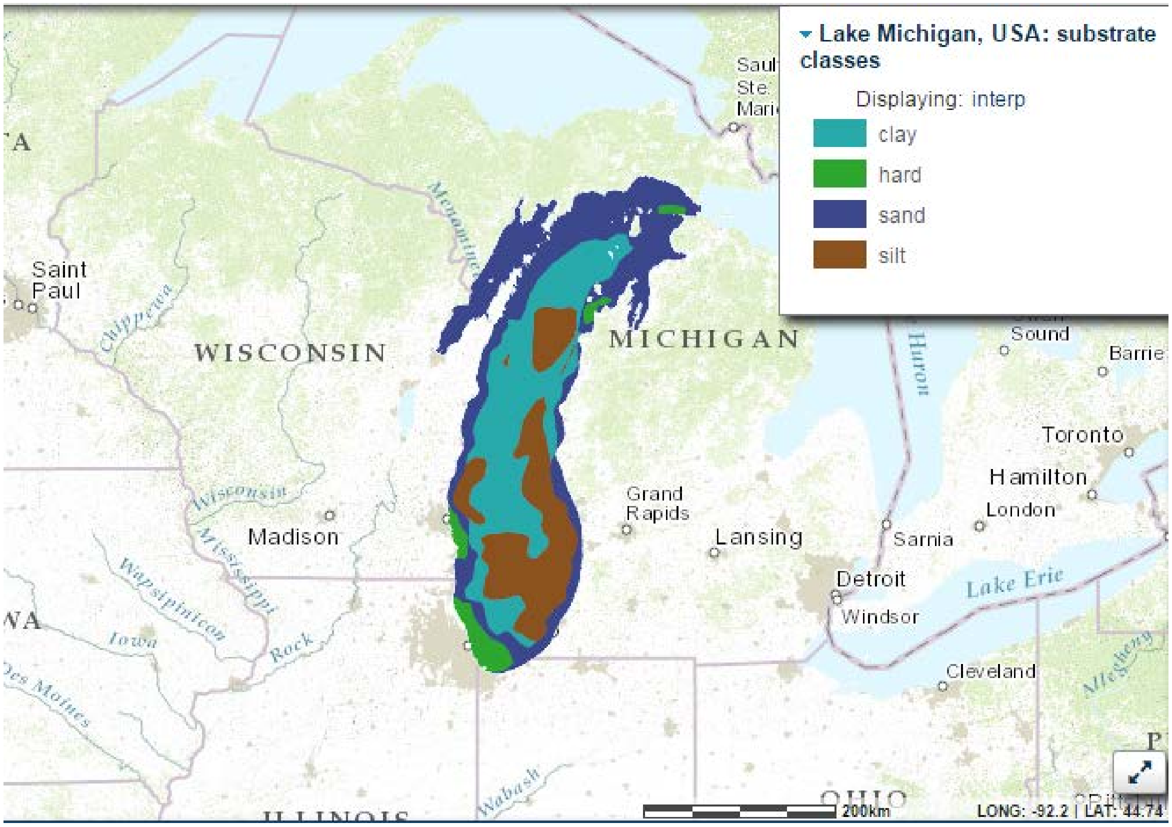


Figure 7 Substrate Map of Lake Michigan

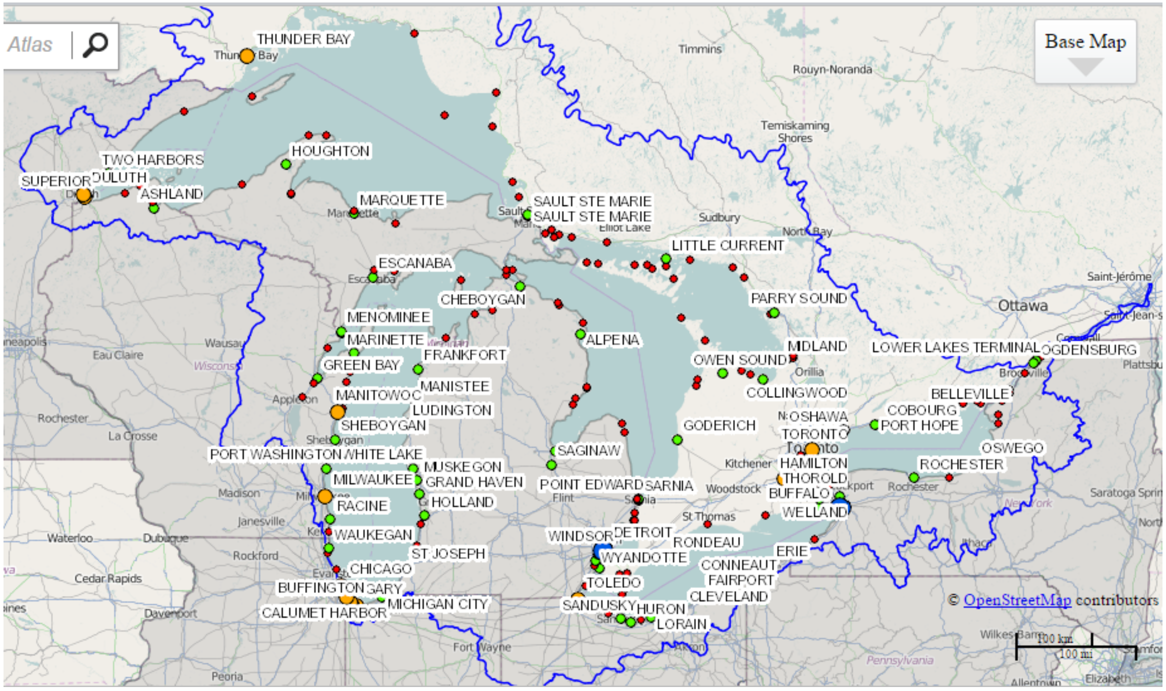


Figure 8 Ports in the Great Lakes

Fish spawning locations: The possibility of predicting SAV habitats from fish spawning locations was investigated, as SAV provides protective fish habitat. Spatial data of fish spawning locations are readily accessible using data from the USGS's *Atlas of Spawning and Nursery Areas of Great Lakes Fishes* (1982). However, freshwater fish often spawn in rocky reefs and shoals, and species that use habitats with SAV are more likely to use these areas for nursery habitat. Through correspondence with fish biologist Joseph Galati it was determined the potential connection between fish spawning sites and potential Hydrilla habitat was too tenuous to be used to predict habitat suitability for Hydrilla. However, the fish spawning dataset was used in the potential environmental impacts analysis as one type of existing natural resource that could be impacted with the establishment of Hydrilla.

D

University of Toledo Dispersal Modeling Report

This appendix includes a copy of *Potential Spread of Hydrilla verticillata in the Great Lakes Basin* prepared by Kristen Hebebrand (Graduate Research Assistant) and Dr. Jonathan Bossenbroek of the University of Toledo, Toledo, Ohio in 2017 under contract with Ecology and Environment, Inc.

Potential Spread of *Hydrilla verticillata* in the Great Lakes Basin

University of Toledo- Hydrilla Risk Assessment

Final Report

March 2017

Prepared for:

Ecology and Environment, Inc.

Prepared by:

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Project Overview

The goal of this project is to analyze the current distribution of hydrilla (*Hydrilla verticillata*) and identify the risk of introduction into the Great Lakes basin via overland recreational boat transport. This analysis will aid in predicting and detecting the spread of invasive hydrilla into new waterways in the Great Lakes basin. The primary objectives of this project are:

Objective 1: To predict the potential spread of hydrilla to the Great Lakes Basin via recreational watercraft and boat trailers and identify high risk areas for introduction.

Objective 2: Assess the current distribution of hydrilla to determine likely vectors of spread.

Objective 1

Our objective was to estimate the potential spread of hydrilla into the Great Lakes Basin from areas of infestation around the US to identify prominent areas at risk for introduction. Based on the literature, recreational boating is the human-mediated pathway most likely responsible for the spread of aquatic invasive species. Hauling recreational boats overland from an infested body of water to a non-infested body of water will most likely contribute to the spread of hydrilla into the Great Lakes Basin (Anderson et al, 2015). Recreational boating has already been identified as a pathway between lakes and rivers in the USA for other invasive species such as zebra mussels (*Dreissena polymorpha*) and other invasive macrophytes (Anderson et al, 2015). Gravity models have shown to be a successful long distance predictor of aquatic invasive species spread via recreational boating (Bossenbroek et al., 2001).

We developed a model of the spread of recreational boaters that included estimates of climate matching to predict the spread of hydrilla to the Great Lakes basin. Specifically, we used a gravity model to predict recreational watercraft and boat trailer movement in order to identify areas at risk for introduction. Gravity models use spatial interactions to predict potential spread based on distance and attraction (e.g. Bossenbroek et al., 2001). We included a climate matching component into our predictions by incorporating the results of a global niche modeling exercise (Barnes unpublished data).

Methods

The goal for our gravity model is to predict hydrilla spread to the Great Lakes Basin via trailered boater movement. In order to model the spread of hydrilla dispersal to the Great Lakes Basin, we needed to take into account the current distribution of hydrilla. Hydrilla is mostly established in the Southeast portion of the United States, thus we built a dispersal model for the continental United States, which allows us to focus on predicting spread to the Great Lakes Basin. Our model was built based on 4-digit Hydrological Unite Codes (HUC), which divide the US into 210 watersheds. At this scale, we are able to get a broader, more generalized look at recreational boater spread and in turn, hydrilla spread for the entire continental United States. The data needed to construct our model included: county boater registrations, watershed boundaries and locations, and known hydrilla occurrences. County boater registration data for the continental United States, following Morandi (2013), was used to provide the number of registered boats per watershed. The National Hydrologic Database provided the waterbody data, NHDPlusV2 data (McKay, 2012). NHD data includes major lakes, reservoirs, rivers, and streams. US Highway data was retrieved from Federal Highway Administration (HEP, 2015). Hydrilla occurrence data was compiled by Ecology and Environment, Inc. All data were managed using ArcGIS 10 (ESRI, 2011) and the model was constructed using R (RStudio Team, 2015). Using ArcGIS 10 the hydrilla occurrence points were joined to the waterbodies they infest, using a 50m buffer to account for occurrence coordinates that do not fall directly within an NHD waterbody. These waterbody areas were then assigned the infested designation and were used as the current infested area for our model.

Model Development

To model the spread of hydrilla in the United States, we developed a model using the following steps: 1) estimate number of boaters traveling from each watershed, 2) estimate the proportion of those boats that will travel from watersheds infested with hydrilla, 3) assign new infestations based on the watershed's habitat suitability and the number of boaters traveling from infested locations. 4) estimate the area of lakes and rivers that are newly infested in each watershed each year.

Our gravity model is based on Bossenbroek et al. (2007) and predicts the movement of recreational boaters. The base of our model is:

$$T_{ij} = A_i O_i W_j c_{ij}^{-\propto},$$

where T_{ij} represents the number of boaters that travel from watershed *i* to watershed j. O_i is the number of boats that travel from watershed *i*. The attractiveness of waterbodies, W_j, was based on surface area of lakes, reservoirs, rivers, and length of Great Lakes coastlines.

$$W_j = I_j + xS_j,$$

where I_j is the surface area (ha) of lakes, reservoirs, and rivers. S_j is the length of oceanic and Great Lakes shoreline (km). *x* is a scalar to equate the "attractiveness" of shorelines to the "attractiveness" of lakes, which was an estimated parameter (see below and Table 1). $\propto$ defines the deterrent effect of distance estimated from empirical data and previous studies to reflect the likelihood of travel based on distance (Fotheringham 1981). The distance matrix (c_{ij}) was developed to estimate the movement of recreational boaters from a series of origins to a series of destinations (Thomas and Hugget, 1980). The origins and destinations used were calculated for each watershed by finding the centroid of attraction (*Wj*) within each watershed. Distances between watersheds were based on highway distances. We also had to account for boats traveling within a watershed. Although a boat is not leaving a watershed, boaters can further infest the watershed it is currently in. Therefore, we had to estimate the distances traveled by boaters that remain within their watershed of origin. We estimated the within watershed distance (i.e. for *cij*, *i* = *j*) as a proportion of the minimum distance from each watershed to its nearest neighboring watershed (*m*). A_i is the balancing factor that ensures all boats leaving watershed *i* will reach watershed j. The balancing factor, A_i, is defined by

$$A_i = \frac{1}{\sum_{j=1}^{N} W_j c_{ij}^{-\propto}}$$

where N is the total number of waterbodies.

Once the basic gravity model structure was constructed, we developed a dynamic model that begins with a pre-determined infestation of hydrilla and then predicts the spread and increase of hydrilla in range through time. For each iteration of the model (year) we estimated an infestation probability, P_j, for each watershed. The probability of a new infestation event is a function of the number of boats leaving an infested watershed (s), the proportion of a watershed that is already infested (Q_j), and the habitat suitability of each destination watershed (Z_j). Thus,

$$P_j = \frac{Q_j Z_j \sum_{j=1}^{s} T_{ij}}{B}$$

,where s is the number of watersheds currently infested with hydrilla. *B* is an estimated parameter that represents the total possible times a boat leaving an infested watershed has the possibility to infest a different watershed. The probability of a destination watershed becoming infested was also influenced by the habitat suitability of the watershed (Zj) as per Barnes and Soto (Unpublished niche model results). The niche models results were at a finer resolution than our watersheds, thus we averaged the niche model results for each watershed, w_j. A scalar, y, was included to adjust habitat suitability to appropriately fit into this model. The fitted habitat suitability probability for each watershed is Z_j.

$$Z_j = w_j y$$

At the end of each iteration, each destination watershed was assigned a probability of colonization, P_j, and then subjected to a Bernoulli trial, by which each watershed was either designated as colonized (a score of 1 from the Bernoulli trial) or not during that iteration.

For those watersheds determined to have a colonization event, we then predicted the amount of new area, or proportion of the waterbodies within the watershed, that is newly infested with hydrilla. The new area infested per year in each watershed (k_i) was drawn from a normal distribution, $k_i \sim N(\mu, \sigma^2)$, where μ was calculated using the estimated parameter (k_i) infested area per watershed and σ^2 was one. This area (k_j) was added to the area of already infested with a watershed and thus updating Q_i, the area within a watershed infested with hydrilla.

Model Parameterization

To parameterize our model we need to assess six parameters: a distance coefficient (α), a distance multiplier (m), scalar to estimate the "attractiveness" of shoreline in terms of the “attractiveness” of lakes (*x*), scalar to adjust habitat suitability to be properly weighted for this model (*y*), denominator for probability that boats infest another watershed (*B*), and area infested per year (k_j; see Table 1 for more details). Our goal was to select parameter values that mimic actual spread patterns. The current hydrilla occurrence data was used for the parameterization routine. During the parameterization, 1000 trials of a least squares sum analysis was performed for each parameter. We tested each parameter across a range of values (Table 2) while the other parameters were held at a constant value, in order to estimate the best fit values. The least sum squares was calculated by taking the squared sum of the difference of the current infested area for each watershed and the predicted infested area for each watershed. By comparing the current infested area to the predicted infested area, that we got by testing the parameters across a range of value. We were able to look at the relationship between the parameters and how they affected the model. The best fit values for each parameter allow for our model to best fit current distribution and gives us the confidence that our model can predict the spread of hydrilla into the future. This model was parameterized by our ability to replicate current distribution by running our model from the first known infested watershed in 1953 to 2015.

We also compared the current infestation acreage to the average of 1,000 trials which we predicted from 1953 to 2015. This showed that our parameters and model is appropriate for predicting potential spread into the future because both the distribution and acreage of the actual data was mimicked with our parameter model.

To predict the spread of hydrilla over the next 10 years we ran our gravity model using the best fit parameters. The model was initiated using the current occurrence data (2015) and ran for ten iterations (2025) and 1,000 trials.

Table 1. Parameters of gravity model including description and how parameter value was determined.

Parameter	Description	How value was determined
T_{ij}	Number of boaters that travel from watershed i to watershed j	Equation 1
A_i	Balancing factor that ensures all boaters leaving watershed i reach a destination j	Equation 2
O_i	Number of boats traveling from watershed i	Estimated from data
W_j	Attractiveness of watershed j	Estimated from data
c_{ij}	Distance from watershed i to watershed j using US road data (Centroid of watershed based on waterbody surface area)	Estimated from data
α	Distance coefficient	Fit parameter
I	Area of surface water of lakes, reservoirs, and rivers	Estimated from data
S_j	Length of oceanic and great lakes shoreline	Estimated from data
x	Scalar to estimate the "attractiveness" of shoreline in terms of the "attractiveness" of lakes	Fit parameter
m	Parameter to estimate the distance traveled within a watershed	Fit parameter
w_i	Habitat suitability probability for each watershed	Estimated from data (provided from MaxEnt)
y	Scalar to adjust habitat suitability	Fit parameter
B	All possible, denominator to calculate the proportion of boats infested	Fit parameter
k_i	Area infested per year per watershed	Fit parameter

Results

Parameterization Routine

Based on results of the 1,000 trials of our parameterization we estimated the best fit results for each parameter (Table 2) and used those values to mimic the 63 year spread we see in the current distribution data from 1953-2015. The current area of hydrilla infestation in the continental U.S. is 1,553,643ha based on our hydrilla occurrence data from 1953 to 2015. On average our model resulted in an over estimation, estimating that 1,859,367 ha would be infested by 2015. However, the observed value of 1,553,643 ha is well within the 1st and 3rd quartiles of the distribution (1st - 1,409,404, 3rd - 2,258,049) of our results. The overall range of infested area over 1,000 trials was 544,301 ha to 3,935,747 ha.

According to our model, hydrilla has a higher likelihood to continue to spread in areas that have had established populations of hydrilla and continuing to infest the non-infested waterbodies surrounding those areas. For example, in Florida where hydrilla has been established since 1953 there may be waterbodies that are not reported to be infested or for reasons our model does not take into consideration are not becoming infested. This results in our model over predicting infested area compared to the area infested from our hydrilla occurrence data. Figure 1 shows hydrilla's actual current distribution as of 2015. Figure 2 shows the distribution predicted by the parameterization. Figure 2 visually shows that the model follows trends of current prediction based on our set parameters. The final gravity model uses these estimated best fit values (Table 2).

Table 2. Results from parameterization routine.

Parameter	Best Fit Value	Range Tested
m	0.7	0.1-0.9
x	0.08	0.0001-0.9
B	4000	500-8000
k	2500	500-8000
α	4.08	0.01-10
y	1.64	0.1-10

Gravity Model

To predict the extent of hydrilla infestation in the United States by 2025, our model was run with the best fit parameter values for 1,000 trials and for ten iterations (years) from the last updated data in 2015. The results, taken from the average of the 1,000 trials (Figure 3), for all 210 watersheds can be found in the attached Excel workbook titled "Gravity Model Results." The area of reported infestation for 2015 was 1,553,642 ha; on average our model predicts an increase to 2,833,053 ha. From 1953 to 2015 hydrilla spread an average of 123 ha per infested watershed per year. The model predicts an infestation rate of about 609 ha per watershed per year (2015-2025).

Our primary objective was to predict the potential spread of hydrilla to the Great Lakes Basin via recreational watercraft and boat trailers and identify high risk areas for introduction. To assess this we ranked the watersheds based on those that are at risk for new infestations. As well as ranking the watersheds that are predicted to have largest increase in infestation proportion on average. Table 3 shows the top ten watersheds that have the largest new infestation proportions of infested acreage to total acreage per watershed. Table 4 shows the top ten watersheds that have the largest increase to infestation proportions of infested acreage to total acreage per watershed for current and new infestations.

Table 3: The top ten watersheds that have the largest new infestation proportions of infested acreage to total acreage per watershed.

Watershed Name	Current Infested Area (ha)	Predicted Infested Area (ha)	Proportion Infested
Kentucky-Licking	0	13686.26	0.94
Great Miami	0	11015.01	0.79
Pascagoula	0	19174.11	0.51
Green	0	8383.49	0.32
Upper Tennessee	0	20497.88	0.22
Lower Missouri	0	7740.19	0.19
Lower Mississippi-Hatchie	0	9507.04	0.09
Upper Mississippi-Salt	0	2427.42	0.05
Connecticut	0	2557.57	0.04
St. Clair-Detroit	0	2755.31	0.04

Table 4. The top ten watersheds that have the largest increase to infestation proportions of infested acreage to total acreage per watershed for current and new infestations.

Watershed	Current Infested Area(ha)	Current Infested Proportion	Predicted Infested Area(ha)	Predicted Infested Proportion
Kentucky-Licking	0	0	13686.3	0.94
Muskingum	3671.4	0.17	21450.9	0.99
Great Miami	0	0	11015	0.79
Choctawhatchee-Escambia	2202.9	0.078	24360.2	0.86
Scioto	5805.7	0.37	15700	1.00
Middle Tennessee-Hiwassee	10390.4	0.35	28360.8	0.95
Middle Ohio	14450.1	0.4	35846.8	1.00
Kanawha	7109.9	0.39	17977.7	0.98
Pee Dee	3587.1	0.09	28587	0.68
Cape Fear	7562.9	0.18	32562.9	0.76
Connecticut Coastal	119.3	0.004	17544.2	0.54
Pascagoula	0	0	19174.1	0.51
Upper Ohio	21871.7	0.51	42500	1

Discussion

Continental United States

Hydrilla is expected to continue to spread throughout the continental United States and into the Great Lakes Basin over the next 10 years. The watersheds that currently have infestations of hydrilla are at the highest risk for further infestation (Figure 4). Watersheds with large areas of water and high boater registration and are in or near watersheds with established hydrilla populations are also at high risk for hydrilla infestation. We ranked the watersheds based on the overall proportion infestation from our gravity model results. The five watersheds surrounding the Great Lakes that are at highest risk are Upper Ohio, Scioto, Muskingum, Great Miami, and Susquehanna (Figure 5). It is important to recognize these and monitor hydrilla infestation within these watersheds because these will be important indicators for where to monitor in the Great Lakes Basin watersheds. The top five watersheds in the Great Lakes Basin at highest risk for overall infestation proportion are Southeastern Lake Ontario, St. Clair-Detroit, Western Lake Erie, Southern Lake Erie, and Southwestern Lake Ontario (Table 5 and Figure 6).

The Ohio River Valley is predicted to have a much higher proportion of each watershed infested over the next 10 years compared to surrounding watershed (Fig. 3). These watersheds either have current infestations or are surrounded by watersheds that have current infestations. These watersheds also all have less than 1,000 ha of total waterbody area. Taking these factors into account along with our model results it is likely that these watersheds will have new or further hydrilla infestation within the next ten years. Since these watersheds have less than 1,000 ha total waterbody area their infestation proportion is fast to increase, this is why we see these watersheds stand out in Figure 3.

The Scioto and the Muskingum watersheds surrounding the Great Lakes Basin currently do not have established hydrilla populations reported; however, due to the NHD data format they are reported to have current infested area. The portion of the Ohio River that is considered infested crosses over into the Scioto and Muskingum boundaries, which resulted in our designation of the Scioto and Muskingum watershed as being currently infested. Although there are no current infestations in these watersheds our model produces results for these watersheds that we would expect to see based on their location and attributes (e.g. total waterbody acreage, surrounding watershed hydrilla infestations).

Our model suggests an increase in infestation rate over the next 10 years compared to the past. There are a two primary explanations for this. First, as sources of hydrilla increase, more boats will likely transport hydrilla to new areas that are not yet infested. An increase in the rate of spread is typical for the spread of invasive species. Second, the observed distribution of hyrilla may be a low estimate as hydrilla may exist in locations and unreported, particularly in areas such as the southeastern United States where hydrilla in not a new issue.

Model Limitations

When modeling at the scale of the continental United States, there are logistical and data limitations that constrain the accuracy or specificity of our model results. As expected our model shows watersheds with high boater registration and those surrounded watersheds with high boater registration have a higher risk of infestation. However, we did not distinguish between different types of boats, e.g., give example of different types of boats. Resident boats for instance that stay in one body of water are not likely to transport hydrilla to other waterbodies. Our model focuses on transient boats; therefore, if a watershed has a high number of resident boats then the results may overestimate the risk of that watershed or surrounding watersheds. Also that waterbody data that we used, which is appropriate for this scale, does not include minor waterways (NHDPlusV2 data). As a result, not all infestations will be reflected in our model. For example, the current Tonawanda creek infestation in western New York is not reflected in our model. In the future, if a finer scale is used, minor waterways could potentially be included as well as more specific attraction parameters, such as boat ramps. Giving these limitations, our results can give regional guidance as to where to monitor and prioritize additional modeling or analyses to provide further refinement of our predictions.

Our model shows an increase in infestation rate that may be due to low current estimates. It is important to remember that the observed distribution of hydrilla is the result of a dynamic and stochastic process that has occurred for over 50 years. The range of potential outcomes is likely very broad and the best fit parameters that we choose suggest that the current distribution is lower than would be expected on average.

Table 5. Gravity model results for all the Great Lakes Basin watersheds ranked on overall proportion current infested area of water to the overall acreage of water within that watershed. Current Infested Acreage (ha) is the current infested area of water within that watershed. Current proportion of infested waterbodies per watershed is the current infested area of water to the overall acreage of water within that watershed. 2025 Acreage (ha) is predicted area of infestation based on our 10 year model results per watershed. 2025 Proportion is the proportion of the predicted area of infestation to the total the overall acreage of water within that watershed.

Watershed Name	Current Acreage (ha)	Current proportion	2025 Acreage (ha)	2025 Proportion
Southeastern Lake Ontario	17166.90	0.03	29434.11	0.0514
St. Clair-Detroit	0	0	2755.31	0.0392
Western Lake Erie	0	0	14837.34	0.0365
Southern Lake Erie	15.70	0.00	20879.03	0.0338
Southwestern Lake Ontario	0	0	4369.41	0.0134
Eastern Lake Erie-Lake Erie	0	0	6694.21	0.0128
Southwestern Lake Michigan 2	0	0	5553.05	0.0099
Southeastern Lake Michigan	0	0	8753.82	0.0088
Southwestern Lake Huron-Lake Huron	0	0	843.34	0.0069
Northeastern Lake Ontario-Lake Ontario-St. Lawrence	0	0	508.01	0.0015
Northeastern Lake Michigan-Lake Michigan 2	0	0	312.81	0.0014
Southwestern Lake Michigan 1	0	0	190.19	0.0009
Northwestern Lake Huron 2	0	0	362.87	0.0004
Northeastern Lake Michigan-Lake Michigan 1	0	0	147.64	0.0002
Northwestern Lake Huron 1	0	0	72.57	0.0001
Northwestern Lake Michigan	0	0	17.52	0.0001
Southern Lake Superior-Lake Superior	0	0	12.51	0.0001
Western Lake Superior	0	0	0	0

Objective 2

We assessed the current distribution of hydrilla to determine likely vectors of spread. There are various mechanisms for spread of aquatic invasive plants including hydrologic pathways, animal mediated dispersal, and aerial dispersal (Keller 2009). A study performed in Mystic, Connecticut suggests that hydrilla may be spread by waterfowl via transport of fragments and stem tubers from water body to waterbody (Langeland 1996). Hydrologic pathways, such as rivers and streams, are also a potential mechanism for hydrilla dispersal into other connected waterbodies (Keller 2009) Based on the data we could obtain and based off literature on what would most likely contribute to spread of hydrilla we performed a proximity and connectedness analysis to evaluate natural dispersal.

To assess if connectedness and proximity within watersheds is related to the pattern of hydrilla infested lakes, we chose a random subset of upstream lakes that were both infested and connected to another lake downstream. We followed the downstream flow and categorized downstream lakes/reservoirs as infested or not infested/not detected as in Bobeldyk et al.(2005). We measured the distance between the connected lakes and assessed to see if there were trends, for example; the closer the connected lakes the more likely the downstream lake will be infested. The results of these assessments are shown in table 6.

Methods

Natural Dispersal Analysis

Invasive species are spread by various mechanisms including hydrologic pathways, animal mediated dispersal, and aerial dispersal (Keller 2009). A study performed in Mystic, Connecticut suggests that hydrilla may be spread by waterfowl via transport of fragments and stem tubers from waterbody to waterbody (Langeland 1996). Hydrologic pathways, such as rivers and streams, are also potential mechanisms for hydrilla dispersal into other connected waterbodies (Keller 2009). Based on the data we had available and the literature describing likely vectors of hydrilla spread, we decided to perform a proximity and connectedness analysis to evaluate natural dispersal.

Study Area and Data

The data needed for this analysis includes the hydrilla locations, date of infestation, hydrography data for the United States, and the lake and stream data including size, location, and name. The hydrilla occurrence data was compiled by Ecology and Environment, Inc. from multiple databases, Early Detection and Distribution Mapping System (EDDMapS) and Global Biodiversity Information Facility (GBIF). The waterbody data, which includes surface areas and locations of lakes, ponds, rivers, and streams area, were acquired as a shapefile from the National Hydrography Dataset, generated by the US Geological Survey and US Environmental Protection Agency and analyzed in ArcMaps 10.3.

Results

No significant patterns were found from natural dispersal analysis based on stream/river connectedness. For this analysis, we hypothesized connected lakes that were closer in proximity to each other would be more likely to be infested. However, the results from our analysis, shown in table 6, did not support this hypothesis. We performed a two sample t-test, the results gave us a p-value of 0.5 which indicates we do not have strong evidence. The mean distance to infested waterbodies was 23.66km. The mean distance to a not infested/ not detected was 13.52km. The small sample size along with the lack of strong evidence from the results of the t-test lead us to conclude that this analysis does not give us confidence to make a conclusion about the relationship of proximity and infestation.

Discussion

In the regions where hydrilla is currently established the connections between lakes are infrequent and we found little evidence of the importance of downstream flow as a major vector of dispersal. However, in areas surrounding the Great Lakes, particularly in Michigan, Wisconsin, and Minnesota, lakes are often highly connected. In these areas we expect to see lakes in closer proximity to infested lakes to have a higher probability of becoming infested due to downstream connections as has occurred with other invasive species, such as zebra mussels (Bobeldyk, 2005).

Table 6. Results from natural dispersal analysis.

Watershed	Infested Lake	Downstream Lake	Distance (km)	Infestation Status
Susquehanna	Highland Lake	NA	0.01	not infested
Merrimack	South Meadow Pond	NA	0.04	not infested
Cape Fear	Lake Kennedy	NA	0.13	not infested
Edisto-Santee	Lake Johnson	Lake Edwin Johnson	0.14	not infested
St Johns	Lake Virginia	Lake Osceola	0.22	infested
Massachusetts-Rhode Island Coastal.	Oakman Pond	Hatch Pond	0.29	not infested
Massachusetts-Rhode Island Coastal.	Long Pond	Seine Pond	0.97	not infested
Saco	Pickerel Pond	Lake Arrowhead	2.35	not infested
St Johns	Puzzle Lake	Lake Harney	3.31	infested
Southern Flroida	Cypress Lake	Lake Hatchineha	3.83	infested
Ochlockonee	Lake Munson	NA	4.74	not infested
St Johns	Sawgrass Lake	Lake Washington	5.11	infested
Susquehanna	Harveys Lake	NA	5.17	not infested
Ogeechee-Savannah	Lake Keowee	NA	7.26	not infested
Edisto-Santee	Lake Norman	Mountain Island Lake	11.77	infested
Kanawha	Claytor Lake	Bluestone Lake	12.90	infested
Lower Tennesee/ Middle Tennesee Elk	Pickwick Lake	Kentucky Lake	14.00	infested
St Johns	Lake Washington	Lake Winder	14.24	infested
Edisto-Santee	Buzzard Roost	Lake Murray	35.13	infested
Chowan-Roanoke	John H. Kerr Reservoir	Roanoke Rapids Lake	54.78	infested
Apalachicola	Walter F George Reservoir	Lake Seminole	105.00	infested
Alabama	Allatoona Lake	Weiss Lake	127.66	not infested

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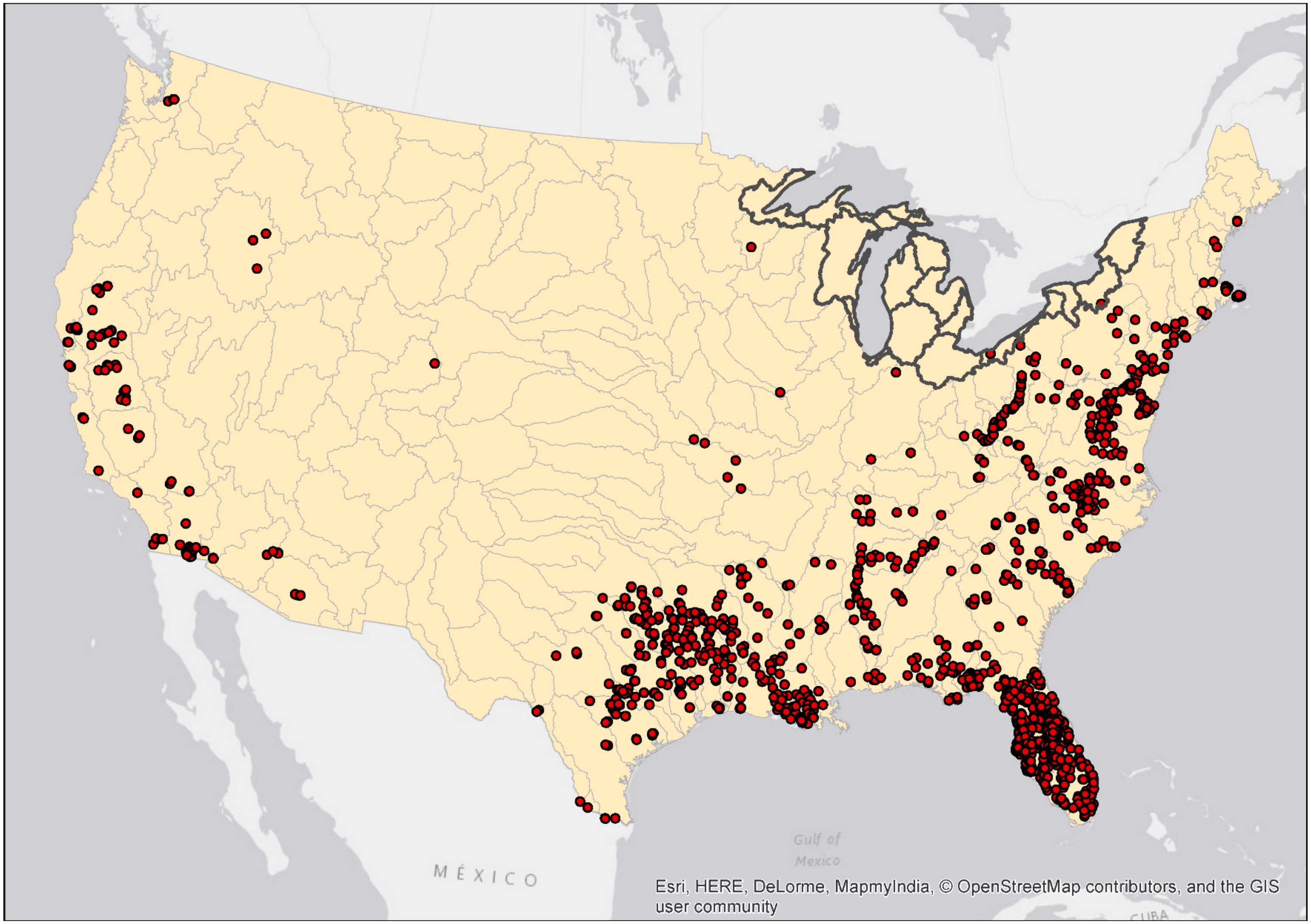

Figure 1. Map of current distribution of hydrilla in the continental United States.

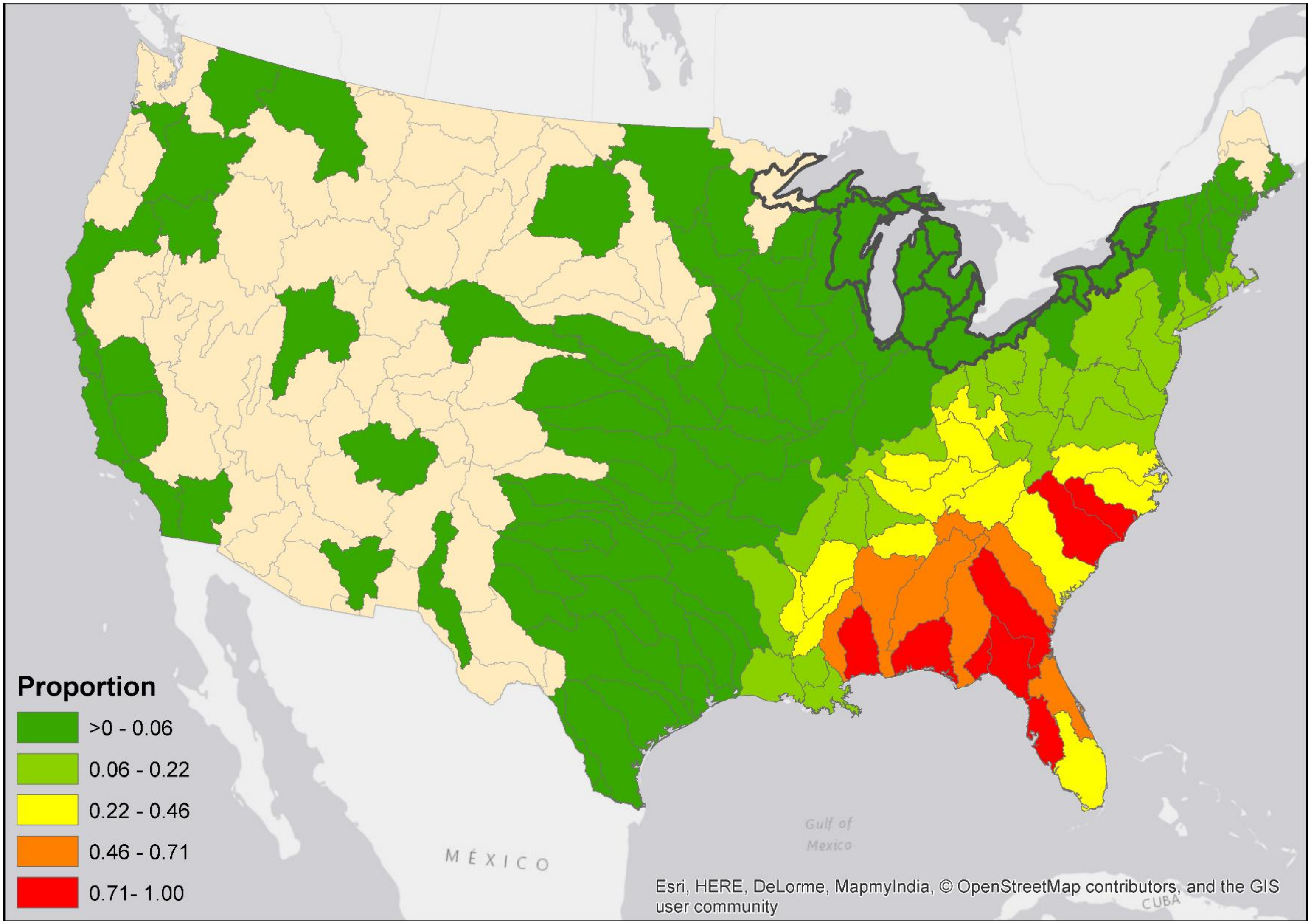

Figure 2. Map of predicted infested proportion distribution (1953-2015) from parameterization.

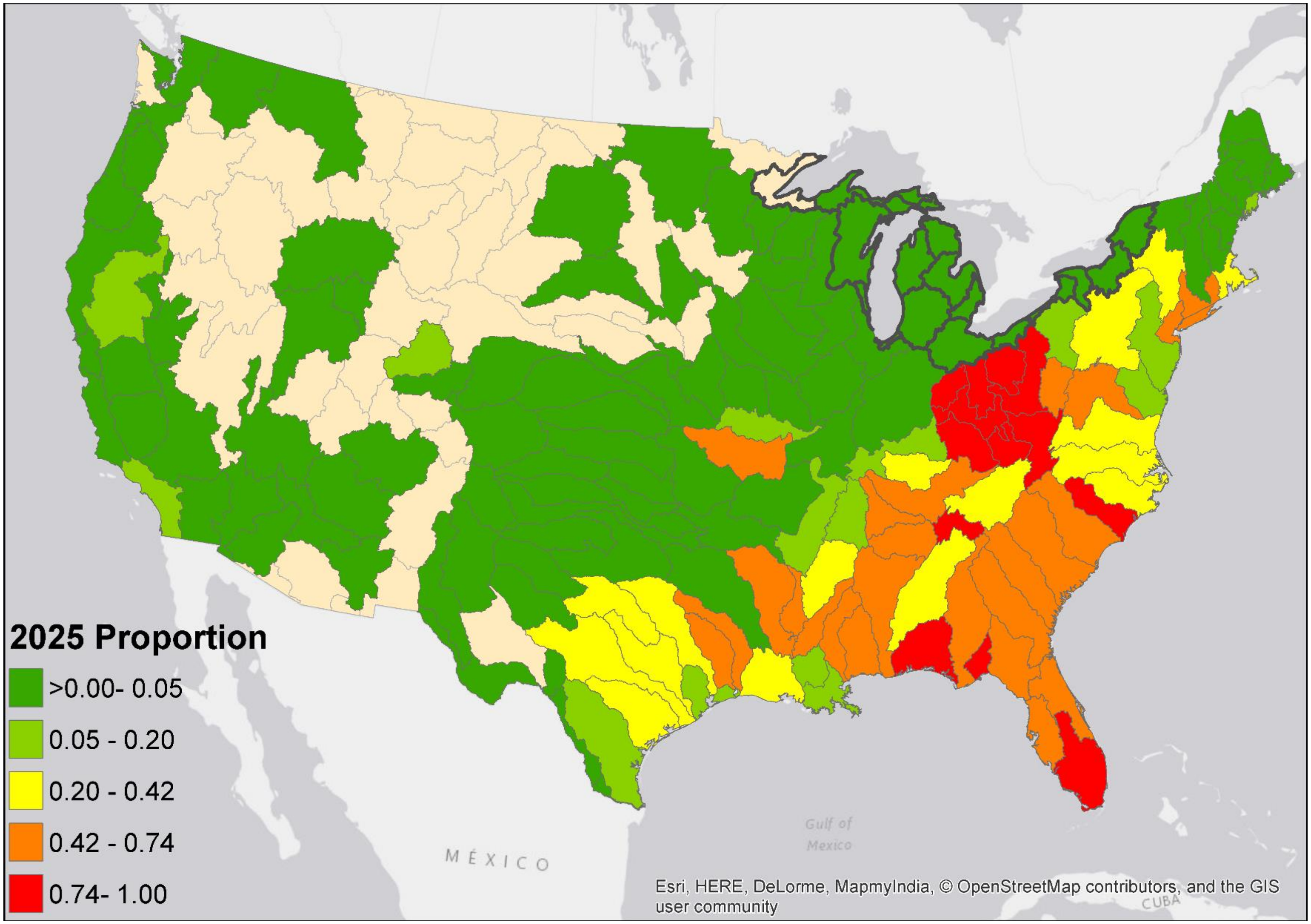

Figure 3. Gravity model results. The average infestation proportion per watershed taken from 1,000 trials and 10 iterations (years) 2015-2025.

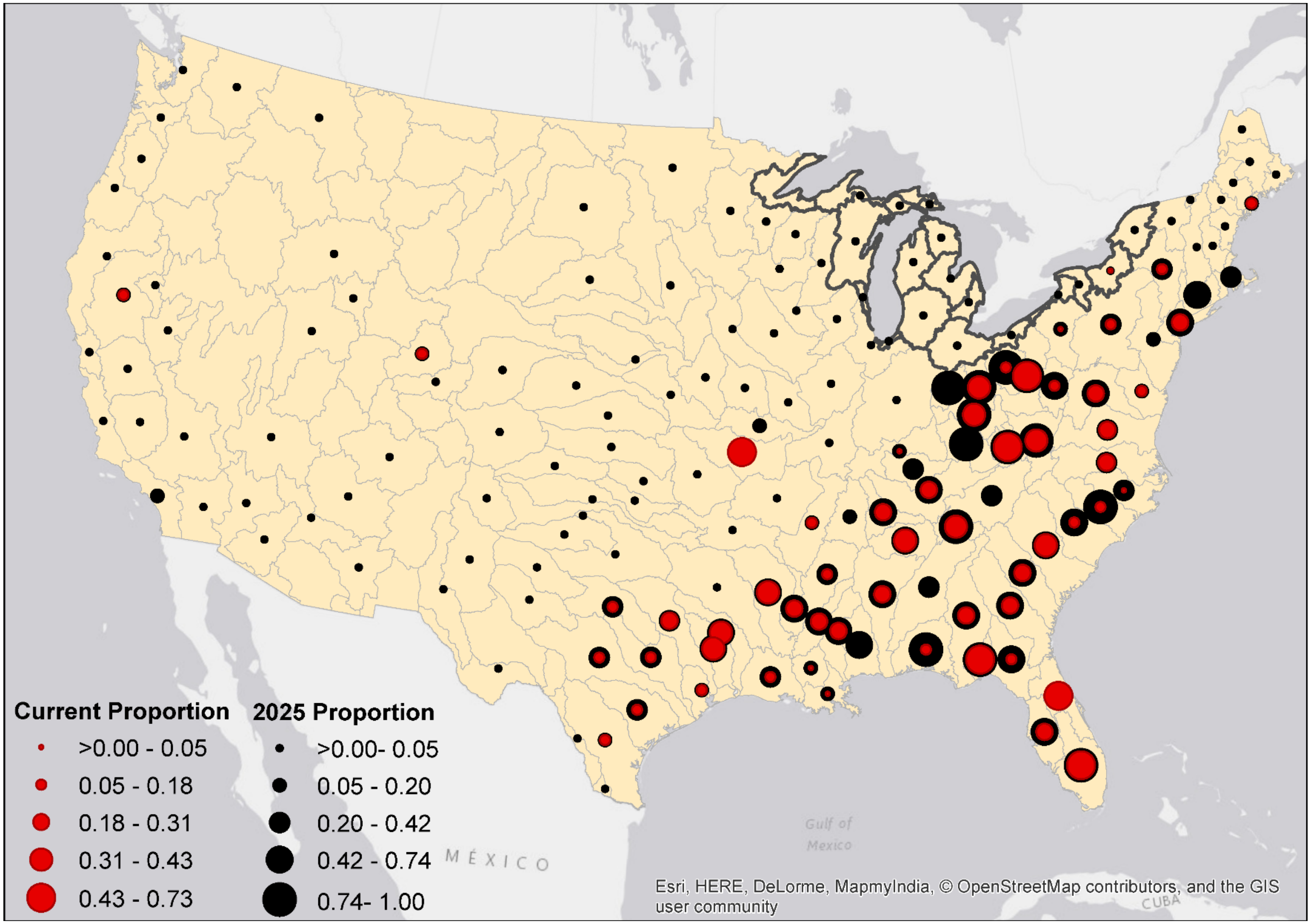

Figure 4. Comparison of the infestation proportion per watershed from the current (red circles) to the 2025 prediction (black).

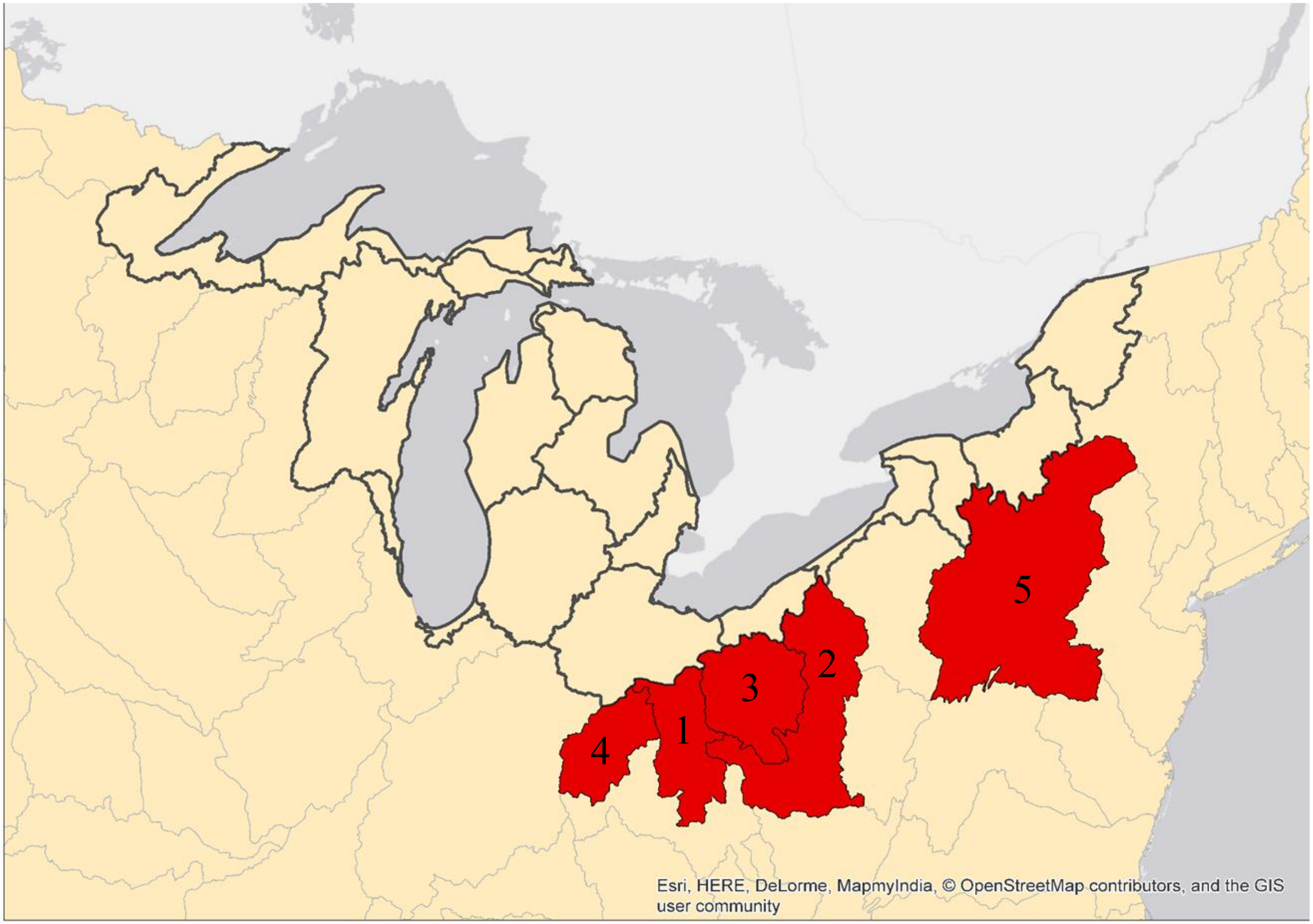

Figure 5. The top five watersheds surrounding the Great Lakes Basin at highest risk are Upper Ohio, Scioto, Muskingum, Great Miami, and Susquehanna.

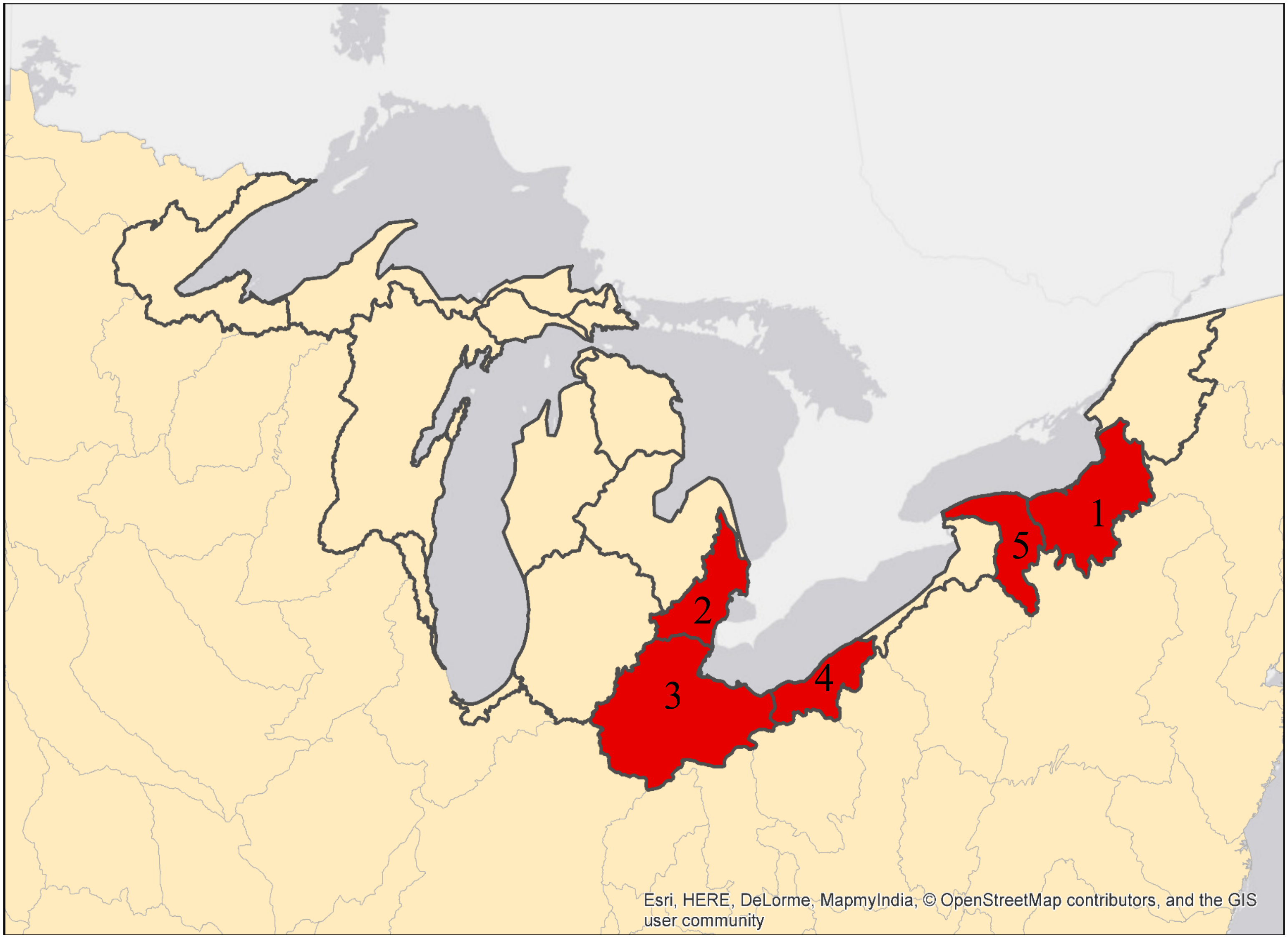

Figure 6. The top five watersheds in the Great Lakes Basin at highest risk are Southeastern Lake Ontario, St. Clair-Detroit, Western Lake Erie, Southern Lake Erie, and Southwestern Lake Ontario.

E

NCSU Monoecious Hydrilla Growth Studies Theses

This appendix includes a copy of:

1) *Monoecious Hydrilla (Hydrilla verticillata (L.f) Royle) Growth and Phenology in Two Dissimilar Climates* prepared by Amy Henry (Graduate Research Assistant) and Dr. Robert Richardson of North Carolina State University, Raleigh, North Carolina in 2017 under contract with Ecology and Environment, Inc.; and
2) *Factors Affecting Monoecious Hydrilla (Hydrilla verticillata) in Dynamic Systems* prepared by Shannon Regan (Graduate Research Assistant) and Dr. Robert Richardson of North Carolina State University, Raleigh, North Carolina in 2017

E.1 Monoecious Hydrilla Growth and Phenology in Two Dissimilar Climates (Henry 2017)

ABSTRACT

HENRY, AMY LOU. Monoecious Hydrilla (*Hydrilla verticillata* (L.f) Royle) Growth and Phenology in Two Dissimilar Climates. Under the direction of Dr. Robert J. Richardson.

Hydrilla (*Hydrilla verticillata* (L.f.) Royle) is a federal noxious submersed aquatic macrophyte that is expanding its range in North America. There are two biotypes, a triploid monoecious form and a triploid female dioecious form that have different growth habits, suitable environments, and physiology. The majority of research has been conducted on dioecious biotypes in warmer climates, which results in a large knowledge gap of how monoecious hydrilla will behave in cooler climates. To investigate the growth behavior of monoecious hydrilla in different climates, outdoor mesocosm trials were conducted at two separate research locations in Raleigh (35.7796° N, 78.6382° W; 96 m) and Laurel Springs (39.8201° N, 75.0063° W; 838 m), North Carolina. Phenology studies were completed, where timing of six life stages were recorded. All life stages occurred earlier in the warmer climate than the cooler climate. In the warm climate, turion and tuber sprouting, female and male floral initiation, turion formation, and plant senescence occurred at 12.4, 15.0, 27.7, 23.9, 24.2 and 8.5° C, respectively. In the cool climate, turion and tuber sprouting, female and male floral initiation, turion formation, and plant senescence occurred at 7.0, 10.1, 25.9, 23.1, 20.1 and 7.5° C, respectively. A year long competition study was also conducted in these two climates. Hydrilla tuber production ranged from 246 to 998 tubers m^{-2} in the warm climate, and from 0 to 1000 tubers m^{-2} in the cool climate. Dry weight of hydrilla ranged from 29.80 to 67.00 g in the warm climate and 0.34 to 72.17 g in the cool climate. Water temperatures affected the competitive abilities of both monoecious hydrilla and three competitor plants. In the cool climate, the competitor plants were able to suppress hydrilla growth compared to hydrilla grown alone. This suppression was not observed in the warm climate. This has major implications on the spread of hydrilla in northern

bodies of water that are known for their biodiversity and highly developed plant communities. Information about chilling requirements and behavior of these propagules in cooler climates is limited in the literature. Climatic conditions impact the production, viability, and sprouting of propagules were investigated. Temperatures during hydrilla development also affected the production and viability of asexual propagules. When overwintered at 4° C after being grown in the warm climate, tubers had an average viability rate of 63%, while when grown in cooler climates, the average viability rate was 89%. Tubers produced in the cooler climate were able to withstand 0° C temperatures for seven months, while tubers produced in the warmer climate did not remain viable at any of the harvests. Tubers were heavier when grown in the cool climate, averaging 0.113 g, while warm climate tubers averaged 0.096 g. Tuber densities also differed between climates, with cool climate hydrilla averaging 823 tubers m^{-2}, while the warm climate averaged 2142 tubers m^{-2}. Results from these studies demonstrates the difference in growth and phenology of monoecious hydrilla is impacted by ambient and water temperatures.

Monoecious Hydrilla (Hydrilla verticillata (L.f) Royle) Growth and Phenology in Two Dissimilar Climates.

by
Amy Lou Henry

A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Master of Science

Crop Science

Raleigh, North Carolina

2017

APPROVED BY:

Dr. Robert J. Richardson Committee Chair	Dr. David Jordan

Dr. Michael D. Netherland

BIOGRAPHY

Amy Lou Henry was born and raised in Kidron, Ohio. Drawing from her early experiences on her grandmother's farm, she attended The Ohio State University Agricultural Technical Institute, receiving an Associate's Degree in Greenhouse Production and Management. After working full time for a commercial perennial grower, she returned back to OSU to receive a Bachelor's Degree is Sustainable Plant Systems, specializing in Horticulture. Then, she moved to North Carolina to pursue a Master's Degree in Crop and Soil Science, focused on Aquatic Weed Control. She is looking forward to entering a rewarding research career in plant sciences after graduation.

ACKNOWLEDGMENTS

I would like to thank Dr. Rob Richardson for the incredible opportunity of pursuing my Master's Degree and the ability to work and learn in his lab. This opening allowed me to move to a new state and embark on a different adventure. In addition, I would like to thank the remaining members of my committee- Dr. Michael Netherland, and Dr. David Jordan. I truly appreciate their guidance and advice. Without help from my lab, I would not have been able to complete my research. I would like to express my sincere appreciation for everyone who assisted me. Their help was integral to my research, and I thank them for their countless hours of assistance. Thank you to my parents, who have always been supportive of me, no matter how crazy my future plans appeared to be. Finally, I would like to thank my extremely supportive and patient husband for standing by me and supporting me through this entire process.

Table of Contents

List of Tables

List of Figures

Chapter 1 Monoecious Hydrilla Literature Review

Abstract

Invasive aquatic macrophytes may have a negative effects on aquatic and terrestrial ecosystems and impact human health and recreation. Hydrilla (*Hydrilla verticillata* (L.f.) Royle) is a federal noxious, submersed aquatic macrophyte that is expanding its range in the United States (US). There are two biotypes found in the US, a triploid monoecious form and a triploid female dioecious form that have different growth habits, suitable environments, and physiology. The majority of research has been conducted on the dioecious biotype in warm climates, which results in a large knowledge gap of how monoecious hydrilla will behave in cool climates.

Species Overview

Hydrilla is an obligate submersed noxious aquatic weed in the family Hydrocharitaceae (Figure 1-1). This family is believed to have originated 70-100 million years ago (Sculthorpe 1967) with fossil evidence of the genus *Hydrilla* dating back to 40 million years ago (Bowes et al. 2002). All species in this family exhibit a perennial lifecycle, and are especially adapted to aquatic environments, with aerenchyma and uniform internal structures (Ancibor 1979). Hydrilla has been found on every continent except for Antarctica, and is aggressively expanding its range (Langeland 1996, Netherland and Greer 2014). The plant has been discovered growing in Harbin, China, which is at the same latitude as Portland, Oregon and Montreal, Canada. This demonstrates that hydrilla would be able to grow in most of the continental US, including Alaska and southern Canada (Balciunas and Chen 1993). Along with the ability to grow in a variety of climates, hydrilla has developed many adaptations to survive and thrive in diverse aquatic environments. Small ponds, irrigation canals, rivers, lakes, and large reservoirs have all been found to support hydrilla populations (Dayan and Netherland 2005).

As a species, hydrilla contains highly variable genetics, and exhibits different morphological and physiological growth depending on its environment (Cook and Lüönd 1982). Genetically identical plants can exhibit different phenotypes based on water velocity, light penetration, and depth (Madsen 1991). The growth and appearance of hydrilla is impacted by water quality, temperature, and light availability within an aquatic environment (Carter et al. 1994). These characteristics are different throughout the same body of water, so the variability found between bodies of water can be extreme. Correct identification of the species is very difficult, as hydrilla exhibits a plastic phenotype, and appears similar to several other species, such as *Elodea canadensis* (Michx.) and *Egeria densa* (Planch.) (Blackburn et al. 1969, Carter et al. 1994).

Hydrilla grows submersed in the water column, with stems growing towards the water surface. The plant is rooted in the hydrosoil with thin, white or reddish roots and produces several rhizomes and stolons to remain embedded in the sediment (Langeland 1996). Both biotypes grow to the water surface and form thick mats that cause diel temperature and oxygen fluctuations (Dayan and Netherland 2005). Stem fragments break off due to natural water movement and human activities, and are able to survive in the floating state. These fragments sink to the sediment within four days, and are able to root and grow in the new environment (Sutton et al. 1980). Along with the roots anchoring the plant to the hydrosoil, adventitious roots are formed, and can contain chlorophyll to undergo photosynthesis if exposed to sunlight (Langeland 1996).

Leaves are typically in whorls containing four to seven leaves, and are approximately 2-4 mm wide and 6-20 mm long with serrated edges (Langeland 1996), which are influenced by the alkalinity of the water. Plants growing in hard, alkaline water have more distinct edges than those growing in soft, acidic water (Kay 1992). The lamina of the leaf is extremely thin, only consisting of two cells, decreasing protection from the sun, leading to more UV-driven mutations (Dayan and Netherland 2005).

The monoecious biotype produces both female and male flowers on the same plant. Flowering appears to be concurrent with tuber formation, and is influenced by environmental conditions, such as photoperiod (Steward 1993). Flower initiation is different for monoecious hydrilla based on location. For example, North Carolina monoecious hydrilla began flowering earlier and lasted longer than monoecious hydrilla in Delaware. In North Carolina, flowering began in summer and extended into the fall, while in Delaware, flowering began in September and only lasted until October (Harlan et al. 1985; Miller 1988).

Female flowers have three white sepals and three clear petals, and arise from a single spathe (Cook and Lüönd 1982). The sepals are 10-50 mm long, and 4-8 mm wide. The flowers, attached at leaf axils close to the tip of the stems, float on the surface of the water when mature. The female flowers are resistant to wetting, as they are encapsulated in a bubble when submersed, and will immediately return to the surface of the water after being submersed (Langeland 1996). Male flowers have three sepals that are white or brown, are smaller than female flowers, and develop before female flowers (Cook and Lüönd 1982). The male flowers float freely on the surface of the water when mature, and there can be thousands floating in the water at one time (Langeland 1996). Monoecious hydrilla is able to produce viable seeds, which could complicate management plans (Netherland and Greer 2014). However, seed production is more common in tropical regions, and no seed production has been observed in North Carolina (Harlan et al. 1985).

Adaptations

Hydrilla has several adaptations which make it highly competitive, and have led to it being referred to as "the perfect aquatic weed" (Langeland 1996). These adaptations include having several ploidy levels, numerous reproductive strategies, rapid vegetative growth, and the ability to survive in a wide range of environments, including up to 13 ppt salinity (Steward and Van 1987). Additional adaptations include the ability to form thick monospecific mats, alternate from C3 to C4 photosynthetic pathways, and grow in extremely low light and carbon dioxide (CO_2) conditions (Dayan and Netherland 2005, Michel et al. 2004, True-Meadows et al. 2016).

In the same population of hydrilla, there can be several levels of ploidy exhibited-diploid, triploid, and tetraploid (Arias et al. 2005). Variability in ploidy levels may lead to beneficial adaptive features being exhibited by the plant, and also enables genetically identical plants to behave differently in the same environment (Verkleij et al. 1983). Due to increased levels of chromosome sets, the rate of natural mutation in hydrilla DNA is high, along with the increased number of UV light-driven mutations (Dayan and Netherland 2005).

Reproduction of hydrilla is primarily asexual, through the production of propagules and vegetative fragmentation. However, sexual reproduction through seed production has also been observed (Langeland 1996). Aquatic herbaceous perennials have been found to allocate 25% of their resources to asexual reproduction, and less than 5% to seeds, illustrating the importance of asexual reproduction to the plant (Madsen 1991). The two distinct vegetative propagules that are produced are called axillary turions (Figure 1-2) and subterranean turions (Figure 1-3), often called tubers for simplicity.

The green axillary turions are produced in the above-ground biomass leaf axils, and consist of overlapping leaf scales surrounding a single dormant plant meristem (Netherland

1997). Tubers also are covered in leaf scales, and are produced on the terminal ends of rhizomes in the hydrosoil, and come in a variety of colors that depend on soil composition and maturity (Netherland 1997). Monoecious turions are smaller than tubers, and therefore, have a shorter longevity. Turions are viable for one year as compared to tubers, which can remain viable in undisturbed hydrosoil for greater than five years (Nawrocki et al. 2016). Turions are released from the plant by an abscission layer when fully mature, while tubers are separated from the plant when the rhizomes decompose (Netherland 1997).

Mature tubers are resistant to desiccation, herbicides, and freezing when in the hydrosoil, making the management of hydrilla extremely difficult (Langeland 1996). These propagules appear to be the most important mechanism of survival and movement for the plant (Van and Steward 1990), especially tubers, whose control has been described as the most important part of a successful management plan (Netherland 1997). Environmental conditions affect the amount of resources allocated to form turions or tubers. In tropical and cool temperate regions, the majority of the resources go towards producing tubers, while in warm temperate regions, turions are produced at a greater rate (Sastroutomo 1982). A single monoecious hydrilla plant is able to produce more than 5,000 tubers per m^2, leading to a tuber bank, equivalent to a seed bank. This complicates management, as larger meristem banks enable hydrilla to be a more aggressive competitor (Spencer and Rejmánek 2016). Nawrocki et al. (2016) discovered that densities of tubers as low as 11 tubers per m^{-2} were enough for re-infestation, and could result in an 11.36 fold increase in the amount of tubers found after just one season.

Tubers appear to have variable dormancy periods to disperse the hydrilla population over time (Netherland 1997). Environmentally induced dormancy is thought to control sprouting of propagules, though the exact mechanisms and environmental conditions are not understood at this time. Dormancy of aquatic plants has not been studied as extensively as terrestrial plants. However, it is hypothesized that this dormancy inhibits the propagules from sprouting during the same year they were formed, improving the chance of survival over time (Carter et al. 1987).

When tubers are removed from anoxic conditions where they were formed for research purposes, they are exposed to higher levels of light and oxygen as well as reduced levels of CO_2, and dormancy is broken (Netherland 1997). In the laboratory, monoecious hydrilla has a tuber germination rate of 95-100%, regardless of season, while dioecious hydrilla exhibits tuber germination rates of 88%, and is affected by seasonality. The high rates of sprouting in laboratory studies indicates that tubers have an environmentally-induced quiescence instead of an internal dormancy (Netherland 1997).

More tubers are produced by monoecious hydrilla than dioecious hydrilla, due to the higher proportion of resources allocated toward tuber formation (Van 1989). Monoecious hydrilla tubers weigh less and are smaller (Spencer et al 1987). The average monoecious hydrilla tuber is 35.55 mg dry weight while dioecious hydrilla tuber dry weights average 66.66 mg (Madsen 1991).

Hydrilla propagules require a chilling period to sprout. Carter et al. (1987) examined the dormancy of hydrilla propagules, and found after a 7° C chilling period of 42 days, 92% of monoecious propagules sprouted, while 0% of propagules that were not chilled sprouted. Sastroutomo (1980) found that dormancy was broken after a 2° C chilling period for 33 days, while different lengths of photoperiods without a chilling period did not break dormancy. In the same study, photoperiod did not affect the sprouting of the propagules after exposure to a chilling period, signifying the importance of a chilling period.

A single method of completely killing or removing propagules has not been developed and a comprehensive, consistent long term management strategy is essential (Dayan and Netherland 2005). It took 7-10 years of chemical treatment to deplete the tuber bank by 99.5% in North Carolina (Nawrocki 2011). However, if a single year of treatment was missed, tuber densities did recover to 74% of the original amount in one year (Nawrocki 2011). Due to the great abundance of tubers produced, their resistance to unfavorable environmental conditions, and the inability to develop method of control, they are a considerable challenge in management plans.

Along with being able to survive and thrive in many different bodies of water, hydrilla can grow in a wide range of temperatures, sediment types, and pH (Madsen and Owens 2000). For hydrilla turions to sprout, the water temperature must be within 13-35° C, though hydrilla prefers higher temperatures, with an optimum temperature for photosynthesis of 36.5° C (Van et al. 1976). In warm climates, such as in Florida, hydrilla is able to sprout early in the season, when there is little competition for space, light, or carbon. Hydrilla is able to grow in a variety of sediment types, including sand, loam, and marl, again increasing the range of potential infestation (Steward 1984). The aquatic systems where hydrilla is found often experience a diel swing in pH, ranging from 7.1 in the morning to 10.2 in the afternoon as a direct result of hydrilla (Van et al. 1976). Due to the extremely high pH in the afternoon, the availability of inorganic carbon to plants is limited to only bicarbonate (HCO_3-), which several plants cannot utilize. However, hydrilla is able to utilize HCO_3-, allowing the plant to survive in basic environments (Van et al. 1976).

Hydrilla has rapid vegetative growth, and with leaves composed of 90% water, a great deal of biomass can be produced with minimal mineral plant nutrient inputs (Langeland 1996).

Hydrilla's ability to quickly produce vegetative material is evidenced by the fact that a single dioecious hydrilla plant increased its biomass over 1,500 times in just sixteen weeks in laboratory conditions (Sutton et al. 1980). Stems are able to grow up to 15 meters in length, elongating to intercept any available light (Arias et al. 2005). Dioecious hydrilla produce nodes approximately every 12 millimeters, which each node being able to produce a new plant (Langeland 1996). This leads to a huge potential for new sources of plant material, as 40% of fragments consisting of one or two nodes were able to regrow in both greenhouse and field studies (Langeland and Sutton 1980). In the same study, 68% of fragments consisting of three to five nodes were able to regrow. The high potential for plant replication from vegetative fragmentation is an additional challenge in a management system.

Rapid growth leads to issues when the plant forms thick, monospecific mats, which allows hydrilla to increase its competitive advantage by effectively shading out all other submersed plants (Van et al. 1976). This results in a drastic change in community structure, which could lead to a trophic cascade felt throughout the entire aquatic and surrounding terrestrial ecosystems (Grajczyk 2009). Underneath the surface mats, daily temperature fluctuations of up to 20° C have been observed, along with drastic pH and dissolved oxygen changes (Bradshaw et al. 2002; Dayan and Netherland 2005). These environmental conditions cause the majority of photosynthesis to occur in the morning, when there is a greater abundance of carbon and lower irradiance. Underneath a mat of hydrilla, the amount of photosynthetically available radiation (PAR) is reduced 95% in the top 0.3 m of water, while in open waters, there is only a 29% reduction of light (Barko and Smart 1981). It is stated that hydrilla "creates a harsh environment, and then proceeds to thrive there" (Dayan and Netherland 2005). The changes in the environmental conditions of the water body alter which organisms can survive.

Hydrilla has the ability to concentrate carbon around the carboxylation enzyme Rubisco through an inducible C4-type photosynthesis. This pathway uses phosphoenolpyruvate carboxylase (PEPC) instead of Rubisco as the initial fixation enzyme in photosynthesis (Bowes et al. 2002). This adaptation allows hydrilla to eliminate photorespiration, increasing the efficiency of photosynthesis. The evolution of this ability was brought about by unfavorable photosynthetic conditions found in water during the day: supersaturation of oxygen, temperatures above 35° C, pH greater than 10, and low levels of available inorganic carbon (Van et al. 1976).

Out of the 7,600 species of plants that have been found to undergo C4 photosynthesis, there are only a dozen aquatic species that have been identified. Photosynthetic pathway is determined by the pH, oxygen and CO_2 availability in the water (Bowes et al. 2002). In hydrilla, the pathway can change over the course of the day, or over the course of a growing season. Biochemical and molecular changes lead to the switch from C3-C4 pathways without any anatomical alterations, meaning that the plant does not have to grow new leaves when conditions change (Rao et al. 2006). In fact, leaves that were discovered to have C4-like CO_2 compensation points had previously exhibited higher C3 compensation points (Bowes et al. 1977).

Due to these many adaptations, hydrilla has been shown to be a strong competitor with many submersed aquatic plants, both native and invasive. In competition studies and the observation of natural displacement, *Vallisneria americana* (Michx.), *E. densa*, *Myriophyllum spicatum* (L.), and *Ceratophyllum demersum* (L.) have all been seen to be inferior competitors to hydrilla (Hofstra et al. 1999, Mony et al. 2007, Wang et al. 2008). Even though there have been many competition studies between hydrilla and other species of plants, most of the research has been completed on the dioecious biotype in warm climates.

Staminate dioecious hydrilla in New Zealand has been shown to be able to compete and overpower many other species in Hydrocharitaceae (Hofstra et al. 1999). In this study, hydrilla demonstrated the ability to suppress these species, indicating that it has potential to be more invasive than other invasive members in Hydrocharitaceae found in New Zealand. In another competition study, Wang et al. (2008) found that hydrilla was able to compete with *M. spicatum*, accumulating more aboveground biomass and also reducing *M. spicatum* root formation. This shading took place due to quick elongation of hydrilla stems to the water surface, where it was observed that it grew on top of the *M. spicatum* mat (Wang et al. 2008).

In field observations, hydrilla has been recorded to outcompete other submersed plants present (Carter et al. 1994; de Kozlowski 1991). In the Potomac River, monoecious hydrilla occupied greater than seventy percent of the plant community in just five years after being discovered in 1982 (Carter et al. 1994). Before the hydrilla infestation, *V. americana* and *M. spicatum* were the most dominant plant species present. Historically, this river supported a rich diversity of submersed macrophytes until 1972, when tropical storm Agnes hit (Serafy et al. 1994). After this year, the dominant macrophyte was hydrilla.

<u>Introduction and Spread</u>

Around the world, there are twenty-three different hydrilla biotypes, increasing the genetic diversity and geographical range of hydrilla (Verkleij et al. 1983). In the US, there are two biotypes found: a triploid monoecious form and a triploid female dioecious form (Cook and Lüönd 1982). The distribution of both biotypes in the US is shown in (Figure 1-4).

Dioecious hydrilla was initially discovered in Florida in the 1960s, after it was intentionally introduced for aquarium plant trade. It was initially misidentified as Florida elodea, and no management was taken for seven years (Blackburn et al. 1969). This lengthy period between discovery and treatment allowed the plants to establish in the area and quickly expand its range in Florida and be introduced into southern Alabama and Georgia (Blackburn et al. 1969). In just a decade, dioecious hydrilla was found in major bodies of water in every watershed of Florida (Langeland 1996).

Monoecious hydrilla was misidentified as American elodea when it was first discovered in 1976 in the Potomac River in Delaware (Madeira et al. 1997). By 1983, over 162 hectares in the river were infested with the plant (Rybicki and Carter 1986), comprising over 70% of the submersed aquatic vegetation population (Carter et al. 1994). Soon after 1976, other populations of monoecious hydrilla were found in North Carolina, Maryland, and Virginia (Steward and Van 1987). It is believed that at least one of the introductions was accidental, being mixed in with waterlilies in Kenilworth Aquatic Gardens in Washington DC (Vandiver et al. 1982). In North Carolina, monoecious hydrilla was first correctly identified in the 1980s in Umstead Park in Wake County, years after the first discovery of the plant (Harlan et al. 1985). Korea is the likely center of origin for the biotype of monoecious hydrilla that is found in the United States (Madeira et al. 1997).

From 2000-2011, dioecious hydrilla was discovered in three new states, while monoecious hydrilla has been identified in fifteen new states (Netherland and Greer 2014). Eleven of these states are in the northern US that had not experienced previous hydrilla infestations, and the other four are southern states that had only dioecious infestations. Even though monoecious hydrilla is aggressively expanding its range, research on this biotype has not kept pace with the expansion. In a recent search of all published literature on hydrilla, there were 5,011 records. Only 197 published papers mentioned “monoecious” or “biotype” (Netherland

and Greer 2014). That is less than 4% of papers that refer to monoecious hydrilla or even mention biotype.

The monoecious biotype is more adapted to temperate conditions in the US, and has naturalized in areas along the east coast, from North Carolina to Connecticut (True-Meadows et al. 2016). The dioecious biotype is found in tropical regions of the US, as in Florida, Georgia, Alabama, and California (Madeira et al. 1997), and requires a higher temperature for completing its lifecycle. Monoecious hydrilla above ground biomass dies back completely in the winter, exhibiting a herbaceous perennial lifecycle (Madsen 1991), where dioecious hydrilla biomass can overwinter in warmer areas, lengthening the growing season.

States that have both dioecious and monoecious hydrilla include Alabama, South Carolina, Georgia, and Tennessee (Netherland and Greer 2014). Much research has gone into understanding the plant's growth in the warmer, southern climates of the US, but more research is needed about the plant in cooler climates. Understanding the growth and spread and being able to develop appropriate management strategies in northern climates is the most important issue that needs to be tackled in regards to hydrilla control (Netherland and Greer 2014). It is assumed that longer photoperiod lengths and cooler water affect the growth, spread, and reproductive timeline of hydrilla, though research has been lacking in these aspects.

<u>Comparisons between Biotypes</u>

Madeira et al. (2000) reported that dioecious and monoecious biotypes of hydrilla have different life strategies even though they are similar in appearance. These differences need to be understood for appropriate and effective management strategies. These life strategies include differences in physiology, reproduction, and responses to environmental conditions. Experiments have been completed to quantify the differences between monoecious and dioecious hydrilla, looking at tuber formation (Steward and Van 1987, Sutton et al. 1992), and plant biomass accumulation (Grodowitz et al. 2010).

In experimental laboratory conditions, monoecious hydrilla produced tubers more rapidly and in greater abundance than dioecious hydrilla. In the study, monoecious hydrilla produced twice the amount of tubers than dioecious hydrilla did (Sutton et al. 1992). Tubers were also produced under the longer days of summer on monoecious plants, while no tubers were produced under the same lighting conditions on dioecious plants (Van 1989). It was found that tuber formation in dioecious hydrilla is directly tied to short days, where monoecious hydrilla is able to produce tubers regardless of photoperiod though production is increased in response to short days (McFarland and Barko 1999). In laboratory studies, tuber sprouting was greater for monoecious hydrilla and also occurred at lower temperatures than dioecious hydrilla (Sutton et al. 1992, Van 1989).

The growth habit between the two biotypes also differ, with monoecious hydrilla more prone to grow laterally on the sediment, after sprouting while dioecious hydrilla tends to grow vertically first (Grodowitz et al. 2010, Van 1989). Therefore, dioecious hydrilla reaches the surface of the water quicker, so when monoecious hydrilla is seen, the majority of the sediment is already covered by a considerable amount of biomass (Sutton et al. 1992). This decreases the likelihood of effective control, as the complexity and difficulty of control increases as the biomass increases.

These differences enable the specific biotypes to flourish in different environments. Monoecious hydrilla, with its ability to continuously produce a large amount of tubers in a small period of time is better suited for temperate climates, while dioecious hydrilla is more suited for tropical climates (Netherland 1997). In addition, the annual lifecycle of monoecious biotype makes the plant more suited to northern climates.

Issues Associated With Nuisance Aquatic Growth

Invasive aquatic macrophytes have a significant effect on aquatic ecosystems, as aquatic systems are particularly vulnerable to invasive species (Arias et al. 2005). Eutrophication, or the nutrient enrichment of bodies of water has led to increased invasions, and has been acknowledged as one of the main origins of invasive species in developed countries (Andres and Bennett 1975). Habitat destruction and alteration, human population growth, and increased world travel by humans have also increased the range of several plants (Floerl and Inglis 2005, Pimentel et al. 2005). Examples of human alterations of waterways include the building of irrigation canals or reservoirs, or dredging existing lakes. In these instances, the exotic weed may have an adaptive advantage over native species and become dominant very rapidly (Andres and Bennett 1975).When introduced into a new habitat, noxious weeds can become environmental engineers by altering and disrupting water quality, native plant communities, and other ecosystem processes (True-Meadows et al. 2016). Following habitat loss, invasive species are considered the second greatest threat to aquatic organisms, and are found to affect over half of all species on the threatened and endangered species list (Wilcove et al. 1998).

These negative effects can be brought about by hydrilla, affecting both humans and the natural ecosystem. Large infestations of hydrilla interfere with irrigation, recreational activities, drinking water, hydropower generation, industrial uses, transportation, native plant populations, and can harbor mosquitoes that can transmit diseases to humans (True-Meadows et al. 2016). Large hydrilla mats can increase sedimentation of the water body, which slows the flow of water, and increases the chance and intensity of flooding (Sculthorpe 1967).

Thick hydrilla mats can provide suitable habitats for vectors of diseases that affect humans such as malaria, encephalomyelitis, filariasis, and schistosomiasis (Zettler and Freeman 1972). Increased disease risk is not the only effect these species have on humans, as property values are also impacted. Excessive growth of invasive aquatic macrophytes have been estimated to reduce property values from 20-40% (Halstead et al. 2003), and reduce the likelihood of housing development around the body of water by 37% after an invasion (Goodenberger and Klaiber 2016).

Swimming, boating, and recreational fishing are also impeded by thick mats of hydrilla, leading to a loss of revenue. In Florida, there was a loss of $10 million dollars when two lakes were closed due to hydrilla treatment in one year (Pimentel et al. 2005). Swimming in a thick mat of hydrilla is considered a drowning hazard, and also impedes boat traffic reducing the recreational use of the water body (Goodenberger and Klaiber 2016).

In addition to directly altering and impacting the aquatic environment, monoecious hydrilla is able to affect terrestrial food webs indirectly. Avian Vacuolar Myelinopathy (AVM) is a fatal nervous system disease first discovered in bald eagles (*Haliaeetus leucocephalus*) in 1994, though it affects American coots (*Fulica americana*), Canadian geese (*Branta canadensis*), great horned owls (*Bubo virginianus*), and mallards (*Anas platyrhynchos*) (Wilde et al. 2005). This disease is caused by epiphytic cyanobacteria (*Aetokthonos hydrillicola)* in the order Stigonematales that has been discovered on up to 95% of hydrilla biomass in affected areas. AVM is transmitted to birds through ingestion, and appears to bioaccumulate, affecting the top predators more than the initial consumers. Hydrilla, *E. densa*, and *M. spicatum* were the most common aquatic vegetation in areas where there were cases reported of AVM.

Control and Management Strategies

Due to the numerous problems associated with hydrilla, control is necessary if the body of water is to be used to its fullest potential (Sutton et al. 1992). Controlling hydrilla is difficult, expensive, and a continuous process, due to the characteristics of both the target plant and the aquatic environment (Sousa 2011). For example, the distribution and density of submersed aquatic vegetation is controlled by several different factors that interact with each other, and only some of which that can be controlled by humans (Carter et al. 1994). In addition, there are often several unrelated plant species, many of which are valuable, therefore requiring selective control methods. The flow of the system also complicates management strategies, with flowing water systems being more difficult to control. This increase of difficulty in flowing systems is due to increased regulations, downstream concerns, and decreased water contact to plants (Van et al. 1987). There are few management tools available to treat nuisance aquatic macrophytes being restricted by environmental concerns, costs, effectiveness, and public perception (Richardson 2008).

Over one billion dollars per year is spent in the US alone on aquatic vegetation control, which includes the management of hydrilla (Pimentel et al. 2005). In addition to the cost of control, there are ten million dollars per year in losses and damages in the US that are directly related to submersed aquatic vegetation (Pimentel et al. 2005). Eradication programs are not as common as control programs, as turions and tubers allow hydrilla to be extremely persistent. There are four methods of control, which include cultural, mechanical, chemical, and biological methods (Richardson 2008). Each of these methods of control have positives and negatives that need to be considered before an effective management strategy can be developed. All control methods are temporary, except for biological control, though this method takes time for the organism to build up populations (Cuda et al. 2008). An integrated management plan can be used to increase the probability of control. After hydrilla is controlled, it is necessary to restore native plant communities, and reduce external environmental stressors (Chadwell and Engelhardt 2008). Like other invasive species, the best management strategy for hydrilla is prevention, but that is difficult (Langeland 1996.)

Another complication in control is the variety of individuals that have access to the body of water. These individuals can be homeowners, recreational users, power plant companies, and governmental agencies, all having different levels of acceptability of weed presence, knowledge of the problem, and budgets (Richardson 2008). Homeowners and swimmers generally want a completely vegetation-free body of water, which is in direct opposition to hunters and fishers, who would prefer to have aquatic vegetation. Public utility providers will only treat when plant growth interferes with energy production (Richardson 2008). Acceptable hydrilla populations are determined by economic thresholds, or where the company would lose money if the population of hydrilla exceeded the level, not based on ecological harm. As bodies of water can cross jurisdictions and even state lines, this increases the number of governmental agencies involved, and complicates management strategies (Richardson 2008).

Cultural control involves managing the weed problem by manipulating environmental conditions, and includes management actions such as water drawdowns, benthic barriers, and dyes (Poovey and Kay 1996). These control methods are temporary, expensive, difficult to implement, and are not practical on a large scale. Drawdowns involve water levels being artificially altered to expose hydrilla biomass and the hydrosoil to the atmosphere to dry out. There are limitations to this management plan, and it is not always a feasible option. Some ponds and lakes are unable to have their water depth controlled, which eliminates the possibility of using drawdowns. Hydrosoil composition is an important factor in the success of a drawdown (Doyle and Smart 2001). In North Carolina, it had been reported that drawdown was completely ineffective, due to the high percent of clay in the hydrosoil, meaning the tubers in the soil will not dry out enough to cause mortality (Harlan et al. 1985).

In a study conducted on monoecious hydrilla in North Carolina, a winter drawdown had no impact on the tubers in the hydrosoil (Poovey and Kay 1996). Summer drawdowns may be more effective by reducing both the biomass growth and turion production (Barrat-Segretain and Cellot 2007), but hydrilla turions in sediment showed no decline in their viability throughout a 12-month continuous drawdown (Doyle and Smart 2001). Several drawdowns may be used, as the first drawdown would induce tuber sprouting, and then the second drawdown would kill the biomass before new tubers would be formed. However, summer drawdowns are not practical for most water bodies due to recreational, irrigation, drinking water, and other demands.

Benthic barriers are expensive, costing over $4,000/ha, and are a temporary solution. Materials that are utilized include sand, clay, plastic, rubber sheets, and burlap (Nichols and Shaw 1983). Small areas, such as by boat ramps and public swimming areas would be suitable habitats to use this control method, though sediment accumulation on top of the material is a concern, as hydrilla will grow on top of the barrier (Nichols and Shaw 1983).

Liquid dyes and shade are effective in control of hydrilla, as sunlight availability is decreased. At least one pond dye has been registered with the EPA, limiting the potential of using this method of control (Richardson 2008). In addition, native plant populations and other aquatic organisms must be considered, as these organisms will also be affected by the dye. Therefore, the exclusive use of dyes and shade is limited in controlling hydrilla (Nichols and Shaw 1983).

Mechanical control is achieved by hand pulling or using machinery to remove the weed from the aquatic system. This form of control is not common because it is expensive, time consuming, encourages new growth, and has negative impacts to non-target organisms. Mechanical control can cost up to $2,400/ha, and can require up to six treatments in the same growing season (Langeland 1996). In the Potomac River, two 450 m^2 locations of monoecious hydrilla were located and studied. At one location, hydrilla was mechanically harvested, and in the other area, there was no mechanical control. After three weeks, there was an increase of 34% in vegetation in the mechanically harvested site as compared to the control site (Serafy et al. 1994). In the treatment site, along with the eventual increase in hydrilla biomass, there was a 4-23% loss of fish biodiversity, as fish were caught in vegetation that was removed from the lake (Serafy et al. 1994). Another disadvantage to mechanical control is the ability of hydrilla to propagate from stem fragments, which are increased by removal. For mechanical control to be effective, all plant biomass must be removed from the body of water, which is difficult. For all these reasons, mechanical control is only a temporary solution to the problem (Serafy et al. 1994). The use of mechanical control is limited to drinking water reservoirs, fast moving water, or areas where immediate removal of the plant is necessary (Langeland 1996).

Biological control is defined as the intentional release and use of non-native organisms to help diminish the growth, ability to reproduce, or thickness of an unwanted organism. Research into using biological control for aquatic systems began in 1964 on alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.) (Andres and Bennett 1975). Due to the success of control with insects, other forms of organisms were researched for several different aquatic weed species. The three main groups of organisms used in aquatic weed biocontrol programs are arthropods, fish, and pathogens (Cuda et al. 2008).

Both monoecious and dioecious hydrilla may be controlled by sterile triploid grass carp, *Ctenopharyngodon idella* (Cuvier and Valenciennes). These fish are sterilized by shocking the eggs with water of extreme high or low temperature or with pressure. This shock results in the eggs retaining an extra set of chromosomes, making the fish triploid and sterile (Cuda et al. 2008). Even though these fish are not selective feeders, it has been documented that hydrilla is a preferred food source. Once released, capture is difficult, and the carp will remain in the system, eating many submersed plant species.

Another biological control species has been shown to feed on hydrilla is a species of fly, *Hydrellia spp*. (Grodowitz et al. 2010). This fly has been demonstrated to control dioecious hydrilla, but has not shown any impact on monoecious hydrilla (Grodowitz et al. 2010). One reason is that monoecious hydrilla mats tend to stay directly under the water surface, where dioecious biomass is exposed to the air. This decreases the herbivory damage that can be inflicted, and also eliminates habitat area. In addition, monoecious hydrilla biomass doesn't typically overwinter, which decreases the likelihood of the insect overwintering as well (Grodowitz et al. 2010). Ongoing research is being conducted on the feasibility and practicality of using insect biological control on monoecious hydrilla.

There are currently fourteen active ingredients and one pond dye that is approved by the EPA for aquatic weed control (Richardson 2008). Chemical control costs are very expensive, with wide ranges of costs, averaging $1,235/ha (Arias et al. 2005). Along with having steep direct costs, there is a possibility of having large indirect effects, such as impacts to non-target organisms. After a chemical treatment, there may be restrictions to drinking water, fishing, irrigation of crops, and swimming (Richardson and Getsinger 2014).

Treatment of hydrilla is complicated, and requires consistent treatment to be able to control the plant. The best way to control hydrilla is to prevent the spread of the plant, which is done by educating the public and individuals that use the bodies of water (Langeland 1996). However, after hydrilla is present, the possible treatment tools include cultural, mechanical, biological, and chemical control. Integrating more than one of these treatment tools in the management plan increases the potential effectiveness of the control (Chadwell and Engelhardt, 2008).

Despite the fact that hydrilla is one of the most commonly studied aquatic plant, there is still a large amount of knowledge not in the literature. This is due to the fact that most of the research thus far has been completed on the dioecious biotype in warm climates (True-Meadows et al. 2016). Currently, there is a large gap of knowledge of the growth and phenology of monoecious hydrilla in cool climates where the range of hydrilla is actively spreading. This knowledge is important to determine effective management plans (Netherland and Greer 2014). Additional research is needed to determine how different climate conditions, such as photoperiod and temperature affect the growth, reproduction, and competitiveness of monoecious hydrilla.

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Taxon: *Hydrilla verticillata* L.

Kingdom: ***Plantae***- plants

Subkingdom: ***Tracheobionta***- Vascular plants

Superdivision: ***Spermatophyta***- Seed plants

Division: ***Magnoliophyta***- Flowering plants

Class: ***Liliopsida***- Monocotyledons

Subclass: ***Alismatidae***

Order: ***Hydrocharitales***

Family: **Hydrocharitaceae**

Genus: ***Hydrilla*** Rich. - hydrilla

Species: ***Hydrilla verticillata*** (L.f.) Royle

Other common names: waterthyme, Florida elodea

Figure 1-1. Taxonomic identification of *Hydrilla verticillata* (L.f.) Royle.

Figure 1-2. Axillary turions of monoecious *Hydrilla verticillata*.

Figure 1-3. Subterranean turions (tubers) of monoecious *Hydrilla verticillata.*

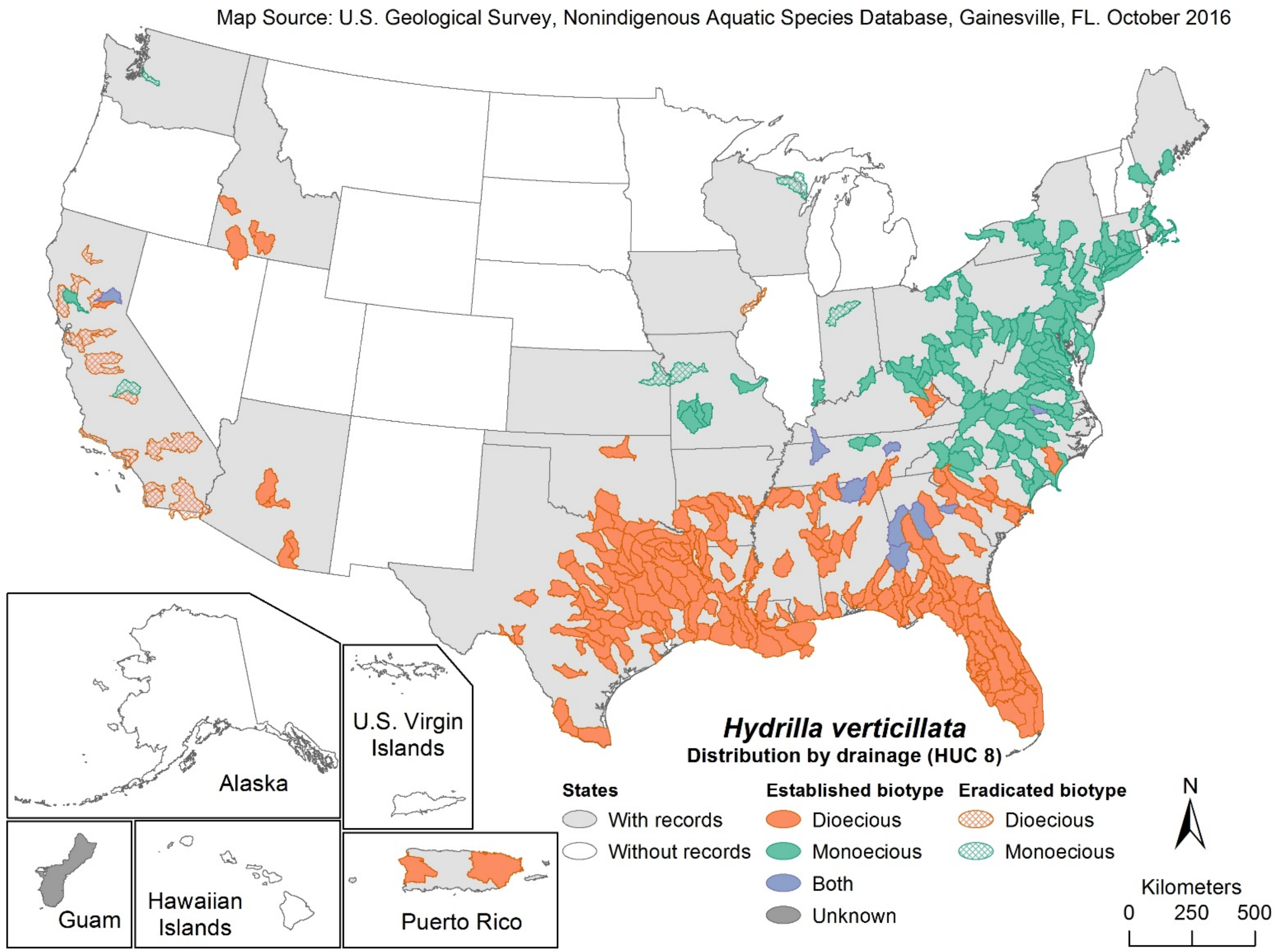

Figure 1-4. Distribution of dioecious and monoecious *Hydrilla verticillata* in the United States. U.S. Geological Survey, 2016, *Hydrilla verticillata*. Nonindigenous Aquatic Species Program, Gainesville, FL. https://nas.er.usgs.gov/XIMAGESERVERX/2016/20161027161554.jpg. Accessed 12/20/2016.

Chapter 2 Monoecious *Hydrilla verticillata* Phenology and Growth in a Simulated Cool Climate Compared to a Warm Climate

Abstract

Hydrilla (*Hydrilla verticillata* (L.f) Royle), a federal noxious submersed aquatic plant, has been referred to as the perfect aquatic weed. There are two biotypes of hydrilla in the United States; a pistillate dioecious biotype and a monoecious biotype. To investigate the growth behavior of monoecious hydrilla in different climates, outdoor observational mesocosm trials were conducted at two separate research locations in Raleigh and Laurel Springs, North Carolina. Throughout the study, water and ambient temperatures were lower in Laurel Springs. All life stages occurred earlier in Raleigh than in Laurel Springs. In Raleigh, mean water temperature of turion and tuber sprouting, female and male floral initiation, turion formation, and plant senescence occurred at 12.4, 15.0, 27.7, 23.9, 24.2, and 8.5° C, respectively. In Laurel Springs, turion and tuber sprouting, female and male floral initiation, turion formation, and plant senescence occurred at 7.0, 10.1, 25.9, 23.1, 20.1, and 7.5° C, respectively.

Introduction

A federal noxious weed, hydrilla has been called “the perfect aquatic weed” (Langeland 1996), and is considered one of the worst aquatic weeds worldwide (Shearer and Jackson 2006). This plant is ubiquitous, being found on every continent except Antarctica, and has the ability to survive in drastically different water systems, from small, natural ponds, man-made canals and reservoirs, to flowing water (Dayan and Netherland 2005). Hydrilla is able to grow in a wide range of pH values, temperature, dissolved oxygen (DO) and nutrient concentrations (Madsen and Owens 2000).

Two biotypes are found in the United States (US) - a triploid monoecious form and a triploid dioecious pistillate form, both of which are expanding their range in North America (Cook and Lüönd 1982). Dioecious hydrilla is typically found in the warmer climate of southern states, while monoecious hydrilla is typically found in North Carolina and north in more temperate climates. From 2000-2011, dioecious hydrilla was found in three new states, while monoecious hydrilla was found in fifteen new states. Despite this range expansion, there is little knowledge as to how monoecious hydrilla will behave in new climates (Netherland and Greer 2014). The majority of research on hydrilla has been conducted in southern climates on the dioecious biotype. Therefore, further research on monoecious hydrilla in northern climates is needed to understand plant growth and phenology (Netherland and Greer 2014).

Madeira et al (2000) stated that even though the biotypes may appear visually similar, there are important differences in the biotypes that must be understood and applied to develop effective management systems. These life strategies differences between the biotypes include physiology, reproduction, and growth behavior. Experiments have been completed to quantify the differences between monoecious and dioecious hydrilla, looking at asexual propagule formation in Florida (Steward and Van 1987; Sutton et al. 1992), and plant biomass accumulation in Texas (Grodowitz et al. 2010).

Hydrilla has two asexual propagules that are vital to the survival of the species over both time and space. These propagules are thought to be the most important source of hydrilla biomass, as monoecious hydrilla has no overwintering biomass in cooler climates (Sutton and Portier 1985). Green axillary turions, produced on stems, are leaf scales surrounding meristematic tissue, and show a longevity of less than a year (Van and Steward 1990). Subterranean turions, referred to as tubers, are formed at the end of underground rhizomes and increase the chance of survival of the species over time, as they remain viable for up to ten years (Hodson et al. 1984). When in the soil, mature tubers are resistant to freezing, desiccation, and chemicals, complicating management strategies (Hodson et al. 1984). Due to the importance, the production potential, and the longevity of these propagules, it is vital to understand the production and maturation of these propagules to have an effective management strategy.

Monoecious hydrilla produces both female and male flowers on the same plant (Langeland 1996). Female flowers have three, white sepals and three clear petals, which arise from a single spathe (Cook and Lüönd 1982). The sepals are 10-50 mm long, and 4-8 mm wide. The flowers, attached at leaf axils close to the tip of the stems, float on the surface of the water when mature (Langeland 1996). Male flowers have three sepals that are white or brown, are smaller than female flowers, and have been observed to develop before female flowers (Cook and Lüönd 1982). Male flowers float freely on the water surface when mature, and there can be thousands floating in the water at one time, reaching densities of 310 male flowers per m^2 in North Carolina (Hodson et al. 1984). Monoecious hydrilla is able to produce viable seeds, though seed production is more common in tropical regions, and no seed production has been observed in North Carolina (Harlan et al. 1985).

Dissimilar climates have been previously reported to affect growth and delopment of monoecious hydrilla. A study by Sutton et al. (1992) showed that monoecious hydrilla biomass was able to overwinter when grown in South Florida. However, when grown in Texas, no monoecious hydrilla biomass overwintered (Owens et al 2012). In both natural systems and mesocosms in North Carolina (NC), no monoecious hydrilla biomass is present over winter (Grodowitz et al 2010; Hodson et al 1984; True-Meadows 2013). Therefore, in a more temperate climate, there is no overwintered biomass, while in a more tropical climate, biomass is able to overwinter.

Hydrilla has a phenotypic plasticity, as its morphology is influenced by different environmental factors (Richards et al. 2006). The ability of the plant to adapt its morphology to the environment optimizes the utilization of light. In fact, species that are able to alter their morphology to survive a wide range of environmental conditions are usually more competitive than plants that are unable to adapt (Barko et al. 1981). Other environmental factors that affect plant plasticity include water velocity, temperature, photoperiod, and water chemistry, all of which are affected by the location of the body of water (Madsen 1991).

Interactions of different climatic conditions, such as increased early season photoperiod and decreased temperature have not been defined for monoecious hydrilla. It is important to understand how different environmental conditions will alter the growth, development, and phenology of monoecious hydrilla, as the range of monoecious hydrilla expands in the US (Netherland 1997). The objective of these mesocosm studies was to gain a better understanding of the growth and development of monoecious hydrilla when grown in different climates.

Methods and Materials

Two different research locations were selected to investigate the effect of different climatic conditions on the growth and development of monoecious hydrilla from May 2015 to December 2016. Cool climate research was conducted at the North Carolina Department of Agriculture and Consumer Science (NCDA&CS) Upper Mountain Research Station (UMRS) in Laurel Springs, NC (36.396656, -81.306981). Warm climate research occurred in Raleigh, NC on North Carolina State University (NCSU) Research Farm #2 (35.815484, -78.732425). Laurel Springs was selected to simulate a northern climate, with yearly average temperatures similar to

Albany, New York, and Ann Arbor, Michigan (Table 2-1). Raleigh was selected as the southern research location because it is climatically different from Laurel Springs, yet still close enough that the same research team could complete the same experiments at the different locations.

Water in Laurel Springs was supplied from a well located on UMRS, while water at Raleigh was supplied by an irrigation pond. Samples of water from both locations were collected and analyzed by the NCDA&CS, Solution Analysis Section in Raleigh, NC, where water quality tests were determined in 2016 (Appendix 1). At both locations, the experiments were covered with 30% shade cloth (DeWitt Company, Sikeston, MO) to moderate the water temperatures. Daily water temperature and lumens available were measured with a HOBO Pendant® data logger (Onset Computer Corporation, Bourne, MA). Ambient temperature and photosynthetically active radiation (PAR) were measured by NCDA&CS weather stations near both research locations from May 2015 to December 2016. Raleigh weather data was collected at Reedy Creek Field Laboratory, while Laurel Springs weather data were collected at UMRS.

Sixty unsprouted monoecious hydrilla tubers were collected from Shearon Harris Reservoir (35.612378, -78.942986) in Wake County, NC on May 25, 2015. This reservoir has been infested with hydrilla since the early 1980s, has no current hydrilla management plan, and has been described in detail by Nawrocki et al (2016).

Tubers were sprouted in a greenhouse, and single sprouted tubers were planted in plastic Classic 300s six-inch nursery pots (2.9 L; 17.8x16.5 cm) (Appendix 2). Pots were filled with approximately 15 cm of Scott's Premium topsoil (Scotts, Marysville OH) and topped with 3 cm of play sand (Quikrete®, Atlanta, GA). After planting, thirty pots were evenly divided into six plastic outdoor 1040 L mesocosms (Benchmark Earth Works, Sanford, NC) at both locations (Appendix 3). Plants were allowed to grow and develop naturally until senescence. Visual observations were recorded on a biweekly basis noting events including as sprouting, flowering, and turion development.

On November 10, 2015, five pots were destructively harvested from Laurel Springs, while a destructive harvest was conducted in Raleigh on November 20, 2015. From these harvests, the number of turions and tubers produced throughout the growing season were counted, measured, and weighed. A greenhouse viability test was conducted in 88.7 mL microcosms with deionized water. A propagule was called viable if it sprouted, and all viability studies were run until the propagules either sprouted or rotted.

From 2015-2016, twenty-five six-inch black plastic pots were overwintered, undisturbed in outdoor mesocosms. In spring of 2016, biweekly observations were taken of the pots, noting sprouting dates of both turions and tubers. After tubers ceased sprouting, another destructive harvest was conducted at both locations, and all propagules were counted, measured, weighed, and a separate greenhouse viability test was conducted. This harvest occurred on June 5, 2016 in Raleigh and on June 18, 2016 in Laurel Springs.

The number of propagules formed, their weight, and sprouting times of both turions and tubers were recorded for both locations. Two-sample t-tests were utilized to compare ambient and water temperature between locations throughout the entire study. Number of propagules produced were compared across locations using a two-sample t-test. This study was focused on evaluating the performance of hydrilla growth, biomass quantity and propagules formed when grown in a cooler climate.

Results and Discussion

During the study period, Raleigh had higher mean, minimum, and maximum ambient temperatures, with a p-value < 0.0001 (Table 2-2). However, mean precipitation and PAR were similar for each location during the duration of the study with p-values of 0.3268 and 0.7548, respectively. Raleigh temperature range was -4.5 to 35.4° C, while Laurel Springs temperatures ranged from -9.5 to 29.1° C. Mean PAR ranged from 98.0 – 580.4 µmoles/m^{-2} s^{-1} in Raleigh and from 95.7 – 616.1 µmoles/m^{-2} s^{-1} in Laurel Springs.

The overall mean water temperature over the entire study was higher at Raleigh, with a p-value of < 0.0001. Mean water temperature averaged 18.6° C in Raleigh, with water in Laurel Springs averaging 13.5° C (Table 2-3). There was not a difference in the amount of light available in the mesocosms between locations, with a p-value of 0.588.

In Raleigh, turions began to sprout in late March when the mean water temperature was 12.4° C with tubers sprouting in early April at mean water temperatures of 15.0° C (Table 2-4). Turion sprouting in Laurel Springs began in early April, with mean water temperature of 7.0° C and tubers sprouted in mid-April at a mean water temperature of 10.1° C. There was a two-week window of time between turions and tubers sprouting in Raleigh, while there was a one-week window between these two events in Laurel Springs (Figure 2-1).

Tubers continued to sprout until early June in Raleigh and mid-June in Laurel Springs. The length of new propagule sprouting was the same between the locations, simply offset two weeks later in Laurel Springs. There was not a difference between locations in the number of sprouted tubers after being overwintered at both locations. On average, there were 5 tubers per pot that sprouted in spring 2016 at both locations (Table 2-5). In Raleigh, approximately 30% of tubers produced sprouted, while in Laurel Springs, close to 65% of tubers sprouted in the spring. As the accumulation of tubers in the hydrosoil makes treatment extremely difficult, the tuber bank is important to management. If cooler climates have a higher tuber sprouting rate than southern climates, the tuber bank might not build up as quickly. Nevertheless, a study completed by Nawrocki et al. (2016) showed that tuber densities a low as 11 tubers per m^{-2} were adequate for a significant recovery in biomass. All mesocosms at both locations had tuber densities that were much higher than 11 tubers m^{-2}, meaning that even though tuber densities might be lower in northern climates, they still would pose serious problems to managers.

Understanding and predicting sprouting of asexual propagules is vital to an efficient management plan, as they are very important to the survival of hydrilla (McFarland and Barko 1999). Hodson et al. (1984) recorded that tubers were the primary method of monoecious hydrilla overwintering in NC lakes. In a field study, it was found that monoecious hydrilla turions in Raleigh, NC sprouted about two weeks before tubers, with sprouted tubers being found in early April (True-Meadows, 2013). The propagules observed in the Raleigh mesocosms sprouted around the same time as the field studies completed in Raleigh. However, turions and tubers sprouted later in Laurel Springs mesocosms, indicating that different temperatures found in these locations influenced the time that sprouting began. Tubers grown in the mesocosms in Raleigh had a shorter sprouting window, two months, when compared to four months found by True-Meadows in that field study. This difference might be explained by the fact that this study utilized pots that might have reached carrying capacity quicker than plants growing in a lake, resulting in a smaller sprouting window. Plants growing in a large body of water are not going to reach this carrying capacity as quickly, and therefore propagules might continue sprouting for a longer time.

Turion formation began after flowering at both locations. Turions were first observed forming in Raleigh in early September at a mean water temperature of 24.2° C while turions were formed in Laurel Springs in late September at a mean water temperature of 20.1° C (Table 2-4).

Hydrilla plants at Laurel Springs produced female flowers in late July, with an average water temperature of 25.9° C and male flowers in late August, with a mean water temperature of 23.1° C. Hydrilla plants in Raleigh produced female flowers in early August, with a mean temperature of 27.7° C and male flowers in late August, with a mean water temperature of 23.9° C. Female flowers were present until late October in both locations, while male flower observations ceased in late September.

The floral initiation window observed in Raleigh, starting in July and lasting until October, is similar to the window described by Harlan et al (1985). However, the window is different than what was observed in the field trial completed by True-Meadows in 2013. In that study, it was discovered that floral initiation was observed in Raleigh from mid-September until late October, much later than in this study.

Altered timings of flowering times of monoecious hydrilla have been reported in different US states. Monoecious hydrilla in Umstead State Park in North Carolina (35.873154, -78.766956) began flowering in June, lasting until October (Harlan et al. 1985), while monoecious hydrilla in Ingrams Pond in southern Delaware (38.588652, -75.329175) began in September, lasting until October (Miller 1988). Flowering at these two locations were influenced by climatic conditions, and differed in both timing and duration.

As monoecious hydrilla produces both female and male flowers from one plant, it opens the possibility of seed production. However, it has been found that aquatic herbaceous perennials allocate approximately 25% of all resources to asexual reproduction, and only around 5% to sexual reproduction (Madsen 1991). Therefore, even though seed production is a possibility, it is not currently viewed as important to the annual survival of monoecious hydrilla found in the

United States. In this study, even though both male and female flowers were observed, no seed or fruit production was observed at either location.

At both locations, female flowers were observed before male flowers. This is in disagreement with Cook and Lüönd (1982), who stated that staminate flowers are produced before pistilate flowers. Observations from Delaware stated that both flowers were produced in September-October, not stating exactly what sex of flower was observed first (Miller 1988). Female flowers on hydrilla plants grown in Laurel Springs were present for a longer period of time than hydrilla grown in Raleigh. However, male flowers were present at both locations for the same amount of time. There is limited information published about the longevity of flowers in monoecious hydrilla in both artificial and natural systems.

At Laurel Springs, plant senescence occurred in early December, when mean water temperature was 7.5° C while plant senescence occurred in Raleigh late December, when mean water temperature reached 10.2° C. As expected, plants in Laurel Springs senesced earlier than Raleigh, most likely due to water cooling down earlier in the year when compared to Raleigh. The detached biomass created from plant senescence is important in the distribution and spread of turions to new areas, as some turions are still attached to the biomass (Netherland 1997). Movement of the mat of biomass is influenced by currents, animal disturbances, or wind. This floating biomass enables turions to mature and abscise in a new area to sprout the following year.

Harlan et al. (1985), reported that hydrilla senescence began in late December in North Carolina lakes, agreeing with the timing of plant senescence in this study. They also noted that across different lakes, hydrilla exhibited a range of biomass production and senescence. Therefore, it is important to look at the environmental conditions specific hydrilla populations are subject to when looking at plant senescence.

All six events measured in this study occurred when mean water temperatures were cooler in Laurel Springs than in Raleigh, demonstrating that hydrilla was able to adapt its phenology to a shorter growing season. Simply looking at water temperatures and phenology in southern climates may not be a reliable method to predict phenological events in northern climates. For example, if turion sprouting would have occurred at the same mean water temperature at both locations, the turion sprouting in Laurel Springs would have been delayed two weeks.

As this study was completed in mesocosm conditions, there was likely an effect on when life stages occurred. In a field study completed by True-Meadows (2013), timing of the events was similar, but mean temperatures for all life stages were higher in the field than what was found in this study. In another field study, it was found that monoecious hydrilla in North Carolina began sprouting in late March-early April, when water temperatures reached 11-13° C (Hodson et al. 1984). Both timing and mean water temperature of tuber sprouting in North Carolina lakes lines up with what was observed in mesocosms in Raleigh, but water temperature was much colder in Laurel Springs. As mesocosms provide an optimal environment for hydrilla growth, with reduced interspecific competition and grazing pressure (Netherland 1997), minimum temperature required to complete a physiological stage might possibly be lower. Timing of events observed at Raleigh in this study lined up with two separate field studies also completed in North Carolina. Therefore, the results from Laurel Springs can be used to give an estimate of hydrilla growth in northern climates. More *in situ* studies will need to be completed in northern climates to investigate possible differences.

From the November harvests, an average of twelve tubers were collected from Raleigh, and seven tubers from Laurel Springs (Table 2-5). An average of ten turions were collected from

Raleigh, and an average of seven turions collected from Laurel Springs. There were zero propagules that sprouted in the greenhouse viability study, as there had not been a chilling period to break dormancy before harvesting. Following the April harvest, there was an average of seven tubers collected from Raleigh and two tubers collected from Laurel Springs. An average of six turions were collected from both locations. In the greenhouse viability study, Raleigh tubers had an 85% viability rate, while turions had a 70% viability rate. Laurel Springs tubers had a viability rate of 95%, and turions had an 85% viability rate.

The destructive harvests and subsequent greenhouse viability studies conducted in this study demonstrates a strong environmentally induced dormancy on the propagules of hydrilla grown in both locations. The chilling period requirement has been well documented for hydrilla (Carter et al. 1987; Netherland 1997), and is still active in hydrilla propagules grown in cooler climates. In November, there were no propagules that sprouted, even though they were fully formed and mature. This dormancy is important to understand and incorporate into a management plan. From a natural system, monoecious hydrilla tubers consistently have a 90-95% viability rate, regardless of season (Hodson et al. 1984). Tubers from both locations had similar viability rates as seen in numerous lab viability studies.

As plants were started at the same time, and all conditions other than environmental conditions were the same, the difference in number of tubers produced was directly influenced by climate. As tuber depletion is the key aspect required to break monoecious hydrilla's life cycle (Netherland 1997), understanding tuber production is essential for effective management. This study indicated that tuber production was achieved at both locations, and these tubers were able to overwinter in their respective ambient conditions. Relying on cooler water temperatures in northern climates to reduce the viability of tubers is not a valid management strategy.

Conclusions

Applying management practices at specific times is vital to controlling hydrilla (True-Meadows 2013), and this study demonstrates that climatic conditions can influence the timing of these events. Completing the same experiments at two separate research locations allowed an investigation into differences of hydrilla growth based on climatic conditions. Different and distinct temperatures were shown to have direct effects on the timeframe of development, along with the amount of tubers that are produced. In a warmer climate, turions and tubers sprouted earlier in the year, but at warmer water temperatures than plants in the cooler climate. Floral initiation of both sexes and plant senescence occurred later in Raleigh. In addition, plants grown in Raleigh produced a greater number of tubers, agreeing with current knowledge of hydrilla growth and development. It was also demonstrated that plants in the cooler climate reached each physiological life stage at a cooler mean water temperature than those grown in the warmer climate. However, this study was completed in artificial settings, there is a need for continued experiments that focus specifically on how hydrilla behaves in cooler climates in natural systems. Results from this research are the most conclusive to date demonstrating the plasticity of hydrilla in dissimilar climates.

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Table 2-1. Mean, minimum, and maximum temperatures, and precipitation for four cities: Raleigh and Laurel Springs, North Carolina, Ann Arbor Michigan, and Albany New York.

	Mean Yearly Temperature °C	Min Yearly Temperature °C	Max Yearly Temperature °C	Mean Annual Rainfall cm	Mean Annual Snowfall cm
Raleigh, NC	16.0	10.2	21.8	118.3	0.0
Laurel Springs, NC	9.8	3.1	16.5	139.3	58.4
Ann Arbor, MI	9.8	4.6	14.9	95.4	144.8
Albany, NY	9.0	3.7	14.3	100.1	149.9

Table 2-2. Ambient weather conditions in Raleigh and Laurel Springs, North Carolina from May 2015-September 2016 as measured by NCDA&CS weather stations.

Ambient Temperatures (°C)			
Locations	Mean	Min	Max
Raleigh	19.27	-4.54	35.37
Laurel Springs	14.01	-9.53	29.13

Precipitation Per Week (cm)			
Locations	Mean	Min	Max
Raleigh	0.43	0.00	2.38
Laurel Springs	0.58	0.00	7.30

Photosynthetically Active Radiation			
Locations	Mean	Min	Max
Raleigh	382.29	98.03	580.44
Laurel Springs	383.55	95.66	616.10

Ambient temperatures were higher in Raleigh ($p < 0.0001$). There was no difference in mean precipitation ($p = 0.3268$) or PAR ($p = 0.7548$) between locations.

Table 2-3. Water temperatures in Raleigh and Laurel Springs from May 2015 - September 2016, as measured by HOBO pendants.

Water Temperatures (°C)			
Locations	Mean	Min	Max
Raleigh	18.60	0.23	33.12
Laurel Springs	13.50	-3.79	27.54

Mean water temperatures were higher in Raleigh ($p < 0.0001$).

Table 2-4. Mean, minimum, and maximum temperatures from March 2016-December 2016 observed for six different physiological growth stages for monoecious *Hydrilla verticillata* at Laurel Springs and Raleigh, North Carolina.

	Laurel Springs				Raleigh			
		Temperature (°C)				Temperature (°C)		
Life Stage	Date	Mean	Min	Max	Date	Mean	Min	Max
Sprouting Turions	3-Apr	7.0	2.0	14.6	23-Mar	12.4	2.1	21.6
Sprouting Tubers	10-Apr	10.1	2.4	15.3	8-Apr	15.0	-0.1	25.4
Female Flowers	24-Jul	25.9	22.8	29.1	7-Aug	27.7	25.7	33.9
Male Flowers	21-Aug	23.1	19.3	27.5	28-Aug	23.9	18.9	31.7
Turion Formation	18-Sep	20.1	17.76	23.1	6-Sep	24.2	18.8	32.2
Plant Senescence	4-Dec	7.5	3.5	14.9	30-Dec	8.5	1.11	7.98

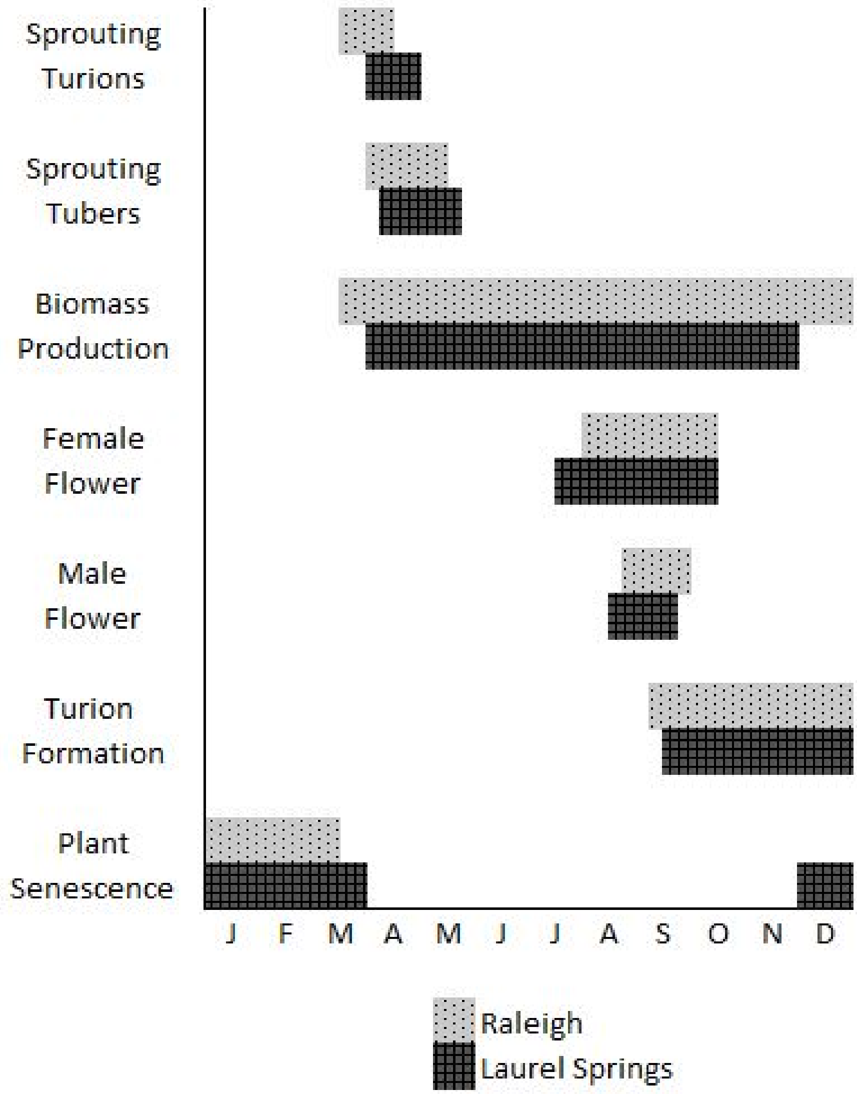

Figure 2-1. Monoecious *Hydrilla verticillata* phenology in Raleigh and Laurel Springs, North Carolina.

Table 2-5. Monoecious *Hydrilla verticillata* propagule production and viability in November 2015 and April 2016.

November Harvest								
	Average Number Tubers Collected		Average Number Turions Collected		Average % Tuber Viability		Average % Turion Viability	
Raleigh	12	a	10	a	0	a	0	a
Laurel Springs	7	b	7	a	0	a	0	a

April Harvest								
	Average Number Tubers Collected		Average Number Turions Collected		Average % Tuber Viability		Average % Turion Viability	
Raleigh	7	a	6	a	85	a	70	a
Laurel Springs	2	b	6	a	95	a	85	a

Values in the same column with same letters are not different, according to Tukey HSD with $p < 0.05$.

Chapter 3 Competition Study Between Monoecious *Hydrilla verticillata* and Three Submersed Aquatic Plants

Abstract

The perfect aquatic weed, hydrilla (*Hydrilla verticillata* (L.f) Royle) is a federal noxious submersed aquatic weed. A two-year competition study was completed in two mesocosm types at two research locations to compare the competitive ability of monoecious hydrilla in a warm and a cool climate. Two planting densities of hydrilla were grown with Eurasian watermilfoil (*Myriophyllum spicatum* L.), elodea (*Elodea canadensis* Michx), and vallisneria (*Vallisneria americana* Michx.). Mesocosm type affected the growth and development of hydrilla, especially in the cool climate. When grown alone, average hydrilla biomass in the warmer climate was 57.13 and 40.80 g in above and belowground mesocosms, respectively. In the cool climate, when grown alone, average hydrilla biomass was 72.17 g and 1.94 g in above and belowground mesocosms, respectively. When grown alone, average hydrilla tuber density in the warm climate was 971 and 629 tubers m^{-2} in above and belowground mesocosms, respectively. In the cool climate when grown alone, average hydrilla tuber density was 794 and 3 tubers m^{-2} in above and belowground mesocosms, respectively. *M. spicatum* and *E. canadensis* with hydrilla suppressed hydrilla growth and development in both mesocosm types at the cool climate compared to hydrilla alone. Hydrilla dry weight of aboveground mesocosms in the cool climate was 24.60 to 35.73 g with *M. spicatum* and 0.78 to 7.04 g with *E. canadensis*, and was 67.87 to 72.17 g when grown alone. Planting combination did not suppress hydrilla growth in either mesocosm type at the warm climate location. Hydrilla stem growth was more highly correlated in the warm climate, with r^2 ranging from 0.83 to 0.89 than in the cool climate, ranging from 0.16 to 0.84. The results from the cool climate location show that in a more suitable environment for the

competitor plants, hydrilla growth and competitiveness was affected. Ensuring that bodies of water have a healthy, diverse plant community might influence the impact hydrilla can have on the aquatic ecosystems in Northern United States.

Introduction

Hydrilla is a federal noxious aquatic weed that has negative effects on aquatic ecosystems, recreation, and human health (Dayan and Netherland 2005). Hydrilla has several adaptations which make it competitive, and it is referred to as "the perfect aquatic weed" (Langeland 1996). These adaptations include having several ploidy levels, numerous reproductive strategies, rapid vegetative growth, and the ability to form thick monospecific mats (Langeland 1996; Dayan and Netherland 2005). When these mats reach the water surface, it is referred to as being "topped out".

There are two biotypes of hydrilla in the United States (US), a triploid monoecious form and a triploid female dioecious form, with both biotypes expanding their range of growth in North America (Cook and Lüönd 1982). Dioecious hydrilla is typically found in tropical climates, while monoecious hydrilla is typically found in more temperate climates. The majority of hydrilla research has been conducted in southern climates on the dioecious biotype, and results might not be able to predict monoecious hydrilla growth and development in cooler climates (Netherland and Greer 2014).

Aquatic plant community composition is an important component to consider when predicting the invasion potential of hydrilla (Smart et al. 1994). Invasive plants that fill an empty niche are much more likely to establish and thrive in an environment than when that niche is occupied by another species. It is believed that a healthy population of native plants could be a means of slowing down the invasion of hydrilla through competition (Owens et al. 2008).

Northern water bodies are known for a diverse mix of submersed aquatic vegetation (Serafy et al. 1994), adding another variable into the uncertainty as how hydrilla will perform and compete in these climates.

Hydrilla has two asexual propagules that are vital to the survival of the species over both space and time. Green axillary turions are produced on the above ground biomass, and are distributed with currents on plant fragments (Madiera et al. 2000). Subterranean turions, referred to as tubers in literature, are formed at the end of underground rhizomes and can remain viable for five to ten years (Nawrocki et al. 2016). These propagules have been identified as the most important sources for growth the following year, especially since monoecious hydrilla maintains no overwintering biomass in cooler climates (Hodson et al. 1984). Production of these propagules increases the competitive abilities of hydrilla (Chadwell and Engelhardt 2008).

Previous hydrilla competition studies have been conducted, but no study has observed the influence of climate on the competitive advantages of hydrilla and other species. In previous studies, hydrilla has been shown to be a superior competitor with many submersed aquatic plants, both native and invasive, such as *Vallisneria americana* Michx., *Egeria densa* Planch., *Myriophyllum spicatum* L., and *Ceratophyllum demersum* L. (Hofstra et al. 1999; Mony et al. 2007; True-Meadows 2013; Wang et al. 2008).

Hofstra et al. (1999) determined that when some plant species were able to establish before staminate dioecious hydrilla introduction, hydrilla growth was more likely to be suppressed in New Zealand. Therefore, the more established and diverse a plant community is, the greater resistance to hydrilla infestation an ecosystem would be. A study by Owens et al. (2008) reported that established *V. americana* plants could suppress hydrilla growth. This led the authors to suggest planting native plants to remove empty space in an ecosystem as a practical hydrilla management method.

M. spicatum is an introduced, invasive submersed aquatic weed in the family Haloragaceae that is especially a problem in the northern US, though it found throughout the continental US (Trudeau 1982). This plant was originally introduced to the US from Eurasia for the aquarium plant trade before the 1880s, though it was not considered a weed problem until the 1920s (Nichols and Shaw 1986). The only submersed plant that has demonstrated the ability to compete with *M. spicatum* in North America is hydrilla (Aiken et al. 1979). A complete plant description can be found completed by Aiken et al (1979).

E. canadensis is a member of Hydrocharitaceae that is native to North America and shares many morphological and physiological similarities to hydrilla (Ancibor 1979). These similarities include the ability to utilize bicarbonate as an inorganic carbon source, vegetative fragmentation, growth habit and plant biomass production potential. Elodea was specifically selected for this study due to similarities in growth habit and phenology to hydrilla. *E. canadensis* does not produce asexual propagules, and relies on fragmentation for survival (Ancibor 1979). Despite being a native species to North America, it has been reported as a nuisance weed in the Chesapeake Bay, Tennessee Valley, and the Currituck Sound in recent years, due to its many adaptive features (Zettler and Freeman 1972). It is also considered a weedy species in Canada and several other countries (Spicer and Catlin 1988)

V. americana is a North America native plant in Hydrocharitaceae, and is an important food source for many species of waterfowl and other organisms (Catling et al. 1994). This plant is native to and widespread in eastern North America, with a range from southeastern Canada to Florida. There are several biotypes that allow the plant to grow in different climates (Lokker et al. 1994). *V. americana* is a dioecious clonal macrophyte, and relies on winter buds to reproduce in temperate areas (Titus and Stephens 1983). The plant develops a strong root system and rhizomes, and produces winter buds to overwinter (Catling et al. 1994).

As the majority of competition studies conducted with hydrilla have been completed with the dioecious biotype in southern climates, there is uncertainty as to how competitive hydrilla will be in northern climates. Therefore, the objective of this study was to evaluate the effect of different climatic conditions on the competitive nature of monoecious hydrilla.

Methods and Materials

Outdoor mesocosms were located at two separate research locations to test the effect of climate on species competitiveness. The study was repeated over two years, running from June-October and May-October in 2015 and 2016, respectively. The warm climate research site was at Reedy Creek Research Farm #2 in Raleigh, NC (35.815484, -78.732425). The cool climate research site was the North Carolina Department of Agriculture and Consumer Science (NCDA&CS) Upper Mountain Research Station (UMRS) in Laurel Springs, NC (36.396656, -81.306981). These two locations were selected because they exhibited different climates, but were close enough in proximity that one research team could complete the same experiments at both locations. Raleigh has an elevation of 96 m, while Laurel Springs has an elevation of 838 m, leading to dissimilar climates. Ambient weather temperature and photosynthetically active radiation (PAR) were measured for Laurel Springs at UMRS, and for Raleigh from the Reedy Creek Field Laboratory weather stations from May 2015-October 2016, spanning the entire study.

In 2015, plastic 120 L aboveground mesocosms (US Plastic Corp, Lima, OH) (Appendix 4) were used in Raleigh, while plastic 208 L belowground mesocosms (Benchmark Earth Works, Sanford, NC) (Appendix 5) were used in Laurel Springs. Aboveground mesocosms had no constant exchange of water, though water was replenished biweekly to a constant height. Occasional flushing of these containers occurred to reduce algal growth as needed. Water flowed through belowground mesocosms with sixteen complete water exchanges per day. Both mesocosm types were utilized at both locations in 2016.

For both years, each research site was covered by 30% shade cloth (DeWitt Company, Sikeston, MO) to regulate water temperature and light intensity reaching the plants. Water for the Raleigh location was supplied by an irrigation pond, and a well supplied water to Laurel Springs. Water samples were processed by NCDA&CS (Appendix 1). Light intensity, measured in µmol m^{-2} sec^{-1} and water temperature was continuously measured every six hours with a HOBO Pendant® data logger (Onset computer Corporation, Bourne, MA) that was clipped to the pot rim (Appendix 6).

Plants used in the study included monoecious *H. verticillata, M. spicatum, E. canadensis*, and *V. americana*. The last three plants will be referred to as the competitor species hereafter, and were selected because of their likelihood of competing with new hydrilla invasions. In late May 2015 and early May 2016, unsprouted hydrilla tubers were collected from Shearon Harris Reservoir in Wake County, North Carolina. This reservoir became infested with hydrilla in the 1980s, and has no current management plan, with a complete description by Nawrocki et al. (2016). *E. canadensis* and *M. spicatum* were collected from local sources and the northern biotype of *V. americana* was collected in New York and shipped to Raleigh. All plants, including hydrilla were allowed to grow and become established in a greenhouse in Raleigh in 3.5 L buckets until they were transplanted.

Transplanting into outdoor mesocosms occurred in late May 2016 and early June 2015. In both mesocosm types, all competitor plants were planted at a density of two plants, and were grown with a density of zero, two, or four hydrilla plants. 700 Series Nursery pots (23.02 L; 36 x 30 cm) were filled with 15 cm of bagged topsoil (Scotts Premium Topsoil, Scotts, Marysville OH), amended with 15-9-12 slow release fertilizer (Osmocote Plus, Scotts, Marysville OH) and covered in a 3 cm layer of play sand (Quikrete®, Atlanta, GA). Fertilizer was incorporated to ensure that plants initially had sufficient nutrient levels. Sand was used to reduce soil and nutrient suspension in the water, further limiting algal growth. After planting, pots were placed in the belowground mesocosms. 1000S Series nursery pots (39.7 L; 45 x 30 cm) were prepared in the same manner as previously described, except they were filled with 14 cm of bagged topsoil (Scotts Premium Topsoil, Marysville OH). These pots were planted and then placed in the aboveground mesocosms.

Biweekly measurements were taken on the longest stem lengths of all species, beginning when plants were transplanted in May until harvest in October of both years. Percent coverage of all plants were also recorded, along with water pH, temperature, and dissolved oxygen. A destructive harvested occurred in October at both locations in both years. Aboveground biomass and belowground biomass were kept separate, and rinsed before drying at 70° C for 72 hours. Asexual propagules were counted and separated from treatments with hydrilla (turions and tubers) by using 3 mm sieves. Hydrilla tuber production and aboveground dry weight were recorded with aboveground dry weight of all corresponding competitor species. These parameters were compared both within and between locations in 2016 in the same mesocosm type. 2015 results were compared to 2016 results within the same location and mesocosm type.

Treatments were replicated three times and arranged in a completely randomized block design. Plant dry weight and hydrilla propagule production were analyzed using SAS statistical software (SAS Institute Inc., Cary, North Carolina). Comparisons between climatic conditions between locations were carried out using two-tailed t-tests, with $p < 0.05$. Plant biomass, and propagule formation comparisons within locations were analyzed using analysis of variance (ANOVA), with means separated by Tukey's HSD ($p < 0.05$). Regression analysis was run on hydrilla stem length over time, with $p < 0.05$.

Results and Discussion

Weather data

Raleigh had higher mean ambient temperatures in both years $p < 0.0001$ (Figure 3-1). Temperature in Raleigh averaged 23.7° C, while Laurel Springs averaged 18.3° C from May to October in 2015 and 2016. There was no difference in the amount of precipitation $p = 0.247$ or the mean PAR $p = 0.877$ that each location received. Between years in the same location, there were no differences in parameters measured. Within each location, mean water temperatures were not different between the mesocosm types, but were between locations, with cooler temperatures in Laurel Springs $p < 0.0001$ (Figure 3-2). The mean water temperature in Raleigh was 25.3° C in Raleigh and 22.4° C in Laurel Springs.

At both locations, aboveground mesocosms had more light availability as measured by the HOBO Data Loggers. In Raleigh, aboveground mesocosms received an average of 1.0 μmol m^{-2} s^{-1} while belowground mesocosms received an average of 0.4 μmol m^{-2} s^{-1}. Laurel Springs aboveground mesocosms received 3.2 μmol m^{-2} s^{-1} on average, while belowground mesocosms averaged 0.7 μmol m^{-2} s^{-1}.Between locations, greater lumens were measured at Laurel Springs.

As reduction in irradiance has the ability to alter submersed species composition (Barko et al. 1986), light availability has a large impact on community structure and subsequent competitiveness. Light availability decreased at both locations in all containers throughout the study due to biomass accumulation and algal accumulation on the pendants. As less overall biomass was present in Laurel Springs in both mesocosms, more available light was recorded by the pendants. Light availability and temperature impact the growth and development of aquatic submersed vegetation (Barko et al. 1986). Results from this study indicate that climatic conditions had a large impact on the growth and competitiveness of monoecious hydrilla and the three competitor plants.

The growth and development of monoecious hydrilla at Laurel Springs was not compared at different photoperiods or amounts of precipitation. Therefore, more research will need to be conducted in areas with completely different climates. In addition, *in situ* experiments will need to be conducted in areas to determine what effect the artificial environments of mesocosms had on the results.

Mesocosm Effect

There was a mesocosm effect on both hydrilla biomass and propagule production within the same location in 2016, especially when hydrilla was grown without competition $p < 0.0001$ (Figure 3-3). At both locations, aboveground mesocosms produced more hydrilla biomass than belowground mesocosms. This effect was more pronounced in Laurel Springs, where there was an interaction of mesocosm type on all hydrilla parameters measured.

In Raleigh aboveground mesocosms, the dry weight of hydrilla grown without competition averaged 57.13 g, while in belowground mesocosms averaged 40.80 g (Figure 3-3). In Laurel Springs aboveground mesocosms, the dry weight of hydrilla without competition averaged 72.17 g, while belowground mesocosms averaged 1.94 g. Tuber production in Raleigh averaged 971 tubers m^{-2} and 629 tubers m^{-2} for above and belowground mesocosms, respectively. Laurel Springs tuber production averaged 794 tubers m^{-2} and 3 tubers m^{-2} in above and belowground mesocosms, respectively.

As mesocosms received the same environmental conditions and water quality was similar within locations, there was an interaction between mesocosm type and location, especially in Laurel Springs. Cooler temperatures experienced by Laurel Springs and the lower light levels experienced by belowground mesocosms most likely created a less suitable environment for hydrilla growth. Reduced light availability might have led to the greatly reduced hydrilla biomass and propagule production in Laurel Springs. However, it has been found that hydrilla can grow at extremely low levels of light (Van et al. 1976), so it is more likely that interactions between these and other climatic conditions that were experienced in Laurel Springs explains this difference.

Another aspect that might have been influenced by mesocosm size is total hydrilla biomass accumulation. Hydrilla has been shown to be able to occupy as much space as possible (Steve Hoyle, pers. comm.). In this study, hydrilla occupied all the available growing space and quickly reached the carrying capacity of the mesocosms, except for belowground mesocosms in Laurel Springs. The lower dry weights of hydrilla seen in this study compared to natural systems can be explained by limited expansion potential, as hydrilla reached growing capacity quickly in the mesocosms, especially in Raleigh.

Hydrilla plasticity is demonstrated by the changes in biomass accumulation and tuber production based on both location and mesocosm type. This study indicates that the volume, position, and set up conditions are able to affect the results of mesocosm trials, and are an important aspect of any study. Greater understanding of how mesocosms influence research results will be important to be able to predict what might happen in natural systems, especially in temperate climates.

Within Location Results

Raleigh

In aboveground mesocosms, hydrilla tuber production and biomass accumulation were similar, ranging from 524 to 998 tubers m^{-2} and 34.47 to 67.00 g regardless of planting combinations in 2016 (Table 3-1). Hydrilla grown in Raleigh belowground mesocosms had no differences in tuber production or biomass accumulation. Tuber production ranged from 246 to 629 tubers m^{-2} and dry weight of hydrilla ranged from 29.8 to 41.93 g.

In aboveground mesocosms in Raleigh, all competitor species' dry weights were suppressed when grown with any density of hydrilla (Table 3-2). *M. spicatum* dry weight was 15.57 g when grown alone, but only 0.62 and 0.43 g when grown with two and four hydrilla, respectively. *E. canadensis* dry weight was 36.67 g when grown alone, and was 11.62 and 4.76 g when grown with two and four hydrilla, respectively. *V. americana* was 56.61 g when grown alone and only 7.52 and 1.89 g when grown with two and four hydrilla, respectively. The same pattern was seen in belowground mesocosms in Raleigh. *M. spicatum* dry weight was 2.48 g when grown alone, and 0.07 and 1.01 g when grown with two and four hydrilla, respectively. *E. canadensis* dry weight was 31.83 g when grown alone, and 0.00 and 1.41 g when grown with two and four hydrilla, respectively. *V. americana* was 23.94 g when grown alone and 4.64 and 0.03 g when grown with two and four hydrilla, respectively.

In this study, hydrilla grown in both mesocosms at Raleigh was not negatively impacted by competition. This was demonstrated by the fact that there were no differences between the number of tubers or biomass produced between hydrilla grown without competition or at any density with all competitor species. In practical terms, this means that hydrilla is a more robust competitor in warmer climates, which is what has been observed in the Potomac River (Carter et al. 1994).

All competitor dry weights were negatively affected when grown with any density of hydrilla. This demonstrates that both climate and competition with hydrilla impact the growth and development of the three competitor plants used in this study. A more suitable climate for hydrilla and less suitable climate for the competitor species explains the reduced growth of all competitor plants. The decreased competitive nature of the other species might be that *M. spicatum* and *E. canadensis* are cool-season plants, and more suited for growth at Laurel Springs as compared to Raleigh. Therefore, it would be expected that these species would grow less robustly in a warmer climate.

Laurel Springs

In Laurel Springs aboveground mesocosms, both hydrilla tuber production and dry weight were influenced by planting combinations (Table 3-1). Hydrilla tuber production and dry weight was suppressed at both hydrilla densities when grown with either *M. spicatum* or *E. canadensis*. With *M. spicatum*, tuber production ranged between 90 to 120 tubers m^{-2} and with *E. canadensis,* tuber production ranged from 15 to 65 tubers m^{-2}. All other planting combinations ranged from 711 to 1,000 tubers m^{-2}. Hydrilla dry weight was 24.60 to 35.73 g when grown with *M. spicatum* and 0.78 to 7.04 g when grown with *E. canadensis.* When grown at any density with *V. americana* or grown alone, hydrilla dry weight ranged from 67.87 to 72.17 g.

In Laurel Springs belowground mesocosms, hydrilla tuber production was not affected by planting combination (Table 3-1). Tuber production ranged from 0 to 49 tubers m^{-2}. However, hydrilla biomass was influenced by planting combinations. When two hydrilla plants were grown with *E. canadensis* or *V. americana*, a reduction of hydrilla biomass was observed compared to hydrilla grown alone. When grown with *E. canadensis* and *V. americana*, hydrilla dry weight was 1.09 and 0.34 g, respectively. In addition, four hydrilla grown with *M. spicatum* resulted in a suppression of hydrilla biomass. This planting combination resulted in 0.34 g of hydrilla dry weight. With all other planting combinations, hydrilla dry weight ranged from 1.40 to 7.88 g.

In Laurel Springs, the suppression of the competitor plant was not observed with *M. spicatum* or *E. canadensis* when grown in both mesocosm types (Table 3-2). In aboveground mesocosms, *M. spicatum* dry weight was 42.37 g when grown alone, and 26.91 and 38.81 g when grown with two and four hydrilla, respectively. *E. canadensis* dry weight was 83.31 g when grown alone, and 91.12 and 97.53 g when grown with two and four hydrilla, respectively (Table 3-2). *V. americana* exhibited suppressed stem dry weight accumulation when grown with both densities of hydrilla in aboveground mesocosms. *V. americana* weight was 34.41 g when grown alone and 8.88 and 5.64 g when grown with two and four hydrilla, respectively.

No competitor dry weights were suppressed when grown with any density of hydrilla in belowground mesocosms in Laurel Springs (Table 3-2). *M. spicatum* grown alone had a dry weight of 8.10 g, with 4.13 and 7.73 g when grown with two and four hydrilla, respectively. *E. canadensis* dry weight was 2.73 g when grown alone and 3.69 and 3.42 g when grown with two and four hydrilla, respectively. *V. americana* dry weight was 34.23 g when grown alone, and 34.53 and 29.23 g when grown with two and four hydrilla, respectively.

Hydrilla biomass results in Laurel Springs contradict the results found by True-Meadows et al. (2013), where hydrilla decreased the biomass of the other species of plants. At Laurel Springs, *M. spicatum* and *E. canadensis* biomass was not affected by any density of hydrilla. In fact, these two species of plants actually suppressed the biomass accumulation of hydrilla. Differences in temperatures between locations appeared to have created a more suitable environment for the competitor species and a less suitable environment for hydrilla in Laurel Springs.

Tuber production has been found to be affected by the type of hydrosoil, season, nutrient availability, and health of plants (Basiouny et al. 1978). Differences in tuber densities found in other mesocosm trials can be explained with different environmental conditions, soils, and vitality of plants used in other studies. This study utilized amended top soil, which was different than other sediments used for mesocosm trials, and different than natural sediment.

Nawrocki et al. (2016) reported that in a reservoir in North Carolina, a tuber density of 11 tubers m^{-2} was enough to support hydrilla regrowth. With no hydrilla treatment, at the end of the growing season, densities were found to have increased over 100 fold. This exhibits the tremendous potential of hydrilla to produce tubers in one growing season. The average number of tubers produced in this study in all planting combinations in both mesocosms at both locations were greater than this threshold. This demonstrates that if hydrilla is able to produce tubers, the plant will be able to establish in that area.

In general, aboveground tuber densities in both mesocosms at Raleigh and Laurel Springs were more comparable to natural systems (Harlan et al. 1985) while Laurel Springs belowground tuber densities more closely aligned with a previous competition study (True-Meadows 2013). Discrepancies between tuber production in artificial mesocosms and natural systems have been documented (Netherland 1997). Traditionally, hydrilla grown in mesocosm trials produces a greater number of propagules. This is thought to be due to more favorable environment, with reduced grazing and competition, enhancing hydrilla growth (Netherland 1997). Added stress to hydrilla plants from competition could help explain the lower tuber densities found in this study compared to other monoecious hydrilla mesocosm trials.

<u>2016 Between Location Results</u>

In aboveground mesocosms, hydrilla tuber production differed between locations when grown with *M. spicatum* and *E. canadensis* (Table 3-3). In Raleigh, more tubers were produced at both hydrilla densities when grown with these two plants. All other planting densities did not differ in regards to tuber production between locations in 2016. Dry weight of hydrilla differed between locations when grown at both densities with *E. canadensis*, with biomass being greater in Raleigh at both hydrilla densities. When grown alone, hydrilla produced more biomass in Laurel Springs in 2016.

In belowground mesocosms, there were differences between hydrilla tuber production, and biomass between locations based on planting combinations (Table 3-3). Tuber production was greater in Raleigh in all planting combinations except for two hydrilla with *E. canadensis*, where tuber production was similar between locations. Hydrilla dry weight was greater in Raleigh for all planting combinations.

Complete topping out of hydrilla in aboveground mesocosms occurred first at Laurel Springs, being observed in late June of both years, while topping out was not observed in Raleigh until mid-July of both years. In belowground mesocosms, hydrilla did not top out in Laurel Springs, while Raleigh plants topped out in mid-July. Even though hydrilla topping out occurred first at Laurel Springs, the competitor species' biomass was not suppressed as it was in Raleigh (Table 3-2).

In aboveground mesocosms, there was no difference between *M. spicatum* or *V. americana* regardless of planting combination biomass between locations (Table 3-2). In all planting combinations with *E. canadensis*, more biomass was accumulated in Laurel Springs compared to Raleigh. In belowground mesocosms, *M. spicatum* biomass was greater when grown at a density of two hydrilla at Laurel Springs. No other planting combination affected *M. spicatum* biomass between locations. *E. canadensis* grown alone had more biomass in Raleigh, but did not vary when grown with either two or four hydrilla between locations. *V. americana* grown alone did not have a different biomass between locations. However, when grown in any competition with hydrilla, higher biomass was recorded in Laurel Springs.

M. spicatum and *E. canadensis*, while both being able to grow in several different environmental conditions, are more commonly found in northern climates. This helps explain why *E. canadensis* was more productive in Laurel Springs. The northern biotype of *V. americana* was used in this study, and biomass was not different between locations in aboveground mesocosms, but in belowground mesocosms, was greater in Laurel Springs.

Trends within location with competitor plants were similar, while trends across locations were different. Practically speaking, this means that competitor plant growth was more similar within locations than between locations. This demonstrates that ambient and water temperatures affected the competitive nature of both hydrilla and the competitor plants. The fact that when grown with any density of hydrilla in either mesocosm, the competitor plants produced more biomass in Laurel Springs supports the empty niche theory (Owens et al. 2008).

From this study, *V. americana* does not appear to be an effective competitor of hydrilla at both locations. When grown with *V. americana*, hydrilla growth and development did not differ from hydrilla grown by itself. Therefore, planting communities of this species to discourage the infestation of hydrilla may not be the most effective management strategy, especially if the plants are not given enough time to establish. This study suggests *E. canadensis* would be a better selection of a native plant to fill any empty niches in the environment.

Hydrilla growth in all planting combinations were more highly correlated in Raleigh than in Laurel Springs, as indicated by regression analysis (Table 3-5). Correlation of stem length ranged from 0.83 to 0.89 in Raleigh, and from 0.16 to 0.84 in Laurel Springs. Maximum growth, or the point where stem lengths did not increase, were achieved earlier in Raleigh than in Laurel Springs in all planting combinations except for two hydrilla with *V. americana*. However, hydrilla alone at Raleigh and both hydrilla densities grown with *E. canadensis* in Laurel Springs did not reach maximum growth within the confines of this study.

Higher correlations in Raleigh indicate that hydrilla grew in a more predictable way than in Laurel Springs. This was not unexpected, as there are large knowledge gaps in the literature as to how monoecious hydrilla will behave in cooler climates (Netherland and Greer 2014). Results from this study supports this concept, by illustrating the greater unknowns of hydrilla growth and development in cooler climates. Understanding the invasive potential and management implications of monoecious hydrilla in northern states is important, as monoecious hydrilla behaves differently in dissimilar climates (Owens et al. 2012; Sutton et al. 1992).

In Raleigh, hydrilla without competition did not reach stem growth maximum, while in Laurel Springs, both hydrilla densities grown with *E. canadensis* did not reach stem growth maximum. This indicates that in Raleigh, hydrilla would have been increasing in stem length if the study was continued. In Laurel Springs, it indicates that *E. canadensis* interfered with hydrilla growth, and suppressed stem elongation in aboveground mesocosms.

Conclusions

Based on results of this study, hydrilla is not as competitive in a cool climate, producing less biomass and fewer tubers when planted with any competitor species than hydrilla in a warm climate. However, hydrilla was able to establish both years in all planting combinations in both containers in Laurel Springs. Therefore, even though hydrilla growth was suppressed when grown with a competitor plant, if hydrilla was introduced into a new water body, it has the potential to become established.

The existing plant community structure is very important to excluding hydrilla or slowing down the invasion. If these communities are established and diverse, hydrilla infestations may cause problems at a slower pace. However, there are already several reports of thick, monospecific areas of hydrilla in northern states, demonstrating that hydrilla is able to compete in the Potomac River (Carter et al. 1994). More information is needed to understand how monoecious hydrilla will behave in new climates, especially with different light availability and temperatures.

Along with establishing biomass, both propagules were produced in all aboveground mesocosms, and in all planting combinations except *E. canadensis* with two hydrilla in belowground mesocosms. This increases the potential for long term infestations, which will need to be investigated further. This research project looked at one season of growth with a similar introduction time. The effect of overwintering structures already being present in the hydrosoil were not addressed. More research will need to look into these aspects in different climates to understand and predict the growth and development of monoecious hydrilla.

As the northern US has greater biodiversity of aquatic species, it would be likely that hydrilla invasions would be slower in overtaking areas. This suppression of hydrilla would be more pronounced in areas with well-established plant communities. However, there are already reports of serious infestations of hydrilla in many states, so it has demonstrated that it is able to survive in different climates. Hydrilla has been called the first aquatic weed that could become an issue for the entire continental US (MD Netherland, pers. comm.), and management plans will need to incorporate climatic conditions to be effective.

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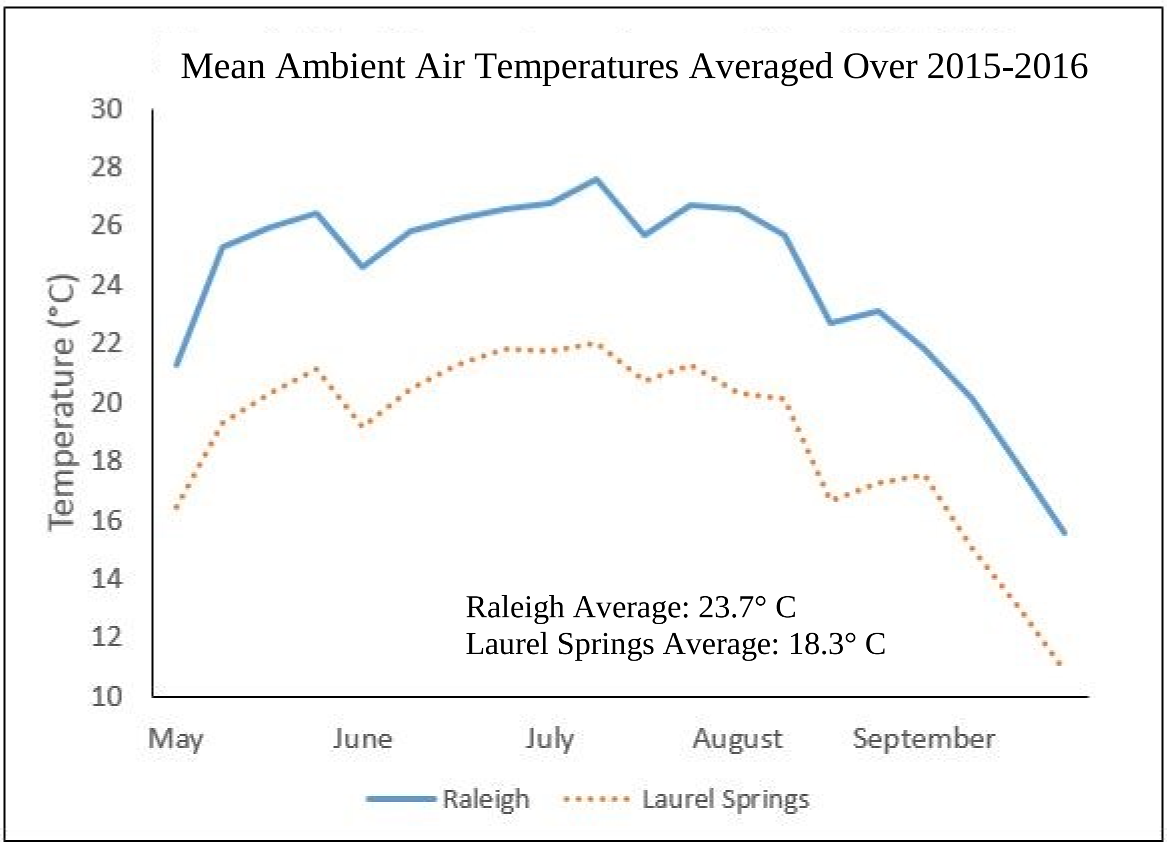

Figure 3-1. Mean Ambient Air Temperatures Recorded by NCDA&CS Weather Stations in 2015 and 2016. Temperatures were higher in Raleigh ($p < 0.0001$).

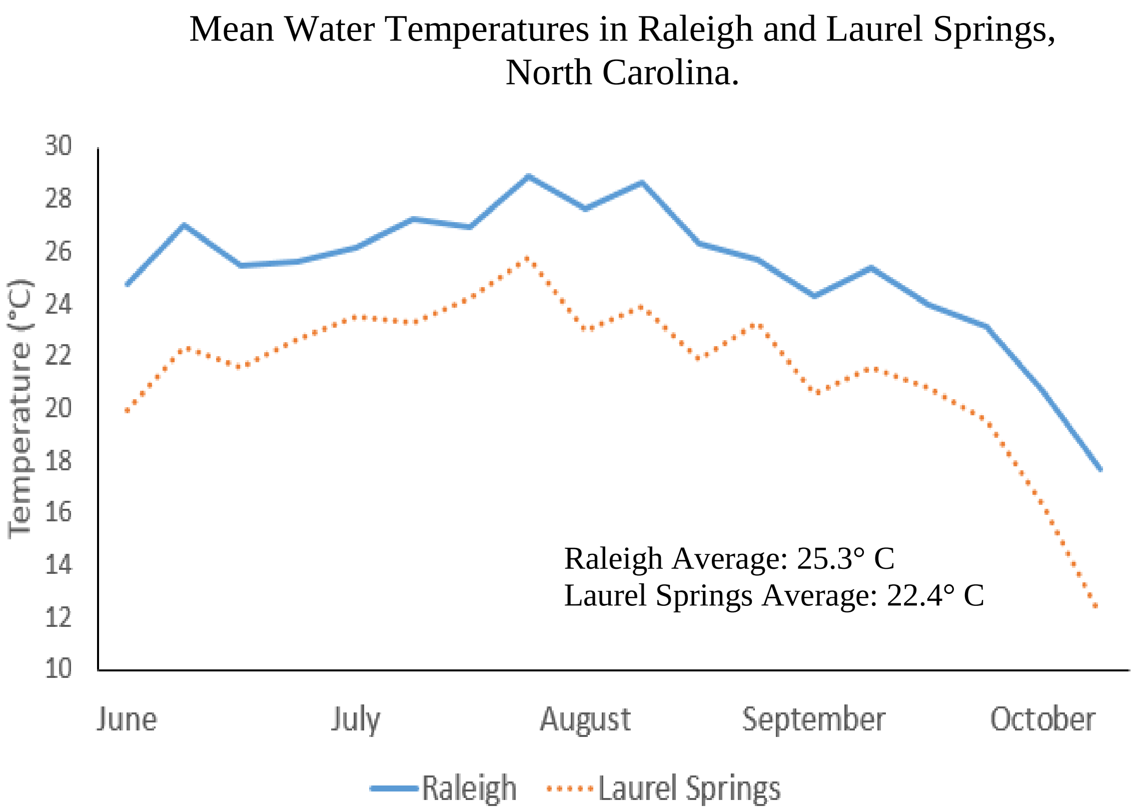

Figure 3-2. Mean Water Temperatures at Raleigh and Laurel Springs, North Carolina. Temperatures were higher in Raleigh ($p < 0.0001$).

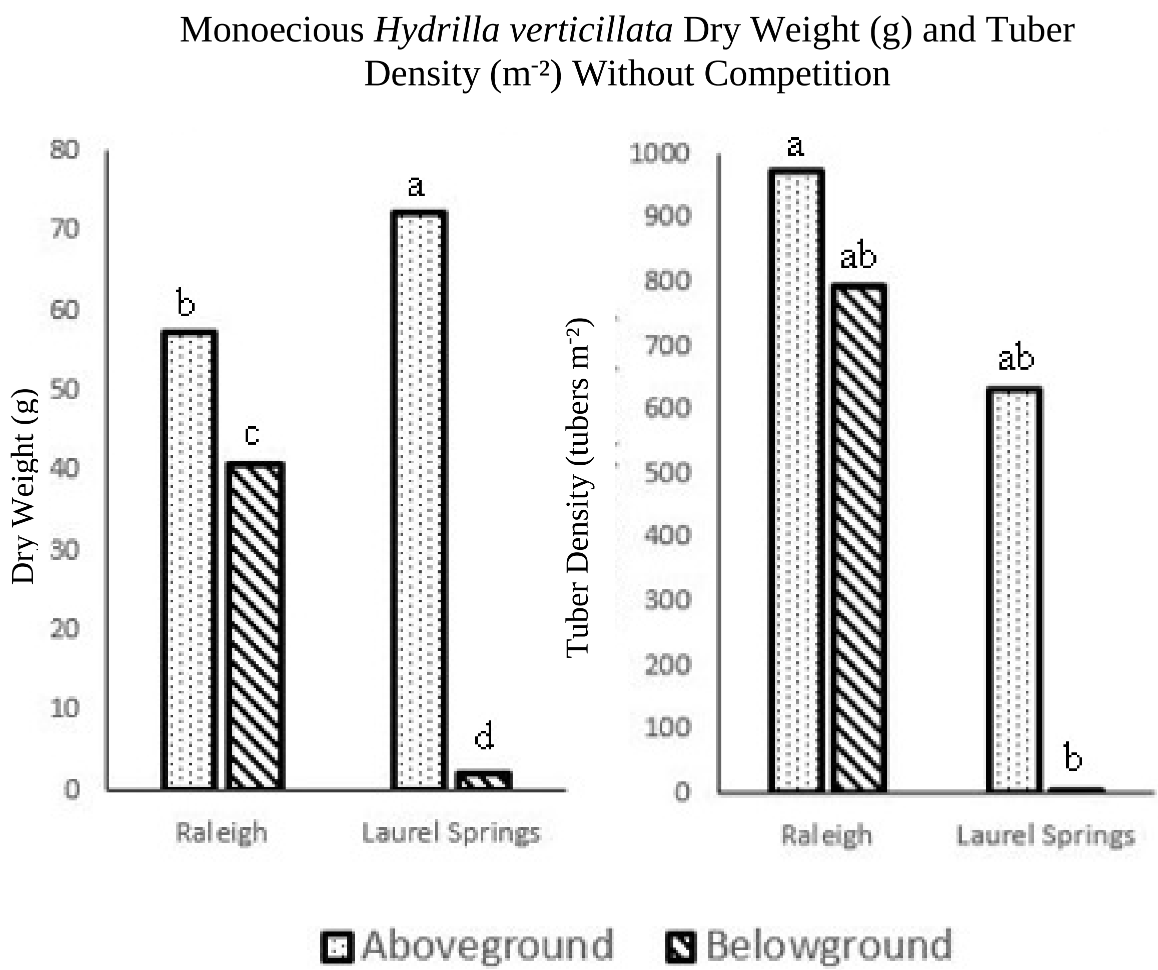

Figure 3-3. Mesocosm Effect on Monoecious *Hydrilla verticillata* Growth in Raleigh and Laurel Springs, North Carolina When Two *H. verticillata* were Grown Alone. Values not separated by different letters are similar, according to Tukey HSD (p < 0.05).

Table 3-1. Mean tuber density (tubers m^{-2}) and dry weight (g) for monoecious *Hydrilla verticillata* grown alone and with three competitor plants in Raleigh and Laurel Springs, North Carolina in above and belowground mesocosms.

	Tuber Production[1]															
	Aboveground Mesocosms								Belowground Mesocosms							
	Raleigh				Laurel Springs				Raleigh				Laurel Springs			
	H. verticillata Density				*H. verticillata* Density				*H. verticillata* Density				*H. verticillata* Density			
	Two		Four		Two		Four		Two		Four		Two		Four	
Competitor	tubers m^{-2}								tubers m^{-2}							
M. spicatum	778	ab	769	abc	90	cde	120	bcde	403	ab	573	a	49	b	3	b
E. canadensis	524	abcde	740	abcd	15	e	65	de	246	ab	344	ab	0	b	0	b
V. americana	998	a	876	a	711	abcd	1000	a	403	ab	570	a	3	b	33	b
None	971	a			794	ab			629	a			3	b		

	Biomass Production[2]															
	Aboveground Mesocosms								Belowground Mesocosms							
	Raleigh				Laurel Springs				Raleigh				Laurel Springs			
	H. verticillata Density				*H. verticillata* Density				*H. verticillata* Density				*H. verticillata* Density			
	Two		Four		Two		Four		Two		Four		Two		Four	
Competitor	(g)								(g)							
M. spicatum	53.87	ab	62.47	ab	24.60	bc	35.73	abc	32.03	a	29.8	a	7.03	b	0.34	b
E. canadensis	34.47	abc	64.67	a	0.78	c	7.04	c	38.8	a	31.23	a	1.09	b	1.4	b
V. americana	61.80	ab	67.00	a	67.87	a	69.93	a	36.97	a	41.93	a	0.34	b	7.88	b
None	57.13	ab			72.17	a			40.8	a			1.94	b		

[1]Mean monoecious *H. verticillata* tuber production in one growing season at a planting density of two or four hydrilla with three competitor plants. Values followed by the same letter are not different according to Tukey HSD $p < 0.05$ within the same mesocosm type.
[2]Mean hydrilla biomass, measured as dry weight produced in one growing season at a planting density of two or four hydrilla with three competitor species. Values followed by the same letter are not different according to Tukey HSD $p < 0.05$ within the same mesocosm type.

Table 3-2. Competitor species shoot biomass dry weight when grown with zero, two or four monoecious *Hydrilla verticillata* at Raleigh and Laurel Springs, North Carolina in above and belowground mesocosms.

Raleigh Aboveground						
H. verticillata			Dry Weight (g)			
Density	*M. spicatum*		*E. canadensis*		*V. americana*	
Zero	15.57	a	36.67	a	56.61	a
Two	0.62	b	11.62	b	7.52	b
Four	0.43	b	4.76	b	1.89	b

Laurel Springs Aboveground						
H. verticillata			Dry Weight (g)			
Density	*M. spicatum*		*E. canadensis*		*V. americana*	
Zero	42.37	a	83.31	a	34.41	a
Two	26.91	a	91.12	a	8.88	b
Four	38.81	a	97.53	a	5.64	b

Raleigh Belowground						
H. verticillata			Dry Weight (g)			
Density	*M. spicatum*		*E. canadensis*		*V. americana*	
Zero	2.48	a	31.83	a	23.94	a
Two	0.07	b	0.00	b	4.64	b
Four	1.01	b	1.41	b	0.03	b

Laurel Springs Belowground						
H. verticillata			Dry Weight (g)			
Density	*M. spicatum*		*E. canadensis*		*V. americana*	
Zero	8.10	a	2.73	a	34.23	a
Two	4.13	a	3.69	a	34.53	a
Four	7.73	a	3.42	a	29.23	a

Myriophyllum spicatum, *Elodea canadensis*, and *Vallisneria americana* shoot dry weight grown at a density of zero, two, or four monoecious *Hydrilla verticillata* plants. Values in columns followed by the same letter are not different, among species according to Tukey HSD $p < 0.05$.

Table 3-3. Raleigh vs Laurel Springs 2016 above and belowground mesocosms monoecious *Hydrilla verticillata* tuber production and shoot biomass.

Aboveground									
		Tuber Production[1]				Biomass[2]			
Competitor Plant	Location	*H. verticillata* Density Two		Four		*H. verticillata* Density Two		Four	
		tubers m^{-2}				dry weight (g)			
M. spicatum	Raleigh	778	a	769	a	53.87	a	62.47	a
	Laurel Springs	90	b	120	b	24.60	a	35.73	a
E. canadensis	Raleigh	524	ab	740	a	34.47	b	64.67	a
	Laurel Springs	15	c	65	cb	0.78	c	7.04	c
V. americana	Raleigh	998	a	876	a	61.80	a	67.00	a
	Laurel Springs	711	a	1000	a	67.87	a	69.93	a
None	Raleigh	971	a			57.13	b		
	Laurel Springs	794	a			72.17	a		

Belowground									
		Tuber Production[1]				Biomass[2]			
Competitor Plant	Location	*H. verticillata* Density Two		Four		*H. verticillata* Density Two		Four	
		tubers m^{-2}				dry weight (g)			
M. spicatum	Raleigh	403	ab	573	a	32.03	a	29.80	a
	Laurel Springs	49	bc	0	c	7.03	b	0.34	b
E. canadensis	Raleigh	246	a	344	a	38.80	a	31.23	a
	Laurel Springs	0	a	7	a	1.40	b	1.09	b
V. americana	Raleigh	391	a	570	a	36.97	a	41.93	a
	Laurel Springs	3	b	33	b	7.86	b	0.34	b
None	Raleigh	629	a			40.80	a		
	Laurel Springs	3	b			1.94	b		

[1]Mean monoecious hydrilla tuber production in one growing season at a planting density of two or four hydrilla plants with three competitor species. Values followed by the same letter are not significantly different within the same planting combination according to Tukey HSD with $p < 0.05$.
[2]Mean monoecious hydrilla biomass, measured as dry weight, produced in one growing season at a planting density of two or four hydrilla with three competitor species. Values followed by the same letter are not significantly different within the same planting combination according to Tukey HSD with $p < 0.05$.

Table 3-4. Competitor stem dry weight comparison between Raleigh and Laurel Springs when grown with zero, two, and four monoecious *Hydrilla verticillata.*

Aboveground								Belowground							
H. verticillata		Dry Weight (g)						*H. verticillata*		Dry Weight (g)					
Density	Location	*M. spicatum*		*E. canadensis*		*V. americana*		Density	Location	*M. spicatum*		*E. canadensis*		*V. americana*	
Zero	Raleigh	15.57	a	36.67	b	56.6	a	Zero	Raleigh	2.48	a	31.83	a	23.94	a
	Laurel Springs	42.37	a	83.31	a	34.433	a		Laurel Springs	8.1	a	2.73	b	34.23	a
Two	Raleigh	0.62	a	11.62	b	7.516	a	Two	Raleigh	0.07	b	0	a	4.64	b
	Laurel Springs	26.91	a	91.12	a	8.88	a		Laurel Springs	4.13	a	3.69	a	34.53	a
Four	Raleigh	0.43	a	4.76	b	1.892	a	Four	Raleigh	1.01	a	1.41	a	0.03	b
	Laurel Springs	38.81	a	97.53	a	5.643	a		Laurel Springs	7.73	a	3.42	a	29.23	a

Myriophyllum spicatum, *Elodea canadensis*, and *Vallisneria americana* shoot dry weight grown at a density of zero, two or four hydrilla plants. Values followed by the same letter are not different among species according to Tukey HSD with $p < 0.05$.

Table 3-5. Regression equations for monoecious *Hydrilla verticillata* stem length from May - October, 2016 when grown alone and with three competitor plants in aboveground mesocosms in Raleigh and Laurel Springs, North Carolina.

Location	Hydrilla Density	Competitor Species	Regression Equation[1]	p-value	Weeks Until Maximum Growth $(X_0)^2$	Maximum Growth (cm)	r^2
Raleigh	2	None	$y = 13.6 + 12.33x - 0.548x^2$	<0.0001	---	83	0.86
	2	*M. spicatum*	$y = 11.2 + 14.32x - 0.845x^2$	<0.0001	17	72	0.85
	2	*E. canadensis*	$y = 2.6 + 18.66x - 1.279x^2$	<0.0001	15	71	0.83
	2	*V. americana*	$y = 11.7 + 14.78 - 0.869x^2$	<0.0001	17	74	0.85
	4	*M. spicatum*	$y = 5.9 + 17.5x - 1.145x^2$	<0.0001	15	73	0.89
	4	*E. canadensis*	$y = 20.1 + 12.05x - 0.736x^2$	<0.0001	16	69	0.83
	4	*V. americana*	$y = 12 + 14.44x - 0.901x^2$	<0.0001	16	70	0.89
Laurel Springs	2	None	$y = 1.8 + 15.81x - 0.897x^2$	<0.0001	18	72	0.81
	2	*M. spicatum*	$y = 7.5 + 12.55x - 0.614x^2$	<0.0001	20	72	0.75
	2	*E. canadensis*[3]	---	---	---	---	---
	2	*V. americana*	$y = (-0.9) + 18.56x - 1.294x^2$	<0.0001	14	66	0.84
	4	*M. spicatum*	$y = 2.7 + 14.17x - 0.786x^2$	<0.0001	18	67	0.73
	4	*E. canadensis*	$y = 2.5 + 15.14x - 1.424x^2$	0.0026	---	72	0.16
	4	*V. americana*	$y = 17 + 10.65x - 0.577x^2$	<0.0001	18	66	0.43

[1]Regression equations and corresponding p-values for each significant model.
[2]Weeks until maximum growth indicate the X_0 value at which maximum growth was achieved, and no significant increases in stem length were observed beyond this plateau. Treatments without X_0 values did not reach a plateau within the confines of this study, and were regressed with a standard quadratic regression model, instead of a quadratic plateau model.
[3]No regression equation fit two hydrilla with *E. canadensis* in Laurel Springs.

Chapter 4 Effects of Temperature during Dormancy on Viability of Monoecious *Hydrilla verticillata* Propagules

Abstract

Hydrilla (*Hydrilla verticillata* (L.f) Royle) is a federal noxious, submersed aquatic weed that causes much economic and environmental harm. This study utilized two research locations- a cool climate and a warm climate to understand climatic effects on the production and viability of asexual hydrilla propagules after an overwintering period in cooling chambers at three different temperatures. Tubers produced in the cooler climate were heavier, averaging 0.113 g compared to 0.096 g in the warmer climate. The cooler climate had higher viability, averaging 89% when overwintered at 4° C and 20% when overwintered at 0° C, while the warmer climate hydrilla tubers had an average viability of 63% when overwintered at 4° C, and 0% when overwintered at 0° C. Tuber densities were different between locations, with the cool climate averaging 823 tubers m^{-2}, while the warm climate averaged 2142 tubers m^{-2}.

Introduction

Hydrilla is an invasive, noxious submersed aquatic weed that has been called "the perfect aquatic weed" (Langeland 1996), and is considered one of the worst submersed aquatic weeds worldwide (Thullen 1990). This plant is ubiquitous, being found on every continent except Antarctica, and based on the current range of hydrilla in China, has the ability to grow anywhere in the continental United States (US) (Balciunus and Chen 1993). Hydrilla has the ability to survive in drastically different water systems, from small, natural ponds, man-made canals and reservoirs, to flowing water (Dayan and Netherland 2005). Hydrilla has a large range of suitable environmental conditions such as pH, temperature, dissolved oxygen (DO), and nutrient content

(Madsen and Owens 2000). Due to the adaptive abilities of this plant, hydrilla has been called the first aquatic weed that has a potential to be a problem nationwide (MD Netherland, pers. comm.).

There are two biotypes of hydrilla in the US, a triploid monoecious form and a triploid female dioecious form, and both are expanding their range of growth in North America (Cook and Lüönd 1982). Dioecious hydrilla is typically found in the warmer climate of southern states, while monoecious hydrilla is typically found in temperate climates. From 2000-2011, dioecious hydrilla was found in three new states, while monoecious hydrilla was found in fifteen new states. Despite the recent range expansions, there is little knowledge as to how monoecious hydrilla will grow and compete in new climates (Netherland and Greer 2014). The majority of research on hydrilla has been conducted in southern climates on the dioecious biotype. Therefore, research on monoecious hydrilla in northern climates is needed to fill in many unknown plant behaviors (Netherland and Greer 2014).

Madeira et al. (2000) stated that even though the biotypes may visually appear similar, there are important differences that must be understood and applied to effective management systems. These include differences in physiology, reproduction, and phenology. Experiments comparing asexual propagule formation have been reported between monoecious and dioecious hydrilla (Steward and Van 1987; Sutton et al. 1992). Therefore, as the range of both dioecious and monoecious hydrilla expand and start to overlap, it will be important to alter management strategies for greatest impact (Netherland 1997).

Asexual propagules have been determined to be the most important to perennation and dispersal of hydrilla (Haller et al. 1976). Hydrilla produces two kinds of these asexual propagules: an axillary turion and a subterranean turion, often called tubers for simplicity (Netherland 1997). Axillary turions are formed on aboveground biomass in axillary buds on the stem, and is a single apical meristem surrounded by leaf scales (Netherland 1997). Turions are able to remain viable for only a year after production. Tubers are formed at the end of rhizomes in the hydrosoil, and contain several buds surrounded by leaf scales (Netherland 1997). Monoecious hydrilla tubers were able to remain viable for up to seven years following intense management in North Carolina waters, supporting the survival of the species over time (Nawrocki et al. 2016).

There appears to be an environmentally induced quiescence of tubers, though the exact mechanisms are not well understood (Netherland 1997). This quiescence prevents the quick depletion of tubers in the hydrosoil, allowing for accumulation in sediment (Van and Steward 1990). However, when tubers are removed from sediment, sprouting rates are consistently high in laboratory conditions. Increased light and oxygen and decreased levels of carbon dioxide (CO_2) are believed to induce these high sprouting rates (Netherland 1997). Turions appear to have an environmentally induced dormancy, and show a seasonality of sprouting in laboratory conditions (Harlan et al. 1985). Periods of chilling have been shown to be the optimal way of breaking turion dormancy. Exposing turions to 2° C for thirty-three days resulted in the highest sprouting rate for monoecious hydrilla turions (Sastroutomo 1980).

It is important to understand the production and maturation of these propagules to develop an effective management strategy, due to the reproductive potential of just one single tuber or stem fragment (Sutton et al. 1992). Being able to predict how northern climates will affect the dormancy and sprouting rate of monoecious hydrilla is imperative to effective control. True-Meadows et al. (2016) suggested that the increased chilling period in northern climates might increase the sprouting rate.

This study examined the ability of propagules produced in two different climates to withstand cool temperatures for different lengths of time. Research evaluating propagule survival in freezing temperatures has been completed on dioecious hydrilla, but not on monoecious hydrilla from a temperate climate. The results from this study will enable managers to better understand and predict tuber behavior in natural systems, and to effectively control hydrilla infestations.

<u>Methods and Materials</u>

This one year experiment was conducted at two locations to test the effect of climate on the viability of propagules from May 2015-September 2016. The warm climate research was completed at North Carolina State University's Reedy Creek Research Farm in Raleigh, North Carolina (35.816907, -78.725034). Cool climate research was conducted at the North Carolina Department of Agriculture and Consumer Science (NCDA&CS) Upper Mountain Research Station (UMRS) in Laurel Springs, NC (36.396470, -81.307561). These locations were selected because they exhibit dissimilar climates due to difference in elevation, with 125 m at Reedy Creek, and UMRS at 975.36 m. Laurel Springs has a similar annual mean temperature as Albany, New York, and Ann Arbor, Michigan. The annual mean temperature of Raleigh is 16.1° C, while Laurel Springs, Albany, and Ann Arbor, are 9.8°, 9.0°, and 9.7° C, respectively (Arguez et al. 2010).

Throughout the entire study, mean, minimum, and maximum temperature, photosynthetically active radiation (PAR), and precipitation were recorded on a daily basis at NCDA&CS weather stations. Raleigh weather data was collected at Reedy Creek Field Laboratory, while the Laurel Springs weather data was collected at the UMRS. Temperature and light regulation was achieved by utilizing 30% shade cloth that covered all mesocosms. Pond water was used in Raleigh, while well water was used in Laurel Springs. Water quality tests were processed at each location by NCDA&CS Agronomic Services (Appendix 1).

In early May 2015, unsprouted monoecious hydrilla tubers were collected from Shearon Harris Lake (35.612378, -78.942986) in Wake County, North Carolina and sprouted in a greenhouse. In late May, sprouted tubers were planted into six-inch plastic nursery pots (2.9L; 17.8 x 16.5 cm), with a single tuber per pot (Appendix 2). Substrate used in the pots was topsoil (Scotts Premium Topsoil, Marysville OH) with three centimeters of sand (Quikrete®, Atlanta, GA) to cover the top, which was utilized to prevent soil from entering the water column, and to also discourage algal growth. The soil was unamended with fertilizer for this study. A total of 164 pots were planted for each location, for a total of 328 plants for this study. Pots were placed in plastic outdoor mesocosms (1040 L; Benchmark Earth, Sanford, NC), with a complete water exchange every 80 hours (Appendix 3). Plants were allowed to grow and develop undisturbed throughout the growing season. Once being placed outside, the plants grew undisturbed throughout the summer until natural senescence.

After senescence, 144 pots were removed from the mesocosms in late November in Laurel Springs and early December in Raleigh. All remaining aboveground biomass was removed from the pot, and the pot was placed in a 2 mm plastic bag with two inches of water. Pots were evenly divided and placed in three different coolers set at 4, 0, and -3° C. Temperatures in the cooling chambers were regulated by a Thermostar Digital Temperature Controller (Northern Brewer LLC, Roseville, MN), and were accurate within one degree. Soil in the pots remained moist for the entirety of the study while in cooling chambers, due to the plastic bags.

A destructive harvest was also completed in Laurel Springs in late November and in Raleigh in early December on five pots from each location. These pots were sifted using a 3 mm sieve to collect all turions and tubers present in the sediment. Each propagule was individually measured and weighed, and a greenhouse viability test was completed. Fresh weight of all propagules were determined. Individual propagules were placed in 88.7 ml microcosms and put in a glass greenhouse under natural photoperiod (Appendix 7). Greenhouse temperatures were maintained between 26-32° C. Daily observations were recorded to note sprouting in both propagules. Propagules were called viable if they sprouted, and all tests were run until every propagule either sprouted or rotted.

The remaining fifteen pots were left to overwinter in ambient weather conditions at each location. Starting early March 2016, these pots were evaluated on a biweekly basis to determine the emergence date for sprouting tubers. The pots in the coolers remained undisturbed until two weeks after the outdoor pots sprouted at each location. At this time, the first of six monthly destructive harvests began. The first harvest occurred in mid-April in Raleigh, and in early May in Laurel Springs, due to the fact that tubers in Raleigh sprouted before tubers in Laurel Springs.

The harvest process consisted of randomly selecting four pots from each of the three different temperatures to be placed in outdoor mesocosms, to observe undisturbed sprouting rates at each harvest at both locations. In addition, four random pots were selected to be destructively harvested from each of the three cooling chambers at each location. These pots were sifted and all propagules were collected. The turions and tubers collected from the destructive harvest were counted, weighed, and measured in the lab. A viability study was conducted in a greenhouse, using microcosms to hold an individual propagule that correlated to the quantitative laboratory measurements previously recorded. Daily observations noted any sprouting, which resulted in average viability rates of each different temperature for each harvest across both locations. A total of seventy two pots were destructively harvested at each of the two locations over the course of the study.

In each of the harvest months, forty unsprouted tubers were collected from Shearon Harris Lake. These tubers were processed in the same way as the propagules collected from the harvests and used as controls for both size and viability rates. Viability studies were conducted on these tubers simultaneously with each of the monthly harvests. Each of the monthly studies were ran until all the propagules either sprouted or rotted, and viability in this study was defined as sprouting.

Two weeks after tuber sprouting ceased in outdoor mesocosms, a destructive harvest was completed on five pots that were overwintered in mesocosms from each location. This harvest was completed in the same manner as the harvest in November to understand the percentage of tubers that had sprouted at each location.

Data for propagules, weight, and viability was analyzed using SAS statistical software (SAS Institute Inc., Cary, North Carolina). Number and mass of asexual propagules were analyzed using analysis of variance (ANOVA), with means being separated by Tukey HSD tests ($p < 0.05$). Differences between viability rates were calculated with a Chi-Squared test, with ($p < 0.05$).

Results and Discussion

Weather

During the study, Raleigh had higher mean, minimum, and maximum ambient temperatures (p values < 0.0001) (Table 4-1). There was not a difference in weekly precipitation, ($p = 0.466$) or mean PAR, ($p = 0.869$) received at each location. There were no differences in measured parameters between 2015 and 2016 in the same location except for precipitation in Laurel Springs. In 2015, there was more weekly precipitation than in 2016 (p = 0.035).

As expected, both ambient temperature and water temperature were cooler in Laurel Springs. Temperature has been demonstrated as an important factor of submersed macrophyte growth and development (Barko et al. 1986). Therefore, differences can be expected between locations with hydrilla development. Although though there were differences in temperatures, PAR, and precipitation did not differ between locations. Differences in precipitation levels at Laurel Springs between years did not have an impact on all other measured parameters between years.

Production of propagules

At both locations, monoecious hydrilla was able to produce turions and tubers (Table 4-2). When combining all harvests, hydrilla grown in Raleigh produced more tubers than plants grown in Laurel Springs. Tuber density at each harvest ranged from 1008 to 3696 tubers m^{-2} in Raleigh, with a mean tuber density of 2142 tubers m^{-2} (Table 4-3). The tuber density at Laurel Springs ranged from 224 to 2352 tubers m^{-2}, with a mean tuber density of 823 tubers m^{-2}. Turion densities ranged from 0 to 1680 turions m^{-2} in Raleigh with a mean of 529 turions m^{-2}. In Laurel Springs, turion densities ranged from 0 to 2016 turions m^{-2} with a mean of 593 turions m^{-2}.

Within locations, tuber numbers collected from each harvest did not vary over harvests (Table 4-2). Between locations, the amount of tubers collected in Raleigh was higher than in Laurel Springs except for the September harvest. The number of tubers collected in this last harvest was not different between locations. In addition, the amount of tubers collected from Raleigh during the September harvest were not different from the June harvest at Laurel Springs.

When combining tubers and turions across all harvests at Laurel Springs, there were differences in average propagule densities between harvests (Table 4-2). The July and August harvests both had lower numbers of propagules, both months averaging 560 tubers m^{-2}, than the September harvest, which averaged 1120 tubers m^{-2}. All other harvests at Laurel Springs did not vary in the average number of propagules collected.

Tuber production depends on many environmental factors, such as nutrient availability, health of the plant, hydrosoil composition, and climatic conditions (Basiouny et al. 1978). All of these factors interact with the production of tubers. However, since nutrient content and hydrilla health were similar at both locations, the differences in number of tubers produced in this study can be contributed to different temperatures experienced by the two locations. This has large implications on management, as being able to predict how temperatures will impact tuber production is a key aspect of hydrilla management (McFarland and Barko 1999). This study demonstrated that warmer temperatures facilitated greater tuber production with greater uniformity than cooler temperatures.

Although mesocosm tuber densities are traditionally higher than densities found in natural systems (Netherland 1997), this was not the case in this study. Tuber densities in Raleigh were comparable to monoecious tuber densities in North Carolina lakes (Harlan et al. 1985; Hodson et al. 1984), and were less than other mesocosm trials (Steward and Van 1987; Sutton et al. 1992), likely due to longer experiment times in these other studies.

Plants grown in Laurel Springs produced heavier tubers compared to plants grown in Raleigh (Table 4-4). On average, tubers from Raleigh had a fresh weight of 96 mg, while tubers had a fresh weight of 113 mg from Laurel Springs. The control tubers that were collected every month had an average fresh weight of 110 mg. Tubers had statistically different weights based on when they were harvested. Control tubers had the lowest weight in August, as smaller, less mature tubers were collected, lowering the average weight. In September, the tubers were more mature, increasing the average tuber weight.

There were no differences in the average fresh weight of turions between locations, with 41 mg from Raleigh and 42 mg from Laurel Springs (Table 4-5). No turions were collected from natural systems to act as controls. Within the same natural system, propagules vary significantly in weight (True-Meadows et al. 2016). Therefore, weight differences between locations are expected to be great. Fresh weight of monoecious hydrilla turions average 36 to 77 mg (Spencer et al. 1987), while tubers average between 30 to 320 mg in North Carolina (Nawrocki 2011). Both propagules from each location in this study fell within these ranges, though on the lower end.

Carbohydrate reserves are important to the survival of submersed aquatic macrophyte propagules (Titus and Adams 1979). It is believed that larger propagules are able to withstand greater stress and still remain viable. Therefore, heavier tubers in Laurel Springs would increase their chance of surviving colder temperatures for a longer period of time, which was observed in the greenhouse viability studies.

Overwintered temp effects- Greenhouse Studies

Due to the constant darkness and above freezing temperatures experienced by propagules overwintered at 4° C, propagule disintegration occurred at both locations, but to a greater degree in Raleigh. Propagules were considered disintegrated when they were soft and falling apart at harvest. Less tuber disintegration occurred in 0° C, while no tuber disintegration was observed when kept at -3° C. Tubers were more resilient to disintegration than turions in all temperatures at both locations.

Tubers from Laurel Springs were subjected to and survived freezing temperatures for seven months. It has been found that in natural settings, mature tubers are resistant to freezing temperatures when insulated by sediment (Hodson et al. 1984). As turions are not buried in sediment are less resistant to freezing, monoecious hydrilla turions survived only a week in freezing conditions (Sastroutomo, 1982).

In natural systems the specific temperatures experienced by the pots in this study would not be seen uniformly. The effectiveness of using a winter drawdown to expose sediment to cold temperatures is highly site specific. Tubers in the upper portion of sediment might be affected by the temperatures; however, tubers would be more likely to survive deeper in the sediment. Another downside of using drawdown is that the results from this study demonstrate that even when sediment was exposed to freezing temperatures, tubers were able to remain viable for seven months in Laurel Springs. Therefore, even higher viability rates can be expected in natural systems, due to the temporal difference in sediment temperatures. Because of this, relying on colder, longer winter conditions to kill tubers is not a viable management option.

When combining viability rates for the same overwintered temperature, tubers from Laurel Springs had a higher viability rate at both 0 and 4° C (Table 4-5). Turions from Laurel Springs had a higher viability rate than those from Raleigh, with an average viability rate of 78% from Laurel Springs and 38% from Raleigh. There was no difference in viability rates at all other overwintering temperatures. When tubers were overwintered at 0° C, in Raleigh, no tubers were viable (Table 4-8). In Laurel Springs, initial viability was 57% and declined to 0 to 3% for harvests three through six.

There was not a difference in tuber viability from both locations when overwintered at 4° C (Table 4-6). The viability rates from Raleigh ranged from 29 to 93%. Viability rates of tubers from Laurel Springs ranged from 73 to 100%. Control tubers viability rates ranged from 90 to 100% (Table 4-7). In Raleigh, when overwintered at 4° C, turion viability did not differ based on harvest time, and ranged from 19 to 62% (Table 4-6). However, in Laurel Springs the number of viable turions was different for the July harvest, at 18% compared to 70 to 99% for all harvests.

When all harvests across locations were combined, tubers took longer to sprout at Laurel Springs, but there was no difference for turions between locations (Table 4-9). Tubers produced in Raleigh exhibited no difference in the amount of time required for sprouting. However, turion sprouting from Raleigh varied, with June turions requiring the longest period of time to sprout. Laurel Springs tubers did not differ in the time to sprouting, while turions did across harvests. Turions harvested in July required a longer sprouting time than all other harvests. When data collected from both locations were combined across all harvests, both tubers and turions showed differences in sprouting time. The number of days for tuber and turion sprouting at both locations was 4.1 days. Over the course of the study, the length of time it took tubers and turions to sprout did not differ.

Propagules that overwintered in constant temperatures had faster and more uniform sprouting times than those overwintered in ambient conditions at both Laurel Springs and Raleigh. Monoecious hydrilla tubers have synchronous sprouting in cooler climates, meaning that sprouting occurs in a narrow time period instead of yearlong sprouting, as observed in warmer climates (Michael Netherland, pers. comm.). Therefore, as photoperiod was different between monthly harvests, but tuber sprouting in outdoor mesocosms did not vary in length to sprout or amount, temperature is likely the most important que for synchronous sprouting.

Greenhouse viability studies had higher sprouting rates than the mesocosm studies at each month. However, high propagule sprouting in greenhouse trials has been well documented (Netherland 1997; personal experience). It is hypothesized that when tubers are removed from the anoxic conditions found in the hydrosoil, and exposed to oxygen, the environmentally imposed dormancy is broken (Netherland 1997). In natural systems, hydrilla would benefit if some viable tubers did not sprout immediately, allowing the plant to build up a tuber bank.

Mesocosms trials

When placed into the outdoor mesocosms, tubers in this study were able to sprout regardless of natural photoperiod or ambient temperatures. All pots overwintered at 4° C sprouted at each harvest, from April to September. At both locations after each harvest, it took an average of two weeks for the first sprouted tuber to be observed. There was not a difference in length of sprouting time between harvests or locations. On average, five to seven tubers sprouted per pot at both locations. There was not a difference in tuber sprouting between locations, though the percent of tubers that sprouted was higher in Laurel Springs.

Results from the mesocosm trial represents a more natural setting, as tubers were not removed from the hydrosoil. Therefore, it can be expected that longer chilling times would increase the amount of tubers that sprouted in northern climates, which was hypothesized by True-Meadows et al. (2016). This study supports that hypothesis, as a greater proportion of tubers sprouted in Laurel Springs compared to Raleigh. If this trend continues in natural systems, it will impact monoecious hydrilla management in northern climates. If more tubers sprout in a season, current management strategies will need to change. In southern climates, the accumulation of tubers is rapid, complicating management efforts (Nawrocki et al. 2016). Though if timely management strategies are implemented after tubers sprout but before new tubers are formed, in northern states, large tuber banks may not accumulate as quickly compared to southern states. Even if this is the case, Nawrocki (2016) found that in a North Carolina reservoir, a tuber density of just 11 tubers m^{-2} was enough to repopulate an area with hydrilla. In addition, when no management was implemented, the tuber bank increased over 1000% in just one growing season. Tuber densities found in Laurel Springs after tubers ceased sprouting in the spring was approximately 187 tubers m^{-2}. Therefore, even though the tuber bank is smaller, it is significant.

Plants grown in Raleigh had zero viable tubers at any harvest when overwintered at either 0° C or -3°. In Laurel Springs, six pots that were overwintered at 0° C had viable tubers through the first two harvests. After the second harvest, there were no viable propagules overwintered at 0° C when placed in the outdoor mesocosms in Laurel Springs.

Pots harvested in June demonstrated that there were viable tubers at both locations that did not sprout in the undisturbed mesocosm. In Laurel Springs, pots averaged 4 unsprouted tubers, while Raleigh averaged nine unsprouted tubers. Average tuber viability rates were 98% from Raleigh and 95% from Laurel Springs when removed from the sediment and placed in the greenhouse. Even though these tubers were viable, they required longer to sprout. Tubers collected from Raleigh averaged 8.7 days to sprout, while Laurel Springs tubers averaged 4.8 days to sprout. One tuber from Raleigh required 21 days to sprout, while the longest time to sprouting at Laurel Springs was 7 days. A larger percentage of tubers sprouted in Laurel Springs in the mesocosms, creating a smaller tuber bank than at Raleigh.

<u>November 2016 Year Harvest</u>

At the harvest in November 2016, pots from Laurel Springs averaged 896 tubers m^{-2} and 336 turions m^{-2}, while Raleigh averaged 1008 tubers m^{-2} and 0 turions m^{-2}. There was no difference in amount of propagules collected or their weight at this harvest. Laurel Springs had a 97% viability rate of tubers and a 75% survival of turions, which was not different than rate measured throughout the six monthly viability tests. Raleigh had a 90% viability rate of tubers, which was not different than rates observed previously in greenhouse trials. As there were no turions collected from Raleigh, there was no viability rate. The number of propagules collected from Raleigh was lower than harvests for the six monthly harvests, due to the disintegration of propagules. However, tuber weights at Raleigh were not different than those observed in the monthly harvests. All propagules from both locations required a longer time to sprout at the year harvest than the six monthly trials.

Conclusions

Interactions between two or more climatic conditions were not captured with this study, as temperature was the major climatic difference seen between locations. Other interactions, especially with photoperiod length and light intensity may influence growth and development of hydrilla. However, temperature difference influenced tuber production, weight, and viability. These tuber dynamics are vital for effective management. From this study, tuber production was more variable in Laurel Springs when compared to Raleigh, having a wider range of production. However, Raleigh hydrilla produced a greater amount of tubers. Tuber weights were larger in Laurel Springs, theoretically allowing these propagules to withstand more intense environmental stress and still remain viable. Within locations, tubers were more resistant to environmental stresses, having higher viability rates and surviving in colder temperatures in Laurel Springs for longer. In addition, turions were more susceptible to rotting than tubers in the same overwintering temperature.

Tubers were present at a high enough density after sprouting ceased in the spring, that the tubers would act as perennation means for at least one season. Therefore, tuber bank management is still required even though a greater proportion of tubers sprouted in Laurel Springs compared to Raleigh. In addition, relying on the colder, longer winters in northern US to reduce viability of tubers will not be an effective management strategy, as tubers were able to withstand seven months of freezing temperatures and still remain viable.

More research is required to observe how interactions of climatic conditions affect hydrilla biomass and production of asexual propagules. Longevity of propagules and the accumulation of tubers were not measured in this study, and need to be understood to be effectively incorporated into management and control strategies of monoecious hydrilla in northern climates.

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Table 4-1. Ambient temperature, photosynthetically active radiation (PAR), and precipitation per week in Raleigh and Laurel Springs, North Carolina from May 2015 - September 2016, as measured by NCDA&CS weather stations.

Average Ambient Temperatures °C			
	Mean	Minimum	Maximum
Raleigh	19.27	13.98	24.55
Laurel Springs	14.01	8.82	19.19

Range of Ambient Temperatures °C		
	Minimum	Maximum
Raleigh	-4.50	35.37
Laurel Springs	-9.50	29.13

Photosynthetically Active Radiation (PAR)		
	Mean	Maximum
Raleigh	382.29	2445.57
Laurel Springs	383.55	2726.43

Precipiation Per Week (cm)		
	Mean	Maximum
Raleigh	0.43	2.86
Laurel Springs	0.58	7.3

Raleigh had higher mean, minimum, and maximum temperatures than Laurel Springs over this time period. PAR and precipitation did not vary between locations.

Table 4-2. Average number of tubers and turions m^{-2} collected at each monthly harvest at Raleigh and Laurel Springs.

		Tubers Collected				Turions Collected			
Harvest	Month	Raleigh		Laurel Springs		Raleigh		Laurel Springs	
1	April	2128	a[1]	784	c	2128	a	784	c
2	May	2016	a	784	c	2016	a	784	c
3	June	2016	a	1008	bc	2016	a	1008	bc
4	July	1904	a	784	c	1904	a	784	c
5	August	1904	a	784	c	1904	a	784	c
6	September	1792	ab	1586	abc	1792	ab	1586	abc

[1]Values not followed by the same letter are different among propagule type, according to Tukey HSD $p < 0.05$.

Table 4-3. Monoecious *Hydrilla verticillata* propagule density at Raleigh and Laurel Springs over all harvests.

	Propagule Density (per m^2)					
	Tubers			Turions		
Location	Mean	Min.	Max.	Mean	Min.	Max.
Raleigh	2142 a[1]	1008	3696	529 a	0	1680
Laurel Springs	823 b	224	2352	293 a	0	2016

[1]Tuber densities are compared across locations. Mean values not followed by the same letter are different among propagule types.

Table 4-4. Monoecious *Hydrilla verticillata* tuber and turion fresh weights over six harvests.

		Tuber Fresh Weight				Turions Fresh Weight			
Harvest	Month	Raleigh		Laurel Springs		Raleigh		Laurel Springs	
1	April	0.104	b[1]	0.118	a	0.043	a	0.043	a
2	May	0.093	b	0.117	a	0.039	a	0.038	a
3	June	0.095	a	0.113	a	0.035	a	0.04	a
4	July	0.093	a	0.104	a	0.057	a	0.045	a
5	August	0.098	b	0.113	a	0.043	a	0.039	a
6	September	0.094	b	0.112	a	0.033	a	0.047	a
All		0.096	b[2]	0.113	a	0.042	a	0.042	a

[1]Mean fresh weight comparisons between locations at each harvest within propagule type. Values with different following letters are significantly different between locations within the same harvest.
[2]Overall mean fresh weight comparison between locations within propagule type. Values with different following letters are significantly different over all harvests.

Table 4-5. Overall mean viability rates of monoecious *Hydrilla verticillata* tubers and turions from Raleigh and Laurel Springs

	Tuber Viability Rate			Turion Viability Rate		
Temperature	Location	Mean Viability Rate		Location	Mean Viability Rate	
4° C	Raleigh	63%	b[1]	Raleigh	41%	b
	Laurel Springs	89%	a	Laurel Springs	78%	a
0° C	Raleigh	0%	b	Raleigh	0%	a
	Laurel Springs	20%	a	Laurel Springs	0%	a
-3° C	Raleigh	0%	a	Raleigh	0%	a
	Laurel Springs	0%	a	Laurel Springs	0%	a

[1]Viability rates are combined across all harvests within the same location. Values not followed by the same letter are different among temperature and propagule type, according to Tukey HSD $p < 0.05$.

Table 4-6. Monthly viability rates of tubers and turions overwintered at 4° C from Raleigh and Laurel Springs, North Carolina.

		Tubers				Turions			
Harvest	Month	Raleigh		Laurel Springs		Raleigh		Laurel Springs	
1	April	93	a[1]	100	a	20	a	97	a
2	May	29	a	93	a	19	a	99	a
3	June	51	a	98	a	38	a	92	a
4	July	75	a	75	a	62	a	18	a
5	August	66	a	98	a	56	a	97	a
6	September	63	a	73	a	40	a	70	a

[1]Values in the same column followed the same letter are not different, according to Tukey HSD $p < 0.05$.

Table 4-7. Average monthly viability rates of tubers collected from Shearon Harris Reservoir between April and September 2015.

Harvest	Month	Control	
1	April	90	a[1]
2	May	95	a
3	June	99	a
4	July	100	a
5	August	93	a
6	September	90	a

[1]Values followed the same letter are not different, according to Tukey HSD $p < 0.05$.

Table 4-8. Monthly viability rates of tubers overwintered at 0° C from Raleigh and Laurel Springs, North Carolina.

Harvest	Month	Raleigh		Laurel Springs	
1	April	0	a[1]	57	a
2	May	0	a	58	a
3	June	0	a	3	b
4	July	0	a	0	b
5	August	0	a	0	b
6	September	0	a	0	b

[1]Values in the same column followed the same letter are not different, according to Tukey HSD $p < 0.05$.

Table 4-9. Mean days to sprout for monoecious *Hydrilla verticillata* tubers and turions within and between Raleigh and Laurel Springs in greenhouse viability studies.

		Tubers		Turions	
Harvest	Month	Raleigh	Laurel Springs	Raleigh	Laurel Springs
1	April	4.7 a[1]	4.6 a	3.0 cb	4.1 b
2	May	3.4 b	3.8 a	4.2 b	3.0 c
3	June	4.1 ab	4.6 a	6.4 a	4.6 b
4	July	3.9 ab	4.8 a	4.2 b	6.5 a
5	August	3.2 b	3.4 a	2.4 c	3.2 c
6	September	4 ab	4.4 a	3.1 cb	3.8 bc
All	Average	3.9 b[2]	4.3 a	4.0 a	4.2 a

[1]Single harvest mean number of days to sprout comparisons within locations. Values not followed by the same letter are significantly different within location, according to Tukey HSD $p < 0.05$.
[2]Overall six harvest mean number of days to sprout comparisons between locations. Values not followed by the same letter are significantly different within propagule type, according to Tukey HSD $p < 0.05$.

Appendix

Appendix 1. Water quality tests from Raleigh and Laurel Springs, North Carolina.

Nutrient Concentration[1]	Raleigh	Laurel Springs
Inorganic Nitrogen	0.82	0.94
Organic Nitrogen	0.00	0.16
Phosphorus	0.02	0.01
Potassium	1.46	4.49
Calcium	1.28	16.10
Sodium	1.94	6.35
Chlorine	4.55	5.96

Water Quality	Raleigh	Laurel Springs
pH	6.09	8.56
Electrial Conductivity[2]	0.03	0.15
Carbonates[3]	0.00	0.60
Bicarbonates[4]	0.10	0.43
Total Alkalinity[5]	5.00	51.50
Hardness[5]	6.41	47.40

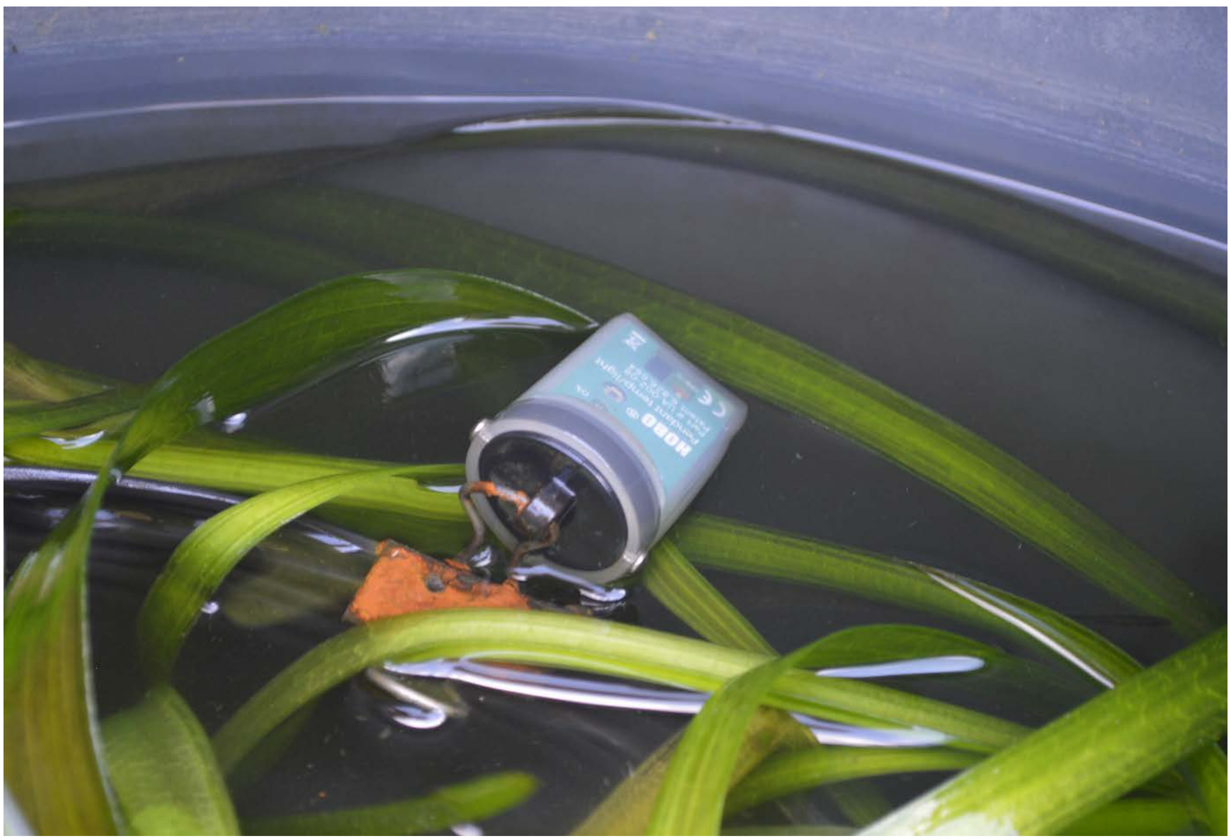
[1]Parts per million. [2]mS/cm. [3]miliequivalent per liter (Meq/L). [4]miliequivalent per liter (Meq/L) [5]Parts per million of $CaCO_3$.

Appendix 2. 2.9 L pots used to determine phenology of monoecious *Hydrilla verticillata* and asexual propagule production and viability.

Appendix 3. 1040 L outdoor mesocosms


Appendix 4. 120 L aboveground mesocosms,

Appendix 5. 208 L belowground mesocosms.



Appendix 6. Location of HOBO pendants in competition study.

Appendix 7. Greenhouse viability study set up.

E.2 Factors Affecting Monoecious Hydrilla in Dynamic Systems (Regan 2017)

ABSTRACT

REGAN, SHANNON MARIE. Factors Affecting Monoecious Hydrilla (*Hydrilla verticillata*) in Dynamic Systems (Under the direction of Dr. Robert J. Richardson).

Monoecious hydrilla (*Hydrilla verticillata* L.f. Royle) is an invasive submersed macrophyte, and is one of the most difficult weeds to control in the United States. It is steadily invading more northern latitudes and increasingly dynamic systems such as high biodiversity rivers, estuaries, and reservoirs with high water fluctuation. It behaves as a herbaceous perennial that senesces in the late fall to early winter. Regrowth is dependent upon sprouting of vegetative propagules called turions which are deposited in vast numbers upon or within the substrate each growing season. Sprouting of these propagules appears to be partly a function of temperature. Timing of sprouting and growth rates were evaluated for monoecious hydrilla axillary and subterranean turions across a water temperature gradient over a period of twelve days. Temperatures evaluated included: T1=41.0˚C, T2=34.9˚C, T3=29.3˚C, T4=24.0˚C, T5=17.6˚C, and T6=12.3˚C. Neither axillary nor subterranean turions sprouted in the hottest and coldest temperatures of 41.0 and 12.3˚C. Optimum growth for both propagules types occurred at 29.3˚C. Shoot lengths were significantly reduced for both turion types in 17.6˚C. Timing of sprouting was not significantly different between axillary and subterranean turions.

Salinity tolerance was also evaluated for both sprouted and unsprouted monoecious hydrilla subterranean turions. As hydrilla continues to invade rivers that empty into brackish waters, salinity will likely be a major factor limiting its expandable range. Salinities evaluated included a range of 0 to 24 ppt at exposure times of 2 to 8 weeks followed by a two-week recovery period. Shoot length, number of lateral branches, and fresh and dry weights were

determined. Sprouted subterranean turions tolerated 8 weeks in 6 ppt and 4 weeks in 9 ppt, following the recovery period. Sprouting occurred in salinities up to 12 ppt. Lateral branching increased in salinities of 3 to 6 ppt.

A final research area focused on managing hydrilla in dynamic systems. Current hydrilla management options are limited for flowing systems with high biodiversity, and have not been extensively studied. A two year pilot herbicide trial was implemented in the Eno River, located in the piedmont region of North Carolina, to investigate the efficacy of treating hydrilla in a lotic system with high biodiversity and threatened or rare species. Two consecutive years of treatment were conducted using a low rate of fluridone maintained over a window of 60-100 days. Treatment impacts to selected target and non-target aquatic species were evaluated. Efforts included quantitative sampling of hydrilla, *Somatogyrus virginicus* Walker (a rare, endemic snail), and *Podostemum ceratophyllum* Michx. (a native macrophyte and habitat of *S. virginicus*) at seven spatially separated sites along the Eno River. Biweekly vegetation monitoring and monthly snail sampling began two weeks before treatment in 2015, and continued through 2016. Hydrilla biomass, shoot length, and tuber density significantly decreased within the treated section of the river. *P. ceratophyllum* densities and lengths were not significantly different between sampling years. *S. virginicus* densities exhibited patterns consistent with annual reproductive cycles. Overall, fluridone effectively controlled hydrilla within the treated area with no apparent negative impacts to the monitored non-target species.

Factors Affecting Monoecious Hydrilla (*Hydrilla verticillata*) in Dynamic Systems

by
Shannon Marie Regan

A thesis submitted to the Graduate Faculty of
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2017

APPROVED BY:

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DEDICATION

To my ridiculously supportive parents, siblings, and husband

BIOGRAPHY

Shannon Regan was born and raised in northwestern Pennsylvania. Her love of the water was evident from a young age and lead her to pursue a degree in Marine Science at Coastal Carolina University. Upon receiving her BS, she moved to Raleigh, NC where she was given the opportunity to continue her education in a Master's program at NC State University where she began studying aquatic plant management and ecology. Outside of school she can be found walking in the woods with her dog or cooking elaborate meals.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

CHAPTER 2

CHAPTER 3

CHAPTER 1

Literature review

Hydrilla verticillata (L.f.) Royle is a submersed aquatic macrophyte in the Hydrocharitaceae family. It is distributed world-wide with populations found on every continent except Antarctica (Madeira et al. 1997; Dayan and Netherland 2005). Hydrilla was first introduced into the United States in the 1950s in Florida, and is now established in waters extending as far north as Maine (Maine DEP), and as far west as California and Washington (Figure 1) (Netherland 1997; USGS 2016).

There are two distinct biotypes of hydrilla established within the U.S.: a monoecious biotype with staminate and pistillate flowers located on the same plant, and a female dioecious biotype with only pistillate flowers present (Blackburn et al. 1969; Cook and Luond 1982). Dioecious hydrilla was first introduced to the U.S. in Florida and can be found throughout the southern and western states (Dayan and Netherland 2005; Haller 2014). Monoecious hydrilla was first documented in 1980 in Umstead Lake, NC and is typically suited to more temperate climates of the U.S. such as North Carolina northward (True-Meadows et al. 2016). Populations of monoecious hydrilla have also recently been confirmed in Guntersville Reservoir, Alabama and Lake J. Strom Thurmond, Georgia (Williams et al. 2017).

H. verticillata is a monocotyledonous, rooted species with highly branched shoots. Sessile, oblong, finely serrated leaves are 0.75 - 1.5 cm long and arranged in whorls of 3-8 along the length of the stem (Aulbach-Smith and Kozlowski 1996). It is similar in appearance to *Elodea canadensis* Michx. and *Egeria densa* Planch., but can be distinguished by its rougher texture. Hydrilla also has an average of 4+ leaves per whorl whereas *E. canadensis* leaves are arranged in whorls of three (Aulbach-Smith and Kozlowski 1996).

Hydrilla has spread across much of the United States due in part to its multiple modes of reproduction. It is capable of reproducing via fragments, stolons, rhizomes, seed (monoecious biotype only), and vegetative propagules (Cook and Luond 1982; Langeland and Smith 1984). These vegetative propagules called turions form in leaf or branch axils and at the terminal end of positively geotropic rhizomes (Yeo et al. 1984). Subterranean formed turions are commonly referred to as tubers throughout the literature, and will be referred to as such throughout the remainder of this text. Turions and tubers are formed in vast numbers each growing season. Monoecious hydrilla tuber densities in North Carolina lakes have been reported to be as high as 1,312 to 1,512 T/m^2 (Hodson et al. 1984; Harlan et al. 1985). A more recent study reported an even higher density of 3,077 T/m^2 (Nawrocki 2011). Undisturbed monoecious tubers can remain viable within the hydrosoil in North Carolina for at least six years (Nawrocki 2016). Prolific tuber production leads to the establishment of a tuber bank within the sediment of infested waterbodies. This is essentially akin to a terrestrial seed bank, and is the mechanism that allows the regrowth of monoecious hydrilla in temperate climates and is responsible for the rapid revegetation after ecological stress or control treatments (Netherland 1997).

Hydrilla has adaptations that enable it to withstand and even thrive in a variety of environments. It is able to grow in varying nutrient and pH levels as it is found in oligotrophic to eutrophic waters as well as highly acidic to alkaline environments (Cook and Luond 1982). Nawrocki et al. (2011) reported little difference in initial growth of monoecious hydrilla tubers sprouted in pH ranging from 4-10. Some level of salinity tolerance has also been reported for this notoriously freshwater species. However, there are discrepancies within the literature. Some report that hydrilla will have little productivity in 4 ppt, will not grow in 6 ppt, will die 10 ppt, and will not survive even 1 day of exposure to 15 ppt (Haller et al. 1974; Twilley and Barko 1990; Frazer et al. 2006). However, Steward and Van (1987) reported tolerances up to 13 ppt. The ability of hydrilla to tolerate brackish waters in its native range of south and southeast Asia has also been noted (Cook and Luond 1982). Hydrilla has lower light requirements for photosynthesis than many other submersed species. It can photosynthesize in < 1% sunlight (Langeland 1996). This lends to its competitive advantage in both time and space as it can begin photosynthesizing earlier in the morning and colonize greater depths than other aquatic species (Langeland 1996). In Crystal River, Florida, the plant was found growing 15 meters deep (Langeland 1996). The dioecious biotype also has special adaptations that allow it to sequester carbon more efficiently. These include utilization of the bicarbonate ion and the ability to switch between C3 and C4-like acid metabolism (Van et al. 1976). It is unknown whether the monoecious biotype fits into this same photosynthetic category, but speculation suggests it does (Steward and Van 1987).

These physiological adaptations and competitive strategies facilitate rapid hydrilla spread within infested waterbodies. Its aggressive, opportunistic growth characteristics allow it to form dense monocultures that reach the water's surface (Sutton 1986). These topped out mats of vegetation shade out native species, alter fish populations, and can incite rapid fluctuations in temperature, pH, and dissolved oxygen levels (Dayan and Netherland 2005). Hydrilla has been shown to outcompete other submersed species including *Elodea canadensis*, *Vallisneria americana* Michx., *Potamogeton crispus* L., and *Myriophyllum spicatum* L. (Haller and Sutton 1975; True-Meadows 2013). This superior competition and enhanced dominance is due to its ability to limit light penetration throughout the water column and due to the "presence of millions of meristematic tissues per ha" (Haller and Sutton 1975). Colle and Shireman (1980) determined that large monocultures of hydrilla negatively affect fish species such as redear (*Lepomis microlophus* Günther) and bluegill (*Lepomis macrochirus* Rafinesque). They also reported that largemouth bass (*Micropterus salmoides* Lacepède) of harvestable size were negatively affected by hydrilla cover exceeding 30%, but that the condition of small sized largemouth bass was not affected until coverage exceeded 50% (Colle and Shireman 1980). Colle et al. (1987) also found that redear and bluegill populations were negatively correlated with hydrilla coverage estimates. However, they reported that increased coverage did not affect harvestable populations of largemouth bass or black crappie (*Pomoxis nigromaculatu* Lesueur). Hydrilla has also been identified as the host of a neurotoxin-producing cyanobacteria, *Aetokthonos hydrillicola* which is linked to a neurological disease (Avian Vacuolar Myelinopathy- AVM). This toxin leads to the formation of brain lesions that affect bald eagles (*Haliaeetus leucocephalus* Linnaeus), American coots (*Fulica americana* Gmelin), grass carp (*Ctenopharyngodon idella* Val.), and herbivorous turtles like *Chrysemys picta* Schneider (Mercurio et al. 2014; Wilde et al. 2014). In addition to causing ecological harm, hydrilla also causes major economic damage by reducing flow in drainage canals, clogging water intakes, interfering with recreational activities such as boating, fishing, and swimming, and reducing lakefront property values (Langeland 1996).

The aggressive growth, high propagule production, and ability of this hardy plant to tolerate a wide range of disturbances are all characteristics of an invasive species (Cook and Luond 1982; Kolar and Lodge 2001). Therefore, it is not surprising that hydrilla, deemed "the perfect aquatic weed", is listed on the United States Federal Noxious Weed List, and costs millions of dollars to manage each year (Langeland 1996; USDA 2012).

Macrophyte growth in lotic systems is often limited by high water velocity, ever changing substrate, and variable water depths (Sousa et al. 2010). In Brazil, hydrilla has been shown to be able to colonize deeper areas within a river than a similar native species, *Egeria najas* Planch (Sousa et al. 2010). As such, hydrilla is better able to overcome these challenging environmental conditions as compared to egeria. As monoecious hydrilla continues to invade more lotic systems in the U.S. such as the Ohio River, the Eno River in the Piedmont region of NC, and the Chowan River in Eastern NC, it may outcompete the native species in these lotic systems as well. However, the data to support this conclusion has yet to be reported in the published literature. Invasive species characteristically take hold in disturbed areas (Frazer et al. 2006). Lotic systems provide the dynamic environment necessary to create intermittently disturbed areas. For invasive species that can survive in lotic systems, the intermittent disturbance provides competition free zones for rapid colonization. This pattern was observed in Kings Bay, FL where native species were replaced by the invasive macrophytes *Myriophyllum spicatum* and hydrilla (Frazer et al. 2006). It also occurred in the Potomac River where native species were displaced in the 1930s (apparently due to storm damage, nutrient enrichment, and grazing) and hydrilla became dominant by the 1980s (Carter and Rybicki 1986). Lotic systems represent a relatively new and challenging area of hydrilla research.

Long term hydrilla management is difficult due to its perennation through prolific production of tubers and turions. Current management techniques include cultural control, biological control, mechanical removal, and chemical control (Haller 2014). However, most of these practices, particularly in North Carolina, have been studied in low biodiversity, lentic environments (Nawrocki 2011), and may not be practical or feasible to implement in lotic systems with high biodiversity.

Cultural control methods involve physically altering the environment to discourage weed growth. Water level drawdowns are an example of this type of control and have previously been used for hydrilla management. This exposes the plants and sediment to the air, thus eliminating standing biomass and disrupting the life cycle of the plant. (Haller et al. 1976). This method has been successful in providing temporary control of dioecious hydrilla in Florida (Langeland 1996). Haller et al. (1976) proposed that two drawdowns would be effective in controlling hydrilla. The first would kill the existing biomass and aerate the soil to stimulate tuber germination. The second drawdown would kill the resulting biomass and should be initiated before additional tubers are formed. However, this method is not feasible in natural flowing systems where a mechanism to draw down water levels does not exist. Furthermore, it would prove fatal to the native flora and fauna of the system.

Biological control methods for hydrilla include stocking the waterbody with herbivorous grass carp, *Ctenopharyngodon idella* Val., or releasing the leaf-mining fly, *Hydrellia pakistanae* Deonier. Triploid (sterile) grass carp have been an effective tool in aquatic plant management since the 1970s. These fish can consume more than 100% of their body weight per day, and have been successful in significantly reducing, even eliminating populations of invasive macrophytes (Opuszynski 1972; Leslie et al. 1987). However, due to their selective generalist feeding habits, they will feed on more palatable vegetation first which may or may not be the invasive for which they were prescribed (Leslie et al. 1987). The majority of grass carp research to date has focused on the eradication of invasive plants (Dibble and Kovalenko 2009). Partial control of plant populations is rarely achieved (Bonar et al. 2002). It is for these reasons, coupled with the lack of research pertaining to the mobility of grass carp in lotic systems, that we believe this biocontrol agent is not a viable option for hydrilla management in flowing, high biodiversity systems.

Hydrellia pakistanae, a fly whose larvae mine hydrilla leaves, is another biocontrol option (Buckingham et al. 1989). *H. pakistanae* is a host specific feeder that prefers hydrilla (Driesche et al. 2002). "The overwintering stage is unknown but larvae have been found on hydrilla throughout the entire winter" (Driesche et al. 2002). While this does not present a problem for management of dioecious hydrilla that overwinters, it may for monoecious hydrilla which acts a herbaceous perennial in North Carolina with senescence occurring in late fall/early winter (Harlan et al. 1985). Past releases of this fly in NC have not been successful due to its failure to overwinter (Nawrocki 2011). Therefore, *H. pakistanae* do not provide a means for monoecious hydrilla control in temperate climates.

Mechanical control methods involve physical removal of the plant via hand-pulling or a harvester that sheers off vegetation. As hydrilla spreads rapidly via fragmentation, mechanical removal may not be the best option for this species as fragments are difficult to contain particularly in flowing waters. It also does not address the issue of the tuber bank for only aboveground biomass is removed. Serafy et al. (1994) reported that mechanical harvesting had a "pruning effect" on hydrilla which resulted in even denser plant stands than at un-harvested sites. They also reported a 23% decline in fish numbers and biomass. Haller et al. (1980) also reported declines in fish populations and biomass due to mechanical harvesting techniques. Costs for this control option are estimated at over $2000/hectare

(Langeland 1996). Mechanical harvesting causes more harm than good in some situations as it may lead to the significant decline of fish populations and biomass, and may exacerbate the spread of hydrilla via fragmentation (Haller et al. 1980). It would also be nearly impossible to implement in a rocky river environment with large boulders scattered throughout.

Chemical control with the use of aquatic herbicides is an effective and popular means of hydrilla management. Currently, eight herbicides are registered for hydrilla control in the United States. These include bispyribac-sodium, copper, diquat, endothall, flumioxazin, fluridone, imazamox, and penoxsulam (Table 1). Herbicides used in hydrilla management are either fast or slow acting. Fast acting herbicides, such as copper, diquat, endothall, and flumioxazin, do not require long exposure times. Whereas, slow acting translocated herbicides, such as bispyribac, fluridone, imazamox, and penoxsulam, require days or weeks of contact with the target plant to provide control. Hydrilla may require multiple applications of fast acting herbicides in one growing season due to its rapid growth rates and asynchronous sprouting. Hydrilla tubers contain multiple growth buds within a single tuber. Therefore, sprouting may occur subsequently from the same tuber post application with fast acting herbicides that do not typically translocate to below ground tissue (Nawrocki 2011). Van and Conant (1988) reported that both biotypes of hydrilla could be controlled with applications of 1 mg/L of organic copper, 0.25 mg/L of diquat, or 0.5-1 mg/L of endothall. However, in a flowing system with high water exchange, a minimum of 2.0 mg/L diquat or 5.0 mg/L of endothall and a contact time of six hours would be required. Consequently, these higher required rates may be lethal to valuable non-target species as well (Van and Conant

1988). Flumioxazin has been reported to reduce chlorophyll levels in dioecious hydrilla at concentrations of 100-1,600 µg/L (Mudge et al. 2012). However, efficacy is reduced in high pH or at low light levels. Penoxsulam has been shown to be effective on monoecious hydrilla at rates of 20 µg/L with a 90 day exposure time (Getsinger et al. 2011). The efficacy of imazamox on monoecious hydrilla has also been reported at rates of 200 µg/L (Getsinger et al. 2011). Limited research on bispyribac-sodium shows that it has strong activity on dioecious hydrilla at rates between 10-25 µg/L (Netherland 2011).

Of the slow acting herbicides, fluridone was the first herbicide to provide long-term hydrilla control and has been reported to inhibit tuber and turion production at rates of 5-50 µg/L (MacDonald et al. 1993). Netherland and Getsinger (1995) reported greater than 90% control with treatments of 5 µg/L maintained over a period of 105 days. Netherland et al. (1993) reported 88% control with 12 µg/L maintained for 90 days, and concluded that low rates of fluridone maintained over long periods would be effective in controlling hydrilla in lotic systems. While there is ample research pertaining to the efficacy of chemical control on hydrilla, much of the research has been focused on the dioecious biotype (True-Meadows et al. 2016). Even fewer studies address the efficacy of use in dynamic, flowing systems with high biodiversity and in the presence of rare, threatened, or endangered species (Getsinger et al. 2008).

As hydrilla continues to invade more dynamic, high biodiversity systems such as rivers, estuaries, and reservoirs with high water fluctuation as has been reported in North Carolina

(True-Meadows et al. 2016), there is an increasing urgency to address these gaps in the literature in the areas that pertain to the biology, ecology, and control of this species in such systems.

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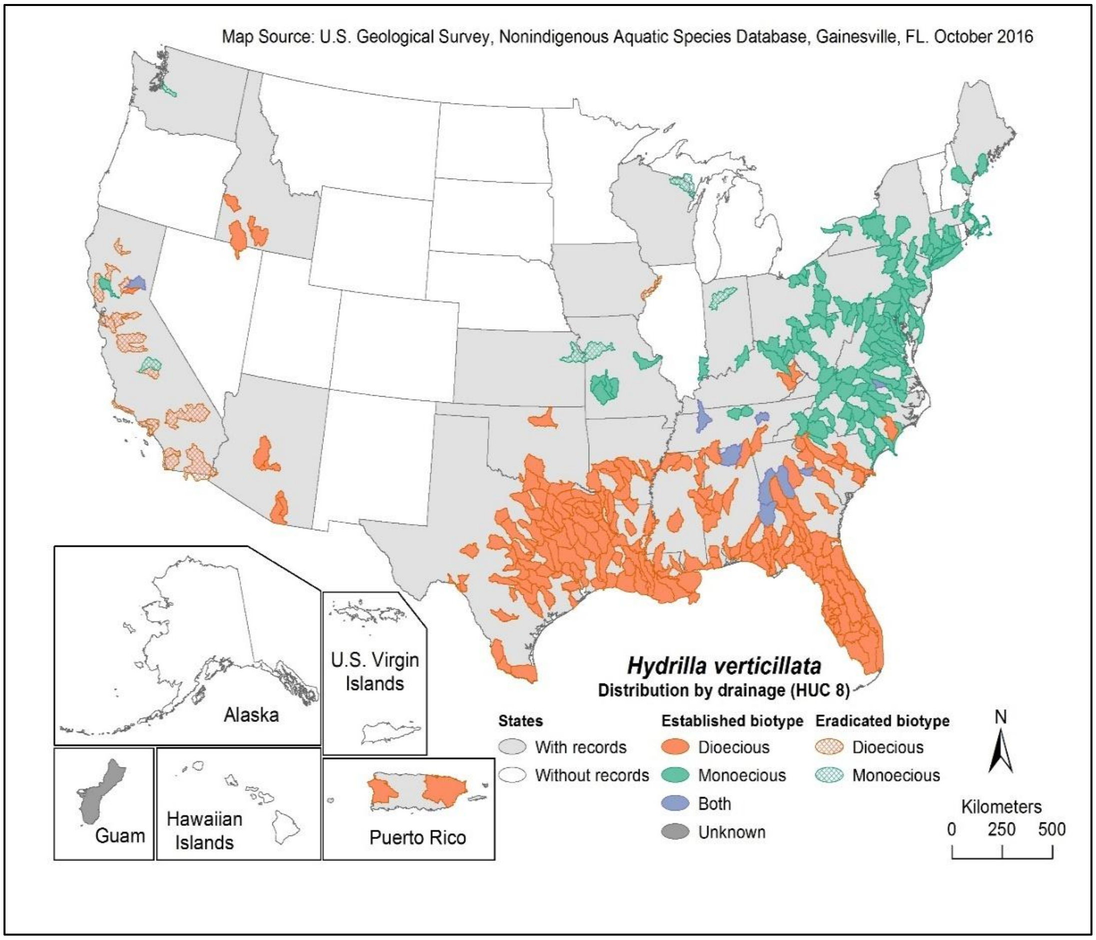

Figure 1. Monoecious and dioecious hydrilla distribution in the United States (USGS 2016).

Table 1. Current EPA registered herbicides for aquatic plant management with activity on hydrilla (Nawrocki 2011, UF / IFAS Center for Aquatic and Invasive Plants)

Active Ingredient	Mode of Action	Application Rates	Fast or Slow Acting
Bispyribac-sodium	Acetolactate synthase inhibitor	5-100 µg/L	Slow
Copper	Cell wall disrupter	0.4-1 mg/L	Fast
Diquat	Photosystem I disrupter	0.25-0.37 mg/L	Fast
Endothall	Protein phosphatase inhibitor	2-5 mg/L	Fast
Flumioxazin	Protoporphyrinogen oxidase inhibitor	100-400 µg/L	Fast
Fluridone	Phytoene desaturase inhibitor	5-90 µg/L	Slow
Imazamox	Acetolactate synthase inhibitor	150-200 µg/L	Slow
Penoxsulam	Acetolactate synthase inhibitor	5-40 µg/L	Slow
Topramezone	4-HPPD enzyme inhibitor	30-50 µg/L	Slow

CHAPTER 2

The Effect of Temperature on Monoecious Hydrilla Tubers and Turions

Abstract

Monoecious hydrilla (*Hydrilla verticillata*) is a problematic submersed weed across the United States and is steadily spreading into more northern latitudes. It behaves as a herbaceous perennial that senesces in the late fall to early winter. Regrowth is dependent upon sprouting of vegetative propagules called turions, which are deposited in vast numbers upon or within the substrate each growing season. Sprouting appears to be at least partly a function of temperature. Timing of sprouting and shoot elongation rates were evaluated for monoecious hydrilla axillary and subterranean turions across a water temperature gradient over a period of twelve days. Propagules were floated in glass jars and placed on a thermal gradient table in row with rows corresponding to six different temperatures. Temperatures evaluated included: T1=41.0˚C, T2=34.9˚C, T3=29.3˚C, T4=24.0˚C, T5=17.6˚C, and T6=12.3˚C. Neither axillary nor subterranean turions sprouted in the hottest and coldest temperatures of 41.0 and 12.3˚C. Optimum shoot elongation for both propagules occurred at 29.3˚C. Shoot lengths were significantly reduced for both turion types in 17.6˚C. Timing of sprouting was not significantly different between axillary and subterranean turions. Results will be useful for predicting the timing of sprouting, and therefore will aid in determining the appropriate timing of herbicide treatments and survey efforts.

Introduction

Hydrilla (*Hydrilla verticillata* (L.f.) Royle) is a submersed macrophyte often called “the perfect aquatic weed” (Langeland 1996), and is one of the most expensive and difficult to control aquatic weeds in the U.S. (Langeland 1996). Two genetically distinct biotypes exist in the United States; a dioecious biotype with only female flowers present, and a monoecious biotype with male and female flowers located on the same plant (Cook and Luond 1982). Monoecious hydrilla was first documented in the U.S. in 1980 in Umstead Lake, NC (True-Meadows et al. 2016), and has been steadily making its way across much of the Atlantic basin and parts of the Pacific and Interior basins of the continental U.S. (Madeira et al. 2000; True-Meadows et al. 2016). In contrast to the dioecious biotype, the monoecious strain appears to be better suited to temperate climates in the U.S., such as regions from North Carolina northward. It also acts as a herbaceous perennial (Harlan et al. 1985). Therefore, regrowth is dependent upon sprouting of subterranean and axillary turions (Harlan et al. 1985). Hydrilla produces large amounts of subterranean and axillary turions, and it is the sprouting of these vegetative propagules that help facilitate its persistence throughout the United States. Subterranean turions form at terminal rhizome nodes, and are widely referred to as tubers and will be referred to as such from here on. Axillary turions, often referred to as just turions, are formed in leaf or branch axils (Yeo et al. 1984). Turions become detached from the parent plant via development of an abscission zone. Whereas, tubers become detached when the parent rhizome senesces (Yeo et al. 1984). Once detached, tubers and turions “serve as a persistent meristem bank (analogous to a seed bank)” (Netherland, 1997), thereby hindering management.

In general, there is considerably less research pertaining to monoecious hydrilla as compared to dioecious hydrilla (Steward and Van 1987; True-Meadows et al. 2016), especially regarding the sprouting of tubers and turions under varying temperatures. Steward and Vann (1987) reported that monoecious tubers sprout at lower temperatures than dioecious. However, turions were not considered in their studies. Carter et al. (1987) determined that a chilling period is required in order to induce sprouting in monoecious tubers, however temperature induced sprouting was not explored. As successful management of this plant is largely dependent upon understanding factors which influence the sprouting and growth of tubers and turions (Netherland 1997), there is an increasing need to investigate sprouting requirements for both tubers and turions. This study aims to determine differences in sprouting frequencies and growth rates for both tubers and turions across a water temperature gradient.

Methods

Lab studies were conducted at North Carolina State University in 2015 and 2016. Hydrilla propagules were collected from Shearon-Harris Reservoir located near New Hill, NC. Prior to the study, propagules were refrigerated for approximately 15 to 30 days. Hydrilla propagules were floated in glass jars (Pyrex 100 x 80 mm No. 3250) and placed on a thermal gradient table to determine differences in sprouting frequencies and shoot elongation rates at varying temperatures. Jars were filled with 1.5 cm of pea gravel with a filter paper placed on top followed by 320 ml of deionized water. Five tubers and five turions were placed in each jar. Watch glasses were placed on all jars to limit water loss through evaporation (Figure 2). Jars were arranged in rows on a thermal gradient table with rows corresponding to six different temperatures. Treatments were replicated five times with jars as replications. Temperature of each jar was determined every other day via an electronic thermometer.

Average temperature by row was as follows T1=41.0˚C, T2=34.9˚C, T3=29.3˚C, T4=24.0˚C, T5=17.6˚C, and T6=12.3˚C. Sprouting frequency and maximum shoot length were determined every other day for 12 days. Shoot length was measured in millimeters via electronic calipers. Two runs were completed with run 1 conducted in February 2015 and run 2 conducted in March 2016.

Shoot length data were analyzed using a linear mixed model in JMP Pro 12 (SAS Institute Inc., Cary, NC). Prior to analysis, data were log transformed [Log (length+0.5)] to improve normality. However, untransformed means are presented for clarity. Run, as a fixed effect, was determined to be insignificant ($p > F = 0.93$; $\alpha=0.05$), therefore, data were combined across both runs. Sprouting frequency data were modeled using a logistic regression model (PROC LOGISTIC in SAS) (SAS Institute Inc., Cary, NC) as number of sprouted propagules/number available. Neither tubers nor turions sprouted in the highest or lowest temperatures (T1=41.01˚C and T6=12.30˚C). Therefore, data for T1 and T6 are not presented.

Results & Discussion

In this study, the attached tuber or turion served as the only nutrient source for the plant. Use of deionized water free from the artificial addition of nutrients as the test solution eliminated outside influences on sprouting rates and stem elongation. Both tubers and turions sprouted more rapidly and had maximum shoot lengths at T3, with average shoot lengths of 42.0 and 33.9 mm, respectively (Figure 3). Shoot lengths were significantly reduced at T5 for both propagule types (Figure 3). Turions sprouted faster than tubers, however final tuber shoot lengths exceeded final turion shoot lengths at all temperatures. These results are similar to Mcfarland and Barko (1987) who reported optimum biomass production at 28 and 32˚C and severely reduced growth at 12 and 16˚C.

Earlier sprouting of turions is consistent with the findings of Spencer and Ksander (2001). However, sprouting frequency by type (tuber vs. turion) was not significant ($p = 0.97$) in our model. Temperature was a significant factor influencing both turion and tuber sprouting rates ($p < 0.0001$). Near complete sprouting was observed for both tubers and turions at T2 and T3 with average sprouting at 96-100% at T2 and 96% at T3 (Table 2). Steward and Van (1987) found similar results at 22 and 30˚C. After twelve days, 68-100% of tubers and turions had sprouted at our lowest temperature (T5=17.6˚C). This is a higher sprouting frequency than reported by Steward and Van (1987) who observed only 35-68% sprouting after three weeks of exposure to 15˚C. These differences could be due to our slightly higher temperature of 17.6˚C versus their temperature of 15˚C indicating that a mere two degrees could have serious impacts on sprouting rates *in situ*.

Previous research indicates that hydrilla has the capacity to become established in more northern latitudes than where it is currently found. These include Alaska and the sub-arctic ranges of Canada (Hartis 2013). These latitudes exhibit cooler water temperatures in the spring compared to spring water temperatures in monoecious hydrilla's current range. Therefore, sprouting may be delayed in these regions. Elevation may also influence the timing of sprouting due to lower temperatures found at higher elevations (Meays 2000).

Temperature gradients witnessed on a smaller spatial scale should also be considered. Within a single stream, temperatures typically increase with distance from the source (Hawkins et al. 1997). Strong vertical thermal stratification has also been documented in lentic environments with temperature differences reaching 10 to 15˚C between surface and bottom waters in the peak of summer stratification (Imberger 1985).

Timing of sprouting or propagule emergence may also play a role in competitive plant interactions (Spencer and Ksander 2001). Hydrilla has been shown to outcompete other submersed species including *Elodea canadensis* Michx., *Vallisneria americana* Michx., *Potamogeton crispus* L., and Eurasian watermilfoil (*Myriophyllum spicatum* L.) (True-Meadows 2013). Eurasian watermilfoil is also a highly invasive aquatic weed that is a large problem in the northern U.S. and southern Canada. Sprouting followed by rapid growth occurs when water temperatures reach 15˚C (Smith and Barko 1990). Hydrilla's previously documented competition with Eurasian watermilfoil coupled with its ability to sprout in similar temperatures further points to the potential for hydrilla to become a nuisance species in northern latitudes.

The results of this study have practical implications because management practices can be optimized by monitoring environmental conditions. Low temperatures that reduce sprouting or subsequent growth should also delay herbicide applications. Failure to monitor sediment temperatures or identify temperature gradients in a water body could lead to reduced control and/or wasted resources. Surveys should not be conducted until water temperatures reach

17˚C for at least two weeks. This is especially important in lotic systems that often exhibit cooler temperatures in their headwaters. Our results should also be considered when implementing management programs across latitudes or elevations.

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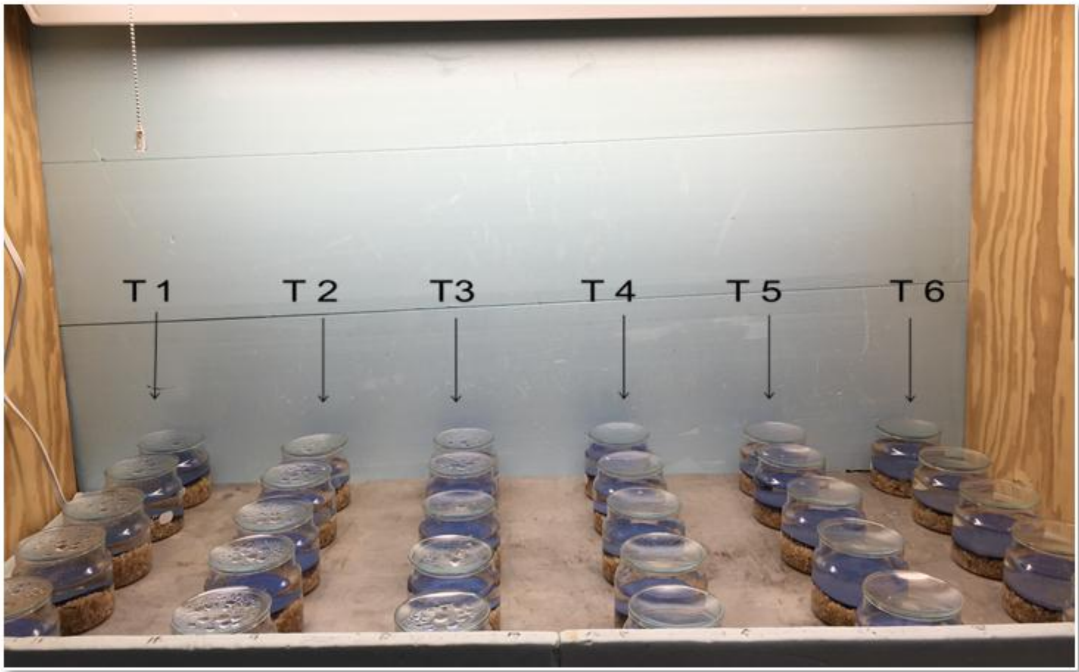

Figure 2. Picture of experimental setup with test jars placed on thermal gradient table in their respective temperature row.

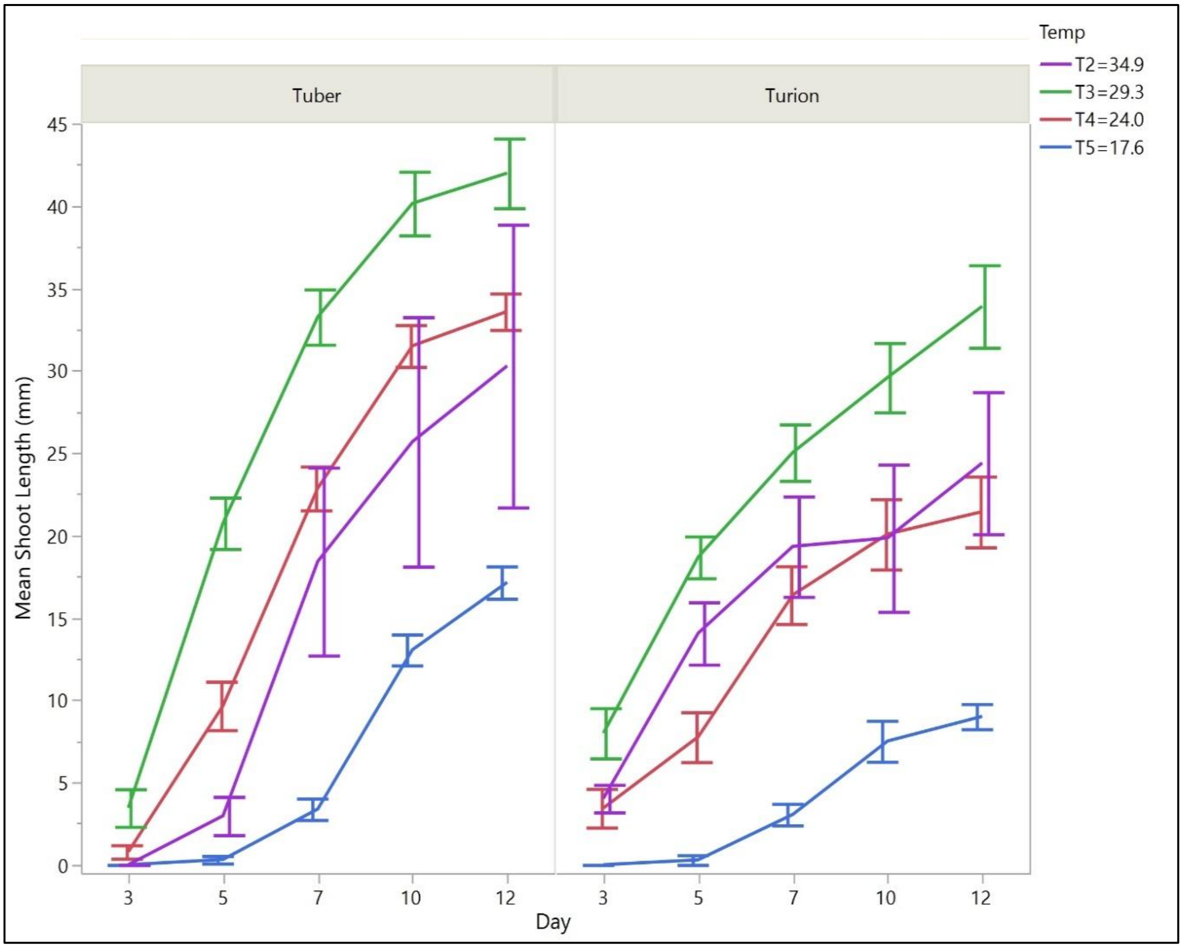

Figure 3. Average shoot length of sprouted hydrilla tubers and turions over time.

Table 2. Hydrilla sprouting frequency means for tubers and turions over a period of 12 days at T2-T5 (34.9-17.6˚C).

Temperature		Time	Sprouting frequency	
			Tuber	Turion
˚C	#		%	
34.9	2	Day 3	0	52
		Day 5	24	96
		Day 7	92	96
		Day 10	100	96
		Day 12	100	96
29.3	3	Day 3	12	76
		Day 5	96	92
		Day 7	96	96
		Day 10	96	96
		Day 12	96	96
24.0	4	Day 3	0	0
		Day 5	80	44
		Day 7	80	72
		Day 10	92	72
		Day 12	92	72
17.6	5	Day 3	0	0
		Day 5	0	0
		Day 7	44	24
		Day 10	100	60
		Day 12	100	68

CHAPTER 3

Salinity Tolerance of Monoecious Hydrilla: Survivability, Growth, and Sprouting

Abstract

Monoecious *Hydrilla verticillata* is one of the most difficult weeds to control in the United States. As hydrilla continues to invade increasingly dynamic systems, namely rivers that empty into brackish waters, salinity will likely be the greatest factor in determining its expandable range. Salinity tolerance was evaluated for both sprouted and unsprouted monoecious hydrilla tubers. Sprouted tubers were placed in an incubator held at 23˚C with a photoperiod of 14 h light: 10 h dark. Unsprouted tuber trials were conducted in a greenhouse facility. Tested salinities included a range of 0 to 24 ppt at exposure times of 2 to 8 weeks followed by a two-week recovery period. Shoot length, number of lateral branches, and fresh and dry weights were determined. Sprouted tubers tolerated 8 weeks in 6 ppt and 4 weeks in 9 ppt, following the recovery period. Fresh weights of sprouted tubers increased from starting weights in salinities up to 9 ppt, however, all dry weights were reduced from the control. Unsprouted tubers sprouted in salinities up to 12 ppt, although shoot lengths and fresh weights were reduced from the control. Lateral branching increased in salinities of 3 to 6 ppt, relative to the control. Results indicate the potential for hydrilla to spread into brackish waters and withstand periodic salt intrusion events.

Introduction

Hydrilla verticillata (L.f.) Royle is a highly invasive submersed weed. It was first introduced to the United States in 1960 in Florida, and has made its way as far west as California (Harlan et al. 1985) and as far north as Maine (Maine DEP). There are two distinct biotypes of hydrilla established within the U.S.: a monoecious and a female dioecious biotype (Blackburn et al. 1969; Cook and Luond 1982). The monoecious biotype is typically found in more temperate climates within the U.S. (Netherland 1997) such as North Carolina and northward. Whereas, the dioecious biotype is found in warmer climates of the U.S. (Netherland 1997).

Hydrilla is notoriously difficult and costly to control due in part to its prolific production of vegetative propagules (True-Meadows et al. 2016). These vegetative buds, called turions, are formed in leaf or branch axils and at the terminal end of positively geotropic rhizomes (Van et al. 1978). Rhizome formed turions, or subterranean turions, are widely referred to as tubers and will be referred to as such from here on. Tubers and turions detach from the parent plant either from an abscission zone for turions, or as the parent rhizome senesces for tubers (Yeo et al. 1984). Great numbers of tubers are formed in the sediment each growing season adding to the "tuber bank" which acts as a seed bank. This is the mechanism that allows monoecious hydrilla to overwinter in temperate climates, and aids in rapid revegetation after control treatments or ecological stress (Netherland 1997).

As monoecious hydrilla continues to invade increasingly dynamic and high biodiversity systems such as "flowing rivers, estuaries, and reservoirs with high water fluctuation" (True-Meadows et al. 2016), there is a need to determine how hydrilla will respond when exposed to varying environmental stressors that the aforementioned systems may present. Determining salinity tolerance is of particular importance since many of these more recent sites of hydrilla invasion, such as the Chowan and Roanoke rivers in eastern NC, empty into brackish waters which imparts a salinity gradient that may determine hydrilla's expandable range. Additionally, current climate change models predict that salinity variability will increase along the eastern mid-Atlantic coastal waters, and that salt water intrusion events lasting greater than a month will be more frequent (Najjar et al. 2010). Salinity tolerance of hydrilla has been previously reported, however, there are discrepancies within the literature. It was reported that dioecious hydrilla failed to grow after four weeks in 6 ppt (Haller et al. 1974), and monoecious hydrilla showed little productivity at 4 ppt (Twilley and Barko 1990). In contrast, Steward & Van (1984) reported a 13 ppt threshold for both monoecious and dioecious hydrilla. These studies did not address the effect of salinity on unsprouted tubers, nor did they evaluate the ability of the plant to recover after varying exposure times. Therefore, the objective of this study was to determine growth rate, biomass production, and survivability of both sprouted and unsprouted monoecious hydrilla tubers across a salinity gradient at multiple exposure times followed by a recovery period in fresh water.

Methods

Test propagules. Unsprouted monoecious hydrilla tubers were collected from Shearon-Harris Reservoir located near New Hill, NC with the exception of tubers used in run 2 of the greenhouse salinity tests. Tubers used in run 2 were collected from stock plants grown in outdoor mesocosms which originated from NC sources. Tubers intended for laboratory tests were sprouted in de-chlorinated tap water until average shoot length reached approximately 40 millimeters. Tubers intended for greenhouse tests were refrigerated for a minimum of one week.

Laboratory salinity tolerance test. Salinity tolerance tests on sprouted tubers were conducted in the Aquatic Toxicology Laboratory in the Department of Applied Ecology, North Carolina State University. Instant Ocean (Aquarium Systems, Mentor, OH) was mixed with reconstituted soft water to achieve our desired salinities of 0, 3, 6, 9, 12, 18, and 24 ppt. No fertilizer was added to the test solution in order to eliminate outside influences on stem elongation rates. Sprouted tubers were randomly selected and placed in Pyrex No. 3250 jars containing our test salinity solution with five tubers per jar. Watch glasses were placed on all jars to limit evaporation and changes in salinity. Initial shoot lengths were measured, and total fresh weight by jar was determined. Jars were placed in an incubator at 23˚C with a photoperiod of 14 h light: 10 h dark using Phillips Natural Sunshine bulbs. Sprouted tubers were subjected to the various salinities for 2, 4, 6, or 8 weeks. Three replicates were included for each concentration (salinity) exposure time combination. After their respective exposure time, sprouted tubers were rinsed and placed in fresh reconstituted soft water for an additional two weeks. Shoot length was measured weekly and number of lateral branches was noted. Weekly measurements were collected on a subsample of the population (105 shoots; 3 jars per salinity). Ending fresh and dry weights were determined for each jar. Fifty percent water renewals occurred every week for every treatment. Water quality tests were performed at the start of the trial and during water renewals by testing a composite sample of each salinity. Parameters measured included temperature, salinity, dissolved oxygen, conductivity, pH, hardness, and alkalinity. Standard methods as described by Bringolf et al. (2005) were followed for all water chemistry analyses.

Greenhouse salinity tolerance tests. Salinity tolerance tests on unsprouted tubers were performed in the greenhouse facility at the Weed Control Lab at North Carolina State University. Instant Ocean was mixed with de-chlorinated tap water to achieve the same salinities as above. No nutrients were added to the test solution in order to eliminate outside influences on sprouting and stem elongation rates. Tubers were floated in Pyrex No. 3250 jars with five tubers per jar. Watch glasses were placed on jars to limit evaporation and changes in salinity. Beginning tuber fresh weight by jar was determined prior to treatment. Shoot length (mm), sprouting frequency, and number of lateral branches were determined weekly. Ending biomass was harvested and fresh and dry weights were recorded. Two rounds were completed with three replications.

Analysis. Data including shoot length, fresh and dry weights, and lateral branching were analyzed using a linear model in JMP Pro 12 (SAS Institute Inc., Cary, NC). Prior to analysis, lateral branching data were log transformed [Log (#branches+1)] to improve normality. However, untransformed means are presented for clarity. Tubers exposed to 18 and 24 ppt in our greenhouse trials did not sprout, therefore, data from these salinities are not presented. Data from both runs in the greenhouse trials were not able to be combined, therefore they are presented separately.

Results & Discussion

Laboratory salinity tolerance tests. Salinity was a significant factor affecting shoot length, number of lateral branches, and biomass production of sprouted hydrilla tubers.

Water quality. Average temperature was 22.7˚C. Dissolved oxygen values ranged from 6.01-10.90 mg/L with an average value of 8.35 mg/L. Average pH was 8.21 with a range of 7.47-9.48. Conductivity, alkalinity, and hardness increased with increasing salinity (Table 3). Hardness values in salinities of 6 ppt and above exceeded 600 mg $CaCO_3$/L and were higher than could be measured with our equipment and methods.

Shoot length. Shoot length decreased with increasing salinity. After eight weeks of exposure, average shoot length was reduced between 32 to 88 % from the control at all salinities (Figure 4). Although extension rates were reduced, shoot length continued to increase in salinities of 6 ppt or lower after eight weeks of exposure (Figure 5). Shoots exposed to 9 ppt or higher did not exhibit any significant increase in shoot length regardless of exposure time.

Shoot length following recovery period. Shoots subjected to salinities up to 3 ppt showed little to no change in shoot length after the recovery period of two weeks in fresh water (Figure 6). Change in shoot length after recovery was not significant. Shoots exposed to 6 ppt were able to recover after eight weeks of exposure, and those subjected to 9 ppt recovered from four weeks of exposure. However, no increase in shoot length occurred in exposures greater than four weeks for 9 ppt salinity. Shoots subjected to salinities of 12 ppt and higher did not exhibit any ability to recover even after the shortest exposure time (Figure 6) (Recovery is indicated by a positive change in shoot length after exposure to fresh water).

Number of lateral branches. Salinity significantly affected the number of lateral branches ($p < 0.0003$) (Figure 7). Shoots exposed to salinities of 3 and 6 ppt had significantly more lateral branches than any other treatments with means of 9.07 and 7.33, respectively. Shoots exposed to 0 and 9 ppt had the next highest levels of lateral branching with means of 6.25 and 4.01, respectively. All other treatments averaged less than two lateral branches per shoot.

Biomass production. Overall biomass increased in treatments of 0, 3, 6, and 9 ppt as indicated by a positive change in ending versus starting fresh weights (Figure 8). However, biomass decreased in treatments of 12 ppt and higher indicated by a negative change of fresh weights. Decreased biomass is due to the necrosis of a portion of the shoots. Dry weights of all treatments were significantly reduced from the control ($p = 0.0029$) (Figure 9). Weights were averaged over all exposure times including the two-week recovery period.

Greenhouse salinity tolerance tests. Salinity significantly affected stem extension rates, lateral branching, and biomass production of unsprouted monoecious tubers.

Sprouting.

Run 1. Sprouting was significantly affected by salinity ($p < 0.0001$). Tubers began sprouting within the first five days of exposure for salinities of 0-9 ppt (Figure 10). Average sprouting frequencies for these salinities reached 70-90 %. Sprouting in 12 ppt did not occur until 4 weeks after exposure, and only an average of 30% of the tubers sprouted.

Run 2. Sprouting was significantly affected by salinity ($p < 0.0001$). Tubers exposed to 0 ppt began sprouting within the first five days (Figure 10), and average sprouting frequencies reached 90% over the course of the study. Sprouting in 3 and 6 ppt did not occur until 2 weeks after exposure with average sprouting frequencies reaching 6-13 %. Tubers exposed to 9 ppt and above did not sprout.

Shoot length.

Run 1. Shoot length was inversely related to salinity. After eight weeks of exposure, all shoot lengths were significantly reduced from the control ($p = 0.0105$) with average ending shoot length for 0 ppt at 55.2 mm. However, shoots subjected to 3 ppt, albeit reduced, were not significantly different from the control up to the seven-week mark (Figure 11). Shoots exposed to 6 ppt and above were reduced from the control for the entire length of treatment (Figure 11).

Run 2. All shoot lengths were reduced from the control ($p = 0.0096$) with average ending shoot length for 0 ppt at 39.7 mm. Shoots in 3 ppt and 6 ppt were not significantly different from each other with ending average shoot lengths of 9.8 and 14.0 mm, respectively (Figure 12).

Number of lateral branches.

Run 1. Salinity affected the number of lateral branches ($p < 0.0001$). Shoots exposed to 3 ppt had the highest number of lateral branches with an average of 5.6 branches (Figure 13). Shoots from 0 and 6 ppt had the next highest level of lateral branching with means of 4.5 and 4.8, respectively. Salinities of 9 and 12 ppt further reduced lateral branching with means of 3.1 and 0.3, respectively (Figure 13).

Run 2. Lateral branching was reduced in run 2 as compared to run 1. Average ending number of lateral branches in the control was 2.5 and less than 1 in all other treatments (Figure 14).

Biomass production.

Run 1. Salinity significantly affected ending fresh ($p = 0.0004$) and dry weights ($p = 0.0193$). Fresh weights were reduced from the control in salinities of 6 ppt and above (Figure 15). Shoots in 0 and 3 ppt had the highest fresh weights at 3.19 and 2.5 grams, respectively

(Figure 15). In contrast, dry weight did not reflect as much variability between salinities. Only shoots subjected to 12 ppt had dry weights that were significantly reduced from the control (Figure 16).

Run 2. Ending average fresh weights were reduced from the control at all salinities ($p = 0.0025$). Fresh weights from all other salinities were not significantly different from each other (Figure 17). No differences were detected in dry weights between the control and all other treatments (data not shown).

In this study, monoecious *Hydrilla verticillata* was negatively affected by long periods of exposure to high salinities. However, it appears to be tolerant to short periods of exposure to low salinities. Shoots from sprouted tubers were still growing at eight weeks of exposure to 6 ppt and were able to recover after four weeks at 9 ppt as evidenced by increased shoot length and fresh weight. These results differ from previous studies that report that hydrilla did not grow in 6.66 ppt, died in 10 ppt, and did not survive after 1 day of exposure to 15 ppt (Haller et al. 1974; Frazer et al. 2006). The difference in results could be due to variances in salinity tolerance between biotypes of monoecious and dioecious hydrilla. Both Haller et al. (1974) and Frazer et al. (2006) conducted their studies on the dioecious biotype (Haller et al. biotype assumed to be dioecious due to location of plant collection). However, Twilley and Barko (1990) reported little productivity of monoecious hydrilla above exposure to 4 ppt which is also lower than our reported range, and Steward and Van (1987) reported no discernible differences between biotypes. Studies that reported lower salinity tolerance than our study were conducted using shoot cuttings that were not attached to a tuber or turion (Haller et al.

1974; Twilley and Barko 1990; Frazer et al. 2006). In contrast, Steward and Van (1987) used sprouted tubers in their salinity exposure tests. They reported tolerances up to 13 ppt (regardless of biotype) which more closely aligns with our results. Therefore, it seems likely that the notable discrepancies within the literature are more a factor of whether or not the plants were attached to the tuber or turion during the length of exposure rather than biotype.

Monoecious hydrilla may be able to survive in these low salinities by increased lateral branching at 3 ppt and 6 ppt, relative to the control. This, in turn, may increase the number of viable fragments which could lead to further spread and new infestations of this highly invasive plant should the fragments be transported to areas with favorable conditions. Previous studies with dioecious hydrilla had contradictory results in which the control had the highest branching and no branches were added in 15 and 25 ppt (Frazer et al. 2006).

These results indicate that plants grown from sprouted monoecious hydrilla tubers show little difference in growth parameters as compared to the control in salinities up to 3 ppt, and were able to recover after four weeks in 9 ppt and at least eight weeks at 6 ppt. Minimal recovery was seen in the control and in 3 ppt. As aforementioned, this was likely due to variances between subsamples. Recovery conditions were not drastically different (or not different at all in the case of the control) from treatment conditions for these salinities. This resulted in little change. Recovery conditions were drastically different from treatment conditions in the higher salinities resulting in greater recovery. Therefore, the impact of the variance between subsamples in 0 and 3 ppt was exacerbated by these lower stem extension rates.

Unsprouted tubers appeared to be less tolerant to salinity with reduced shoot lengths and fresh weights occurring in salinities of 6 ppt and above in the greenhouse trials. Although dry weights at 6 ppt were not reduced. Sprouting occurred in salinities up to 12 ppt. This is higher than the previously reported maximum sprouting salinity of 9 ppt (Carter et al. 1987). Run 2 of our unsprouted tuber trial showed even greater sensitivity, and sprouting did not occur in salinities of 9 ppt and higher. However, this run of the trial was conducted toward the end of the year when day lengths were shorter. This and the difference in tuber origin may have contributed to reduced sprouting and stem extension rates in run 2.

Monoecious hydrilla produces tubers in vast numbers each growing season. In a laboratory study, a single monoecious tuber produced over 6,000 new tubers in just 16 weeks (Sutton et al. 1992). In hydrilla infested water bodies in North Carolina, tuber bank densities have been reported to be as great as 1,312 – 3,077 tubers/m^2 (Harlan et al. 1985; Nawrocki 2011). Recent research suggests that monoecious hydrilla tubers can remain viable within the hydosoil for at least six years (Nawrocki 2016). These structures allow hydrilla to withstand and recover from ecological stress (Netherland 1997). Our results suggest that once a tuber bank becomes established it may be able to withstand temporary salt intrusion of low salinities.

If current climate change models are correct in predicting more frequent, month-long salt water intrusion events along the east coast (Najjar et al. 2000; Najjar et al. 2010), hydrilla may be able to survive when other submersed fresh water species may not. This lowered interspecific competition coupled with predicted increased spread through fragmentation could exacerbate the spread of hydrilla along the mid-Atlantic tidal waters.

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Table 3. Average water quality conditions for laboratory hydrilla salinity testing.

Salinity ppt	Temp ˚C	DO mg/L	pH	Alkalinity mg $CaCO_3$/L	Hardness mg $CaCO_3$/L	Conductivity µS
0	23.24	9.50	9.01	22	39	180
3	23.08	9.33	8.66	32	562	5,327
6	22.72	8.51	8.06	43	>600	10,702
9	22.49	7.78	7.87	51	>600	14,717
12	22.37	7.63	7.78	57	>600	19,317
18	22.47	7.97	8.12	66	>600	28,883
24	22.60	7.73	7.97	77	>600	35,679

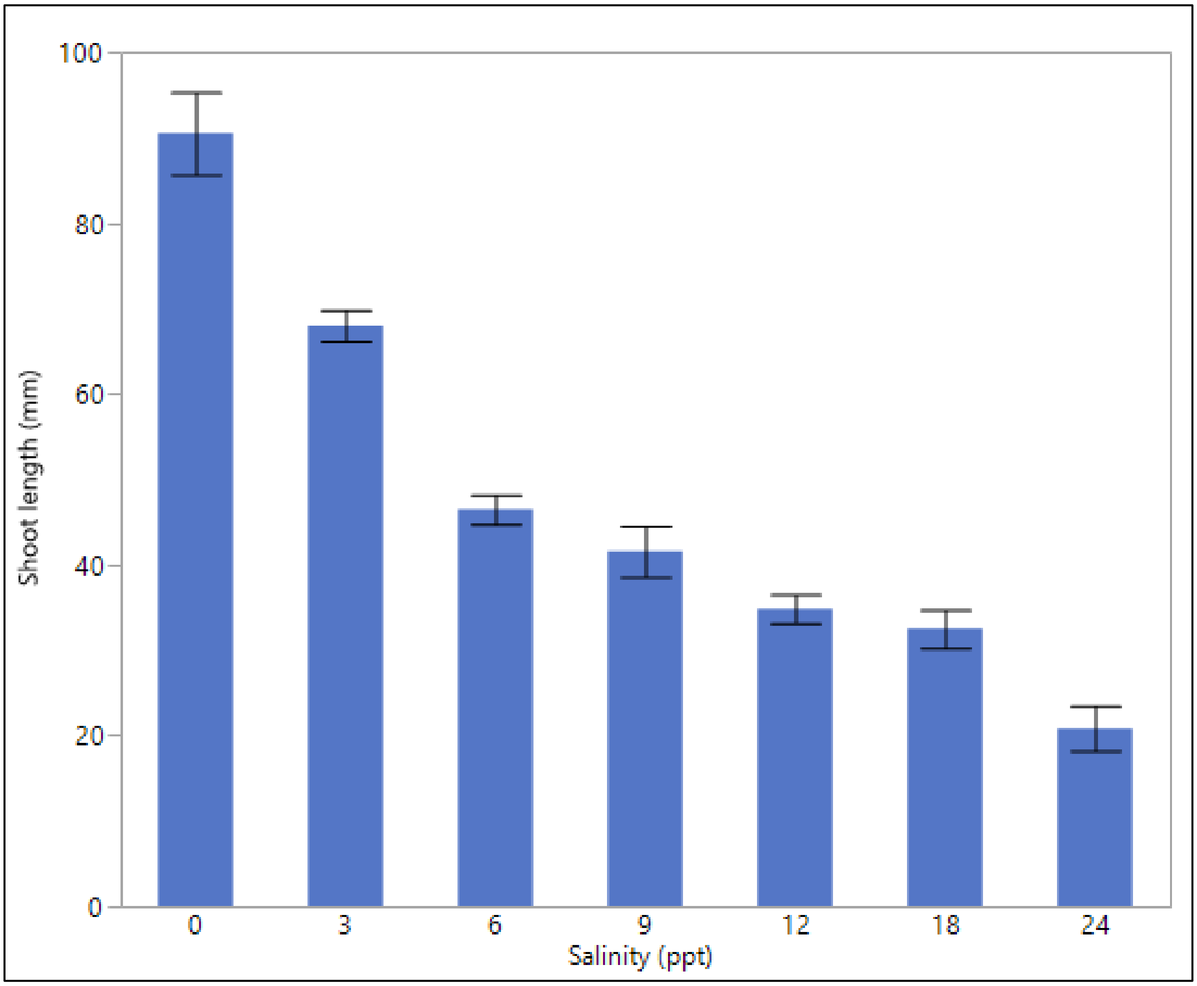

Figure 4. Average ending shoot length of sprouted hydrilla tubers (including those that no longer had shoots attached) after eight weeks of exposure to varying salinities. Average starting shoot length was 40 mm. Shoot lengths were reduced from the control (0 ppt) at all salinities ($p < 0.001$). Error bars were constructed using 1 standard error from the mean.

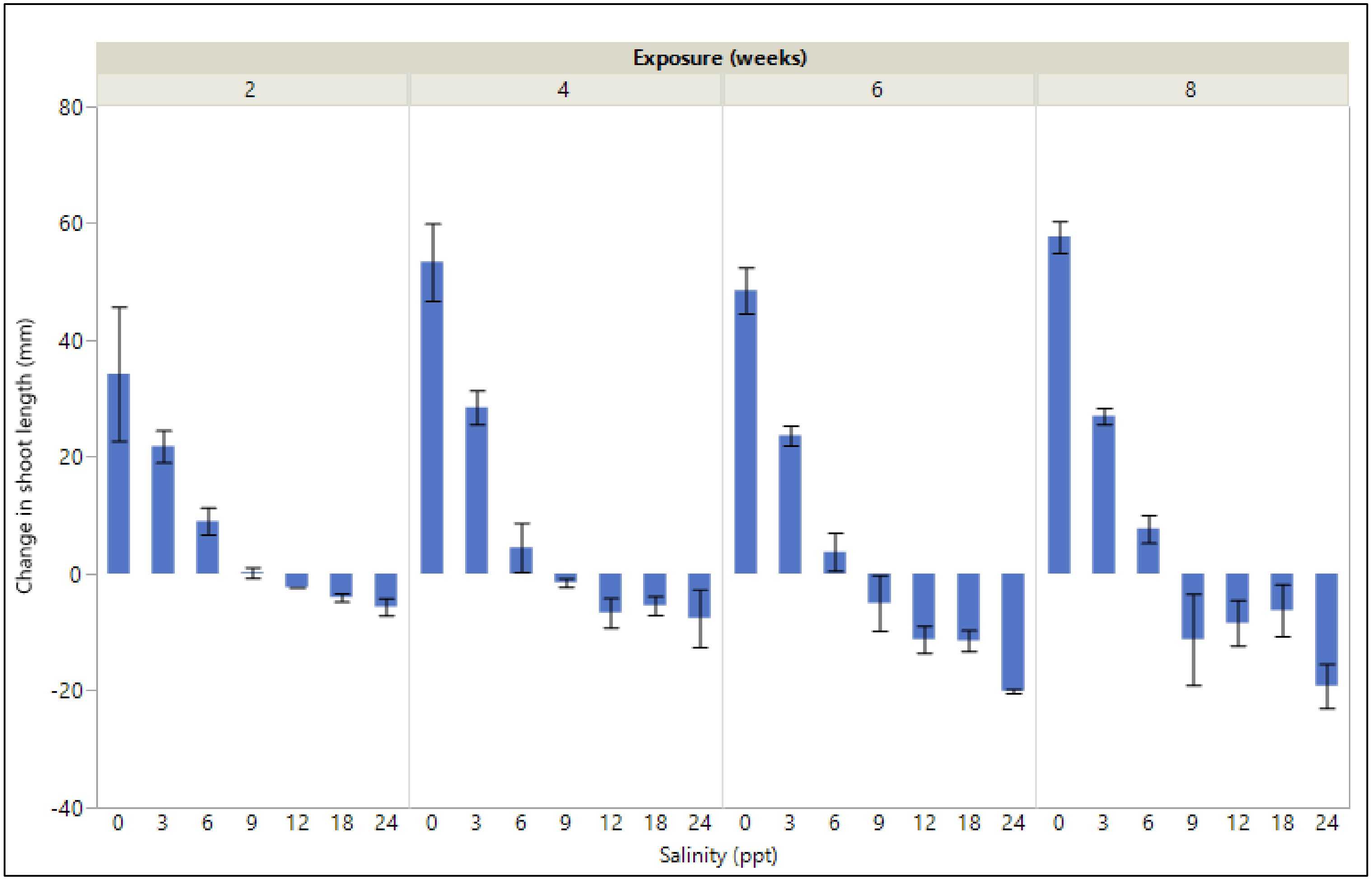

Figure 5. Average change in hydrilla shoot length across multiple salinities and exposure times with error bars representing 1 standard error from the mean. Shoot length was significantly affected by exposure time ($p = 0.0481$) and salinity ($p < 0.0001$). Positive values indicate an increase in shoot length. Negative values indicate mortality of a portion of the shoots.

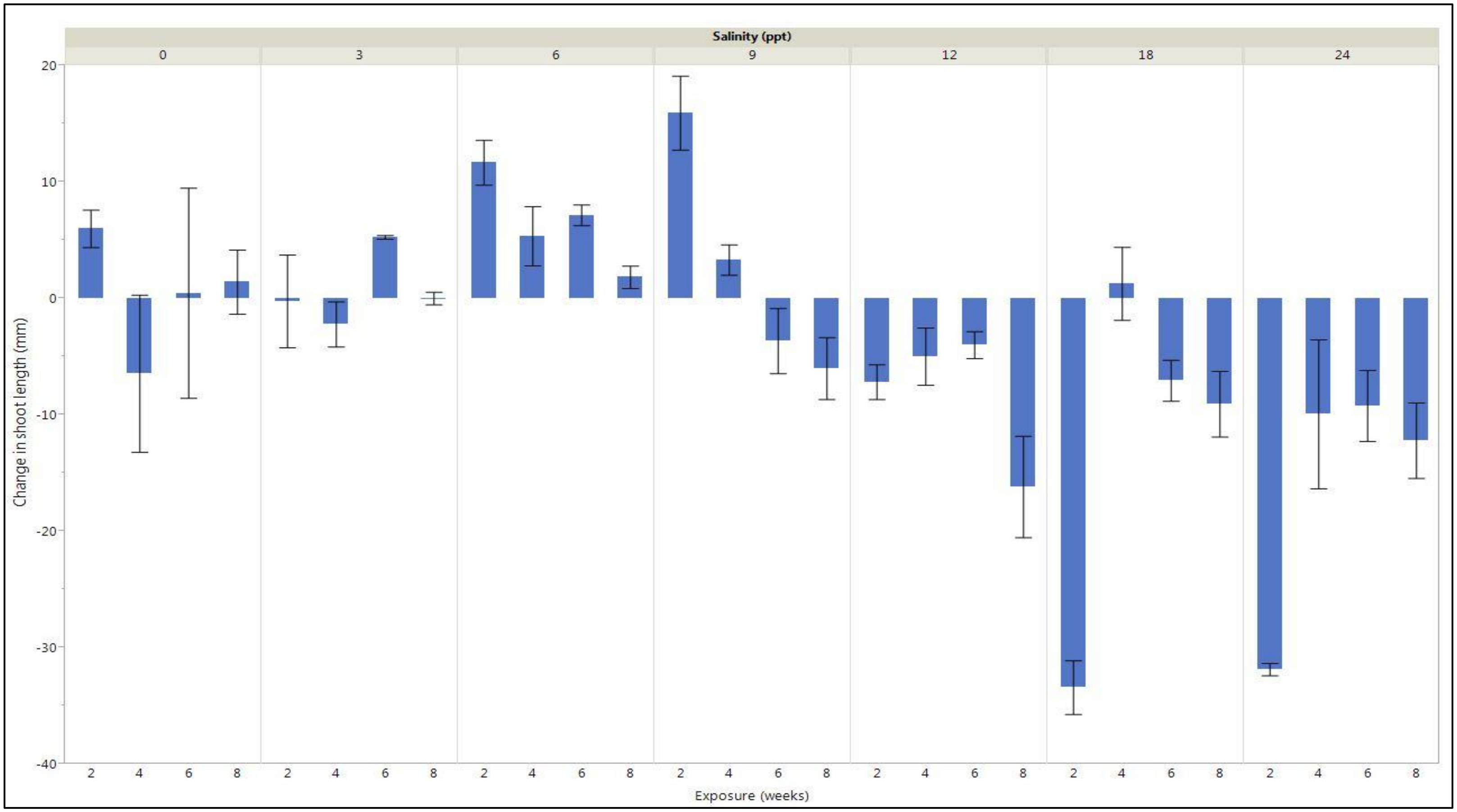

Figure 6. Mean change in hydrilla shoot length across multiple exposure times to salinities of 0-24 ppt followed by a two-week recovery period in fresh water. Shoot lengths were significantly affected by exposure time ($p = 0.0481$) and salinity ($p < 0.0001$). Positive values indicate an increase in shoot length. Negative values indicate further necrosis. Error bars represent 1 standard error from the mean.

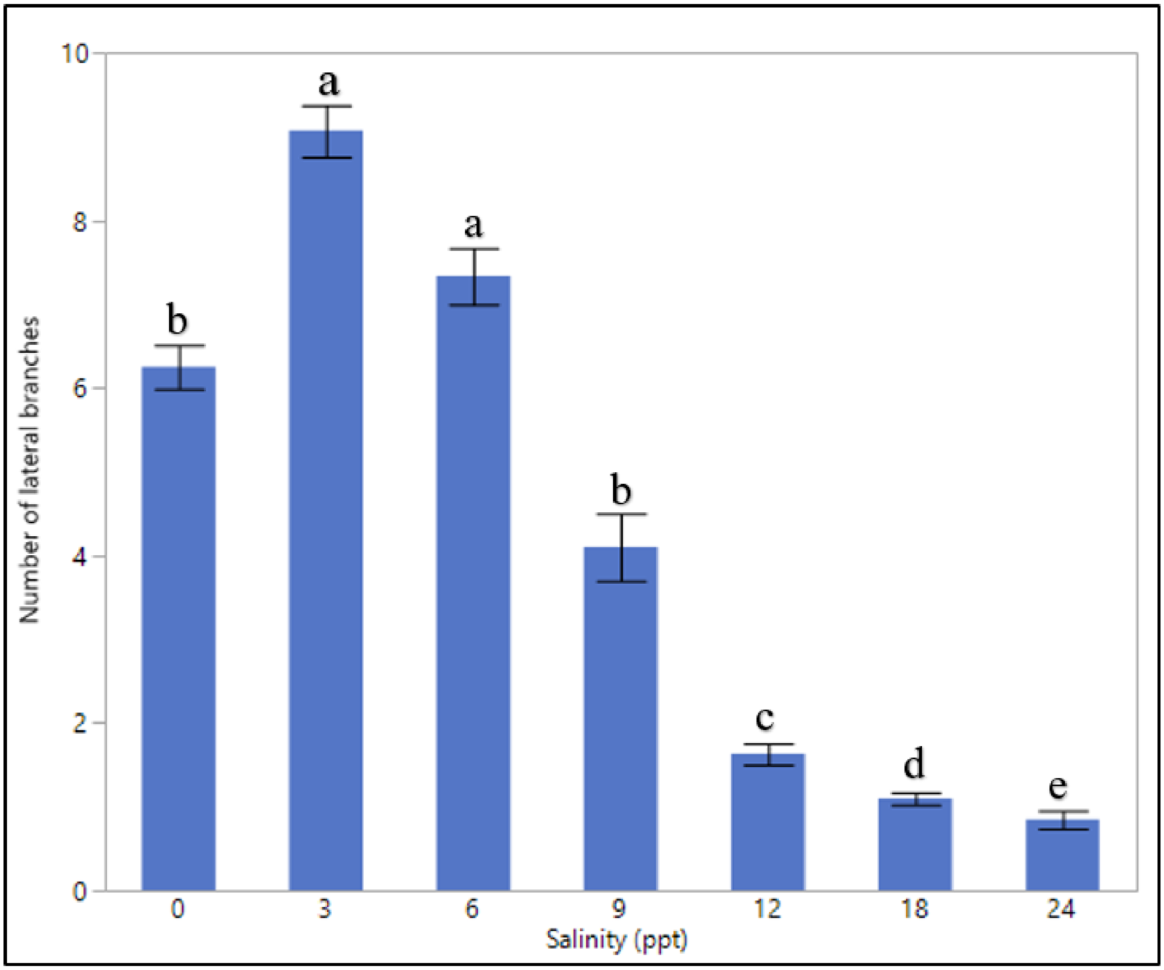

Figure 7. Mean number of lateral branches by salinity averaged over all exposure times. Treatments of 3 and 6 ppt had the highest number of lateral branches ($p < 0.0001$). Means with different letters are significantly different. Significance was determined using log transformed means. Error bars represent 1 standard error from the mean using untransformed means.

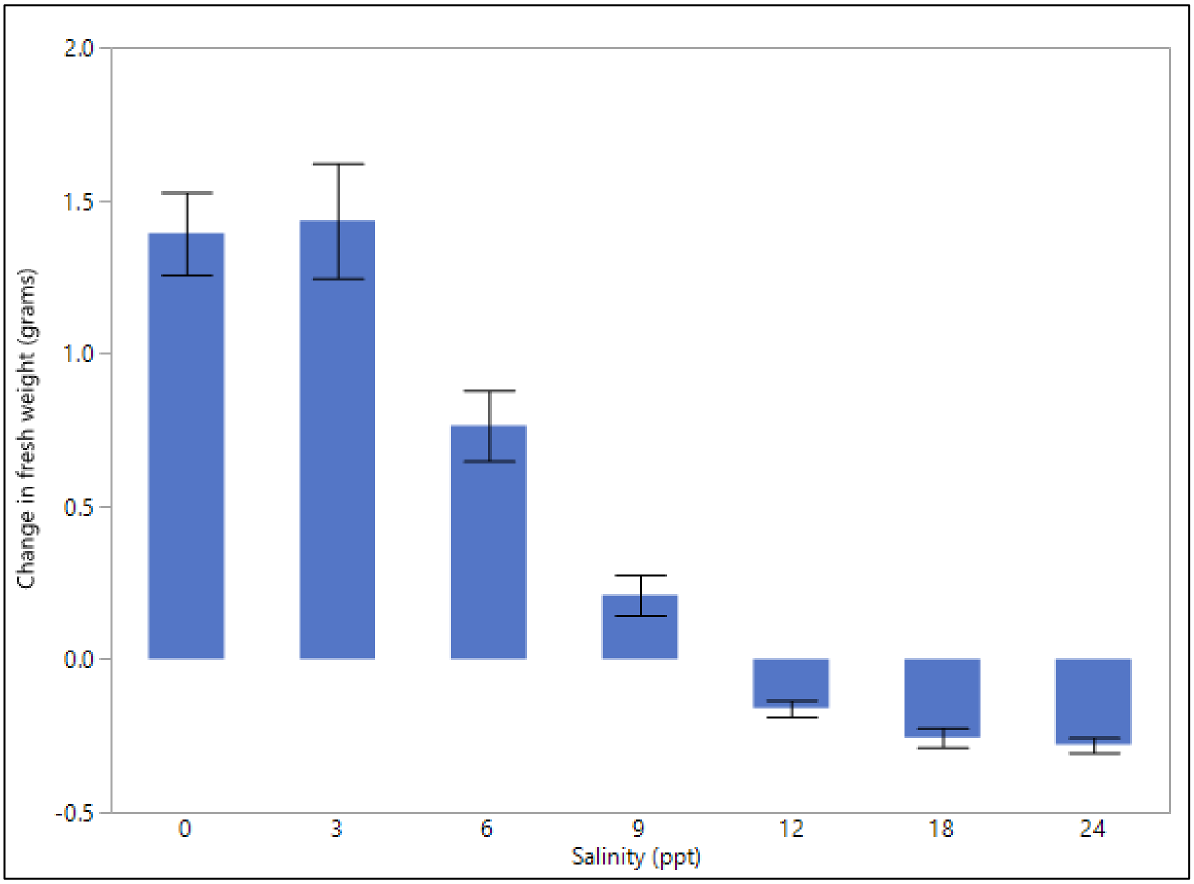

Figure 8. Mean change in fresh weight of hydrilla averaged over all exposure times after a 2-week recovery period. Salinity significantly affected the change in fresh weight ($p < 0.0001$). Positive values indicate an increase in biomass, whereas, negative values indicate that a portion of the plants had died. Error bars represent 1 standard error from the mean.

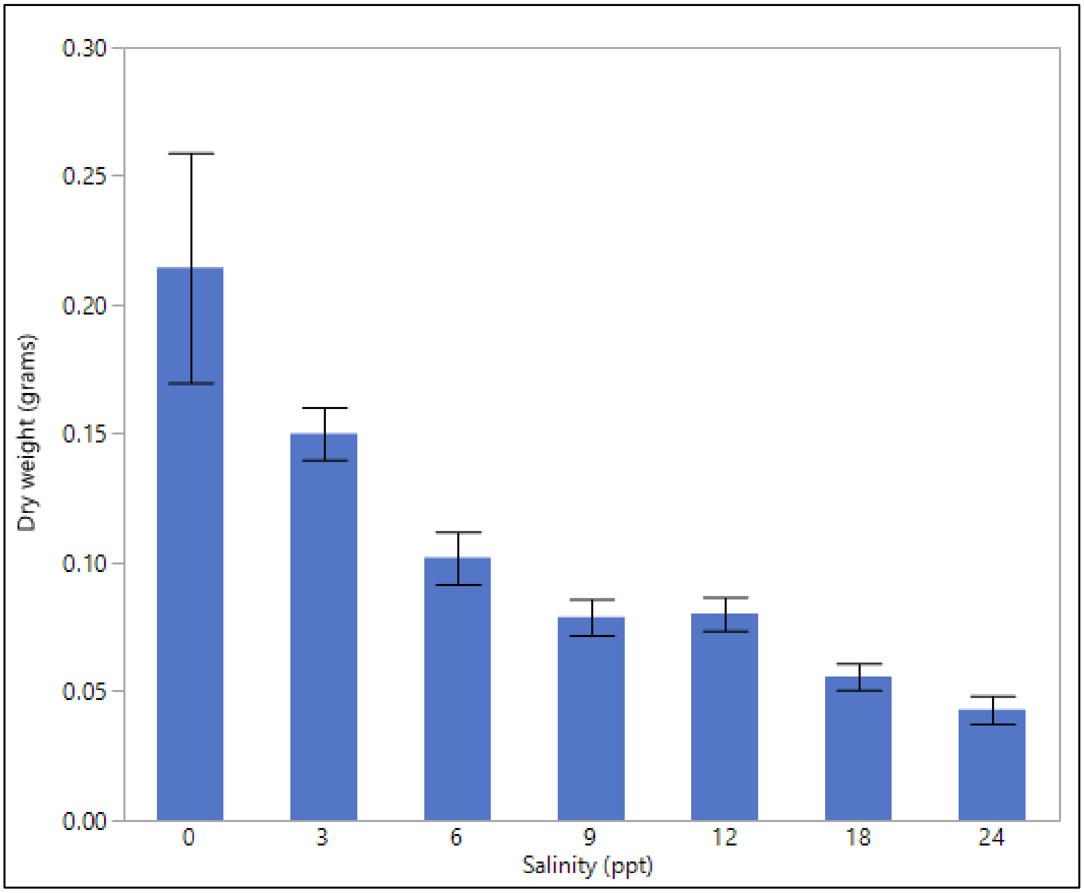

Figure 9. Average hydrilla dry weight by salinity averaged over all exposure times. Error bars indicate 1 standard error from the mean. Dry weights were reduced from the control at all salinities ($p = 0.0029$).

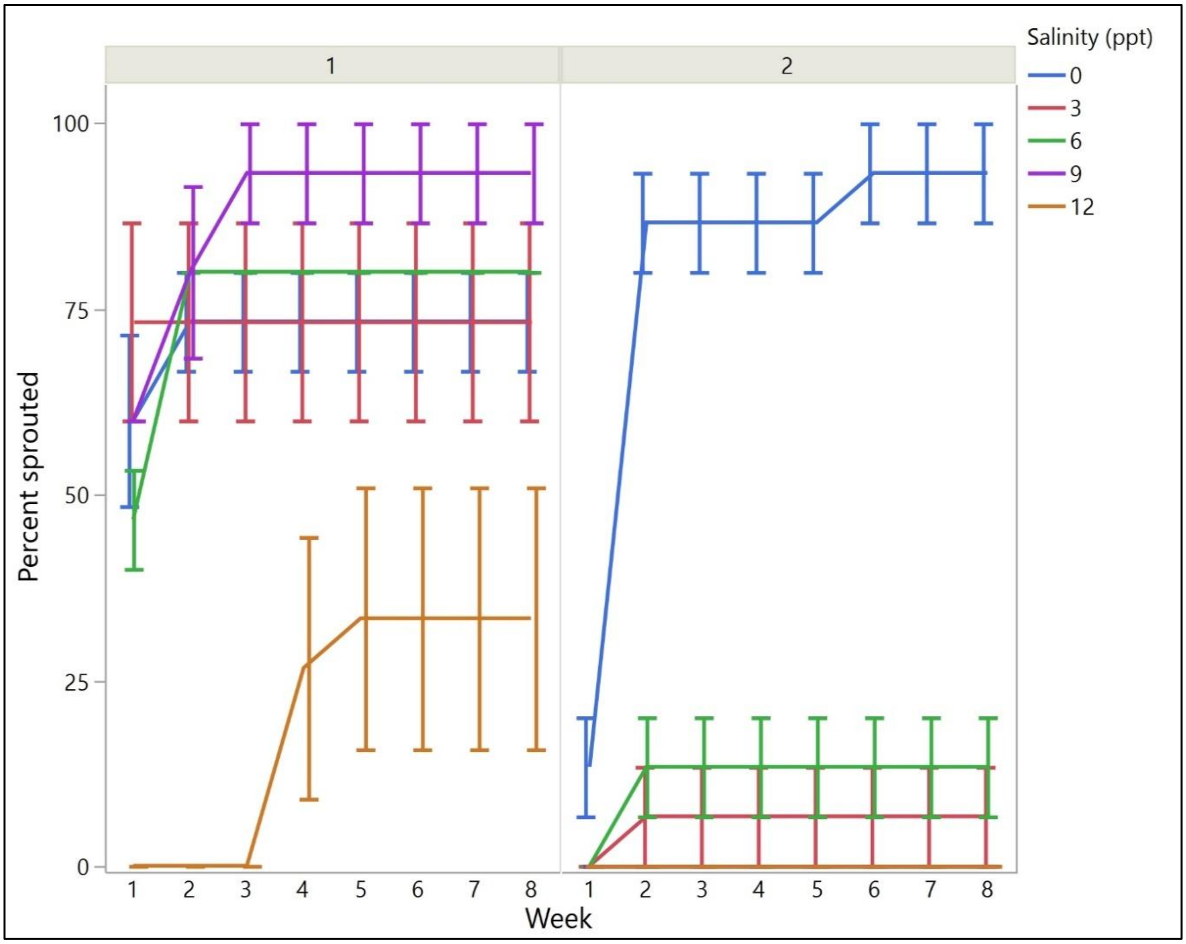

Figure 10. Mean hydrilla sprouting rates from unsprouted tubers placed in varying salinities over eight weeks of exposure, separated by run 1 and run 2. Sprouting was significantly different by run ($p < 0.0001$) and salinity for run 1 ($p < 0.0001$) and run 2 ($p < 0.0001$). Error bars indicate one standard error from the mean.

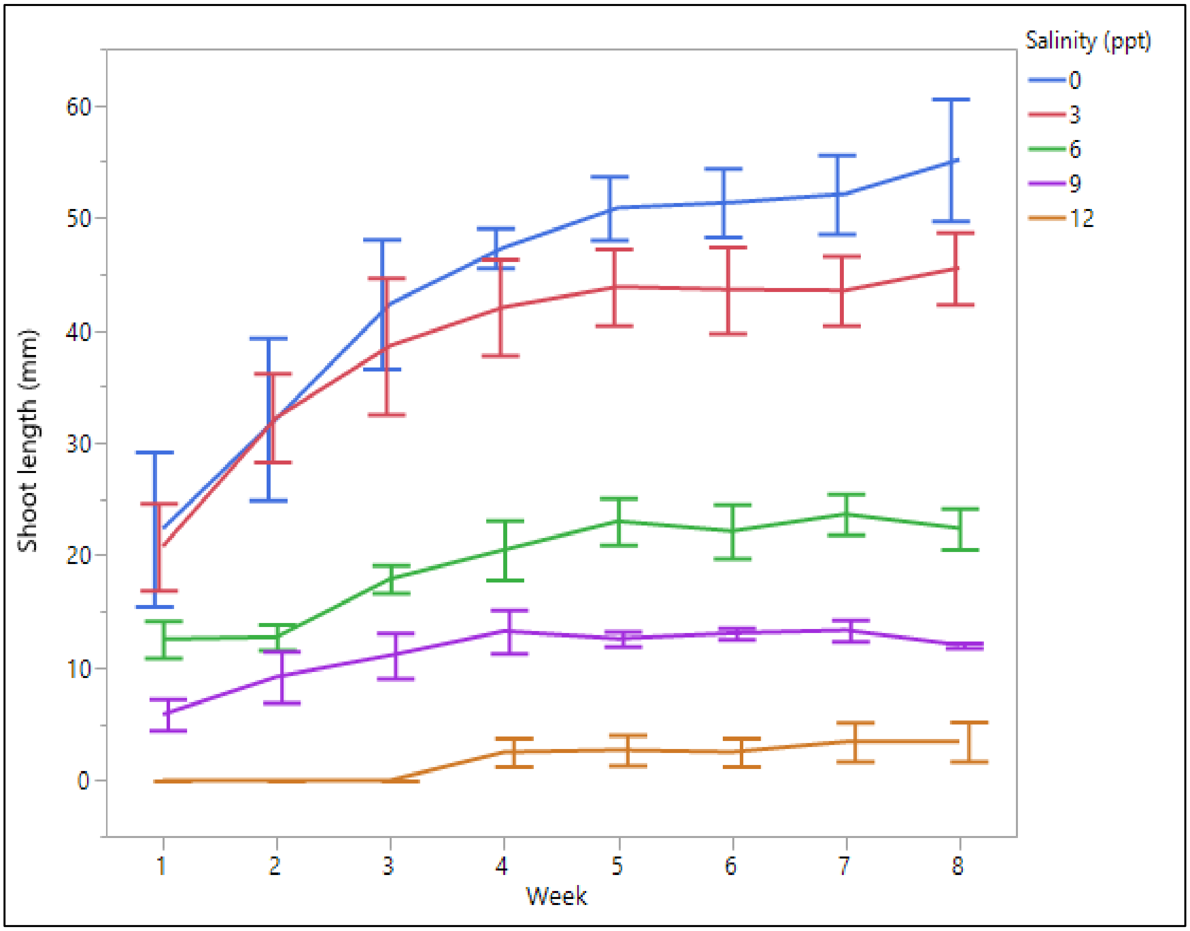

Figure 11. Mean hydrilla shoot length from unsprouted tubers placed in varying salinities after eight weeks of exposure, run 1. Shoot lengths were reduced from the control (0 ppt) after 8 weeks at all salinities ($p = 0.0105$). Error bars indicate one standard error from the mean.

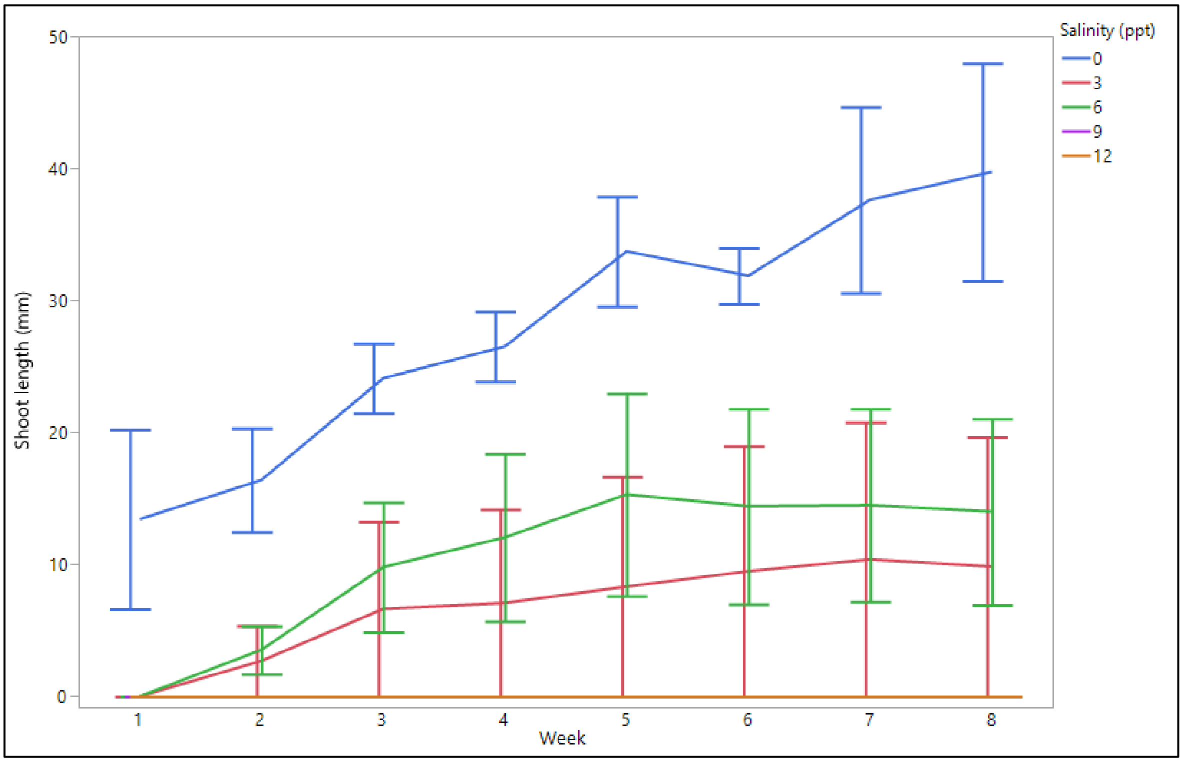

Figure 12. Mean hydrilla shoot length from unsprouted tubers placed in varying salinities after eight weeks of exposure, run 2. Shoot lengths were reduced from the control (0 ppt) at all salinities ($p = 0.0096$). No sprouting occurred in 9 and 12 ppt. Error bars indicate one standard error from the mean.

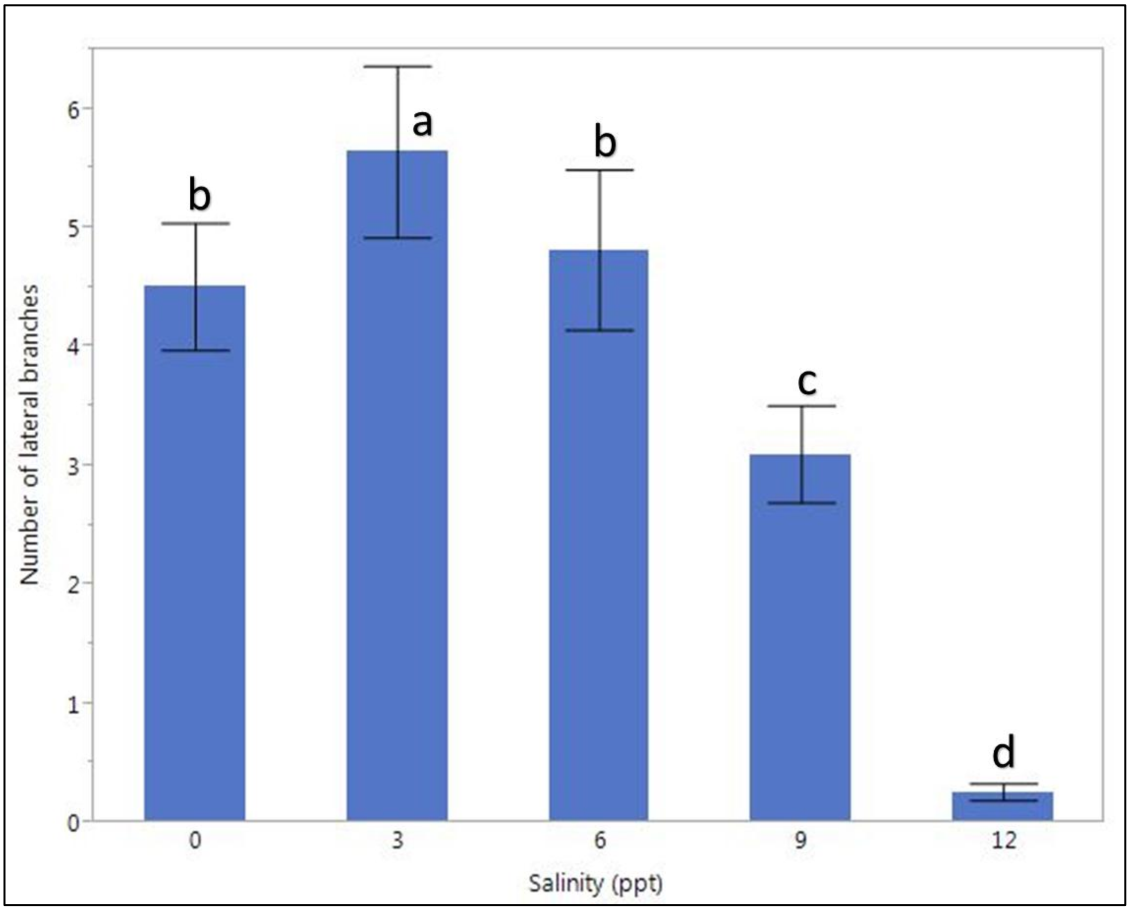

Figure 13. Mean number of lateral branches from unsprouted tubers placed in varying salinities after eight weeks of exposure, run 1. Lateral branching was highest at 3 ppt and significantly reduced at 9 and 12 ppt ($p < 0.0001$). Means not connected by the same letter are significantly different. Significance was determined by using log transformed means. Error bars indicate one standard error from the mean using untransformed means.

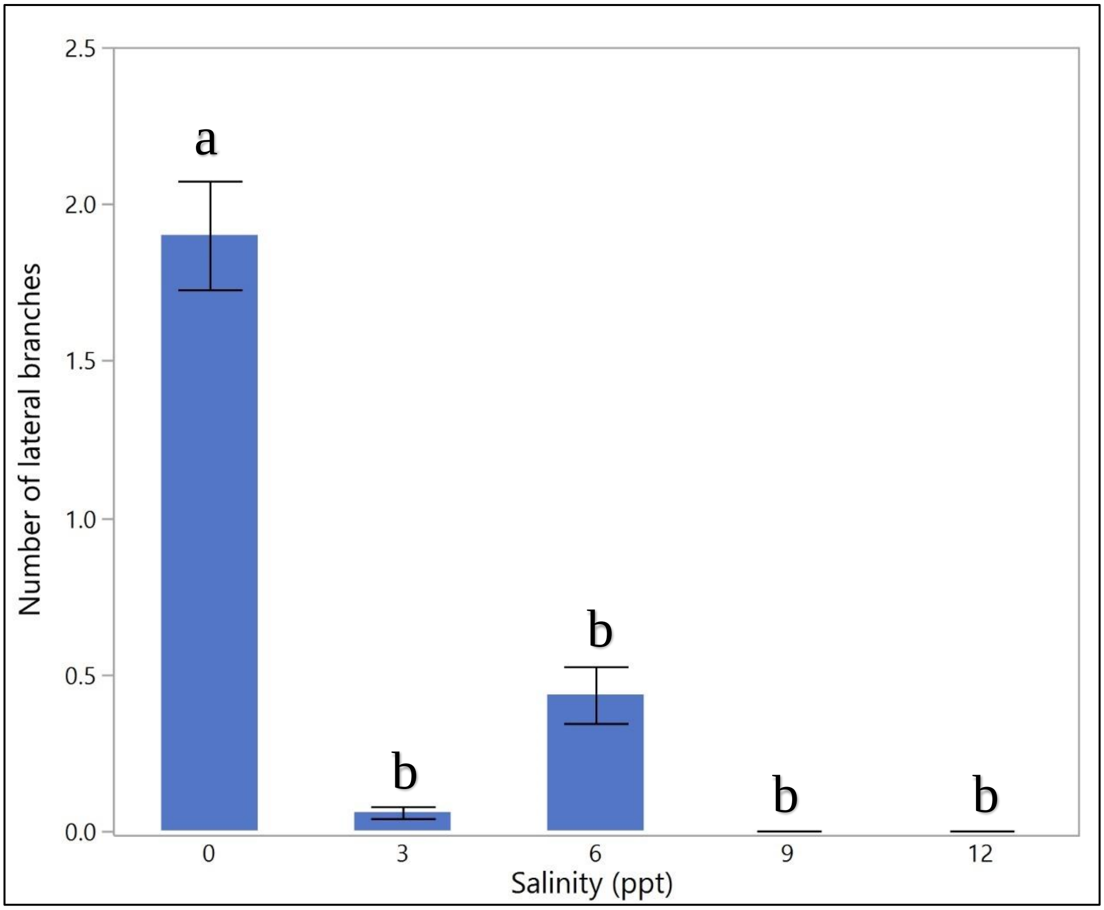

Figure 14. Mean number of lateral branches from unsprouted tubers placed in varying salinities after eight weeks of exposure, run 2. Lateral branching was reduced at all salinities relative to the control ($p < 0.0001$). Means not connected by the same letter are significantly different. Significance was determined by using log transformed means. Error bars indicate one standard error from the mean using untransformed means.

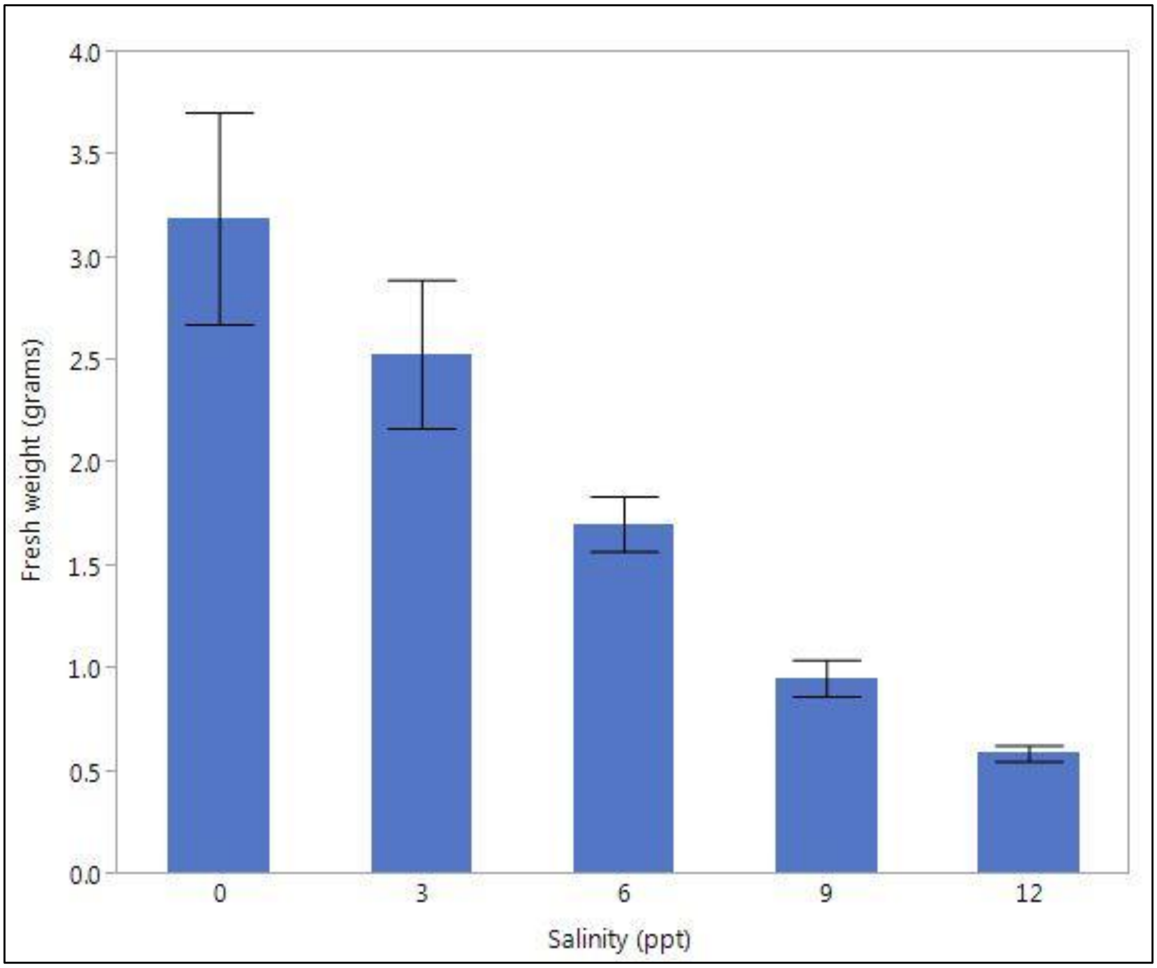

Figure 15. Mean fresh weight from unsprouted tubers placed in varying salinities after eight weeks of exposure, run 1. Salinity significantly affected fresh weight ($p = 0.0004$). Fresh weight of shoots exposed to 3 ppt did not differ from the control (0 ppt). Error bars indicate one standard error from the mean.

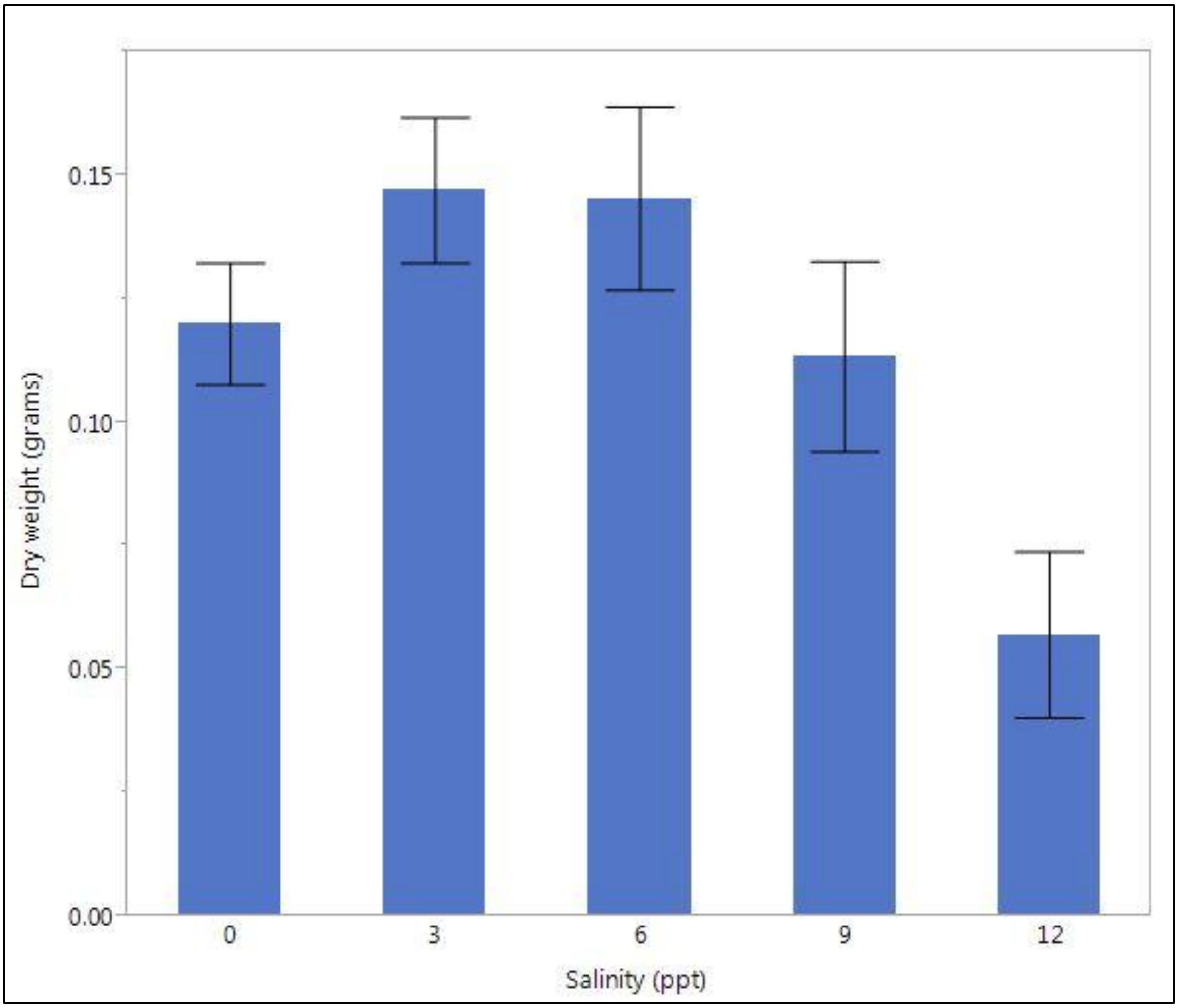

Figure 16. Mean hydrilla dry weight from unsprouted tubers placed in varying salinities after eight weeks of exposure, run 1. Salinity significantly affected dry weight ($p = 0.0193$). Shoots in 12 ppt had reduced dry weight from all other salinities. Error bars indicate one standard error from the mean.

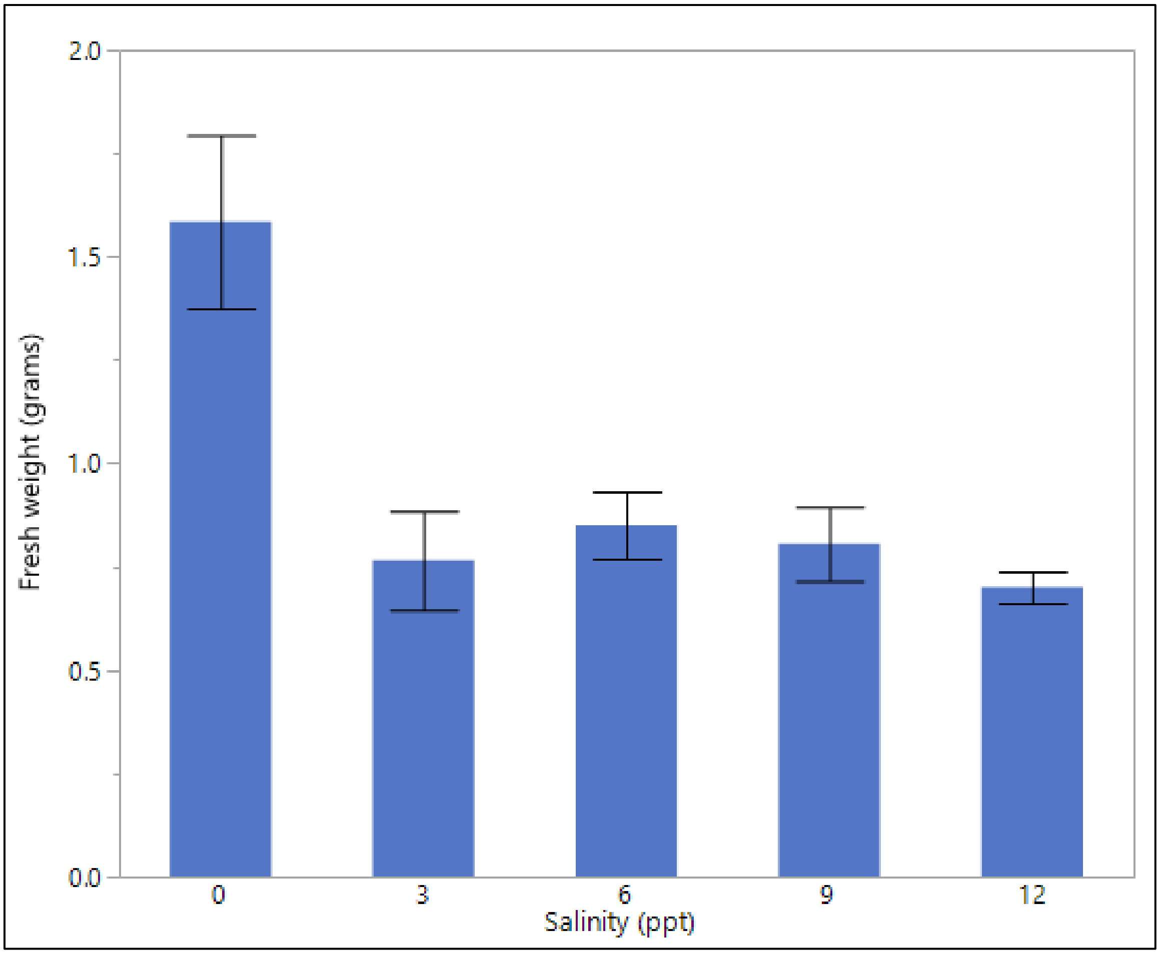

Figure 17. Mean hydrilla fresh weight from unsprouted tubers placed in varying salinities after eight weeks of exposure, run 2. Fresh weights were reduced from control at all salinities ($p = 0.0025$). Error bars indicate one standard error from the mean.

CHAPTER 4

Hydrilla in the Eno River: A Case Study for the Management of Hydrilla in Lotic, High Biodiversity Systems

Abstract

Flowing waters such as rivers and streams are important sources for drinking water, energy production, irrigation, and recreational activities. The increased dispersal of invasive species is one of the greatest threats to these systems and the species they contain. *Hydrilla verticillata*, a submersed macrophyte, is one of the worst aquatic invaders in the United States. Current hydrilla management options are limited for flowing systems with high biodiversity, and have not been extensively studied. A pilot project was implemented in the Eno River, located in the Piedmont region of North Carolina, to investigate the efficacy of treating hydrilla in a lotic system with high biodiversity and threatened or rare species. Two consecutive years of treatment were conducted using a low fluridone rate maintained over a window of 60-100 days. Treatment impacts to selected target and non-target aquatic species were evaluated. Efforts included quantitative sampling of *H. verticillata*, *Somatogyrus virginicus* (a rare, endemic snail), and *Podostemum ceratophyllum* (a native macrophyte and habitat of *S. virginicus*) at seven spatially separated sites along the Eno River. Biweekly vegetation monitoring and monthly snail sampling began two weeks before treatment in 2015, and continued through 2016. Hydrilla biomass, shoot length, and tuber density significantly decreased within the treated section of the river. *P. ceratophyllum* densities and lengths were not significantly different between sampling years. *S. virginicus* densities exhibited patterns with high annual variation which were consistent with reproductive cycles

of this species. Overall, fluridone effectively controlled hydrilla within the treated area with no apparent negative impacts to the studied non-target species.

Introduction

Although flowing waters only make up about 0.0001% of the water on earth, they are of enormous importance to humans (Wetzel 2001). They provide a source for drinking water, energy production, irrigation, navigation, and recreation (Friberg 2014). Flowing water, or lotic, systems are distinguishable from standing water, or lentic, systems by their unidirectional flow and water retention time. Water is constantly cycling through a flowing system. Therefore, downstream areas are affected by upstream waters, and water retention times are much shorter than in a lentic system such as a lake or pond (Wetzel 2001). The erosive action of flowing waters produces ever-changing channel morphology and substrate. Flow is variable as lotic systems often respond rapidly to precipitation. Physical, chemical, and biological characteristics are also highly variable within and across different systems. These aspects make lotic systems more difficult to generalize than standing waters (Wetzel 2001).

Lotic ecosystems are highly susceptible to anthropogenic influences, and are threatened world-wide through the construction of dams and impoundments, pollution, climate change, direct habitat destruction, and increased dispersal of invasive species (Van Wilgen et al. 2007; Friberg 2014). Of these, invasive species are one of the most significant threats to global biodiversity (Van Wilgen et al. 2007). While submersed aquatic plants provide many benefits to lotic systems such as nutrient cycling, habitat availability, increased water clarity, and decreased erosion, these beneficial traits can become harmful with excessive growth; as is the case with invasive submersed species (Santos et al. 2011). Invasive aquatic plants have no native predators and have competitive growth advantages such as low light requirements and high propagule production. Therefore they often grow to nuisance levels, and out-compete native species for space and resources (Santos et al. 2011).

Hydrilla verticillata (L.f.) Royle is an extremely costly and difficult to control submersed invasive aquatic plant in the United States (Langeland 1996). Hydrilla's aggressive growth habits allow it to form dense monocultures that displace native vegetation thereby causing detrimental effects such as clogged waterways, decreased dissolved oxygen, and altered fish populations (Langeland 1996). It has also been identified as the host of a neurotoxin-producing cyanobacteria, *Aetokthonos hydrillicola*. This toxin is linked to a neurological disease (Avian Vacuolar Myelinopathy- AVM) that affects bald eagles (Haliaeetus leucocephalus Linnaeus), American coots (Fulica americana Gmelin), grass carp (Ctenopharyngodon idella Val.), and painted turtles (*Chrysemys picta* Schneider) (Mercurio et al. 2014; Wilde et al. 2014).

Two biotypes of this plant exist in the United States: a monoecious and a dioecious strain (Blackburn et al. 1969; Cook and Luond 1982). The monoecious biotype, typically found in more temperate climates of the United States such as North Carolina northward, acts as a herbaceous perennial with senescence occurring in the late fall/early winter and regrowth occurring in the spring/early summer (Harlan et al. 1985). Hydrilla reproduces rapidly through fragmentation, stolons, seed, and vegetative propagules called turions (Cook and Luond 1982; Langeland and Smith 1984). These propagules are formed in leaf or branch axils and in the sediment at the end of rhizomes (Yeo et al. 1984). Subterranean formed turions are often called tubers, and will be referred to as such from here on. Large numbers of tubers are produced in the sediment each growing season allowing monoecious hydrilla to overwinter in temperate climates and regrowth to occur after ecological stress or control treatments (Netherland 1997).

Several methods are commonly used to control hydrilla in the United States. These include mechanical harvesting, introduction of sterilized triploid grass carp, and herbicide applications (Langeland 1996; True-Meadows et al. 2016). There is a large amount of peer-reviewed research pertaining to the control of dioecious hydrilla. However, there is considerably less research focused on controlling monoecious hydrilla; particularly in flowing systems with high biodiversity and water fluctuation (Getsinger et al. 2008; True-Meadows et al. 2016). Mechanical harvesting may do more harm than good due to its destructive nature and tendency to increase fragmentation of hydrilla. This method has been reported to decrease fish biomass and sometimes exacerbate the growth of hydrilla (Haller et al. 1980; Serafy et al. 1994). Introducing grass carp to a lotic, high biodiversity system to control hydrilla is also not a feasible option as grass carp are “selective generalist” feeders and may, in turn, feed on desirable native species (Leslie et al. 1987). Additionally, more research is needed to determine if introduced fish will remain where stocked in a lotic system with varying flow. Aquatic herbicides have successfully been used to control hydrilla. Two of the most commonly applied herbicides for the control of hydrilla in lentic systems include fluridone and the dipotassium salt of endothall (Archambault and Cope 2016). However, there are still some unanswered questions pertaining to their use in flowing systems that have short water retention times and protected or threatened native species. Netherland et al. (1993) reported that low rates of fluridone maintained over long periods will effectively control hydrilla in lotic systems. While this study was an important first step, it focused on dioecious hydrilla in a laboratory setting. Netherland (2015) reported that low rates of fluridone (6-12 ppb) prevented sprouting monoecious hydrilla tubers from emerging, and even lower rates (1.5-3 ppb) reduced biomass by 84 to 96 %. However, this study was also conducted in a greenhouse setting and did not address the potential effects on non-target species. The current study sought to address these gaps in the literature.

The impetus for this study was the lack of research pertaining to management of monoecious hydrilla in flowing systems in the presence of native, desirable, and threatened species. The study site for this pilot project was the Eno River, a high biodiversity river located in the Piedmont region of North Carolina in Durham and Orange counties. The Eno River is a municipal water source, and is also recreationally important for it flows through most of the Eno River State Park. It also has high rates of endemism, and is home to several threatened and endangered species (Archambault and Cope 2016). One of these said species is a rare aquatic snail, the Panhandle pebblesnail *Somatogyrus virginicus* Walker. *S. virginicus* is listed as a species of greatest conservation need and as a federal species of concern in the

North Carolina Wildlife Action Plan (NCWRC 2015). The only confirmed population in North Carolina is within the Eno River (Ratcliffe et al. 2016). It lives within the native macrophyte species *Podostemum ceratophyllum* Michx., commonly referred to as riverweed or riffleweed. Riffleweed is an extremely important native plant species for it provides surface area for algal growth which benefits scrapers, and provides stable habitat for aquatic macroinvertebrates such as filter feeders (Hutchens et al. 2004). The invasion of alien aquatic plants in this system, particularly hydrilla, is a serious threat to these invaluable native plants and their respective inhabitants.

Hydrilla has been an ongoing problem within the Eno River since it was first documented in 2005. A two-year pilot project was implemented in 2015 for an evaluation utilizing a metered system to maintain low concentrations of fluridone (market name Sonar® Genesis Aquatic Herbicide) within the hydrilla infested areas of the Eno River from late spring through the summer in order to control hydrilla. Prior to this, a metered herbicide treatment within a lotic system had never been reported in North Carolina. The objective of this research was to evaluate the efficacy of treatment on monoecious hydrilla, and elucidate impacts to the non-target species, riffleweed and the panhandle pebblesnail.

Methods

Vegetation. Hydrilla and riffleweed were monitored pre, during, and post treatment to determine any potential effects on density, shoot length, and chlorophyll levels. Monitoring began in May 2015 and occurred biweekly through September 2015. Winter and spring sampling was conducted approximately bi-monthly from October 2015 through May 2016.

Biweekly sampling resumed in June through September 2016. Six sites were monitored; two controls located outside (upstream) of the treatment zone and four located within the treatment zone (Figure 18). Parameters measured included riffleweed density, shoot length, and percent bottom coverage, and hydrilla length and percent bottom coverage. Riffleweed density was determined by randomly selecting four rocks per site and counting the number of stems per 25 cm^2. Shoot length for each species was determined by measuring the four longest shoot lengths at each site. Percent bottom coverage of the stream bed was visually estimated at the same swath at each site. In 2015, samples of each species at each sampling date were collected for analysis of chlorophyll *a* concentrations. Temperature (°C), pH, and dissolved oxygen (mg/L) were also recorded with the use of a handheld YSI meter. Tuber sampling was conducted prior to treatment in November 2014 and again in April 2016 after one year of treatment. Metal quadrats (50cm x 50cm) were used to determine area. Quadrats were randomly placed in areas that were known to have contained hydrilla in the previous growing season. Substrate from four quadrats per site was sampled to an approximate depth of 30cm. Substrate was sieved and turions/tubers were counted. Sites sampled in 2014 included Pleasant Green, Cole Mill, and Guess Road. Sites sampled in 2016 included Dumont, Pleasant Green, Cole Mill, Guess Road (Figure 18), and an additional four untreated sites near Weaver Street Market in Hillsborough, NC where hydrilla growth was prolific in 2015.

Panhandle pebblesnail. Snails were monitored pre, during, and post treatment to identify any potential treatment effects on population numbers. Monthly monitoring began May 2015 and continued through October 2015. Winter sampling occurred bi-monthly from December 2015 through April 2016. Monthly sampling resumed in May and continued through September 2016. Seven sites were monitored: two controls located outside of the treatment zone and five located within the treatment zone (Figure 19). Snail density was calculated by randomly selecting ten riffleweed-covered rocks at each site from optimal habitat and counting the number of snails on a per unit effort basis. This was achieved by rinsing the rock off into a clear plastic bucket and counting the number of snails for ten minutes per rock. Two rocks per site were recounted to determine detection probability. Optimal habitat here is defined as fast flowing portions of the stream, or riffles. Maximum height, length, width, and percent riffleweed coverage of the top surface of each rock was calculated to determine area.

River survey. Kayak surveys were conducted on the Eno River for two consecutive years in order to assess vegetation density and to determine stream morphology in the treated section of the channel. The first survey was conducted in May 2015, prior to treatment, and the second survey was conducted in May 2016 after one year of treatment. Approximately sixteen miles of the river were surveyed, and data was collected at roughly 0.25 km intervals. Survey data included presence/absence data of riffleweed, hydrilla, and waterwillow (*Justicia americana* (L.) Vahl), a native shoreline emergent plant. Species were given a rating of 0-3 with 0 being absent and 3 being very dense. Both sides of the channel were given a rating, and ratings were averaged for each point in post-hoc analyses. Stream width and five depth readings across the channel were also recorded at every survey point to determine an average channel depth throughout the treatment area. Stream morphology was also classified at each point as either a run, riffle, or pool. ArcGIS was used to create shapefiles and publication quality maps from the data.

Analysis. Neither hydrilla nor panhandle pebblesnails were found in the untreated control sites. Therefore, reference sites were removed from the hydrilla and snail analyses. Pre- and post-treatment sampling for both years corrected for this bias. Results from the vegetation and snail sampling data were analyzed using a linear model and kayak survey data were analyzed using an ordinal logistic model. All analyses were performed using JMP Pro 12 (SAS Institute Inc., Cary, NC). Snail density and riffleweed length data were log transformed [Log (snails/m^2 + 0.5)] and [Log (length + 1)] to improve normality. Untransformed means are presented for clarity.

Results & Discussion

Vegetation. Hydrilla shoot length and percent coverage were significantly different by year and sampling occasion ($p < 0.0001$), but did not differ by sampling site. In 2015, shoot lengths and percent coverage increased from May into June, and then sharply dropped off roughly half-way through the treatment window (Figure 20). Recovery was seen after treatment ceased, and shoot lengths continued to increase into September (Figure 20). Plants then began to naturally senesce until no stems were found at any sites during our December sampling. Biomass, measured as percent coverage, did not return to pre-treatment levels once treatment ceased (Figure 21). In 2016, hydrilla shoots were an average of 13.7 cm long at our May sampling, and were not significantly different from shoot lengths found in May of 2015 (Figure 20). Treatment effects were seen much earlier in the treatment window in 2016.

Average shoot length declined from May into June, and hydrilla was not found at any sampling sites after the last sampling occasion in June. Percent hydrilla coverage in 2016 never reached greater than 1% (data not shown). Temperature, pH, and dissolved oxygen were not significant factors affecting shoot length or percent coverage.

Treatment in 2015 began in late May and continued through mid-July. Average fluridone concentration over the 2015 treatment period was 4.3 ppb (Heilman 2016). As this was a pilot-project slated to continue at least two years, the goal was not eradication of hydrilla. Therefore, the recovery seen in August 2015, after treatment ceased, was due to the sprouting of previously unsprouted tubers or recovery from existing biomass and was not unexpected. Netherland et al. (1993) also reported recovery of dioecious hydrilla after fluridone treatments lasting 60 days or less. Treatment in 2016 began in early May and continued through late August. Average fluridone concentration over the 2016 treatment period was 1.8 ppb (Heilman 2016). Since immature plants are more susceptible to fluridone (MacDonald et al. 1993), the earlier start date could explain why treatment effects (bleached tips, shorter shoot lengths) were seen earlier in 2016 compared to 2015. The longer treatment window in 2016 provided better control as evidenced by the absence of hydrilla post June sampling and the lack of regrowth after treatment ceased.

Riffleweed density and shoot length were not different by year, but there were differences by site and sampling occasion. Lowest densities were found at our control sites 70 W and Gold Park with means of 29.4 and 24.7 cm, respectively (Figure 22). Shortest shoot lengths were found at Gold Park and Dumont with means of 8.5 and 8.8 cm, respectively (Figure 23). Shoot lengths at the second control site, 70 W, were not significantly different from all other treated sites (Figure 23). Seasonality was observed with riffleweed growth. Shoot lengths decreased during warm summer months with low flow, and increased during cooler months with higher water levels. Percent riffleweed coverage was also significantly different by site. Gold Park and Pleasant Green had the lowest averages of 47 and 50%, respectively (data not shown). Temperature, pH, and dissolved oxygen were not significant factors in predicting shoot length, density, or percent coverage.

Riffleweed appears to be tolerant to low levels of fluridone maintained over several months indicated by the lack of difference in density and shoot length between sampling years. Similar shoot lengths found at our control site 70 W compared to the treated sites also indicates that observed changes in shoot length were most likely environmentally mediated and not an effect of treatment. Riffleweed's growth is highly correlated with water levels; shoots lengthen as water levels rise and flowering occurs when levels drop and plants are exposed to the air (Philbrick et al. 2015). This trend was observed in the Eno where water levels are lowest during the hot, often dry summer months (Figure 23).

Chlorophyll *a* concentrations were not significantly different between riffleweed and hydrilla over the course of the 2015 sampling season. Concentrations differed by site ($p < 0.0001$). Both control sites, 70 W and Gold Park, had significantly higher concentrations of chlorophyll *a* than all other sites (Figure 24). Fluridone "inhibits the biosynthesis of carotenoid precursors” causing chlorophyll photodegradation (McCowen et al. 1979). Therefore, the lower chlorophyll levels observed in plants located within the treatment area indicate the herbicide efficacy. While riffleweed may have had reduced chlorophyll levels due to treatment, it was not as sensitive as hydrilla and did not exhibit any long term effects. This may be a factor of the aforementioned seasonal growth patterns of riffleweed versus hydrilla for fluridone is more effective on actively growing, immature plants with low carotenoid levels (MacDonald et al. 1993; Philbrick et al. 2015).

Average pre-treatment tuber densities in 2014 were approximately 390 tubers m^{-2} (data not shown). In 2016, tuber densities in the same sites were only 1 tuber/m^2 with tubers only found on one site, Pleasant Green. Average density in the untreated sites in 2016 was 9.5 tubers m^{-2}.

Decreasing the tuber bank is one of the greatest challenges of long term hydrilla management. Tuber density decreases as we observed bode well for the success of long-term hydrilla control in lotic systems. The significant reduction of hydrilla presence within the treatment area coupled with low tuber densities may indicate that these dynamic flowing systems exhibit higher sprouting frequencies than what has been reported in lentic systems actively managed for hydrilla (Nawrocki et al. 2016). Factors such as increasing soil depth and anaerobic conditions have been reported to inhibit tuber sprouting (Miller et al. 1976; Van and Steward 1990). The rocky substrate and oxygen rich waters of the Eno River could lead to shallow tuber deposition in oxygenated sediments, thus having the opposite effect on tuber quiescence. Tuber densities in the untreated areas in 2016 were also relatively low. Qualitative observations of hydrilla in this area indicated that biomass was reduced in 2016 as compared to 2015. This is presumably a factor of increased turbidity associated with high flow for the Eno experienced record flow rates during the 2016 treatment. This also supports the “rapid tuber bank depletion” theory for if the majority of tubers produced during the previous growing season sprout each year, and tuber production for 2016 was inhibited by environmental factors, then we would expect to see low tuber densities following a year of reduced propagule production.

Panhandle pebblesnail. Average panhandle pebblesnail densities were positively correlated with percent coverage of riffleweed ($p < 0.0001$). Average snail densities were higher in 2015 compared to 2016 ($p < 0.0001$), and significantly different by site ($p < 0.001$) and sampling month ($p < 0.0001$) (Figure 26). Highest densities were found at Few’s Ford and were lowest at Pleasant Green. Highest densities by sampling month were found in June, July, August, and September of 2015 and in September of 2016. Lowest densities were observed in May of 2015 followed by February, April, and May of 2016. Our sampling encompassed the full life cycle of the panhandle pebblesnail. At our first pre-treatment sampling in May 2015, the overwintering population was laying eggs (Figure 27). Densities swiftly increased into June as the juveniles began hatching, and then slowly declined as the species returned to its overwintering population. Egg laying and juvenile hatching occurred during the same time frame in 2016. Recounted values were positively correlated with original counts (correlation = 0.95) indicating a high detection probability.

Patterns observed reflect an r-strategist "boom and bust" type reproductive periodicity typical for this species (Figueiredo-Barrosa et al. 2006; Johnson et al. 2013). Timing of egg laying and hatching were similar to what has previously been reported for this species in the Eno River (Archambault and Cope 2016). Snail densities were positively correlated with riffleweed coverage, therefore, it is not surprising that lowest snail numbers were found at Pleasant Green. This site exhibited the lowest percent coverage of riffleweed throughout the two years of sampling. It is unclear why overall densities were lower in 2016. However, it is likely that higher than average flow rates in 2016 may have negatively impacted this species. While increased flow rates on their own may not pose a problem (due to the characteristically strong foot of the *Somatogyrus* genus (Archambault and Cope 2016), associated turbidity would. *S. virginicus* prefers clean water and has been notably absent in areas of light siltation (Archambault and Cope 2016). Furthermore, laboratory studies confirm that concentrations of fluridone found throughout the treatment were much lower than concentrations needed to cause any detrimental effects to the egg, juvenile, or adult life stages (Archambault and Cope 2016). Quantitative studies assessing panhandle pebblesnail populations within the Eno have not been previously conducted. Given the aforementioned reasons, we assume that a level of variation in population size from year to year is normal and may be a factor of increased siltation due to high turbidity.

River survey. Ninety-eight points within the treatment area were surveyed in 2015 and again in 2016. In 2015, hydrilla was present in 38% of points. Of these occurrences, 92% had an average rating of 0.5-1 and were considered sparse, while 8% were rated as moderate with average density ratings of 1.5-2 (Figure 28). No dense stands (2.5-3 rating) were found at this time. Riffleweed was present in 29% of points in 2015 with 71% of occurrences rated as sparse, 25% as moderate, and 3% as dense (Figure 29). Waterwillow was present in 37% of points surveyed in 2015 with 58% classified as sparse, 31% as moderate, and 11% as dense (Figure 30). In 2016, hydrilla was only found in 6% of the points surveyed. All occurrences were rated as sparse (Figure 31). Riffleweed occurred in 26% of survey points. Of these, 44% had average density ratings of sparse, 36% as moderate, and 20% as dense (Figure 32). Waterwillow was found in 44% of points in 2016 with 67% rated as sparse, 21% as moderate, and 12% as dense (Figure 33). Densities and occurrences of riffleweed and waterwillow were not significantly different by year ($p = 0.2085$ & $p = 0.3711$, respectively). However, hydrilla densities were significantly reduced in 2016 ($p < 0.0001$). Neither riffleweed nor waterwillow presence were significant in predicting occurrence of hydrilla. Average channel depth was approximately 2.6 ft, and average channel width was approximately 74 ft (Figure 34). Channel depth and width were averaged across survey years as differences were minimal. The majority of the Eno River channel morphology within the surveyed area can be classified as a run (~67% of points surveyed) (Figure 35).

This survey showed significant reduction in hydrilla presence/density with no notable differences in native plant populations after one year of treatment. This supports the results from our bi-weekly vegetation point sampling and further points to the success of this project.

Overall, this two-year pilot project provided excellent selective control of hydrilla within the treated area. Low rates of fluridone maintained for approximately 90 days were effective at controlling early stage growth of hydrilla located within and adjacent to populations of native and threatened species while limiting detrimental effects to said species. This protocol provides a framework on which to base future management plans that call for the complex management of hydrilla in high biodiversity, flowing systems.

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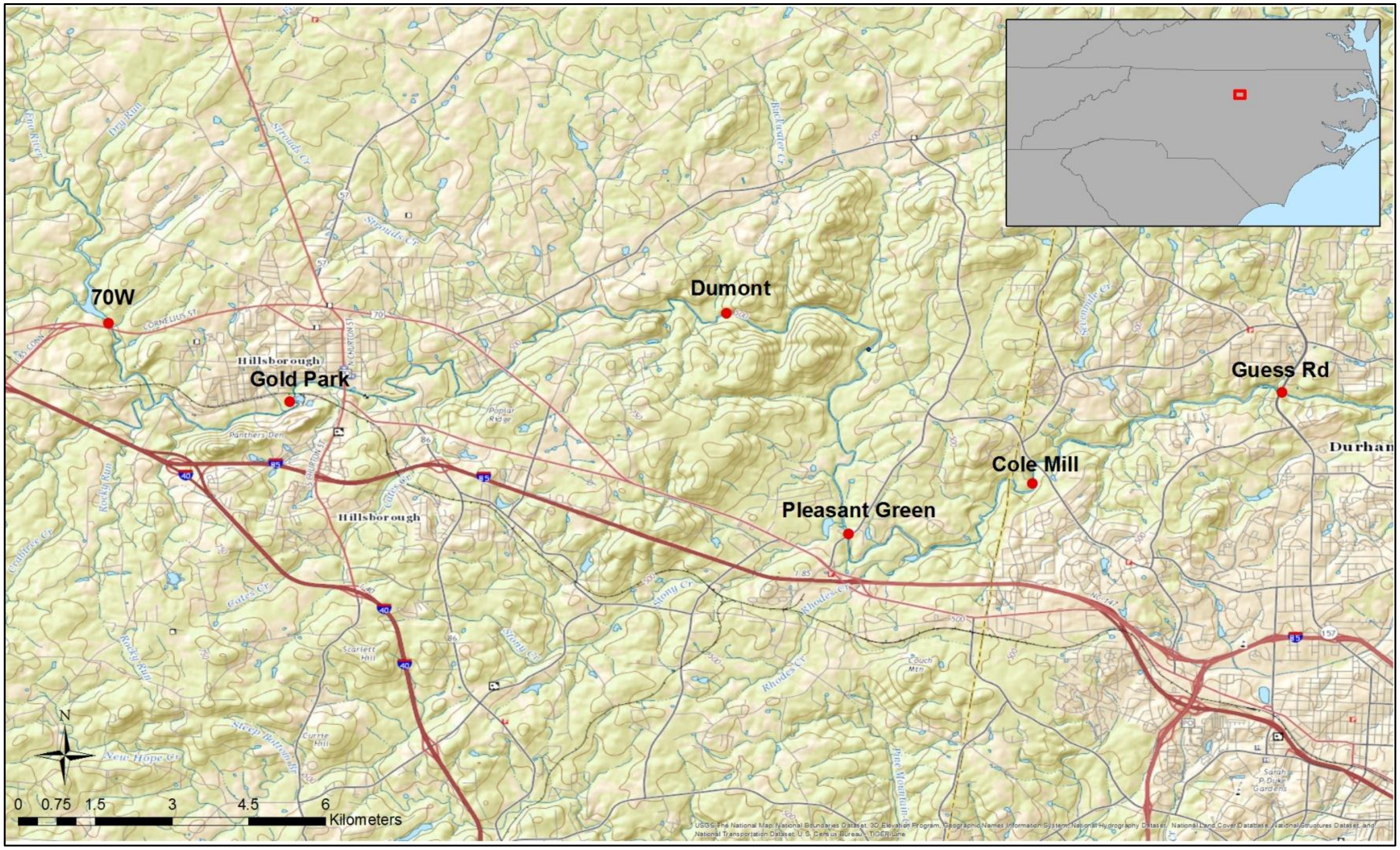

Figure 18. Eno River vegetation sampling sites. 70 W and Gold Park are control sites located upstream of the treatment zone.

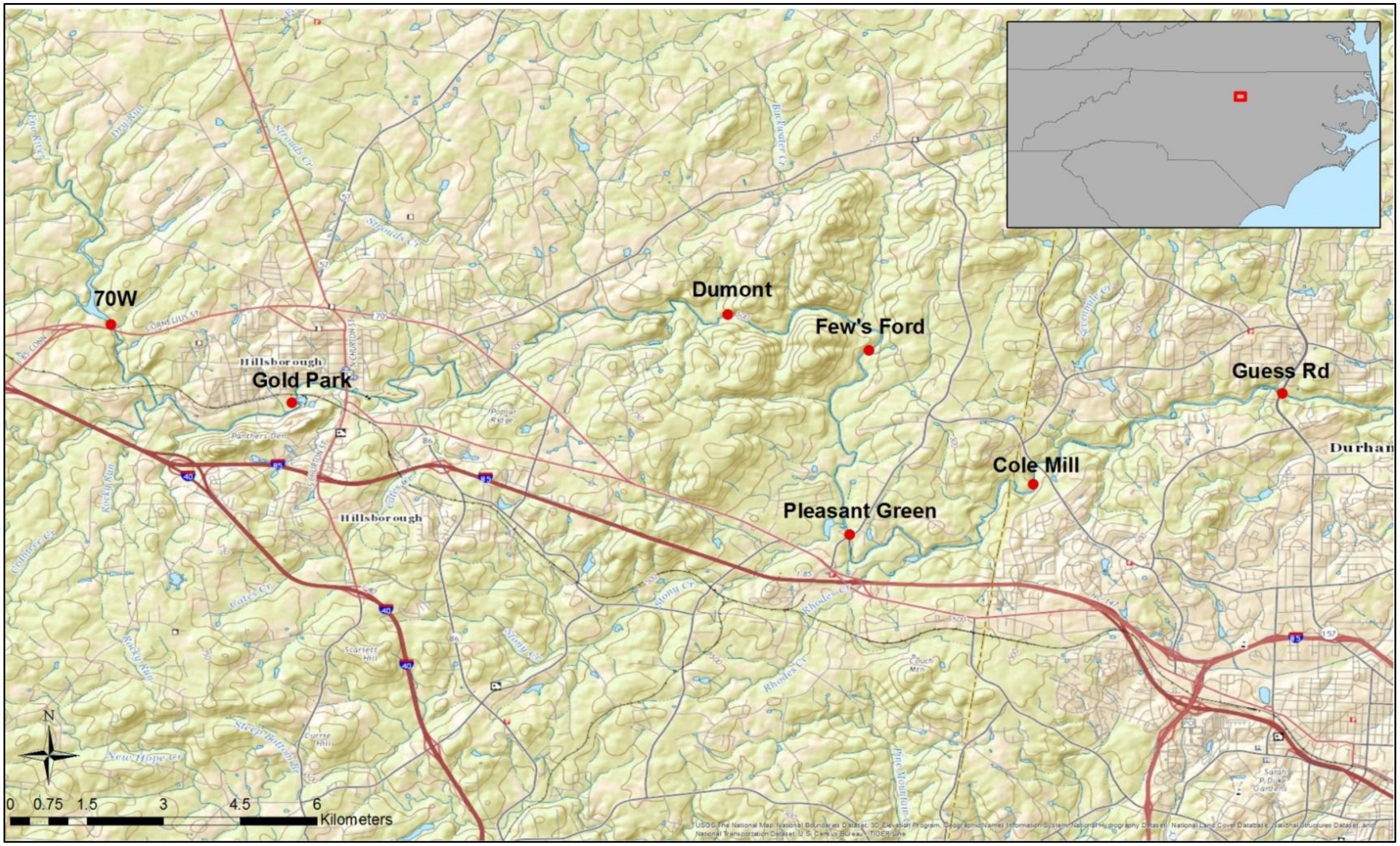

Figure 19. Eno River panhandle pebblesnail sampling sites. 70 W and Gold Park are control sites located upstream of the treatment zone.

82

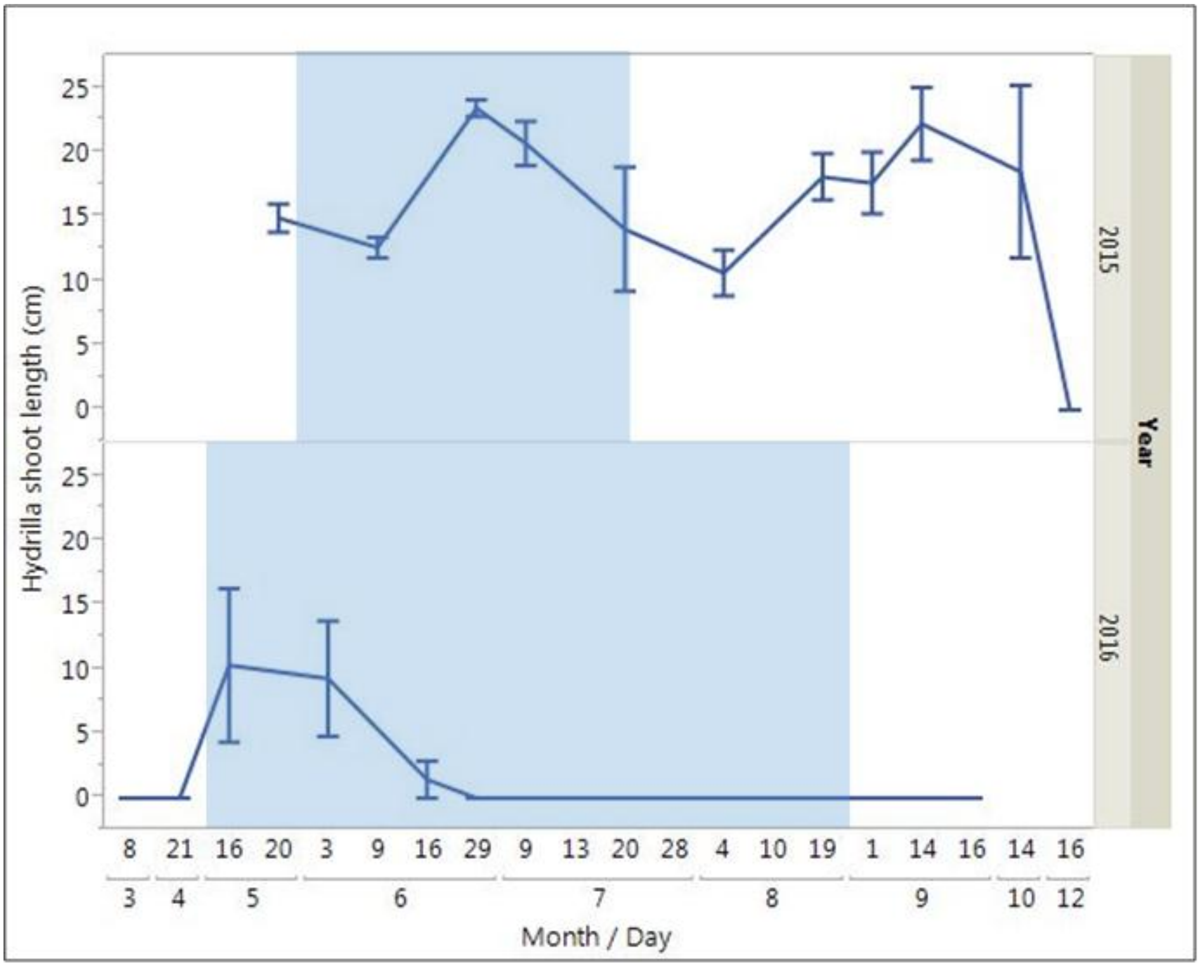

Figure 20. Mean hydrilla shoot length by sampling month and day of the month in a standard twelve month calendar year. Lengths differed by year and sampling occasion ($p < 0.0001$). Shaded portions represent the period of treatment. Error bars indicate one standard error from the mean.

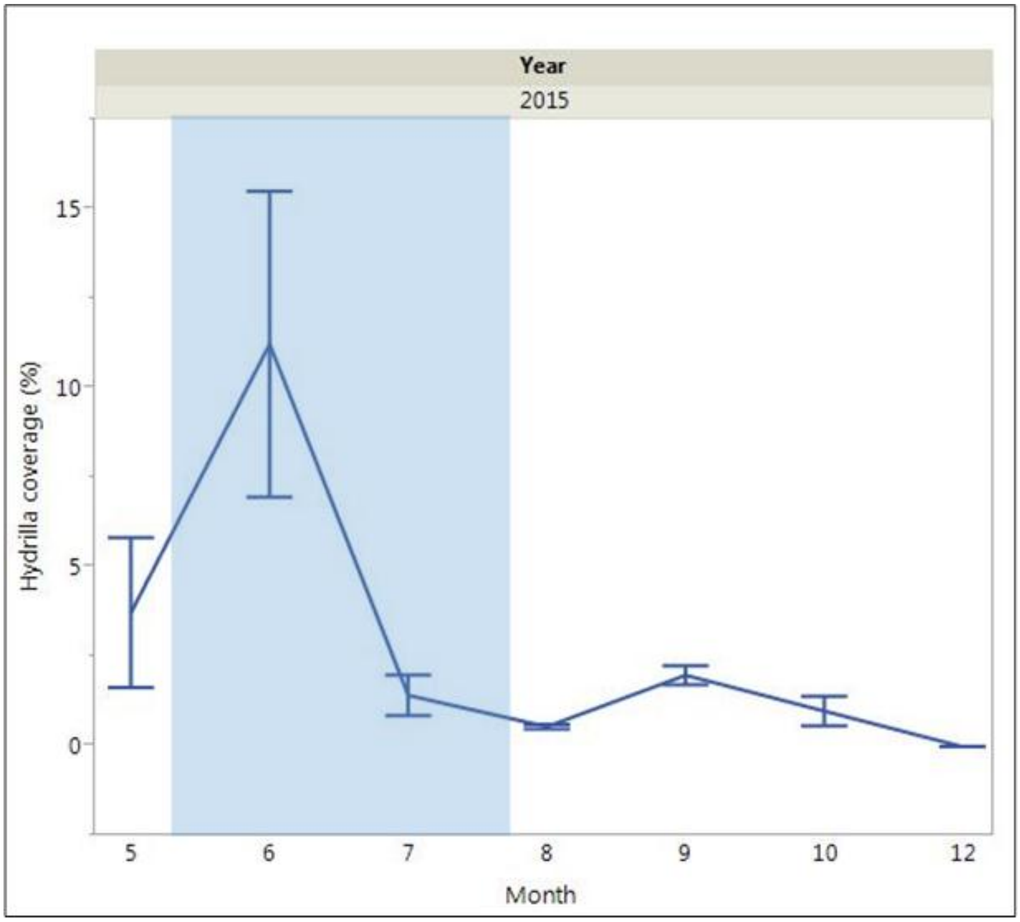

Figure 21. Average hydrilla percent coverage by month in 2015. The shaded portion represents the period of treatment. Error bars indicate one standard error from the mean.

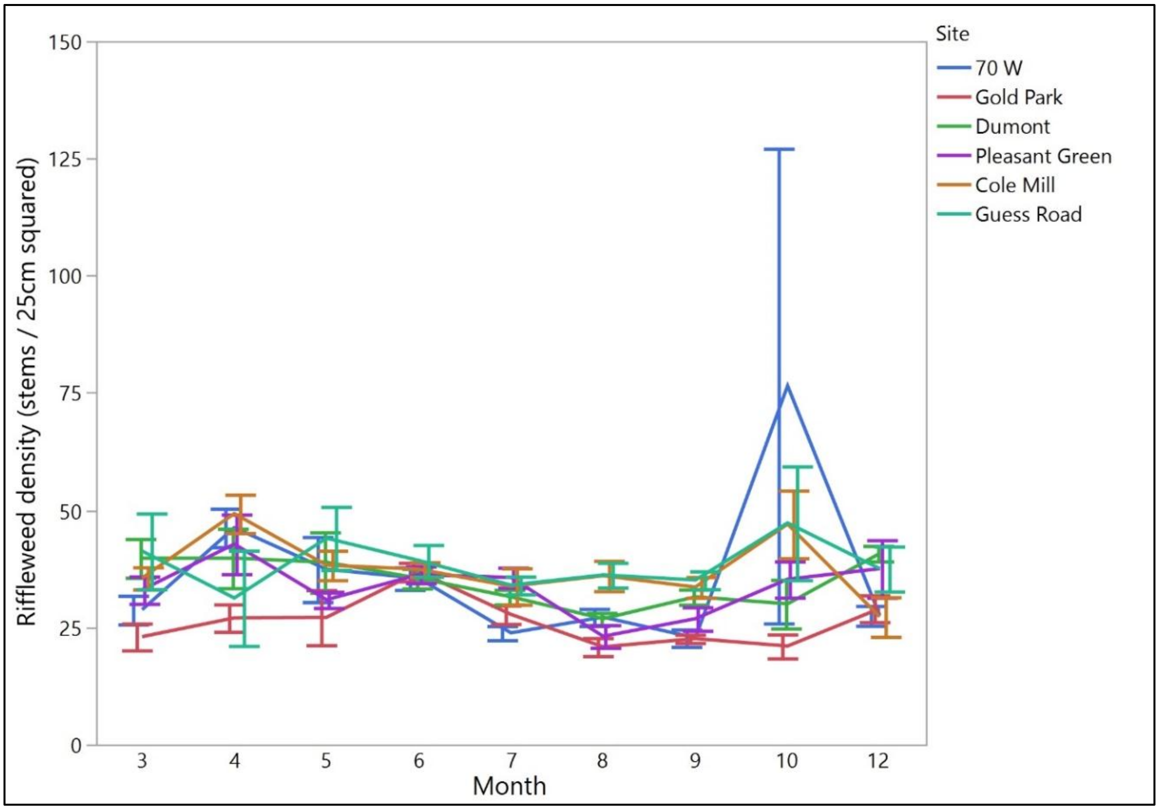

Figure 22. Average riffleweed stem density by site pooled across 2015 and 2016. 70 W and Gold Park, the control sites, have lower densities in comparison to all other sites ($p = 0.0031$). Error bars indicate one standard error from the mean.

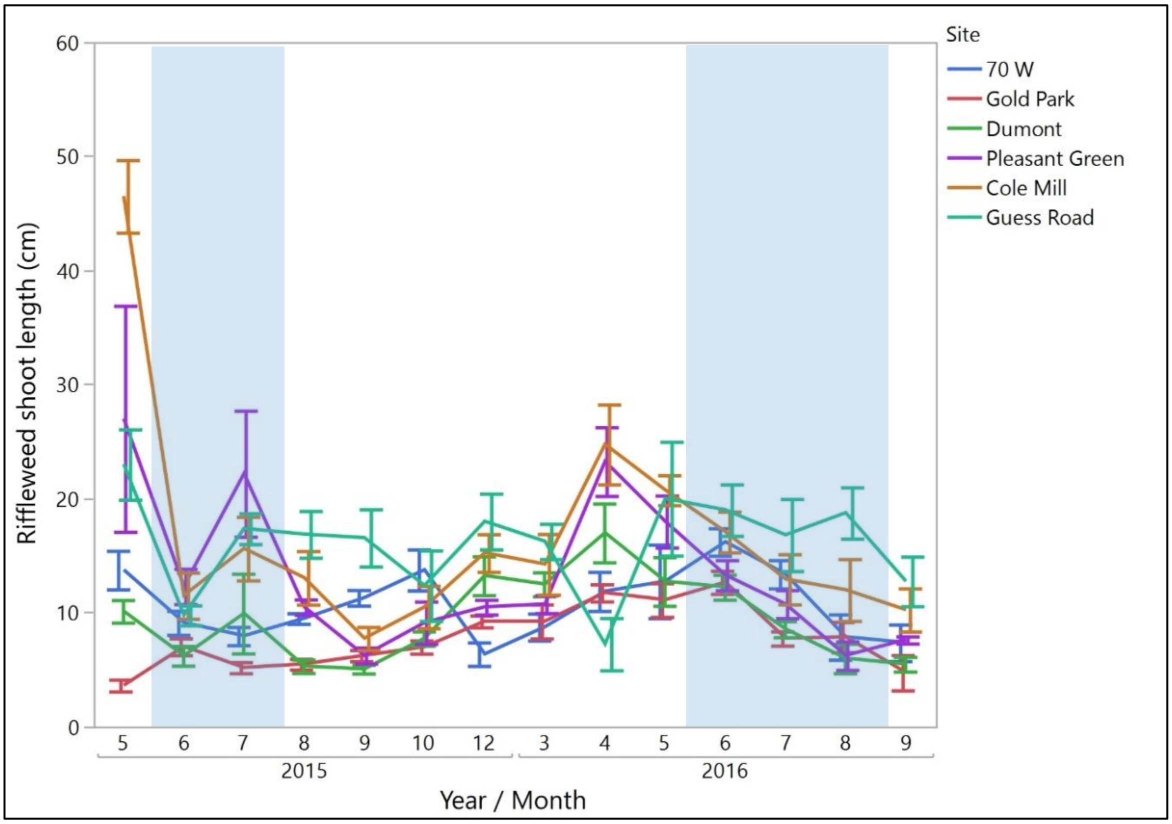

Figure 23. Average riffleweed shoot length by site separated by month within year. Gold Park and Dumont shoot lengths are shorter in comparison to all other sites ($p < 0.0001$). The shaded portion represents the period of treatment. Error bars indicate one standard error from the mean.

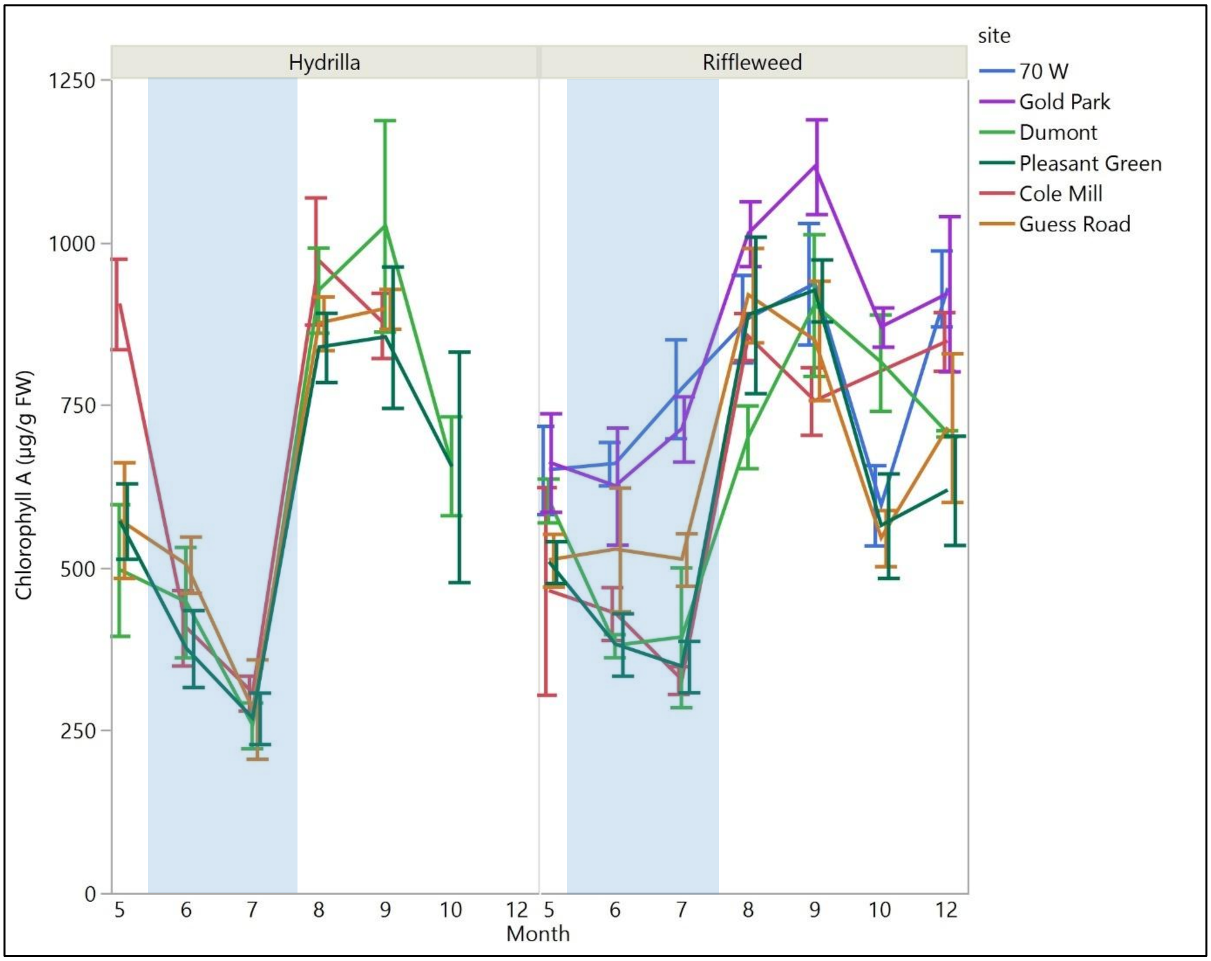

Figure 24. Average chlorophyll *a* concentration of hydrilla and riffleweed over the course of the 2015 sampling season by site. The shaded portion represents the period of treatment. FW = fresh weight. Highest concentrations were found at our reference sites, 70W and Gold Park ($p < 0.0001$) Error bars represent one standard error from the mean.

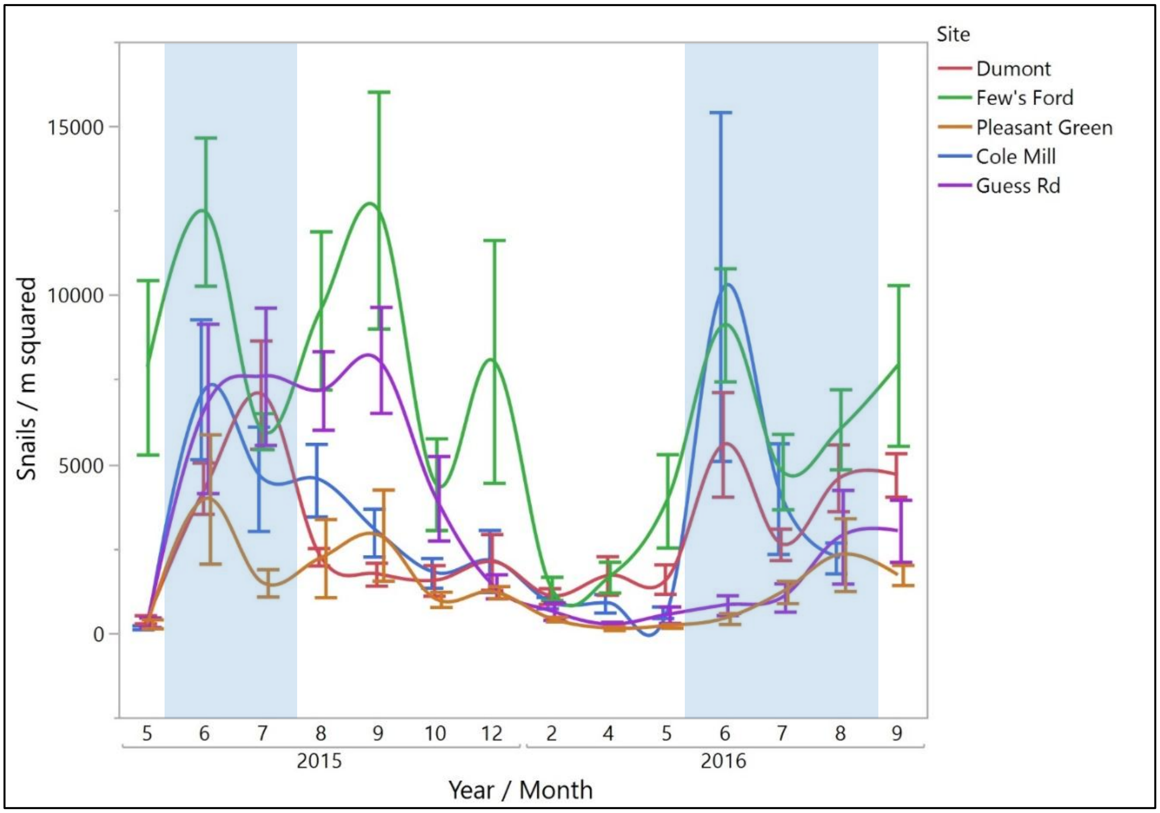

Figure 25. Panhandle pebblesnail density over two years by site. Shaded portions represent the period of treatment. Densities were higher in 2015 compared to 2016 ($p < 0.0001$) and varied by site ($p < 0.001$) and sampling month ($p < 0.0001$). Error bars represent one standard error from the mean.

Figure 26. Panhandle pebblesnails laying eggs on the bottom of riffleweed covered rock.

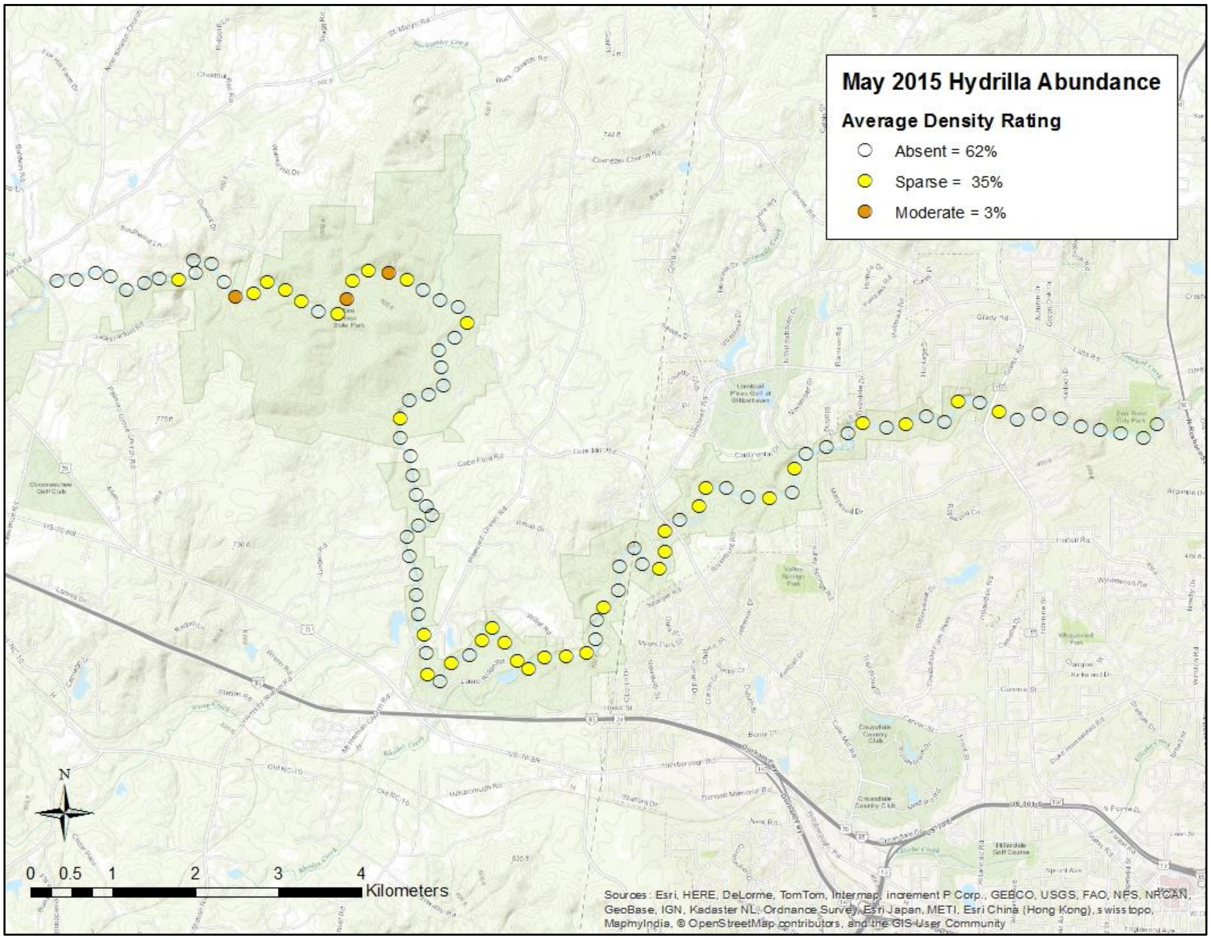

Figure 27. Eno River hydrilla abundance during 2015 kayak survey. Density ratings correspond to a scale of 0-3, with 0 being absent, and 3 being dense. Frequency of occurrence is included in the legend. Ratings were averaged for left and right bank data.

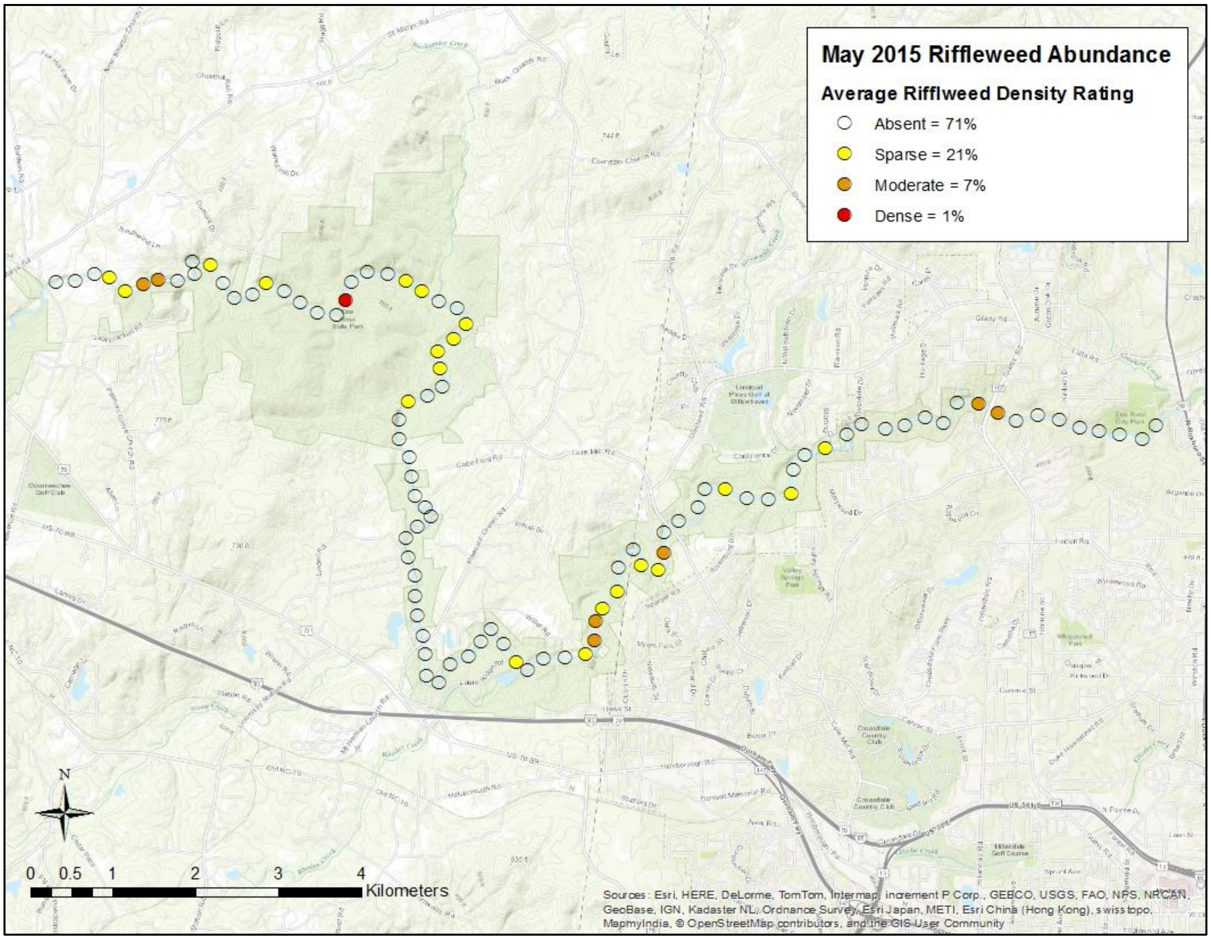

Figure 28. Eno River riffleweed abundance during 2015 kayak survey. Density ratings correspond to a scale of 0-3, with 0 being absent, and 3 being dense. Frequency of occurrence is included in the legend. Ratings were averaged for left and right bank data.

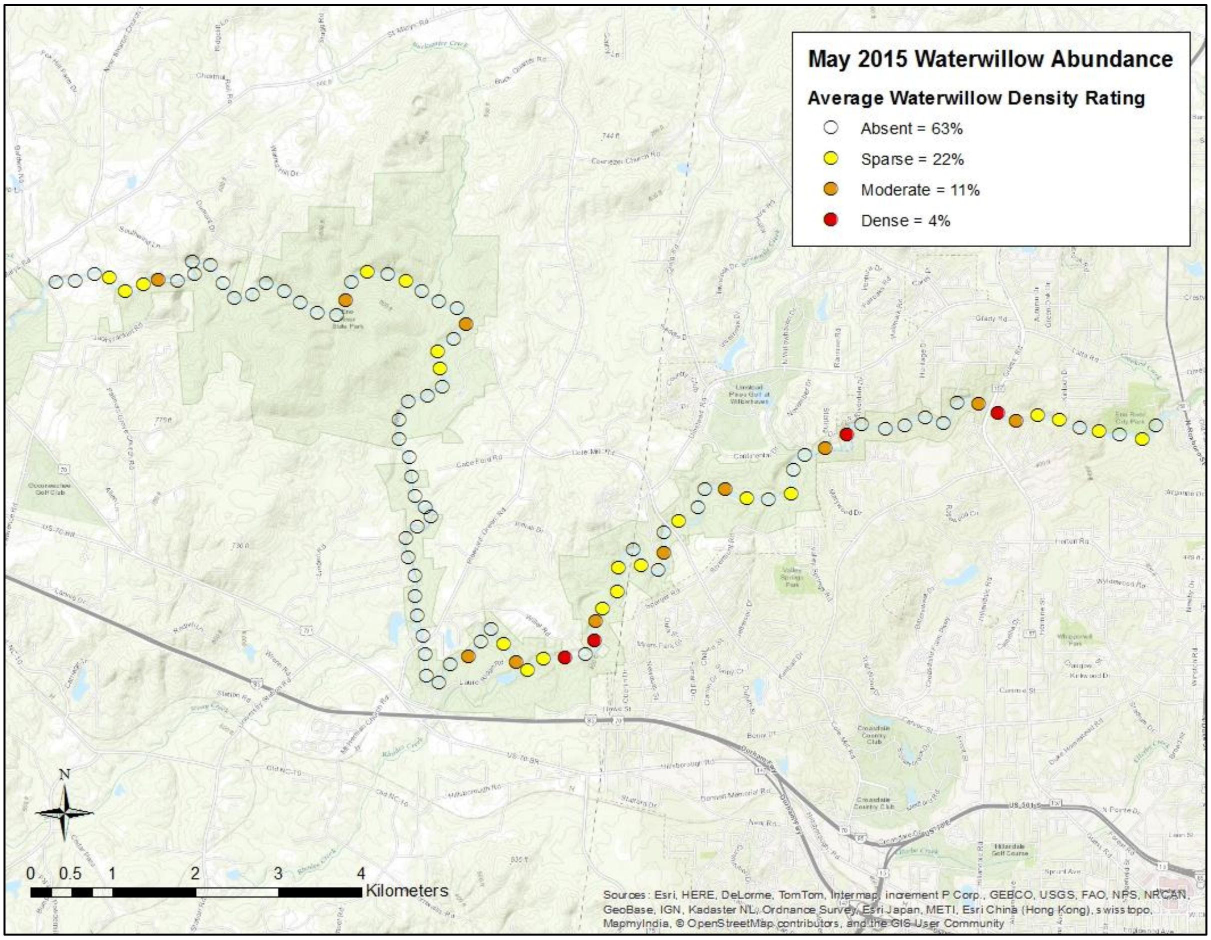

Figure 29. Eno River waterwillow abundance during 2015 kayak survey. Density ratings correspond to a scale of 0-3, with 0 being absent, and 3 being dense. Frequency of occurrence is included in the legend. Ratings were averaged for left and right bank data.

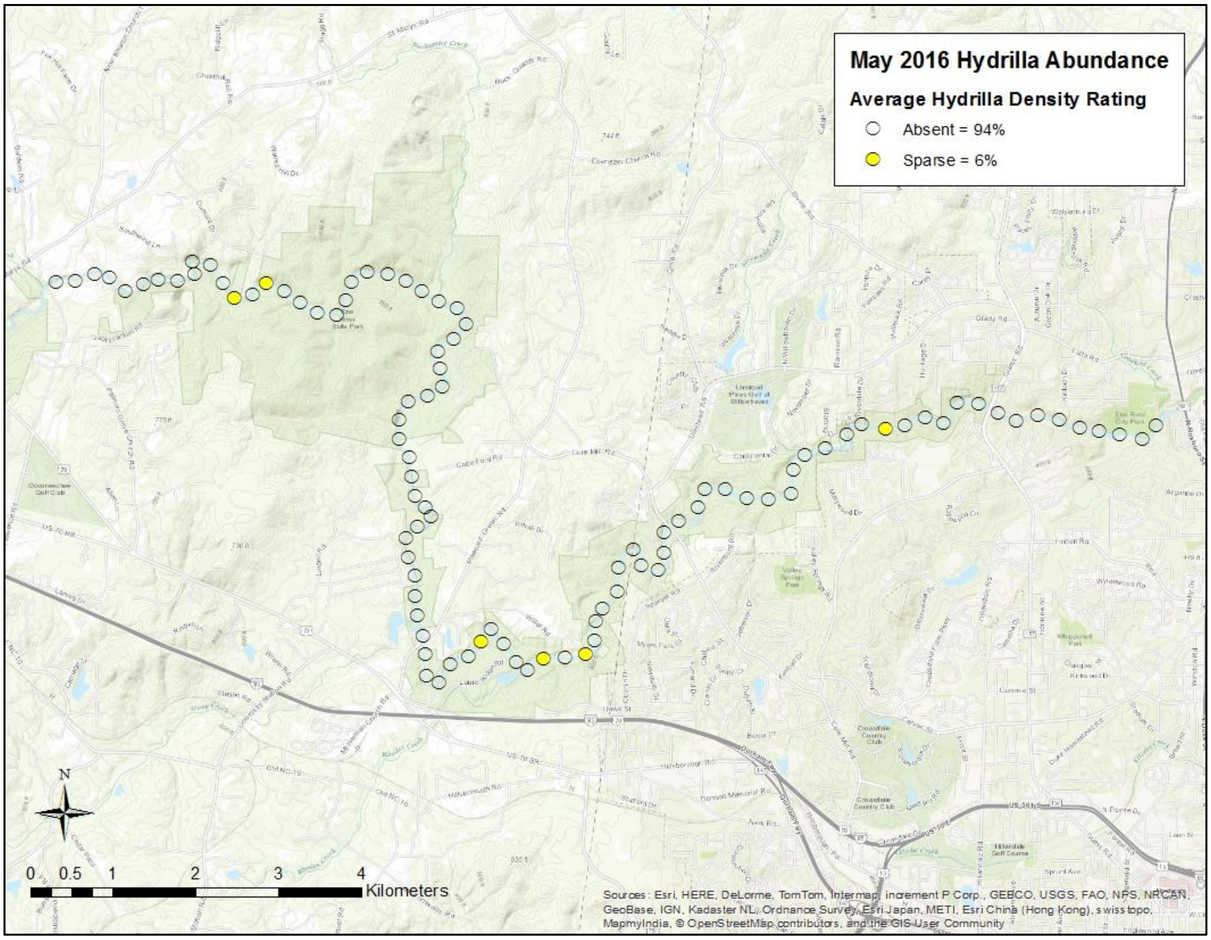

Figure 30. Eno River hydrilla abundance during 2016 kayak survey. Density ratings correspond to a scale of 0-3, with 0 being absent, and 3 being dense. Frequency of occurrence is included in the legend. Ratings were averaged for left and right bank data.

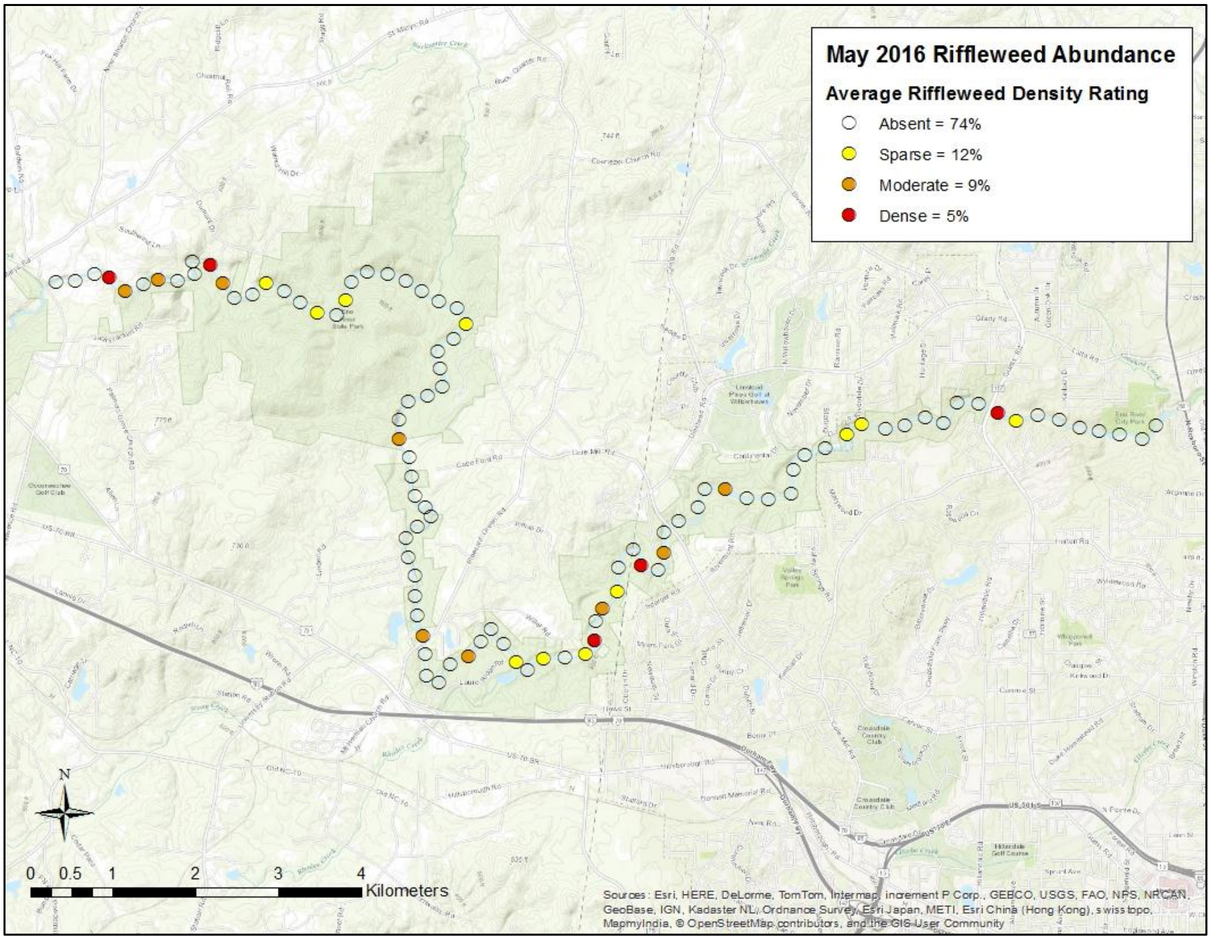

Figure 31. Eno River riffleweed abundance during 2016 kayak survey. Density ratings correspond to a scale of 0-3, with 0 being absent, and 3 being dense. Frequency of occurrence is included in the legend. Ratings were averaged for left and right bank data.

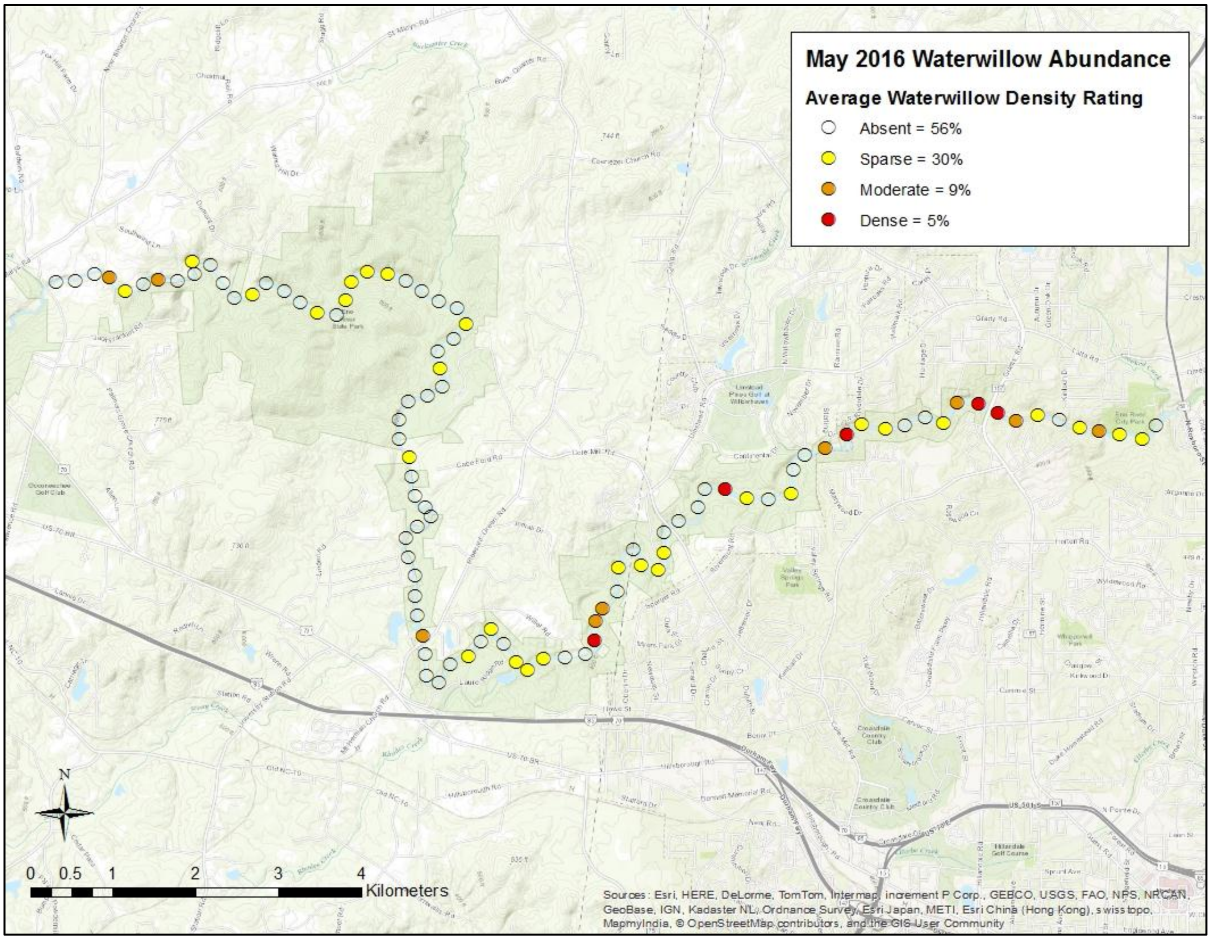

Figure 32. Eno River waterwillow abundance during 2015 kayak survey. Density ratings correspond to a scale of 0-3, with 0 being absent, and 3 being dense. Frequency of occurrence is included in the legend. Ratings were averaged for left and right bank data.

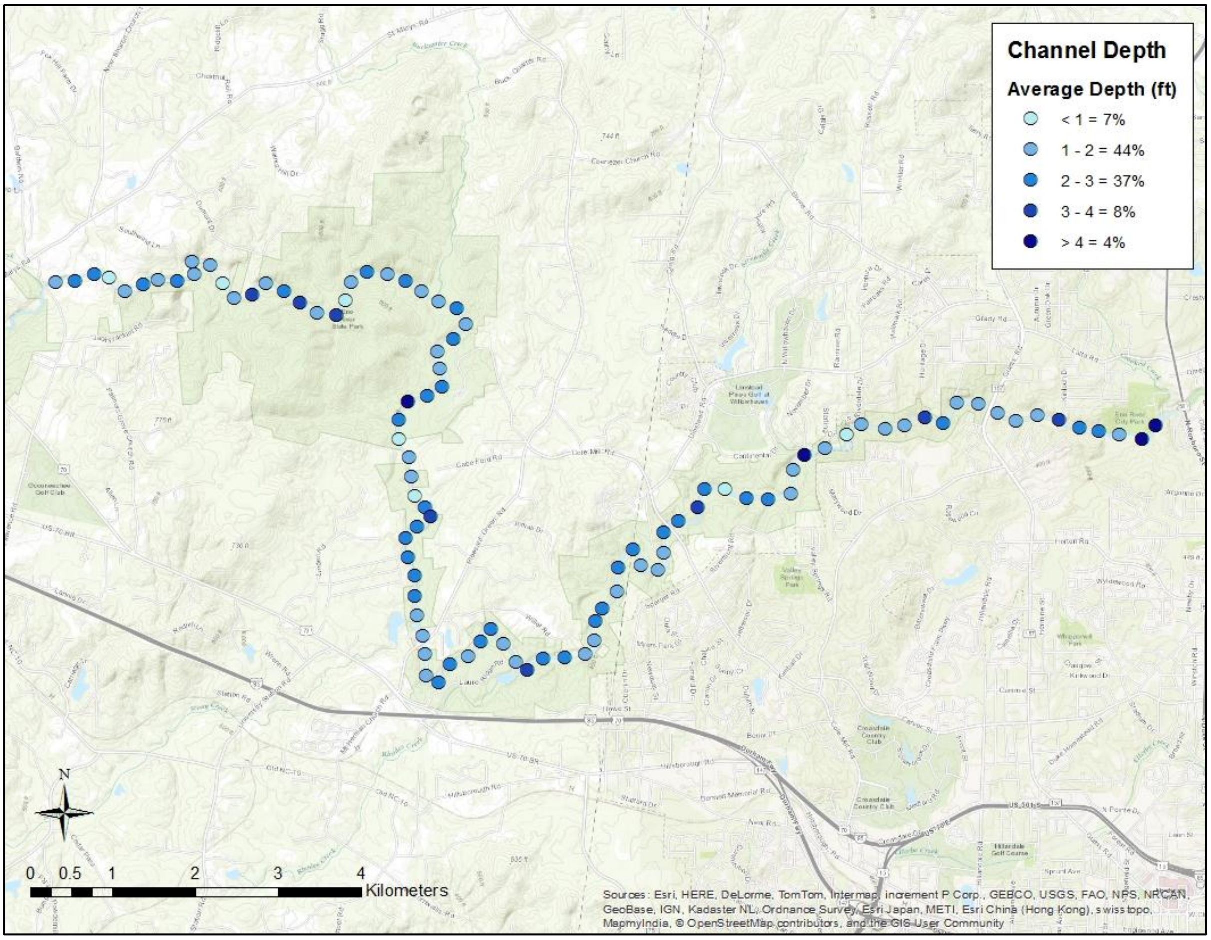

Figure 33. Average channel depth for a portion of the Eno River. Five depth readings were taken across the channel at each survey point. Frequency of occurrence is included in the legend. Readings were averaged for each point over two years.

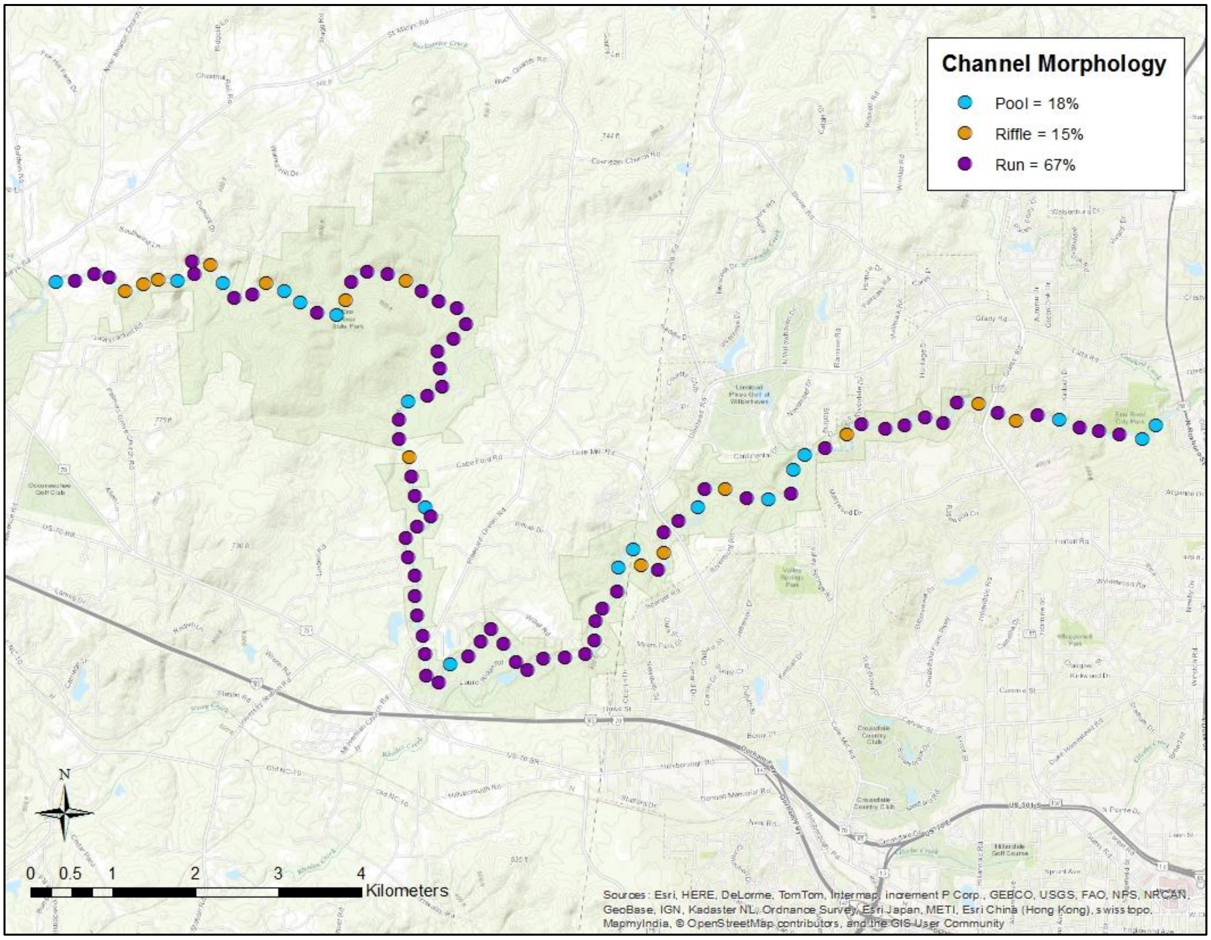

Figure 34. Eno River channel morphology classified as either a riffle, run, or pool. 67% of points were classified as a run. Frequency of occurrence is included in the legend.

F

Social and Cultural Impact Analysis

This appendix presents the results of the desktop analysis to identify potential social and cultural resources in specific, representative locations of selected watersheds in the Great Lakes Basin. This information was then used to evaluate potential impacts of Hydrilla occurrence on these social and cultural resources, as described in Section 3.3.1 of this report.

F.1 Potential Socio-Cultural Impacts: SE Lake Ontario Watershed

The SE Lake Ontario watershed is located at the eastern end of Lake Ontario. Located entirely within northwestern New York State, it extends over portions of five counties: (from west to northeast) Monroe, Wayne, Cayuga, Oswego, and Jefferson.

According to modeling conducted for the introduction and establishment of Hydrilla within the larger Great Lakes basin, the SE Lake Ontario watershed is considered to have a high potential for the introduction of Hydrilla, primarily via recreational boating, and a moderate potential for the establishment of Hydrilla in suitable nearshore aquatic habitat if it were to be introduced.

The following impact assessment describes the various features that comprise the existing socio-cultural setting of 31 focus areas along the approximately 221-mile-long shoreline area within the SE Lake Ontario watershed. These 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed were selected for detailed analysis because they include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet, as discussed in greater detail in Section F.1.1. The following impact assessment then considers the potential impacts of the introduction and subsequent establishment of Hydrilla on the various features that collectively represent the community character of these focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. It is recognized that the SE Lake Ontario watershed encompasses additional areas along the shoreline as well as interior areas that are not located along the Lake Ontario shoreline. However, the following impact assessment considers the socio-cultural setting and community character of only those counties, townships, villages, towns, and cities within which the 31 focus areas are located. This approach was adopted to make the impact assessment more manageable given the total length of the Lake Ontario shoreline (221 miles) in the SE Lake Ontario watershed.

Similarly, it is recognized that a wide variety of agencies, organizations, and special interest groups may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the SE Lake Ontario watershed. These stakeholders would consist of the civic and governmental areas with jurisdiction over the areas included in the SE Lake Ontario watershed and additional stakeholders that could include: state agencies such as New York State Office of Parks, Recreation, and Historic Preservation (NYSOPRHP) or New York State Department of Environmental Conservation (NYSDEC) that manage parks, historic sites, natural areas, and public access for waterbodies; federal agencies such as the U.S. Army Corps of Engineers, which manages navigable waterways, and the Nuclear Regulatory Commission, which provides regulatory oversight of nuclear power plants; federally recognized Indian tribes that have a cultural or historical affiliation with areas along the Lake Ontario shoreline in the SE Lake Ontario watershed or retain treaty rights to lands, waters, and resources along the shoreline of the SE Lake Ontario watershed; universities that conduct ecological research in or along the shores of Lake Ontario, such as the State University of New York (SUNY) College at Brockport (SUNY Brockport) or the SUNY College of Environmental Science and Forestry at Syracuse (SUNY-ESF); or special interest groups such as The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that have a broadly defined interest in areas and resources along the shoreline of the SE Lake Ontario watershed. These additional stakeholders could be involved as part of continued consideration of the potential impacts associated with the introduction and establishment of Hydrilla within the larger Great Lakes basin.

Potential impacts on the socio-cultural setting of shoreline areas of the SE Lake Ontario watershed are discussed in terms of whether they would be: short-term (temporary) or long-term (permanent): direct or indirect, positive (beneficial) or negative (detrimental), and cumulative. Additionally, these impacts are considered with reference to two scenarios: one where Hydrilla is untreated (worst-case scenario) and one where Hydrilla is treated (managed scenario).

It is expected that the results of this assessment of the introduction and subsequent establishment of Hydrilla on the socio-cultural setting and community character of the 31 focus areas along the Lake Ontario shoreline within the SE Lake Ontario watershed would be generally representative of potential impacts that would occur in interior areas of this same watershed. The results would also be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

F.1.1 Methodology and Definitions for the Socio-Cultural Impact Assessment for the SE Lake Ontario Watershed

This socio-cultural impact assessment assumes that the introduction and/or establishment of Hydrilla along the shoreline of the SE Lake Ontario watershed will affect the natural and socio-cultural features located in these areas, resulting in changes to the watershed's community character. For the purposes of this impact assessment, natural features are defined as uplands, points, bluffs, coves, beaches, embayments, creeks, streams, rivers, marshes, etc., and socio-cultural features are defined as villages, towns, cities, parks, other residential areas (neighborhoods and hamlets), conservation areas (including nature preserves, wildlife preserves, and wildlife management areas), commercial enterprises, industrial facilities, and cultural and historical sites.

This socio-cultural impact assessment further assumes that these natural and socio-cultural features collectively represent tangible (physical) components of the community character of the SE Lake Ontario watershed. For the purposes of this impact assessment of the SE Lake Ontario watershed, which lies entirely within New York State, community character is modelled on the state's guidance for complying with the State Environmental Quality Review Act (SEQR). New York State's SEQR guidance notes that:

> Many people define their community's character in very general terms: suburban, rural, urban, quiet, safe, scenic, or friendly are terms often used. Others describe community character only in terms of visual features.
>
> Community character is broader than this however. Community character is defined by all the man-made and natural features of the area. It includes the visual character of a town, village, or city, and its visual landscape; but also includes the buildings and structures and their uses, the natural environment, activities, town services, and local policies that are in place.
>
> These combine to create a sense of place or character that defines the area" (New York State Department of Environmental Conservation [NYSDEC] 2017).

Alternate definitions of community character are available. For example, the City of Norwalk, Ohio's 2006 Comprehensive Plan defines community character as "the sum of all the attributes and assets that make a community unique, and that establish a sense of place for its residents." While some of the attributes and assets of a community, such as "good work ethic," are intangible, others, such as an attractive central business district, are very visible (City of Norwalk, Ohio 2006). In another example, the City of Rochester's Local Waterfront Redevelopment Program (LWRP) Plan appears to define community character as "the historic, natural, cultural and scenic resources along our waterfront" (City of Rochester 2017).

The introduction and establishment of Hydrilla would occur within natural features located along the shoreline of Lake Ontario in the SE Lake Ontario watershed. These areas typically are locations recognized and used for water-dependent and water-related uses. The natural and man-made (socio-cultural) features of the watershed as a collective physical representation of the community character of the SE Lake Ontario watershed, as defined by the NYSDEC, appears to provide the most comprehensive consideration of the impacts that the introduction and establishment of Hydrilla would have on the community character of the SE Lake Ontario watershed. However, the definition of community character for this impact assessment has been expanded to include the water-dependent and water-related uses of these natural and man-made or socio-cultural features, which also contribute to community character and are deliberately managed by the communities and governmental units that comprise the SE Lake Ontario watershed.

Due to the large extent of the Lake Ontario shoreline in the SE Lake Ontario watershed (approximately 221 miles in length), 31 areas with environmental conditions highly suitable to establishment of Hydrilla were identified within this watershed for an in-depth impact assessment. These 31 areas (henceforth, referred to as focus areas) collectively comprise approximately 124 miles of the

Lake Ontario shoreline in the SE Lake Ontario watershed. They all contain physical conditions that are conducive to the introduction and establishment of Hydrilla. Table F.1-1, at the end of this section, provides a summary description of each of the 31 focus areas identified for the SE Lake Ontario watershed. This section describes the criteria used to identify the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed, which include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet.

Thus, this socio-cultural impact assessment identified the visible and physical natural and socio-cultural features that represent the attributes and assets of the communities and governmental units associated with the 31 focus areas along the shoreline of Lake Ontario in the SE Lake Ontario watershed (see Section F.1.2: see also Attachment F-1 for a listing of these visible and physical natural and socio-cultural features). This socio-cultural impact assessment also considers the management of the visible and physical natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed by the associated counties, towns, and cities or villages (see Section F.1.3), This socio-cultural impact assessment considers the impacts of the introduction and/or establishment of Hydrilla on the natural and socio-cultural features and their associated water-dependent and water-related uses identified for the 31 focus areas in the SE Lake Ontario watershed (see Sections F.1.4 and F.1.5) and considers the impacts of the introduction and establishment of Hydrilla on perceptions of features and uses and on the community character of the 31 focus areas (see Sections F.1.6 and F.1.7). The results of this impact analysis are considered with regard to their broader applicability to the entire SE Lake Ontario watershed (see Section F.1.8). Finally, conclusions and recommendations regarding the results of this impact assessment are presented in Section F.1.9.

Table F.1-1 Description of Focus Areas in the SE Lake Ontario Watershed

Focus Area Number	Description of Focus Area[1]	County	City or Town	Approximate Length (miles)
1	Shoreline of Irondequoit Bay	Monroe and Wayne	Towns of Webster (Monroe County) and Irondequoit (Wayne County)	16.42
2	Shoreline of Bear Creek Harbor at mouth of Bear Creek	Wayne	Town of Ontario	0.30
3	Shoreline of unnamed cove (White Birch Cove)?	Wayne	Town of Williamson	0.39
4	Shoreline of Pultneyville Harbor at mouth of Salmon Creek	Wayne	Town of Williamson	0.86
5	Shoreline of Holland Cove at mouth of Mink Creek	Wayne	Town of Williamson	0.56
6	Shoreline of Maxwell Bay at mouth of Salmon Creek	Wayne	Town of Sodus	1.32

Table F.1-1 Description of Focus Areas in the SE Lake Ontario Watershed

Focus Area Number	Description of Focus Area[1]	County	City or Town	Approximate Length (miles)
7	Shoreline of Sodus Bay, including the mouths of First Creek, Second Creek, Third Creek, Sodus Creek, and Clark Creek	Wayne	Towns of Sodus and Huron	32.26
8	Shoreline of East Bay, including the mouth of Mudge Creek	Wayne	Town of Huron	0.62
9	Shoreline of Port Bay, including the mouths of Beaver Creek and Wolcott Creek	Wayne	Towns of Huron and Wolcott	0.92
10	Shoreline of unnamed marsh at mouth of Red Creek	Wayne	Town of Wolcott	0.92
11	Shoreline of unnamed marsh at mouth of Black Creek	Wayne	Town of Wolcott	1.10
12	Shoreline of Blind Sodus Bay at mouth of Blind Sodus Creek	Wayne and Cayuga	Towns of Wolcott (Wayne County) and Sterling (Cayuga County)	3.19
13	Shoreline of Little Sodus Bay and The Pond, including Meadow Cove (Little Sodus Bay) and The Moat and Sterling Creek (The Pond)	Cayuga	Town of Sterling	11.34
14	Shoreline of Juniper Pond	Cayuga	Town of Sterling	0.23
15	Shoreline of unnamed cove at mouth of Eightmile Creek	Oswego	Town of Oswego	0.79
16	Shoreline of mouth of Rice Creek	Oswego	Town of Oswego	0.26
17	Oswego Harbor at mouth of Oswego River	Oswego	City of Oswego	2.37
18	Shoreline of Sunset Bay	Oswego	Town of Scriba	0.73
19	Shoreline of unnamed cove at mouth of Catfish Creek	Oswego	New Haven	0.88
20	Butterfly Swamp at mouth of Butterfly Creek	Oswego	New Haven	0.52
21	Shoreline of portion of Mexico Bay, at mouths of Little Salmon River and Sage Creeks	Oswego	Town of Mexico	0.86
22	Shoreline of mouth of Salmon River	Oswego	Town of Richland	0.79
23	Shoreline of North Sandy Pond (and South Pond and Deer Creek Marsh), including the mouths of Little Sandy Creek, Blind Creek Cove, Blind Creek, Lindsay Creek, Skinner Creek, and Renshaw Bay (North Sandy Pond)	Oswego and Jefferson	Towns of Sandy Creek (Oswego County) and Ellisburg (Jefferson County)	23.89

Table F.1-1 Description of Focus Areas in the SE Lake Ontario Watershed

Focus Area Number	Description of Focus Area[1]	County	City or Town	Approximate Length (miles)
24	Lake Ontario shoreline and shorelines of Cranberry Pond, South Colwell Pond, North Colwell Pond, Goose Pond, Floodwood Pond, Lakeview Pond, (mouths of South Sandy Creek, Mud Brook, Sandy Creek)	Jefferson	Town of Ellisburg	8.61
25	Black Pond	Jefferson	Town of Ellisburg	1.86
26	Shoreline of mouth of Stony Creek and portion of El Dorado Beach	Jefferson	Town of Henderson	2.04
27	Shoreline of Ray Bay and Boomer Cove	Jefferson	Town of Henderson	1.48
28	Shoreline of Snowshoe Bay (within Henderson Bay)	Jefferson	Town of Henderson	4.63
29	Shoreline of Whites Bay (within Henderson Bay)	Jefferson	Town of Henderson	1.30
30	Shoreline of Henderson Harbor (within Henderson Bay)	Jefferson	Town of Henderson	0.88
31	Beachfront of Durand-Eastman Park	Monroe	City of Rochester	1.34
Total	**N/A**	**N/A**	**N/A**	**123.63**

Notes:
[1] See Section 3.3 of the RA for a detailed discussion of the process used to select these focus areas.

Key:
N/A = Not applicable

F.1.2 Natural and Socio-Cultural Features along the Shoreline of the SE Lake Ontario Watershed

Two hundred twenty-eight named natural and socio-cultural features are located within the 31 focus areas along the shoreline of Lake Ontario in the SE Lake Ontario watershed. These features were identified primarily from an analysis of information included in overlays for Google Earth and identified on 7.5-minute USGS topographic quadrangles and/or coastal maps maintained in the National Oceanic and Atmospheric Administration's (NOAA's) Office of Coast Survey Historical Map and Chart Collection. Collectively, these 228 named natural and socio-cultural features are physical representations of the community character and the socio-cultural setting of the Lake Ontario shoreline in the SE Lake Ontario watershed.

A full listing of the 228 named natural and socio-cultural features identified for the 31 focus areas is included in Attachment F-1. It is noted here that Attachment F-1 is not a definitively complete listing of all the named natural and socio-cultural features in the 31 focus areas or along the entire Lake Ontario shoreline in the SE Lake Ontario watershed. While the list in Attachment F-1 is reasonably comprehensive as to the type of natural and socio-cultural features present, it primarily only includes features that are named (e.g., named waterbodies and communities on 7.5-minute USGS topographic quadrangles) and/or that have been identified in databases that comprise the Google Earth overlays.

These 228 named natural and socio-cultural features can be grouped into 10 different categories of resources (see Table F.1-2). These 10 resource categories consist of (in order of predominance from most to fewest): natural features, private businesses, communities, public parks, built resources, organizations, conservation areas, governmental facilities, industrial facilities, and camps/retreats. The types of natural and socio-cultural features located within, or associated with, these 31 focus areas should be considered generally representative of the larger number of natural and socio-cultural features along the Lake Ontario shoreline in the SE Lake Ontario watershed.

Table F.1-2 Summary of Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Resource Category	Description	Total Number in Watershed (% of total)
Natural features	Named natural features located along the shoreline of Lake Ontario.	112 (49%)
Private businesses	Private enterprises related to a variety of water-dependent or water-related recreational uses and activities along the shoreline of Lake Ontario.	46 (20%)
Communities	Named cities (including named neighborhoods), towns or villages, or hamlets located along the shoreline of Lake Ontario.	27 (12%)
Public parks	State, county, and town parks and beaches located along the shoreline of Lake Ontario.	19 (8%)
Built resources	Specific buildings, structures, objects, or other built features located along the shoreline of Lake Ontario.	8 (4%)
Organizations	Public or private enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the shoreline of Lake Ontario.	7 (3%)
Conservation areas	Federal, state, local, and private natural areas, nature/underwater preserves, and wildlife management areas located along the shoreline of Lake Ontario.	3 (1%)
Governmental facilities	Federal, state, or local government facilities located along the shoreline of Lake Ontario.	3 (1%)
Industrial facilities	Industrial facilities such as power plants or water treatment plants located along the Lake Ontario shoreline.	2 (1%)
Camps/Retreats	Public or private facilities specifically identified as camps or retreats located along the shoreline of Lake Ontario.	1 (1%)
Total		**228 (100%)**

Natural Features

One hundred twelve named natural features were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these 112 named natural features represent approximately 49% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These 112 named natural features consist of named shoreline or nearshore features (such as rivers, shoals, bays, coves, ponds, streams, and wetlands) and named terrestrial features (such as points, islands, and peninsulas). These natural features were generally identified from USGS 7.5-minute topographic quadrangles and the NOAA's Office of Coast Survey Historical Map and Chart Collection. Resources in this category do not include unnamed waterbodies and topographic features, although such natural features are also present within some of the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed.

Private Businesses (Socio-Cultural Feature)

Forty-six private business enterprises were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these 46 private business enterprises represent approximately 20% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These 46 private business enterprises consist of a variety of businesses, primarily related to recreational activities, that all are associated with water-dependent or water-related use of the Lake Ontario shoreline. These private businesses were generally identified from overlays for Google Earth. Resources in this category include marinas, campgrounds, RV parks, hotels/inns/bed-and-breakfasts, restaurants, bars, and boating facilities, and their use may be permanent or seasonal. There are likely to be additional similar private businesses along the Lake Ontario shoreline in the SE Lake Ontario watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Communities (Socio-cultural Feature)

Twenty-seven named communities were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these 27 named communities represent approximately 12% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These 27 named communities consist of named cities (and named neighborhoods within cities), towns, villages, and hamlets. These named communities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category include variously sized named clusters of residential, commercial, and/or industrial development. With regard to residential development, this may be comprised of owner-occupied or rental units, and may be permanent or seasonal. Resources in this category do not include numerous locations of unnamed shoreline development, although such unnamed shoreline development is also present within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed.

Public Parks (Socio-cultural Feature)

Nineteen public parks were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these 19 named public parks represent approximately 8% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These 19 named public parks consist of state, county, and town parks and beaches located along the Lake Ontario shoreline. These public parks were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category are primarily developed for active and passive recreational uses of the waterfront (in urban areas) or the shoreline in suburban and rural areas. Resources in this category do not include nature preserves or camps; these are addressed as separate types of resources.

Built Resources (Socio-cultural Feature)

Eight specific built resources were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these 8 specific built resources represent approximately 4% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These eight specific built resources consist of buildings, structures, objects, or other built features located along the Lake Ontario shoreline that are recognized for their individual or collective importance at the national, state, or local level (e.g., lighthouses, historical sites, or properties listed in the National Register of Historic Places). These specific built resources were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category may or may not be located within communities. Resources in this category may also include, but are not limited to, historic resources.

Organizations (Socio-Cultural Feature)

Seven public or private organizations were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these seven public or private organizations represent approximately 3% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These seven public or private organizations consist of enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the Lake Ontario shoreline. These organizations were generally identified from overlays for Google Earth. Resources in this category include golf courses, yacht clubs, country clubs, and boat clubs. Resources in this category may be owned privately or by non-profit groups. There are likely to be additional similar public or private organizations within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Conservation Areas (Socio-Cultural Feature)

Three conservation areas were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these three conservation areas represent approximately 1% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These three conservation areas consist of federal, state, local, or private natural areas, nature preserves, underwater preserves, or wildlife management areas located along the Lake Ontario shoreline. These conservation areas were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category are primarily intended for ecological preservation, although at least one has been identified for underwater resource preservation, they may also be used for active and/or passive recreational activities. Resources in this category do not include public parks or beaches; these are addressed as a separate resource type.

Governmental Facilities (Socio-Cultural Feature)

Three governmental facilities were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these three governmental facilities represent 1% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These three governmental facilities consist of federal, state, or local governmental facilities located along the Lake Ontario shoreline. Resources in this category include facilities such as U.S. Coast Guard stations or reservations, municipal harbors and wharves, and state and municipal public boat ramps, launches, and access. These governmental facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There are likely to be additional similar governmental facilities along the Lake Ontario shoreline in the SE Lake Ontario watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Industrial Facilities (Socio-Cultural Feature)

Two industrial facilities were identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. Collectively, these two industrial facilities represent approximately 1% of the total natural and socio-cultural features within the focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These two industrial facilities consist of power plants, water treatment plants, or similar facilities located along the Lake Ontario shoreline. Resources in this category may be privately owned or operated by municipalities. These industrial facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There are likely to be additional similar industrial facilities within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Camps and Retreats (Socio-Cultural Feature)

One camp or retreat was identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. This camp or retreat represent less than 1% of the total natural and socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. This camp or retreat consists of a public (municipal) or private facility that was specifically identified as a camp or retreat. This facility was identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category do not include campgrounds, RV parks, groves, or event grounds; these are considered resources that are addressed in the private businesses category. There are likely to be additional similar public or private facilities within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

F.1.3 Existing Management of Natural and Socio-Cultural Features in the SE Lake Ontario Watershed

Due to the size of the SE Lake Ontario watershed and the length of its shoreline along Lake Ontario (approximately 221 miles), the overall nature of development of this watershed varies between highly urbanized areas, such as the city of Rochester and the towns adjacent to the city (e.g., the town of Irondequoit and the town of Webster) in Monroe County or the city of Oswego in Oswego, and very rural areas, such as the town of Wolcott in Wayne County or the town of Henderson in Jefferson County and others. Despite the variation in the type and density of development along the Lake Ontario shoreline in the SE Lake Ontario watershed, the various governmental units (counties, towns, and incorporated municipalities) along the shoreline of Lake Ontario in the SE Lake Ontario watershed all have plans in place that establish baseline natural and socio-cultural conditions.

Such plans typically consist of comprehensive plans developed by the various towns along the shoreline of Lake Ontario, but may also include comprehensive plans or master plans developed by the various counties and/or incorporated communities (e.g., cities or villages) located along the shoreline of Lake Ontario. Additionally, a number of communities or locations along the Lake Ontario shoreline in the SE Lake Ontario watershed have other plans in place to address waterfront development or to manage the various water uses in harbors. These types of plans have typically been developed through New York State Department of State's LWRP and consist of LWRP Plans and Harbor Management Plans (HMPs).

While the various governmental units may have other plans for the management of natural and socio-cultural features within their boundaries, such as plans for recreation, conservation, etc., the comprehensive/master plans and the LWRP plans and HMPs generally present a comprehensive consideration of conditions and uses of the shoreline of the SE Lake Ontario watershed. These plans may specifically address the management of many of the named visible and physical natural and socio-cultural features that have been identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed.

In general, comprehensive or master plans, LWRP plans, and/or HMPs for the communities and governmental units, or for other specific areas such as Irondequoit Bay or Sodus Bay, along the Lake Ontario shoreline in the SE Lake Ontario watershed would indicate the importance of this shoreline to their respective community characters. These various plans may also recognize the various natural features (e.g., uplands, points, bluffs, coves, beaches, embayments, creeks, streams, rivers, and marshes) that physically shape the shoreline of Lake Ontario and socio-culturally shape the uses of the shoreline for residential, commercial, industrial, recreational, and conservation purposes. These various plans may also recognize various socio-cultural features (i.e., villages, towns, cities, parks, conservation areas [including nature preserves, wildlife preserves, and wildlife management areas], and residential areas [neighborhoods and hamlets]).

Similarly, comprehensive or master plans, LWRP plans, and/or HMPs for the communities and governmental units, or for other specific areas such as Irondequoit Bay or Sodus Bay, along the Lake Ontario shoreline in the SE Lake Ontario watershed would identify common issues or concerns regarding their particular natural and socio-cultural features. The common issues or concerns associated with managing waterfronts or shorelines for water-dependent or water-related uses may consist of, but would not necessarily be limited to:

- Protecting or improving the quality of specific natural features along the shoreline (such as beaches, embayments, marshes, and streams);
- Managing or enhancing residential and commercial development along the shoreline;
- Creating or enhancing opportunities for public access to the shoreline, typically for recreational purposes;
- Protecting or developing scenic qualities of the shoreline; and
- Managing or enhancing opportunities for visual access to the shoreline.

Additionally, comprehensive or master plans, LWRP plans, and/or HMPs for the communities and governmental units, or for other specific areas such as Irondequoit Bay or Sodus Bay, along the Lake Ontario shoreline in the SE Lake Ontario watershed would identify specific management goals, objectives, or recommendations to address these issues or concerns, and to manage these shorelines for water-dependent or water-related uses. In general, the purpose for managing their respective shorelines would typically, but not necessarily only, be to:

- Acknowledge and promote the character of the communities along the shoreline;
- Enhance the quality of life for permanent residents;
- Enhance the experience of seasonal residents and visitors; and
- Protect, improve, or otherwise support the natural and socio-cultural features that comprise the shoreline of Lake Ontario.

F.1.4 Potential Impacts of Introduction and Establishment of Hydrilla on Socio-Cultural Setting of the SE Lake Ontario Watershed

This section discusses the potential impacts associated with the introduction and/or establishment of Hydrilla on the socio-cultural setting of the SE Lake Ontario watershed. In general, these impacts can be considered in terms of whether they result in:

- Physical changes to natural and/or socio-cultural features identified along the Lake Ontario shoreline in the SE Lake Ontario watershed;
- Changes to water-dependent or water-related uses of these natural and/or socio-cultural features;
- Changes in perceptions about the features or their uses; and
- Changes in the community character of various locations or focus areas within the watershed.

For the purposes of this impact assessment, water-dependent uses are considered to be facilities or activities that cannot exist without a waterfront location, such as marinas, boat ramps, and sewage treatments plants. Water-related uses are considered facilities or activities that increase their value or importance because of their proximity to a shoreline. Frequently, they function as support services for water-dependent uses and could include parks and other recreational facilities, as well as some types of commercial development (Benson 2011).

In general, the changes identified above are considered in terms of whether they would be an impact that is: (1) direct or indirect; (2) temporary or permanent (short-term or long-term); (3) adverse (negative), neutral, or beneficial (positive); and/or (4) cumulative, per changes and impacts associated with other invasive aquatic plant species in the watershed or at a specific focus area and/or per changes and impacts associated with ongoing or emerging socio-cultural trends in the watershed or at a specific focus area.

Impacts on Natural and Socio-Cultural Resources

The introduction and subsequent establishment of Hydrilla within any of the 31 focus areas along the shoreline of Lake Ontario is likely to result in physical changes to a number of types of natural and socio-cultural features that comprise the socio-cultural setting of these focus areas and of the SE Lake Ontario watershed in general. At its most basic level, the introduction of Hydrilla, and its establishment and increasing density over time, in a natural feature (waterbody or marsh or wetland) with suitable environmental conditions would result in direct changes. The changes would occur to the ecological composition of the natural feature, to the appearance (visible and olfactory) of the natural features, and to the socio-cultural features and water-dependent and water-related uses associated with the natural feature. These changes would consist of new and increasingly visible and dense plants or plant mats beneath and at or on the water surface that would change the composition of ecological communities associated with the natural feature and, with regard to human use, would ultimately impede access on or through the water. At its full extent, Hydrilla present in dense mats at or on the water surface would act as a net, capturing floating detritus (natural and man-made) that would detract from the visual and olfactory setting of the waterbodies. Such changes may be small at first, with the introduction of Hydrilla into a suitable waterbody environment, but such changes may increase incrementally in density, visibility, and/or intensity over time until Hydrilla has exploited the maximum extent of available suitable habitat in the waterbody feature.

Physical changes are likely to occur on natural features and on those socio-cultural features that are comprised of, or associated with, natural features. Physical changes are likely to directly and indirectly impact natural and socio-cultural features. Additionally, these physical changes, considered in conjunction with past, present, or reasonably foreseeable future conditions for these natural and socio-cultural features, may have a cumulative impact on these natural and socio-cultural features.

Socio-cultural features that are comprised of, or associated with, natural features are also likely to undergo physical changes from the introduction and subsequent establishment of Hydrilla. These socio-cultural features would typically consist of: (1) public parks; (2) conservation areas; and (3) public or private business enterprises (e.g., marinas, restaurants, and campgrounds) that are located within the 31 focus areas along the shoreline of Lake Ontario in the SE Lake Ontario watershed and associated with water-dependent and/or water-related uses. However, other socio-cultural features, comprised of communities, organizations, industrial facilities, governmental facilities, camps and retreats, and institutions, are often also associated with natural features, such as those identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed. These are attractive locations for seasonal and permanent residences or specific locations, such as at the mouth of a navigable waterbody at which a U.S. Coast Guard facility is located, or a shoreline location that provides for specific water intake and discharge capacity for an industrial facility.

Descriptions of the potential impacts on the various types of natural and socio-cultural features identified within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed are presented below. Such impacts are considered primarily with regard to the introduction and establishment of Hydrilla without treatment, such direct and indirect impacts would likely be considered long-term or permanent impacts and would also be perceived as negative impacts by the communities and users of the 31 focus areas along Lake Ontario shoreline in the SE Lake Ontario watershed.

Dispersal modeling predicted that approximately 5% of total area of water within the SE Lake Ontario watershed may be infested by Hydrilla by 2025 (see Table 3.1.5-1); therefore, it is possible that some of the 31 focus areas would not be affected by Hydrilla, or that impacts resulting from Hydrilla would not affect some or all of the natural and socio-cultural features that collectively comprise the community character of this watershed as described below. Because dispersal modelling does not indicate specific locations within the watershed that would be affected, it is not possible to determine which of the 31 focus areas would be subject to infestation. Additionally, because the results of dispersal modelling extend through the year 2025, it is likely that the impacts discussed below would occur slowly at first, and become increasingly noticeable over time until full exploitation of available suitably habitat has been achieved. Therefore, the impacts of the introduction and establishment of Hydrilla discussed below should be considered representative of the types of impacts that could occur if these, or similar, natural and socio-cultural features are present within or adjacent to the approximately 5% of the total area of water within the entire watershed that may be infested by Hydrilla in 2025.

Impacts on Natural Features

The introduction and establishment of Hydrilla on natural features would result in a number of different impacts on natural features, depending on the type of natural feature. These impacts are both physical ecosystem effects as well as socio-cultural effects associated with impaired public access or reduced recreational usage. The physical ecosystem impacts on these natural features are summarized in this section to provide a context for considering these natural features as the setting for associated socio-cultural features and uses. The socio-cultural impacts associated with these natural features (e.g., impaired public access, reduced recreational usage) are discussed in greater detail in the following paragraphs as part of the discussion of impacts on socio-cultural features.

Natural features, such as points, bluffs, and islands, are terrestrial natural features that are not likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla. Therefore, the introduction and establishment of Hydrilla is likely to have no impact on these types of natural features, although indirect impacts on socio-cultural features, water-dependent uses, and water-related uses associated with such natural features are likely to occur and are discussed in this section. However, natural features comprised of, or associated with, waterbodies are likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla.

Waterbody features that may be directly impacted by the introduction and establishment of Hydrilla include:

- Shoreline and littoral zone of:
  - Lake Ontario,
  - Beaches, coves, harbors, and bays along the shoreline of the lake, and
  - Outlets or mouths of streams and rivers where they enter the lake or the harbors or bays along the lake shoreline; and
- Marshes or wetlands that are associated with these waterbody features.

Collectively, the 31 focus areas within the SE Lake Ontario watershed include all of these types of natural features.

The direct impacts on these natural features would result from the introduction and establishment of Hydrilla, and would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of these waterbody features, including changes to water quality (e.g., full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface) and changes to species that are located in, or that otherwise use, these waterbody features (e.g., changes to fish species, aquatic plant species, bird species); and
- Negative because such changes are detrimental to species comprising the ecological systems of these waterbodies.

Waterbody features that may be indirectly impacted by the introduction and establishment of Hydrilla include associated terrestrial features such as points, bluffs, and islands, as well as the shoreline and littoral zone of Lake Ontario, beaches, coves, harbors, and bays along the shoreline of the lake, the outlets or mouths of streams and rivers where they enter the lake or the harbors or bays along the lake shoreline, and marshes and wetlands. Collectively, the 31 focus areas within the SE Lake Ontario watershed include all of these natural features.

Finally, impacts from the introduction and establishment of Hydrilla in these natural features could be cumulative under certain conditions, such that the long-term (permanent), direct, negative impacts would be exaggerated or exacerbated.

Cumulative impacts on these natural features from the introduction and establishment of Hydrilla could occur where a waterbody, marsh, or wetland:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil (*Myriophyllum spicatum*); and/or
- Has existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct impacts from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect the waterbodies, resulting in a cumulative impact.

The above impact assessment on natural waterbody or marsh/wetland features is for the introduction and establishment of Hydrilla, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct, negative impacts on the affected natural features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Impacts on Socio-Cultural Features

The introduction and establishment of Hydrilla on socio-cultural features would result in a number of different impacts on socio-cultural features, depending on the type of socio-cultural feature. All of the socio-cultural features considered as part of this impact assessment are associated in some way with natural features that are located adjacent to, or are comprised of, waterbodies.

For the SE Lake Ontario watershed, one type of socio-cultural feature, camps or retreats, is not located adjacent to shoreline areas or waterbody features of the 31 focus areas within which Hydrilla is likely to be introduced and become established. Therefore, no impacts are expected on this type of socio-cultural feature within the 31 focus areas along the shoreline of the SE Lake Ontario watershed.

However, the remaining types of socio-cultural features identified within the 31 focus areas along the shoreline of the SE Lake Ontario watershed are located along shoreline areas or waterbody features within which Hydrilla is likely to be introduced and established. The impacts on these socio-cultural resources may be direct, where the purpose for, or use of, these socio-cultural features is typically water-dependent, or indirect, where the purpose for, or use of, these socio-cultural features is typically water-related, as discussed below.

The following socio-cultural features may be directly impacted by the introduction and establishment of Hydrilla:

- Private businesses (e.g., marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas, nature preserves, and wildlife management areas that contain or are located adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g., public boat launches, U.S. Coast Guard stations, and harbors).

Collectively, the 31 focus areas within the SE Lake Ontario watershed include all of these types of socio-cultural features.

The direct impacts on these socio-cultural features that would result from the introduction and establishment of Hydrilla would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of associated affected waterbody features, such that the purpose for, and use of, these socio-cultural features would be affected. For example, full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface, such that private businesses or governmental facilities such as marinas or harbors could no longer be used by boats; boating or fishing would no longer be desirable or viable activities; use of public parks and beaches along affected waterbodies would no longer be desirable for recreational activities; operation of water intake and discharge systems for industrial facilities would be affected; and,
- Negative because the purpose for, or uses of, these socio-cultural features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

The following socio-cultural features may be indirectly impacted by the introduction and establishment of Hydrilla:

- Private businesses such as shoreline restaurants, bars, event sites, camps or retreats, campgrounds, mobile home parks, RV camping, resorts, hotels, bed and breakfasts;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, for enjoying scenic views and viewsheds);
- Built resources, particularly where underwater or waterfront setting is an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, enjoying scenic views and viewsheds); and
- Organizations associated with golfing, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

Collectively, the 31 focus areas within the SE Lake Ontario watershed include all of these types of socio-cultural features.

The impacts on these socio-cultural features as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the appearance of the setting (visual or olfactory) of these socio-cultural features; and
- Negative, because the intended purpose for, or use of, such features would be impaired, impeded, or prevented, such that they no longer would be enjoyable or desirable by their users or viable by their owners or managers.

As previously discussed for natural features, impacts on these socio-cultural features from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these socio-cultural features from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on socio-cultural features from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these features, resulting in a cumulative impact.

The above impact assessment on socio-cultural features has been for the introduction and establishment of Hydrilla within the 31 focus areas along the shoreline of the SE Lake Ontario watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the socio-cultural features that are associated with these natural waterbody or marsh/wetland features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views because their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Impacts on the water-dependent or water-related uses associated with affected waterbodies are discussed in Section F.1.5.

F.1.5 Impacts on Water-Dependent or Water-related Uses of Resources

The introduction and establishment of Hydrilla would result in a number of different impacts on water-dependent or water-related uses within the 31 focus areas along the Lake Ontario shoreline within the SE Lake Ontario watershed, depending on the type of use and/or the type of natural or socio-cultural feature with which the use is associated. For the purposes of this impact assessment, natural features associated with water-dependent uses include the shoreline and littoral zones of Lake Ontario within the focus areas, such as the following features: coves, harbors, and bays; beaches; outlets or mouths of streams and rivers; and marshes and wetlands. However, all of the natural features identified within the 31 focus areas along the Lake Ontario shoreline are associated with water-related uses, including those identified above for water-related uses along with points, bluffs, and islands.

As discussed above in Section F.1.4, socio-cultural features associated with water-dependent uses would include:

- Private businesses (e.g., marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas, nature preserves, and wildlife management areas that contain or are located in or adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g., public boat launches, U.S. Coast Guard stations, and harbors).

Therefore, the introduction and establishment of Hydrilla is likely to have some type of impact on all of the water-dependent uses associated with these natural and socio-cultural features.

The following water-dependent uses may be directly impacted by the introduction and establishment of Hydrilla:

- Swimming;
- Recreational boating;
- Fishing;
- Sailing;
- Policing waterways and waterbodies;
- Power production; and
- Water and sewage treatment.

Similarly, socio-cultural features associated with water-related uses would include:

- Private businesses such as shoreline restaurants, bars, event sites, camps or retreats, campgrounds, mobile home parks, RV camping, resorts, hotels, bed and breakfasts;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, and for enjoying scenic views and viewsheds);

- Built resources, particularly where underwater or waterfront settings are an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, and enjoying scenic views and viewsheds); and
- Organizations associated with golfing, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

The following water-related uses may be indirectly impacted by the introduction and establishment of Hydrilla:

- Dining;
- Drinking;
- Sightseeing;
- Sunbathing;
- Hiking;
- Golfing;
- Camping;
- Experiencing nature;
- Socializing in large group settings (weddings, picnics, conferences, camps, retreats);
- Vacationing;
- Preserving natural resources;
- Managing natural resources;
- Seasonal (vacation) housing;
- Permanent housing; and
- Commercial and industrial support facilities for recreational, seasonal, and permanent residential activities.

The impacts on the above water-dependent and water-related uses within the 31 focus areas as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), direct and indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it becomes established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would prevent or impede the water-dependent uses such that they could no longer take place;

- Indirect because the introduction and establishment of Hydrilla would result in changes to the conditions within which such water-dependent uses can occur, such that these water-dependent uses could no longer be conducted or sustained by their users or would no longer be considered viable by their owners or managers; and
- Negative where the introduction and establishment of Hydrilla physically prevents or detrimentally impairs these water-dependent uses or the management of these water-dependent uses.

For example, water-dependent uses such as swimming, recreational boating or sailing, and fishing would not be possible or would not be considered desirable water-dependent activities in a waterbody densely infested with Hydrilla. If such water-dependent uses were reduced, there would be a concurrent reduced need for boat maintenance or storage facilities in the absence of recreational boating, sailing, or fishing. The boating actions associated with policing affected waterbodies or using affected waterbodies that are harbors would be impaired. The use of water intakes and discharge outfalls associated with sewage treatment, water treatment, and power plants would be impeded such that treatment or power production would be impaired. Current underwater physical conditions could change in a manner that prevents the physical preservation of underwater resources included in marine sanctuaries or resources such as shipwrecks or prevents the uses of such resources for preservation or scientific study.

Similarly, water-related uses would be considered less desirable primarily because of changes to the setting (visual or olfactory) of socio-cultural features that support such activities. Waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing. Similarly, shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing, sunbathing, hiking, or enjoying nature. Waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities. With changes to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary. Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

As discussed above for natural and socio-cultural features, impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could occur where associated waterbodies or marshes or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on water-dependent or water-related uses from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these uses, resulting in a cumulative impact.

The above impact assessment on water-dependent or water-related uses has been for the introduction and establishment of Hydrilla within the 31 focus areas along the shoreline of Lake Ontario in the SE Lake Ontario watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above for the 31 focus areas are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, such that their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Where the introduction and establishment of Hydrilla would result in impacts on natural or socio-cultural features and/or associate water-dependent or water-related uses, it is likely that perceptions about these features and uses would change. Possible changes to perceptions about the natural or socio-cultural features and their associated water-dependent and water-related uses are considered in Section F.1.6.

F.1.6 Impacts on Community Perceptions of Features and Uses

As noted above in Section F.1.3, counties, towns, cities, and/or other locations (such as Irondequoit Bay or Sodus Bay) associated with the 31 focus areas along the Lake Ontario shoreline of the SE Lake Ontario watershed would manage the natural and socio-cultural features areas located along their respective shorelines or waterfronts to protect, enhance, promote, create, rehabilitate, redevelop, or develop water-dependent and water-related uses. Management would be according to the goals, policies, objectives, or recommendations that are memorialized in comprehensive or master plans, LWRP plans, and/or HMPs.

It is likely that natural and socio-cultural features that are located within the 31 focus areas along the shoreline of Lake Ontario in the SE Lake Ontario watershed may be specifically identified in such plans, indicating that they would be perceived as locations, features, or attributes that define the local community or governmental unit and that they would be perceived and recognized as worthy of protection or improvement. Similarly, water-dependent and water-related uses associated with these natural and socio-cultural features may also be identified and described, either as part of planning efforts or via zoning ordinances, and discussed in such plans. This would indicate that such uses would be perceived as worthy of protection, management, creation, enhancement, or development.

Such perceptions would generally be expected to be identified or expressed by local individuals and groups that comprise the communities or governmental units responsible for the preparation of such plans and would be inherent in such plans because they were made known via charrettes, questionnaires, and other outreach efforts conducted as part of the preparation of such plans. Such local individuals and groups would be expected to be comprised of local residents, or non-local stakeholders with an interest in specific resources or for specific uses (such as individuals or companies that own and/or manage businesses, organizations, or facilities in an area but do not actually reside there). Additionally, the perceptions of federal, state, or local agencies that fund such planning efforts, or that provide guidance for the preparation of such plans, may also be incorporated into the preparation of such plans, albeit indirectly, via the requirements for the preparation of such plans or via the structure and/or content of meetings and materials included in outreach efforts.

Separately, the perceptions of individuals or groups that have an interest in specific or collective natural or socio-cultural features within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed, or their associated water-dependent or water-related uses, may be lacking from such plans. Such individuals or groups may be seasonal users, state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and special interest groups whose involvement would be at a regional or national scale. For example, the perceptions of individuals or groups that are seasonal users would likely be expressed outside of such plans, by changes to patterns of visiting areas for recreational or other purposes, such as vacationing, camping, fishing, boating, etc. Similarly, the perceptions of state or federal agencies with management responsibilities for specific socio-cultural features located within the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed may also be lacking from such plans. These agencies would be as diverse as the New York State Office of Parks and Recreation, for state parks and historic sites; the New York State Department of Environmental Conservation, for state conservation areas, wildlife management areas, public boat launches, etc.; the U.S. Army Corps of Engineers, for navigable waterways; the

NOAA, for the proposed Great Lake Ontario National Marine Sanctuary; or the Nuclear Regulatory Commission, for the Ginna Nuclear Power Plant, Niagara Mohawk Nine Mile Point Nuclear Station, and J.A. Fitzpatrick Nuclear Power Plant.

Finally, the perceptions of special interest groups that would have a broad or unique interest in natural and socio-cultural features in the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed, and/or their water-dependent or water-related uses, would also be expressed outside of such plans. Such groups, whose primary perceptions would be related to regional, national, or cultural interests in a specific area, feature, or use, may include: federally recognized Indian tribes, such as the Cayuga Nation, the Oneida Indian Nation, the Onondaga Nation, the Seneca Nation of Indians, the Tonawanda Seneca Nation, the St. Regis Mohawk Tribe, the Tuscarora Nation, the Oneida Nation (Wisconsin), or the Seneca-Cayuga Nation (Oklahoma), who may have a cultural or historical affiliation with areas that include such features and uses or may have retained treaty rights for use of such areas; or groups such as the Sierra Club, the Nature Conservancy, or Ducks Unlimited, which have national conservation interests that are applied at the local level via ownership of conservation areas or sponsorship for various conservation efforts.

As suggested above in the assessment of water-dependent and water-related uses of natural and socio-cultural features in the 31 focus areas, the potential impacts of the introduction and establishment of Hydrilla would be likely to occur where physical changes would have been made to the features or uses, or where there would be visual or olfactory changes to the setting of such features or uses. For example, the natural or socio-cultural features themselves may no longer be perceived as worthy of being protected, preserved, or managed for their intrinsic natural or socio-cultural values to a community. When changes are made to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary.

Similarly, the water-dependent or water-related uses associated with such features may no longer be perceived as desirable or viable. For example, waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing; shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities (e.g., sightseeing, sunbathing, hiking, or enjoying nature); waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities.

Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent and water-related uses within the 31 focus areas as a result of the introduction and establishment of Hydrilla have the potential to be long-term (permanent), direct indirect, and negative. Specifically, these impacts would likely be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the conditions of affected features or uses, it is the perceptions of these affected features or uses that could change; and
- Negative where the perceptions of affected features or uses conclude that such features and uses are no longer worthy of protection, management, creation, improvement, enhancement, or development.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent or water-related uses within the 31 focus areas from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on perceptions of affected features or uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the indirect impacts on perceptions of affected features or uses from introduction and establishment of Hydrilla would occur at a faster rate or would be greater, resulting in a cumulative impact.

The above impact assessment for perception of affected natural and socio-cultural features and their associated water-dependent or water-related uses within the 31 focus areas has been for the introduction and establishment of Hydrilla. It is understood that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies While it would be unlikely for treatment to completely eliminate or reverse the physical impacts of the introduction and establishment of Hydrilla, treatment would likely receive considerable support by the communities, governmental units, state and federal agencies, stakeholders, special interest groups, and seasonal users in an effort to avoid or minimize impacts on the perceptions of affected features and uses.

F.1.7 Impacts on Community Character of Focus Areas in the SE Lake Ontario Watershed

Dispersal modelling suggests that the primary method of introduction of Hydrilla into specific locations is via recreational boat use, such that locations where recreational boaters launch (via public boat launch or private boat launch locations) are most likely to result in the initial introduction of Hydrilla. It follows that the spread of Hydrilla likely would also occur at secondary locations that are accessible by recreational boaters but do not necessarily contain formal public or private boat launching facilities.

Therefore, impacts on community character resulting from the introduction and establishment of Hydrilla are most likely to occur in locations that: (1) have physical features (i.e., boat launch facilities) suitable for the introduction of Hydrilla; (2) have environmental conditions conducive to the establishment of Hydrilla if it is introduced; and (3) have community character defined by natural and socio-cultural features and associated water-dependent or water-related uses that would be affected by the introduction and establishment of Hydrilla. The 31 focus areas identified along the Lake Ontario shoreline in the SE Lake Ontario watershed either meet all of these criteria or, if a focus area lacks a public or private boat launch, meet the second and third criteria.

The potential impacts of the introduction and establishment of Hydrilla on the community character of the 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed correlates to the impact conclusions for natural and socio-cultural features, their associated water-dependent or water-related uses, and the perceptions of such features and use by communities and governmental units, as discussed above in Sections F.1.4, F.1.5, and F.1.6. Specifically, the long-term (permanent), direct and/or indirect, and negative impacts of the introduction and establishment of Hydrilla on natural and socio-cultural features, on their associated water-dependent or water-related uses, and on the perceptions of these features and uses, also result in the same type of impacts on the community character of these focus areas. The impacts associated with the treatment of Hydrilla would be the same, as would the potential for cumulative impacts.

It is likely, however, that such impacts on community character would be perceived differently. The local individuals and groups that comprise the communities and governmental units associated with these 31 focus areas likely would consider such impacts differently from seasonal users, from state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and from special interest groups whose involvement would be at a regional or national scale. Additionally, impacts on community character would occur at different rates over time, depending on the nature of the affected individuals, groups, agencies, or users.

For example, local individuals and groups that comprise the communities and governmental units associated with these 31 focus areas likely would recognize the impacts. However, they may be reluctant to accept the changes to their community character and be slow to participate in necessary revisions to the management of affected natural and socio-cultural features and their associated water-dependent or water-related uses that would alter their existing community character.

Conversely, state or federal agencies and special interest groups that operate regionally or nationally likely would recognize the impacts and would accept such changes to the affected features and uses. However, they also may be slow to participate in necessary revisions to the management of affected features and uses for any number of administrative reasons (e.g., limited manpower, limited budget, and limited regulatory authority).

Finally, it is likely that seasonal users may differ greatly from both of these other groups. Seasonal users would be likely to recognize the impacts, and while reluctant to accept the changes to community character, quick to abandon those areas that contain affected natural and socio-cultural features and their associated water-dependent and water-related uses. Changes to their seasonal use of affected areas may be either in favor of other similar areas that remain unaffected by the introduction and establishment of Hydrilla or may represent a greater shift in favor of other areas with features and uses that would never be affected by the introduction and establishment of Hydrilla.

F.1.8 Impacts on the Community Character of the SE Lake Ontario Watershed

The 31 focus areas along the Lake Ontario shoreline in the SE Lake Ontario watershed were selected specifically because they contain conditions that are conducive to the introduction and establishment of Hydrilla. Therefore, the potential impacts on the natural and socio-cultural features and their associated water-dependent and water-related uses that contribute to the community character of these focus areas may appear to be disproportionately emphasized when compared to the potential for similar impacts along the entire Lake Ontario shoreline or within the SE Lake Ontario watershed.

For the SE Lake Ontario watershed as a whole, dispersal modelling predicted that by 2025, approximately 5% of the total waterbody area within the watershed would be affected by Hydrilla (see Table 3.1.5-1). Given the overall size of the SE Lake Ontario watershed and prevalence of water resources therein, it can be inferred based on the dispersal model results that future (2025) impacts resulting from introduction and establishment of Hydrilla on the overall community character of the watershed may be relatively small when considered for the entire watershed. However, if perchance all future Hydrilla infestations were to occur along the Lake Ontario shoreline in one or more of the 31 focus areas evaluated in this analysis, the collective impacts likely would garner more attention and have a greater collective impact, especially if future infestations are concentrated in one or more of the high-use, high-value areas located on the shoreline, such as Irondequoit Bay or Sodus Bay,

Although this section describes potential future impacts from Hydrilla in focus areas along the Lake Ontario shoreline, it is expected that similar impacts from the introduction and establishment of Hydrilla would occur at various locations throughout the interior of the SE Lake Ontario watershed. However, it is likely that these impacts would be more localized at or near the point of introduction, and would individually affect a smaller number of natural and socio-cultural features and a smaller number of associated water-dependent or water-related uses. Therefore, perceptions of the impacts on such features and uses, and their overall effect on the community character of the entire watershed would be diluted over a larger area.

As indicated by the above impact analysis, the Lake Ontario shoreline represents a distinct component of the community character of the entire SE Lake Ontario watershed that differs in size and nature when compared to the smaller and dispersed waterbodies (lakes, ponds, rivers, creeks, and streams) that are located in the interior of this watershed. Thus, it is not unusual that the potential impacts of the introduction and establishment of Hydrilla, with or without treatment to control its spread, would be considered a prominent factor in the future of the SE Lake Ontario watershed.

F.1.9 Conclusions and Recommendations

The introduction and establishment of Hydrilla into the SE Lake Ontario watershed has the potential to result in long-term (permanent), direct and indirect, negative impacts on natural and socio-cultural features and their associated water-dependent and water-related uses that comprise the socio-cultural setting of this watershed. Similar impacts would be expected on the perceptions of these features and uses. Collectively, these impacts would represent long-term, indirect, negative impacts on the community character of this watershed.

These conclusions were based on the analysis of features and associated uses that were identified from: publicly available databases and planning documents; overlays for Google Earth; 7.5-minute USGS topographic quadrangles; and/or coastal maps maintained in the NOAA's Office of Coast Survey Historical Map and Chart Collection. These conclusions were also developed considering the management of such features and uses that may be represented in comprehensive plans or master plans for the various counties, towns, and cities located along the Lake Ontario shoreline in the SE Lake Ontario Watershed and/or identified and discussed in LWRP Plans and HMPs prepared by various communities in these locations through New York State Department of State's Local Waterfront Revitalization Program.

These conclusions are based on the analysis of impacts on natural and socio-cultural features and associated water-dependent and water-related uses identified for 31 focus areas that collectively represent approximately 124 miles (56%) of the approximately 221-mile-long Lake Ontario shoreline in the SE Lake Ontario watershed. However, these conclusions are considered generally representative of potential impacts that would occur in interior areas of this same watershed and would be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

Separately, as discussed in this impact assessment (see Sections F.1 and F.1.6), there are a wide variety of agencies, organizations, and special interest groups, in addition to the many communities and governmental units with authority or jurisdiction over the Lake Ontario shoreline in the SE Lake Ontario watershed, that may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the watershed. These stakeholders would include, but may not be limited to:

- State agencies such as New York State Office of Parks, Recreation, and Historic Preservation (NYSOPRHP) or New York State Department of Environmental Conservation (NYSDEC) that manage parks, historic sites, natural areas, and public access for waterbodies;
- Federal agencies such as the U.S. Army Corps of Engineers, which manages navigable waterways throughout the SE Lake Ontario watershed, and the Nuclear Regulatory Commission, that provides regulatory oversight of the nuclear power plants along the Lake Ontario shoreline in the SE Lake Ontario watershed;
- Federally recognized Indian tribes such as the Cayuga Nation, the Oneida Indian Nation, the Onondaga Nation, the Seneca Nation of Indians, the Tonawanda Seneca Nation, the St. Regis Mohawk Tribe, the Tuscarora Nation, the Oneida Nation (Wisconsin), or the Seneca-Cayuga Nation (Oklahoma), who may have cultural or historical affiliation with various areas in the SE Lake Ontario watershed or retain treaty rights to lands, waters, and resources within the SE Lake Ontario watershed;
- Universities that conduct ecological research in or along the shores of Lake Ontario or in other waterbodies in the SE Lake Ontario watershed, such as the State University of New York (SUNY) College at Brockport (SUNY Brockport) or the SUNY College of Environmental Science and Forestry at Syracuse (SUNY-ESF); and
- Special interest groups such as or The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that have a broadly defined interest in areas and resources along the shoreline and in interior areas of the SE Lake Ontario watershed.

Outreach efforts by the U.S. Army Corps of Engineers with the various communities and governmental units for all of the counties, towns, cities, and other areas (such as Irondequoit Bay or Sodus Bay) at both the agency and public level is encouraged in order to collaboratively identify and develop strategies related to raising awareness for, controlling, and jointly managing the introduction and establishment of Hydrilla in this watershed. Similarly, the U.S. Army Corps of Engineers should consider additional similar outreach efforts with the various stakeholders identified above for the same reasons. Many of these communities, governmental units, and stakeholders already have experience managing invasive aquatic plant species other than Hydrilla, and would likely welcome the opportunity to avoid or minimize the potential for new and/or cumulative impacts on the natural and socio-cultural features and associated water-dependent or water-related uses that they already manage or value.

4.1.10 References

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Attachment F-1

Natural and Socio-Cultural Features Along the Shoreline in the SE Lake Ontario Watershed

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Camp Eastman	Monroe	City of Rochester	Public (County) Camp/Retreat.	City-owned year-round lodges and cabins, managed by the Town of Irondequoit and available for rent by individuals, groups, and organizations	31
Durand Eastman County Park	Monroe	City of Rochester	Public (County) Park	County owned park along the Lake Erie shoreline with year-round recreational facilities	31
Johnson Pond	Monroe	City of Rochester	Natural Feature	Small waterbody located within Durand Eastman County Park at the mouth of an intermittent stream, near the Lake Ontario shoreline.	31
Sherry Pond	Monroe	City of Rochester	Natural Feature	Small waterbody located within Durand Eastman County Park at the mouth of an intermittent stream, near the Lake Ontario shoreline.	31
Durand Eastman Beach	Monroe	City of Rochester	Natural feature of Lake Ontario	Located within Durand Eastman County Park	31
Eastman Lake	Monroe	City of Rochester	Natural Feature	Small man-made waterbody located within Durand Eastman County Park at the mouth of an intermittent stream, near the Lake Ontario shoreline.	31
Durand Lake	Monroe	City of Rochester	Natural Feature	Small man-made waterbody located within Durand Eastman County Park at the mouth of an intermittent stream, near the Lake Ontario shoreline.	31

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Irondequoit Bay Marine State Park	Monroe	Town of Irondequoit	Public (State) Park	State-owned boat launch site that provides boating and fishing access to Lake Ontario; managed by Monroe County	1
Sea Breeze	Monroe	Town of Irondequoit	Community	Community associated with privately owned historic amusement park that was established on Irondequoit Bay in 1879 and is still in use	1
Irondequoit Bay	Monroe	Irondequoit	Natural Feature	Coastal bay of Lake Ontario.	1
German Village	Monroe	Irondequoit	Community	Neighborhood on Irondequoit Bay	1
Point Pleasant	Monroe	Irondequoit	Natural feature along Irondequoit Bay	Located on shoreline of Irondequoit Bay	1
Ides Cove	Monroe	Irondequoit	Natural feature of Irondequoit Bay	Located in Irondequoit Bay	1
Birds and Worms [Point]	Monroe	Irondequoit	Natural feature of Irondequoit Bay	Located on shoreline of Irondequoit Bay	1
Big Massaug Cove	Monroe	Irondequoit	Natural Feature of Irondequoit Bay	Located in Irondequoit Bay	1
Newport	Monroe	Irondequoit	Community	(Neighborhood on Irondequoit Bay	1
Newport Marina	Monroe	Irondequoit	Private business	Marina	1
Point Lookout	Monroe	Irondequoit	Natural Feature in Irondequoit Bay	Neighborhood on Irondequoit Bay	1
Densmore Creek	Monroe	Irondequoit	Natural Feature	Tributary to Irondequoit Bay	1
Bay View	Monroe	Irondequoit	Community	Neighborhood on Irondequoit Bay	1
Glen Haven	Monroe	Irondequoit	Community	Neighborhood	1
Snider Island	Monroe	Irondequoit	Natural feature of Irondequoit Bay	Located in Irondequoit Bay	1
Float Bridge	Monroe	Irondequoit	Built resource	NYS Route 104 bridge	1
Irondequoit Bay Park West	Monroe	Irondequoit	Public park	County-owned park on west shore of Irondequoit Bay; undeveloped	1
Sutter's Marina	Monroe	Irondequoit	Private business	Marina	1

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Lucien Morin Park	Monroe	Irondequoit	Public park	County-owned park comprised of the former Ellison Marsh at the south end of Irondequoit Bay; undeveloped	1
LaSalles Landing Park	Monroe	Penfield	Public park	Town-owned park at the south end of Irondequoit Bay	1
Bay Creek Paddling Center	Monroe	Penfield	Private business	Boating	1
McGregor's Grill & Tap Room	Monroe	Penfield	Private business	Restaurant/bar	1
Cris Motors, LLC	Monroe	Penfield	Private business	Boating	1
LaSalles Steak & Crab on the Bay	Monroe	Penfield	Private business	Restaurant	1
Bayside Boat & Tackle	Monroe	Penfield	Private business	Boating and fishing	1
Empire & Empire Marina	Monroe	Penfield	Private business	Marina	1
Bazil Restaurant	Monroe	Penfield	Private business	Restaurant	1
Fleet Boat Club	Monroe	Penfield	Organization	Recreational boating	1
Abraham Lincoln Park (Irondequoit Bay Park)	Monroe	Penfield	Public park	County-owned 812-acre park on the east side of Irondequoit Bay	1
Glen Edith	Monroe	Town of Webster	Community	Resort community associated with the former Glen Edith Hotel/Restaurant, located on the west side of Irondequoit Bay	1
Devils Cove Park	Monroe	Town of Webster	Public park	18-acre County-owned park on the west side of Irondequoit Bay	1
Helds Cove	Monroe	Town of Webster	Natural feature of Irondequoit Bay	Located in Irondequoit Bay, developed with cottages and homes, popular fishing location	1
Inspiration Point	Monroe	Town of Webster	Natural feature along Irondequoit Bay	Located along shoreline of Irondequoit Bay, undeveloped with steep wooded slops	1

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Stony Point	Monroe	Town of Webster	Natural feature along Irondequoit Bay	Located along shoreline of Irondequoit Bay, developed as a marine community with residences and a marina	1
Bay Side Pub	Monroe	Town of Webster	Private business	Restaurant/bar	1
Reel Crazy Charters	Monroe	Town of Webster	Private business	Fishing	1
Mayer's Marina	Monroe	Town of Webster	Private business	Marina	1
Great Lake Ontario National Sanctuary Monument (Nomination)	Multiple (Wayne, Cayuga, Oswego, and Jefferson)	Multiple	Offshore Conservation Area	Proposed National Marine Sanctuary in Lake Ontario along portions of shoreline of the SE Lake Ontario watershed	Multiple (3 through 27)
Bear Creek	Wayne	Town of Ontario	Community	Historic community located along the shoreline of Lake Ontario at Bear Creek Harbor	2
Thompson Park	Wayne	Town of Ontario	Public park	Town-owned park at Bear Creek Harbor with permitted boat-launching facilities and a picnic area	2
Bear Creek Harbor	Wayne	Town of Ontario	Natural feature of Lake Ontario	Located at the mouth of Bear Creek; historic harbor; still used for fishing access	2
Bear Creek	Wayne	Town of Ontario	Natural feature	Tributary to Lake Ontario	2
Salmon Creek	Wayne	Williamson	Natural feature	Tributary to Lake Ontario	4
Pulteneyville	Wayne	Williamson	Community	Historic hamlet on Lake Ontario, at Pulteneyville Harbor; established in 1806, was a significant Great Lakes trading port, historically associated with the French an Indian Wars and the War of 1812	4

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Pultneyville Harbor	Wayne	Williamson	Natural Feature	Historic harbor on Lake Ontario, at the mouth of Salmon Creek	4
Pultneyville Yacht Club	Wayne	Williamson	Organization	Boating	4
Fairbanks Point	Wayne	Williamson	Natural Feature along Lake Ontario	Located near Holland Cove and the mouth of Mink Creek	5
Hughes Marina & Campground	Wayne	Williamson	Private Business/Marina and Campground	Marina/camping	5
St. Peter Shipwreck	Wayne	Williamson (offshore)	Built resource	Offshore shipwreck	5
Holland Cove	Wayne	Williamson	Natural Feature of Lake Ontario	Located at the mouth of Mink Creek, developed with a cottage community of leased land and a commons area	5
Camp Beechwood	Wayne	Sodus	Organization	Former Girl Scout Camp	6
[Maxwell Bay] Campground	Wayne	Sodus	Private business/camping	Camping	6
Beechwood State Park	Wayne	Sodus	Public (state) park	288-acre state park, with 1500 feet of shoreline along Lake Ontario and land along Maxwell Bay; on land that was site of a former Girl Scout Camp; designated a preserve; facilities are abandoned and allowed to decay	6
Maxwell Bay	Wayne	Sodus	Natural feature of Lake Ontario	Located at the mouth of Salmon Creek; enclosed or blind bay	6
Salmon Creek	Wayne	Sodus	Natural feature	Tributary to Lake Ontario	6
Maxwell Creek Inn Bed and Breakfast	Wayne	Sodus	Private business	Bed and Breakfast	6

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Sodus Point	Wayne	Sodus	Community	Historic village on Sodus Bay; associated with the War of 1812; became a popular vacation resort in the late 19th century and is still a popular resort community	7
Sodus Point Beach Park	Wayne	Sodus	Public (county) park	County-owned park on Lake Ontario at the outlet of Sodus Bay , with swimming and picnicking facilities	7
Sodus Bay	Wayne	Towns of Sodus and Huron	Natural feature	Bay on Lake Ontario, developed with permanent and seasonal residences and businesses, known of fishing, boating, swimming, etc.	7
Krenzer Marina	Wayne	Sodus	Private business	Marina	7
Captain Jack's Goodtime Tavern	Wayne	Sodus	Private business	Restaurant/bar	7
Sand Point	Wayne	Sodus	Natural feature of Sodus Bay	Located along Sodus Bay	7
Sodus Bay Yacht Club	Wayne	Sodus	Organization	Boating	7
Willow Park	Wayne	Sodus	Public (village) park	Village-owned municipal park with picnicking and playground facilities	7
Katlynn Marine, Inc.	Wayne	Sodus	Private business	Marina	7
Customs House	Wayne	Sodus	Built resource	NRHP-listed historic property NR # 80002787 Listed May 6, 1980	7
LOTUS (Schooner)	Wayne	Sodus	Built resource	NRHP-listed historic property NR #90000694 Listed May 10, 1990	7
Arney's Marina	Wayne	Sodus	Private business	Marina	7
First Creek	Wayne	Sodus	Natural feature	Tributary to Sodus Bay	7

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Sodus Bay Heights Golf Club	Wayne	Sodus	Organization	Golf course	7
Second Creek	Wayne	Sodus	Natural feature	Tributary to Sodus Bay	7
Thornton Point	Wayne	Sodus	Natural feature along Sodus Bay	Prominent point along Sodus Bay	7
Briscoe Cove	Wayne	Sodus	Natural feature of Sodus Bay	Bay in Sodus Bay	7
Sawmill Cove	Wayne	Huron	Natural feature of Sodus Bay	Bay in Sodus Bay	7
Nicholas Point	Wayne	Huron	Natural feature along Sodus Bay	Point along Sodus Bay	7
Grassy Point	Wayne	Huron	Natural feature along Sodus Bay	Point along Sodus Bay	7
Bay Bridge Sport Shop	Wayne	Huron	Private business	Fishing	7
Waypoint Fine Food & Spirit	Wayne	Huron	Private business	Restaurant	7
Willigs Point	Wayne	Huron	Natural feature along Sodus Bay	Point along Sodus Bay	7
Sodus Creek	Wayne	Huron	Natural feature	Tributary to Sodus Bay	7
Resort	Wayne	Huron	Community	Historic summer resort community (formerly Port Glasgow) on the east side of Sodus Bay	7
Clark Creek	Wayne	Huron	Natural feature	Tributary to Sodus Bay	7
Bonnie Castle	Wayne	Huron	Community	Historic hamlet on the east side of Sodus Bay	7
Bonnie Castle Farm B&B	Wayne	Huron	Private business	Bed and breakfast	7
Sunset View	Wayne	Huron	Community	Historic hamlet on the east side of Sodus Bay	7
Eagle Island	Wayne	Huron	Natural feature of Sodus Bay	Located in Sodus Bay	7
Newark Island	Wayne	Huron	Natural feature of Sodus Bay	Located in Sodus Bay	7
Connelly's Cove	Wayne	Huron	Private business	Restaurant	7
Fowler's Marina, Inc.	Wayne	Huron	Private business	Marina	7
Hog Island	Wayne	Huron	Natural feature of Sodus Bay	Located in Sodus Bay	7
Le Roy Island	Wayne	Huron	Natural feature of Sodus Bay	Located in Sodus Bay	7
Charles Point	Wayne	Huron	Natural feature along Lake Ontario	Located on barrier island at mouth of Sodus Bay	7

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Crescent Beach	Wayne	Huron	Natural feature of Lake Ontario	Located on barrier island at mouth of Sodus Bay	7
Lake Bluff	Wayne	Huron	Community	Historic hamlet on the east side of Sodus Bay, near its outlet into Lake Ontario	7
East Bay Park	Wayne	Huron	Community	Hamlet on Lake Ontario at East Bay	8
East Bay	Wayne	Huron	Natural feature of Lake Ontario	Blind bay located along Lake Ontario	8
Mudge Creek	Wayne	Huron	Natural feature	Tributary to East Bay	8
Port Bay	Wayne	Towns of Huron and Wolcott	Natural feature of Lake Ontario	Blind bay located along Lake Ontario	9
Negrohead Point	Wayne	Huron	Natural feature along Port Bay	Located on Port Bay	9
Loon Point	Wayne	Huron	Natural feature along Port Bay	Located on Port Bay	9
Thompkins Point	Wayne	Wolcott	Natural feature along Port Bay	Located on Port Bay	9
Wolcott Creek	Wayne	Wolcott	Natural feature	Tributary to Port Bay	9
Desbrough Park	Wayne	Wolcott	Community	Historic hamlet on Lake Ontario at Port Bay; historic resort community with hotel and cottages that is still a resort community	9
Port Bay RV Park and Campgrounds	Wayne	Wolcott	Private business	Camping and RV	9)
Red Creek	Wayne	Wolcott	Natural feature	Tributary to Lake Ontario	10
Black Creek	Wayne	Wolcott	Natural feature	Tributary to Lake Ontario	11
Blind Sodus Bay	Wayne	Wolcott	Natural feature of Lake Ontario	Bay on Lake Ontario	12
Holiday Harbor RV Park	Wayne	Wolcott	Private business	Camping (RV)	12
West Barrier Bar County Park	Cayuga	Sterling	public park	Located on Lake Ontario, at the Outlet of Little Sodus Bay	13
Fair Point Marina	Cayuga	Sterling	Private business	Marina	13
Shady Shores Campground	Cayuga	Sterling	Private business/camping	Campground	13

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Little Sodus Bay	Cayuga	Sterling	Natural feature	Bay in Lake Ontario	13
Grass Island	Cayuga	Sterling	Natura feature in Little Sodus Bay	Located in Little Sodus Bay	13
Meadow Cove	Cayuga	Sterling	Natura feature in Little Sodus Bay	Located in Little Sodus Bay	13
Marine Railway	Cayuga	Sterling	Private business	Marina	13
Bayside Marina	Cayuga	Sterling	Private business	Marina	13
Anchor Resort and Marina	Cayuga	Sterling	Private business	Resort and marina	13
Eldridges Point	Cayuga	Sterling	Natural feature of Little Sodus Bay	Located along Little Sodus Bay	13
Fair Haven	Cayuga	Sterling	Community	Historic Village surrounding Little Sodus Bay; originally a shipping port; now a resort community	13
Little Sodus Inn	Cayuga	Sterling	Private business	Hotel	13
Pleasant Beach Hotel	Cayuga	Sterling	Private business	Hotel	13
Fox Point	Cayuga	Sterling	Natural feature along Little Sodus Bay	Located on Little Sodus Bay	13
Pearson Point	Cayuga	Sterling	Natural feature along Little Sodus Bay	Located on Little Sodus Bay	13
North Fair Haven	Cayuga	Sterling	Community	Historic hamlet on Little Sodus Bay	13
Grants Vacation Park	Cayuga	Sterling	Private business	Campground	13
Fair Haven Beach State Park	Cayuga	Sterling	Public beach/state park	1.141-acre state-owned park located on Lake Ontario with camping, swimming, picnicking, boating and golfing facilities	13
The Pond	Cayuga	Sterling	Natural feature	Blind bay along Lake Ontario, at the mouth of Sterling Creek, in Fair Haven Beach State Park	13
The Moat	Cayuga	Sterling	Natural feature	Marsh located along Sterling Creek near The Pond, in Fair Haven Beach State Park	13
Sterling Creek	Cayuga	Sterling	Natural feature	Tributary to The Pond and Lake Ontario	13
Sterling Valley Creek	Cayuga	Sterling	Natural feature	Tributary to Sterling Creek	13

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Sterling Creek Campground	Cayuga	Sterling	Private business	Campground	13
Juniper Pond	Cayuga	Sterling	Natural feature	Blind bay along Lake Ontario	14
West Nine Mile Point	Cayuga	Sterling	Natural feature along Lake Ontario	Located on Lake Ontario	15
Eightmile Creek	Cayuga	Sterling	Natural feature	Tributary to Lake Ontario	15
Rice Creek	Cayuga	Sterling	Natural feature	Tributary to Lake Ontario	16
Niagara Mohawk Steam Plant	Oswego	City of Oswego	Industrial facility	Power plant	17
Breitbeck Park	Oswego	City of Oswego	Public park	Municipal park with views of Lake Ontario	17
Oswego Yacht Club	Oswego	City of Oswego	Organization	Boating	17
Wright’s Landing Marina	Oswego	City of Oswego	Private business	Marina	17
U.S. Coast Guard	Oswego	City of Oswego	Government	U.S. Coast Guard Station on Lake Ontario, at entrance to Oswego River; built in 1875, still in use	17
Oswego River	Oswego	City of Oswego	Natural feature	Tributary to Lake Ontario	17
Oswego Harbor	Oswego	City of Oswego	Natural/commercial feature	Harbor on Lake Ontario; location of Port Oswego, first U.S. port of call and deep-water port on the Great Lakes from the St. Lawrence Seaway, established in 1799	17
Fish Doctor Charters	Oswego	City of Oswego	Private business	Fishing	17
Port of Oswego Marina	Oswego	City of Oswego	Government	Marina	17
Fort Ontario	Oswego	City of Oswego	Built resource	NYS Historical Site	17

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Fort Ontario Park	Oswego	City of Oswego	Public park/State Historic Site	Historic century fort located on Lake Ontario, at the mouth of the Oswego River; associated with the French and Indian Wars, the Revolutionary War, the War of 1812, and World War II	17
Sunset Bay Park	Oswego	Scriba	Public park	Lakeshore park with trails	18
Sunset Bay	Oswego	Scriba	Natural feature of Lake Ontario	Bay in Lake Ontario	18
Pleasant Point	Oswego	New Haven	Community	Lakeshore community along Lake Ontario, near outlet of Otter Creek	19
Catfish Creek Fishing Camp	Oswego	New Haven	Private business	Fishing and camping	19
Catfish Creek	Oswego	New Haven	Natural feature	Tributary to Lake Ontario	19
Hickory Grove	Oswego	New Haven	Community	Lakeshore community along Lake Ontario, near outlet of Catfish Creek	19
Butterfly Creek	Oswego	New Haven	Natural feature	Tributary to Lake Ontario	20
Butterfly Swamp	Oswego	New Haven	Natural feature	Marsh or drowned bay along Lake Ontario, at outlet of Butterfly Creek	20
Mexico Point	Oswego	Richland	Community	Lakeshore community along Lake Ontario, at outlet of Little Salmon River	21
Mexico Bay	Oswego	Richland	Natural feature of Lake Ontario	Bay on Lake Ontario	21
Mexico Point State Park	Oswego	Richland	Public (state) park	120-acre state-owned park along Lake Ontario, with picnicking, trails, and swimming facilities	21
Salmon Country, Inc.	Oswego	Richland	Private business	Fishing	21

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Spy Island Historical Site	Oswego	Richland	State Historical Site	Located within Mexico Point State Park	21
Little Salmon River	Oswego	Richland	Natural feature	Tributary to Lake Ontario	21
Sage Creek	Oswego	Richland	Natural feature	Tributary to Lake Ontario	21
Selkirk Shores State Park	Oswego	Richland	Public Beach and State Park	State-owned park along Lake Ontario, with camping, swimming, fishing, and other year-round recreational facilities	22
Cornell's Pedal and Paddle	Oswego	Richland	Private business	Biking and boating	22
Port Ontario	Oswego	Richland	Community	Community along Salmon River, near its outlet at Lake Ontario	22
Salmon River	Oswego	Richland	Natural feature	Tributary to Lake Ontario	22
Douglaston Salmon Run	Oswego	Richland	Private business	Fishing	22
Bethel Corners	Oswego	Richland	Community	Community along Salmon River, near its outlet at Lake Ontario	22
Selkirk Lighthouse	Oswego	City of Pulaski/ Richland	Built resource	NRHP-listed historic property NR # 79001618 Listed March 3l, 1979	22
Selkirk	Oswego	Richland	Community	Lakeshore community along Lake Ontario, at outlet of Salmon River	22
North Pond	Oswego	Sandy Creek	Natural feature	Bay along Lake Ontario, at outlets of Little Sandy Creek, Blind Creek, Lindsey Creek, and Skinner Creek	23
Sandy Island Beach State Park	Oswego	Sandy Creek	Public Beach and State Park	State-owned beach and park along Lake Ontario shoreline; within the Eastern lake Ontario Dune and Wetland System	23
Angler's Roost B&B	Oswego	Sandy Creek	Private business	Bed and Breakfast	23

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Sandy Pond	Oswego	Sandy Creek	Community	Resort community along North Sandy Pond	23
Little Sandy Creek	Oswego	Sandy Creek	Natural feature	Tributary to North Sandy Pond	23
Sandy Pond Sportsman Association	Oswego	Sandy Creek	Organization	Fishing	23
Lifetime Docks and Hoists	Oswego	Sandy Creek	Private business	Marina	23
Holyoke Cottage	Oswego	Sandy Creek	Built resource	NRHP-listed historic property NR # 88002216 Listed Nov 15, 1988 Part of Sandy Creek MRA	23
Blind Creek Cove	Oswego	Sandy Creek	Natural feature of North Sandy Pond	Located on North Sandy Pond, at outlet of Blind Creek	23
Blind Creek	Oswego	Sandy Creek	Natural feature	Tributary to North Sandy Pond	23
The Elms	Oswego	Sandy Creek	Community	Resort community along North Sandy Pond	23
Carl Island	Oswego	Sandy Creek	Natural feature of North Sandy Pond	Located in North Sandy Point	23
Lindsay Creek	Oswego	Sandy Creek	Natural feature	Tributary to North Sandy Pond	23
Reiter's Marina	Oswego	Sandy Creek	Private business	Marina	23
Burt Goodnough's Marina East	Oswego	Sandy Creek	Private business	Marina	23
Skinner Creek	Oswego	Sandy Creek	Natural feature	Tributary to North Sandy Pond	23
Greene Point	Oswego	Sandy Creek	Natural feature	Located along North Sandy Pond	23
Greene Point Marina & Mobile Home Park	Oswego	Sandy Creek	Private business	Marina and mobile home park	23
Brennan's Bay	Jefferson	Ellisburg	Natural feature	Bay on North Sandy Pond	23
Brennan's Bay	Jefferson	Ellisburg	Private business	Campground	23

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Renshaw Bay	Jefferson and Oswego Counties	Towns of Ellisburg and Sandy Creek	Natural feature	Bay on North Sandy Pond	23
Cranberry Pond	Jefferson	Ellisburg	Natural feature	Blind bay along Lake Ontario	24
Montario Point	Jefferson	Ellisburg	Community	Lakeshore community along Lake Ontario, between Cranberry Pond and South Colwell Pond	24
Lakeview State Wildlife Management Area	Jefferson	Ellisburg	Public nature preserve	3,461-acre state-owned conservation area for wildlife management, wildlife habitat management, and wildlife-dependent recreation; includes an extensive freshwater barrier beach system	23
South Colwell Pond	Jefferson	Ellisburg	Natural feature	Blind bay along Lake Ontario	24
North Colwell Pond	Jefferson	Ellisburg	Natural feature	Blind bay along Lake Ontario	24
South Sandy Creek	Jefferson	Ellisburg	Natural feature	Tributary to Lake Ontario	24
Goose Pond	Jefferson	Ellisburg	Natural feature	Blind bay along Lake Ontario, at outlet of South Sandy Creek	24
Floodwood Pond	Jefferson	Ellisburg	Natural feature	Blind bay along Lake Ontario, at outlets of Mud Brook and Sandy Creek	24
Mud Brook	Jefferson	Ellisburg	Natural feature	Tributary to Floodwood Pond and Lake Ontario	24
North Landing	Jefferson	Ellisburg	Community	Hamlet along Sandy Creek	24
Sandy Creek	Jefferson	Ellisburg	Natural feature	Tributary to Floodwood Pond and Lake Ontario	24
Lakeview Pond	Jefferson	Ellisburg	Natural feature of Lake Ontario	Blind bay along Lake Ontario	24

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Southwick Public Beach/Southwick Beach State Park	Jefferson	Ellisburg	Public Beach	464-acre state-owned park along a 3,5000 foot length of sand beach on the eastern shore of Lake Ontario, facilities include the beach, a campground, swimming, and other recreational facilities	24
Black Pond	Jefferson	Ellisburg	Natural feature	Blind bay along Lake Ontario	25
El Dorado Beach Preserve (The Natural Conservancy)	Jefferson	Ellisburg	Private nature preserve	Private conservation area owned by the Nature Conservancy; comprised of a freshwater dune system	26
El Dorado Beach	Jefferson	Ellisburg	Natural feature of Lake Ontario	Beach along Lake Ontario	26
Little Stony Creek	Jefferson	Henderson	Natural feature	Tributary to Lake Ontario	26
Drowned Island	Jefferson	Henderson	Natural feature of Lake Ontario	Offshore feature of Lake Ontario	26
Stony Creek Boat Launch	Jefferson	Henderson	Government	State (NYSDEC) boat launch	26
Stony Creek	Jefferson	Henderson	Natural feature	Tributary to Lake Ontario	26
Sawyer Point	Jefferson	Henderson	Natural feature	Located on Lake Ontario	26
Ray Bay	Jefferson	Henderson	Natural feature of Lake Ontario	Located in Lake Ontario	27
Boomer Cove	Jefferson	Henderson	Natural feature of Lake Ontario	Located in Lake Ontario	27
Stony Point	Jefferson	Henderson	Natural feature of Lake Ontario	Located along Lake Ontario	28
Henderson Bay	Jefferson	Henderson	Natural feature of Lake Ontario	Located in Lake Ontario	28
Hoveys Island	Jefferson	Henderson	Natural feature of Lake Ontario	Located in Lake Ontario	28
KOA 1000 Islands at Association Island	Jefferson	Henderson	Private business	Campground	28
Association Island	Jefferson	Henderson	Natural feature of Lake Ontario	Located in Lake Ontario	28
Six Town Point	Jefferson	Henderson	Natural feature of Lake Ontario	Located on Lake Ontario	28

Attachment F-1 Natural and Socio-Cultural Features within the 31 Focus Areas along the Lake Ontario Shoreline in the SE Lake Ontario Watershed

Feature or Resource Name	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Lime Barrel Shoal	Jefferson	Henderson	Natural feature of Lake Ontario	Offshore shoal in Lake Ontario	28
Snowshoe Bay	Jefferson	Henderson	Natural feature of Henderson Bay	Located in Lake Ontario	28
Whites Bay	Jefferson	Henderson	Natural feature of Henderson Bay	Located in Lake Ontario	29
Henderson Harbor	Jefferson	Henderson	Natural feature of Henderson Bay	Located in Lake Ontario	30

F.2 Potential Socio-Cultural Impacts: Eastern Lake Erie – Lake Erie Watershed

The Eastern Lake Erie - Lake Erie watershed is located at the eastern end of Lake Erie. Located within western New York, northwestern Pennsylvania, and Northwestern Ohio, it extends over portions of five counties: (from northeast to southwest) Niagara, Erie, and Chautauqua counties, New York; Erie County, Pennsylvania; and Ashtabula County, Ohio.

According to modeling conducted for the introduction and establishment of Hydrilla within the larger Great Lakes basin, the Eastern Lake Erie - Lake Erie watershed is considered to have a medium potential for the introduction of Hydrilla, primarily via recreational boating medium, and a moderate potential for the establishment of Hydrilla in suitable nearshore aquatic habitat once it is introduced.

The following impact assessment describes the various features that comprise the existing socio-cultural setting of 30 focus areas along the approximately 276-mile-long shoreline area within the Eastern Lake Erie - Lake Erie watershed. These 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed were selected for detailed analysis because they include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet, as discussed in greater detail in Section F.2.1. The following impact assessment then considers the potential impacts of the introduction and subsequent establishment of Hydrilla on the various features that collectively represent the community character of these focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. It is recognized that the Eastern Lake Erie - Lake Erie watershed encompasses additional areas along the shoreline as well as interior areas that are not located along the shoreline. However, the following impact assessment considers the socio-cultural setting and community character of only those counties, townships, villages, towns, and cities within which the 30 focus areas are located. This approach was adopted to make the impact assessment more manageable given the total length of the Lake Ontario shoreline (221 miles) in the SE Lake Ontario watershed.

Similarly, it is recognized that a wide variety of agencies, organizations, and special interest groups may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the Eastern Lake Erie - Lake Erie watershed. These stakeholders would consist of the civic and governmental areas with jurisdiction over the areas included in the Eastern Lake Erie - Lake Erie watershed. Additional stakeholders could include state agencies that manage parks, historic sites, natural areas, and public access for waterbodies such as the New York State Office of Parks, Recreation, and Historic Preservation or New York State Department of Environmental Conservation; Pennsylvania Historical and Museum Commission; Pennsylvania Department of Conservation and Natural Resources; Ohio State Historic Preservation Office; and Ohio Department of Natural Resources/Division of Parks and Watercraft. Additional stakeholders could also include federal agencies such as the USACE, which manages navigable waterways; federally recognized Indian tribes that have reservation lands or a cultural or historical affiliation with areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed or retain treaty rights to lands, waters, and resources along the shoreline of the Eastern Lake Erie - Lake Erie watershed, such as the Seneca Nation of Indians' Cattaraugus Indian Reservation with frontage along the shoreline of Lake Erie; or special interest groups such as The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that have a broadly defined interest in areas and resources along the shoreline of the Eastern Lake Erie - Lake Erie watershed. These additional stakeholders could be involved as part of continued consideration of the potential impacts associated with the introduction and establishment of Hydrilla within the larger Great Lakes basin.

Potential impacts on the socio-cultural setting of shoreline areas of the Eastern Lake Erie - Lake Erie watershed are discussed in terms of whether they would be: short-term (temporary) or long-term (permanent), direct or indirect, positive (beneficial) or negative (detrimental), and cumulative. Additionally, these impacts are considered with reference to two scenarios: one where Hydrilla is untreated (worst-case scenario) and one where Hydrilla is treated (managed scenario).

It is expected that the results of this assessment of the introduction and subsequent establishment of Hydrilla on the socio-cultural setting and community character of the 30 focus areas along the shoreline within the Eastern Lake Erie - Lake Erie watershed would be generally representative of potential impacts that would occur in interior areas of this same watershed. The results would also be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

F.2.1 Methodology and Definitions for the Socio-Cultural Impact Assessment for the Eastern Lake Erie - Lake Erie Watershed

This socio-cultural impact assessment assumes that the introduction and/or establishment of Hydrilla along the shoreline of the Eastern Lake Erie - Lake Erie watershed will affect the natural and socio-cultural features located in these areas, resulting in changes to the watershed's community character. For the purposes of this impact assessment, natural features are defined as uplands, points, bluffs, coves, beaches, embayments, creeks, streams, rivers, marshes, etc., and socio-cultural features are defined as villages, towns, cities, parks, other residential areas (neighborhoods and hamlets), conservation areas (including nature preserves, wildlife preserves, and wildlife management areas), commercial enterprises, industrial facilities, and cultural and historical sites.

This socio-cultural impact assessment further assumes that these natural and socio-cultural features collectively represent tangible (physical) components of the community character of the Eastern Lake Erie - Lake Erie watershed. For the purposes of this impact assessment of the Eastern Lake Erie - Lake Erie watershed, which lies within portions of New York, Pennsylvania, and Ohio, community character is modelled on the state's guidance for complying with the State Environmental Quality Review Act (SEQR). New York State's SEQR guidance notes that:

> Many people define their community's character in very general terms: suburban, rural, urban, quiet, safe, scenic, or friendly are terms often used. Others describe community character only in terms of visual features.
>
> Community character is broader than this however. Community character is defined by all the man-made and natural features of the area. It includes the visual character of a town, village, or city, and its visual landscape; but also includes the buildings and structures and their uses, the natural environment, activities, town services, and local policies that are in place.
>
> These combine to create a sense of place or character that defines the area" (New York State Department of Environmental Conservation [NYSDEC] 2017).

Alternate definitions of community character are available. For example, the Pennsylvania Department of Environmental Protection's Environmental Assessment Form, required as part of state permitting for a wide variety of development projects, does not specifically address community character. The form does require documentation that a project proponent has considered whether its proposed project is consistent with local (typically county or municipal) comprehensive plans and/or zoning in accordance with its 2009 *Policy for Consideration of Local Comprehensive Plans and Zoning Ordinances in DEP Review of Authorizations for Facilities and Infrastructure* (Pennsylvania Department of Environmental Protection 2009). This suggests that the definition of community character in Pennsylvania is defined at the local level. Separately, the Pennsylvania Department of Transportation has issued comprehensive guidance on the assessment of impacts of its transportation projects on communities. This guidance notes that:

> The concept of "a community" is abstract. In simple terms, communities are comprised of people with common interests, and the places where these people live, work, shop, socialize, conduct business, and recreate. Communities can be identified based on geographical, natural, physical, social, racial, ethnic, religious, and economic relationships or characteristics that members have in common with one another. Each of these varied relationships contributes to a sense of common unity and community cohesion that define one's sense of place (Pennsylvania Department of Transportation 2005).

The Pennsylvania Department of Transportation's 2005 *Community Impact Assessment Handbook* provides extensive guidance on the methodology for identifying the characteristics of communities. The guidance includes tangible natural and socio-cultural features such as the ones included in this socio-cultural impact assessment, as well as additional intangible features, for evaluating impacts on communities, and for evaluating the significance of any impacts (Pennsylvania Department of Transportation 2005). In general, the guidance in this handbook involves the locally affected communities when defining the various tangible and intangible features that comprise that community. However, the methodology for assessing potential impacts of Hydrilla on community character in this assessment closely aligns with guidance included in Pennsylvania Department of Transportation's 2005 handbook. Finally, Pennsylvania Wilds issued its 2017 Design Guide for Community Character Stewardship, in which processes for identifying and protecting community character are identified. This design guide was developed as a voluntary process that could be used by local communities to assist them with identifying those features of its communities that are character-defining and to provide guidance for proactively managing development so that it is sympathetic with community character (Pennsylvania Wilds 2017). While this design guide is focused on development, its recommendations for considering the contribution of natural areas to community character is consistent with the way that such features have been considered in this assessment of potential impacts of Hydrilla on community character.

A review of publicly available information for Ohio state agencies did not identify specific guidance for assessing community character. However, the Ohio Lake Erie Commission, which, along with its member state agencies, is responsible for actions taken to protect and restore those portions of Lake Erie and its watershed within the State of Ohio (Ohio Lake Erie Commission 2013). In its 2013 *Lake Erie Protection & Restoration Plan*, the Ohio Lake Erie Commission indicated that its mission is "to preserve Lake Erie's natural resources, protect the ecological quality of its watershed, and to promote economic development on the north coast. This is accomplished through coordination and implementation of state policies and programs pertaining to water quality, habitat protection and restoration, recreation and tourism, and resource management within the Lake Erie basin" (Ohio Lake Erie Commission 2013). Many of these areas are defined by the natural and socio-cultural features identified along the shoreline in the Eastern Lake Erie– Lake Erie watershed for this impact assessment.

The introduction and establishment of Hydrilla would occur within natural features located along the shoreline in the Eastern Lake Erie - Lake Erie watershed. These areas typically are locations recognized and used for water-dependent and water-related uses. The natural and man-made (socio-cultural) features of the watershed as a collective physical representation of the community character of the Eastern Lake Erie - Lake Erie watershed, as defined by the NYSDEC, appears to provide the most comprehensive consideration of the impacts that the introduction and establishment of Hydrilla would have on the community character of the Eastern Lake Erie - Lake Erie watershed. However, the definition of community character for this impact assessment has been expanded to include the water-dependent and water-related uses of these natural and man-made or socio-cultural features, which also contribute to community character and are deliberately managed by the communities and governmental units that comprise the Eastern Lake Erie - Lake Erie watershed.

Due to the large extent of the shoreline in the Eastern Lake Erie - Lake Erie watershed (approximately 276 miles in length), 30 areas with environmental conditions highly suitable to establishment of Hydrilla were identified within this watershed for an in-depth impact assessment. These 30 areas (henceforth, referred to as focus areas) collectively comprise approximately 104 miles of the shoreline in the Eastern Lake Erie - Lake Erie watershed. They all contain physical conditions that are conducive to the introduction and establishment of Hydrilla. Table F.2-1, at the end of this section, provides a summary description of each of the 30 focus areas identified for the Eastern Lake Erie - Lake Erie watershed. Section 3.3 in the risk assessment describes the criteria used to identify the 30 focus areas along the shoreline in this watershed, which include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet.

Thus, this socio-cultural impact assessment identifies the visible and physical natural and socio-cultural features that represent the attributes and assets of the communities and governmental units associated with the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed (see Section F.2.2; see Attachment F-2 for a listing of visible and physical natural and socio-cultural features). This socio-cultural impact assessment considers the management of the visible and physical natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed by the associated counties, towns, and cities or villages (see Section F.2.3). This socio-cultural impact assessment considers the impacts of the introduction and/or establishment of Hydrilla on the natural and socio-cultural features and their associated water-dependent and water-related uses identified for the 30 focus areas in the Eastern Lake Erie - Lake Erie watershed (see Sections F.2.4 and F.2.5). This assessment also considers the impacts of the introduction and establishment of Hydrilla on perceptions of features and uses and on the community character of the 30 focus areas (see Sections F.2.6 and F.2.7). The results of this impact analysis are considered with regard to their broader applicability to the entire Eastern Lake Erie - Lake Erie watershed (see Section F.2.8). Finally, conclusions and recommendations regarding the results of this impact assessment are presented in Section F.2.9.

Table F.2-1 Description of Focus Areas in the Eastern Lake Erie - Lake Erie Watershed

Focus Area Number	Description of Focus Area[1]	State	County	City or Town	Approximate Length (miles)
1	Shoreline of Niagara River	NY	Niagara	Town of Lewiston	0.50
2	Shoreline of Niagara River at New York Power Authority Robert Moses Power Plant	NY	Niagara	Town of Lewiston	0.75
3	Shoreline of Niagara River at unnamed cove	NY	Niagara	City of Niagara Falls	0.25
4	Shoreline of Niagara River at mouth of Gill Creek	NY	Niagara	City of Niagara Falls	2.68
5	Shoreline of Tonawanda Channel of Niagara River, Little River by Jayne Island, Cayuga Creek, and Bergholtz Creek	NY	Niagara	City of Niagara Falls	9.73
6	Shoreline of Tonawanda Channel of Niagara River at unnamed marina at end of Felton Street	NY	Niagara	City of North Tonawanda	0.46
7	Shoreline of Tonawanda Channel of Niagara River and Little River at Tonawanda Island, at the mouth of Erie Canal	NY	Niagara and Erie	City of North Tonawanda (Niagara County) and City of Tonawanda (Erie County)	4.13
8	Shoreline of Tonawanda Channel of Niagara River at the mouth of Twomile Creek	NY	Erie	City of Tonawanda	0.12
9	Shoreline of Tonawanda Channel of Niagara River at Collins Marina	NY	Erie	Town of Tonawanda	0.40
10	Shoreline of Tonawanda Channel of Niagara River	NY	Erie	Town of Tonawanda	1.75
11	Shoreline of Tonawanda Channel of Niagara River and Woods Creek	NY	Erie	Town of Grand Island	2.90

Table F.2-1 Description of Focus Areas in the Eastern Lake Erie - Lake Erie Watershed

Focus Area Number	Description of Focus Area[1]	State	County	City or Town	Approximate Length (miles)
12	Shoreline of Tonawanda Channel of Niagara River and Gun Creek	NY	Erie	Town of Grand Island	0.90
13	Shoreline of Tonawanda Channel of Niagara River and Spicer Creek	NY	Erie	Town of Grand Island	0.58
14	Shoreline of Tonawanda Channel of Niagara River at Beaver Island State Park	NY	Erie	Town of Grand Island	2.80
15	Shoreline of Chippewa Channel of Niagara River at Beaver Island	NY	Erie	Town of Grand Island	0.87
16	Boat basin at mouth of Big Sixmile Creek along shoreline of Chippewa Channel of Niagara River		Oswego	Town of Oswego	0.88
17	Shoreline of Chippewa Channel of Niagara River and Burnt Ship Creek	NY	Erie	Town of Grand Island	1.49
18	Shoreline of Niagara River and Black Rock Canal at Unity (formerly Squaw) Island	NY	Erie	City of Buffalo	9.25
19	Shoreline of Lake Erie, Erie Basin, and Buffalo Outer Harbor at mouth of Buffalo River	NY	Erie	Cities of Buffalo and Lackawanna	10.89
20	Shoreline of Lake Erie at Sturgeon Point	NY	Erie	Town of Evans	0.28
21	Shoreline of Lake Erie at mouth of Cattaraugus Creek	NY	Erie and Chautauqua	Cattaraugus Indian Reservation, Town of Evans (Erie County), and Town of Hanover (Chautauqua County)	0.13
22	Shoreline of Lake Erie at Hanover Bay	NY	Chautauqua	Town of Hanover	0.17
23	Shoreline of Lake Erie and Dunkirk Harbor	NY	Chautauqua	Town of Hanover	1.81
24	Shoreline of Lake Erie at Barcelona	NY	Chautauqua	Town of Westfield	0.36

Table F.2-1 Description of Focus Areas in the Eastern Lake Erie - Lake Erie Watershed

Focus Area Number	Description of Focus Area[1]	State	County	City or Town	Approximate Length (miles)
25	Shoreline of Lake Erie at North East Marina	PA	Erie	North East Township	0.17
26	Shoreline of Lake Erie at mouth of Eight Mile Creek	PA	Erie	Harborcreek Township	0.10
27	Shoreline of Lake Erie, Presque Isle Bay, Marina Lake, Long Pond, Big Pond, Misery Bay, Horseshoe Pond, Thompson Bay	PA	Erie	City of Erie	41.08
28	Shoreline of Lake Erie at Manchester Beach and mouth of Walnut Creek	PA	Erie	Fairview Township	0.23
29	Shoreline of Lake Erie at mouth of Conneaut Creek (within Conneaut Harbor)	OH	Ashtabula	City of Conneaut	1.94
30	Shoreline of Lake Erie at mouth of Ashtabula Creek	OH	Ashtabula	City of Ashtabula and Ashtabula Township	6.22
Total	**N/A**		**N/A**	**N/A**	**103.82**

Notes:
[1] See Section 3.3 of the Risk Assessment for a detailed discussion of the process used to select these focus areas.

Key:
N/A = Not applicable

F.2.2 Natural and Socio-Cultural Features along the Shoreline of the Eastern Lake Erie - Lake Erie Watershed

Two hundred sixty-four named natural and socio-cultural features are located within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. These features were identified primarily from an analysis of information included in overlays for Google Earth and identified on 7.5-minute USGS topographic quadrangles and/or coastal maps maintained in the National Oceanic and Atmospheric Administration's (NOAA's) Office of Coast Survey Historical Map and Chart Collection. Collectively, these 264 named natural and socio-cultural features are a physical representation of the community character and the socio-cultural setting of the shoreline in the Eastern Lake Erie - Lake Erie watershed.

A full listing of the 264 named natural and socio-cultural features identified for the 30 focus areas is included in Attachment F-2. It is noted here that Attachment F-2 is not a definitively complete listing of all the named natural and socio-cultural features in the 30 focus areas or along the entire shoreline in the Eastern Lake Erie - Lake Erie watershed. While the list in Attachment F-2 is reasonably comprehensive as to the type of natural and socio-cultural features present, it primarily only includes features that are named (e.g., named waterbodies and communities on 7.5-minute USGS topographic quadrangles) and/or that have been identified in databases that comprise the Google Earth overlays.

These 264 named natural and socio-cultural features can be grouped into 10 different categories of resources (see Table F.2-2). These 10 resource categories consist of (in order of predominance from most to fewest): private businesses, public parks and other public facilities, natural features, built resources, organizations, communities, conservation areas, industrial facilities, governmental facilities, and Indian Reservation lands. The types of natural and socio-cultural features located within, or associated with, these 30 focus areas should be considered generally representative of the larger number of natural and socio-cultural features along the shoreline in the Eastern Lake Erie - Lake Erie watershed.

Table F.2-2 Summary of Natural and Socio-Cultural Features within the 30 focus Areas along the Shoreline in the Eastern Lake Erie - Lake Erie Watershed

Resource Category	Description	Total Number in Watershed (% of total)
Private businesses	Private enterprises related to a variety of water-dependent or water-related recreational uses and activities along the shoreline of Lake Erie.	75 (28%)
Public parks/facilities	State, county, and town parks and beaches located along the shoreline of Lake Erie	53 (20%)
Natural features	Named natural features located along the shoreline of Lake Erie	44 (17%)
Built resources	Specific buildings, structures, objects, or other built features located along the shoreline of Lake Erie	34 (13%)
Organizations	Public or private enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the shoreline of Lake Erie	16 (6%)
Communities	Named cities (including named neighborhoods), towns or villages, or hamlets located along the shoreline of Lake Erie	14 (5%)
Conservation areas	Federal, state, local, and private natural areas, nature/underwater preserves, and wildlife management areas located along the shoreline of Lake Erie	14 (5%)
Industrial facilities	Industrial facilities such as power plants or water treatment plants located along the Lake Erie shoreline	8 (3%)
Governmental facilities	Federal, state, or local government facilities located along the shoreline of Lake Erie	5 (2%)
Indian Reservation Lands	Designated Native American reservation land located along the shoreline of Lake Erie	1 (<1%)
Total		**264 (100%)**

Private Businesses (Socio-Cultural Feature)

Seventy-five private business enterprises were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these 75 private business enterprises represent approximately 28% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. These 75 private business enterprises consist of a variety of businesses, primarily related to recreational activities, that all are associated with water-dependent or water-related use of the shoreline in the Eastern Lake Erie - Lake Erie watershed. These private businesses were generally identified from overlays in Google Earth. Resources in this category include marinas, charter fishing companies, campgrounds, hotels/inns/bed-and-breakfasts, restaurants, bars, and boating facilities. Resource use may be permanent or seasonal. There are likely to be additional similar private businesses along the shoreline in the Eastern Lake Erie - Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Public Parks and Other Public Facilities (Socio-Cultural Feature)

Fifty-three public parks were identified within the 30 focus areas along the Shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these 53 cultural features represent approximately 20% of the total natural and socio-cultural cultural features within the 30 focus areas along the Lake Erie shoreline in the Eastern Lake Erie - Lake Erie watershed. The 53 named public parks consist of state, county, and town parks and beaches located along the Lake Erie shoreline as well as numerous public boat ramps. These public parks and other public facilities were identified from USGS 7.5-minute topographic quadrangles and from Google Earth overlays. Resources in this category are primarily developed for active and passive recreational uses of the waterfront (in urban areas) or the shoreline in suburban and rural areas. There are likely to be additional public facilities, particularly boat ramps, along the shoreline in the Eastern Lake Erie - Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate Google Earth overlays.

Natural Features

Forty-four named natural features were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these 44 named natural features represent approximately 17% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. These 44 named natural features consist of named shoreline or nearshore features (such as rivers, creeks, bays, and streams) and named terrestrial features (such as points and islands). These natural features were generally identified from USGS 7.5-minute topographic quadrangles and the NOAA's Office of Coast Survey Historical Map and Chart Collection. Resources in this category do not include unnamed waterbodies and topographic features, although such natural features are also present within some of the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed.

Built Resources (Socio-Cultural Feature)

Thirty-four specific built resources were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these 34 specific built resources represent approximately 13% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed.

These 34 specific built resources consist of man-made terrestrial and marine features. Man-made terrestrial built resources consist of buildings, structures, objects, or other built features located along the Lake Erie shoreline. Some of these terrestrial buildings or structures are recognized for their individual or collective historic importance at the national, state, or local level (e.g., lighthouses, historical sites, or properties listed in the National Register of Historic Places). Other terrestrial structures consist of industrial docks. Man-made marine features consist of channelized areas within rivers or harbors, including canals and locks, channels, turning basins, harbors, piles, and shipwrecks. These specific built resources were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category may or may not be located within communities. Resources in this category may also include, but are not limited to, historic resources.

Organizations (Socio-Cultural Feature)

Sixteen public or private organizations were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these 16 public or private organizations represent approximately 6% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. These public or private organizations consist of enterprises related to water-dependent or water-related recreational activities associated with the use of the Lake Erie shoreline that were identified from overlays in Google Earth. Resources in this category primarily consist of yacht clubs, boat clubs, and fishing clubs. Resources in this category may be owned privately or by non-profit groups. There are likely to be additional similar public or private organizations within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Communities (Socio-Cultural Feature)

Fourteen named communities were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these 14 named communities represent approximately 5% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. These communities consist of named cities, towns, villages, and hamlets that were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. Resources in this category also include variously sized named clusters of residential, commercial, and/or industrial development. With regard to residential development, this may be comprised of owner-occupied or rental units, and may be permanent or seasonal. Resources in this category do not include numerous locations of unnamed shoreline development, although such unnamed shoreline development is also present within some of the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed.

Conservation Areas (Socio-Cultural Feature)

Fourteen conservation areas were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these 14 conservation areas represent approximately 5% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. The 14 conservation areas consist of state, local, or private natural areas, nature preserves, wildlife management areas, or areas of significant coastal fish and wildlife habitat located along the shoreline. These conservation areas were identified from USGS 7.5-minute topographic quadrangles and from Google Earth overlays. Resources in this category are primarily intended for ecological preservation, although they may also be used for active and/or passive recreational activities. Resources in this category do not include public parks or beaches; these are addressed as a separate resource type.

Industrial Facilities (Socio-Cultural Feature)

Eight industrial facilities were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these eight industrial facilities represent approximately 3% of the total natural and socio-cultural features within the focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. The eight industrial facilities consist of power plants, water treatment plants, sewage or wastewater treatment plants, or similar facilities located along the Lake Erie shoreline. Resources in this category may be privately owned or operated by municipalities. These industrial facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There may be additional similar industrial facilities within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Governmental Facilities (Socio-Cultural Feature)

Five governmental facilities were identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. Collectively, these five governmental facilities represent 2% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. The five governmental facilities consist of federal, state, or local governmental facilities located along the Lake Erie shoreline. Resources in this category include facilities such as USCG stations or reservations, municipal harbors and wharves, and port authorities. These governmental facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There are likely to be additional similar governmental facilities along the shoreline in the Eastern Lake Erie - Lake Erie watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Indian Reservation Lands (Socio-Cultural Feature)

Indian Reservation lands included in the Seneca Nation of Indians' Cattaraugus Indian Reservation were identified within one the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed (Focus Area 21, along the shoreline of Lake Erie at the mouth of Cattaraugus Creek in the town of Brant, Erie County, New York). These lands represent less than 1% of the total natural and socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed.

The Seneca Nation of Indians are a federally recognized Indian tribe. As such, the Cattaraugus Indian Reservation lands along the shoreline in the Eastern Lake Erie - Lake Erie watershed represent lands belonging to a sovereign nation. This Indian reservation was identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. No other Indian Reservation lands were identified for any of the other 29 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed that were identified for this assessment. However, collectively, the 30 focus areas within the Eastern Lake Erie – Lake Erie watershed are located in areas of New York Pennsylvania, and Ohio that may be of ancestral or historical interest to 50 federally recognized Indian tribes, including the six Iroquois tribes located in New York State and 43 additional Iroquois, Chippewa, Potawatomie, Shawnee, Peoria, Wyandotte, Sac and Fox, Delaware, and other tribes located in states other than New York, Pennsylvania, and Ohio. See Section 3.3.4 and Appendix G of the risk assessment for a more detailed discussion of the federally recognized Indian tribes that may have an interest in lands included in the Great Lakes basin in general.

F.2.3 Existing Management of Natural and Socio-Cultural Features in the Eastern Lake Erie - Lake Erie Watershed

Due to the size of the Eastern Lake Erie - Lake Erie watershed and the length of its shoreline (approximately 276 miles), the overall nature of development of this watershed varies between highly urbanized areas, such as the cities of Niagara Falls, Buffalo, Lackawanna, and Dunkirk in New York, the city of Erie in Pennsylvania, and the cities of Conneaut and Ashtabula in Ohio, and very rural areas in between. Despite the variation in the type and density of development along the shoreline in the Eastern Lake Erie - Lake Erie watershed, the various governmental units (counties, towns, and incorporated municipalities) along the shoreline in the Eastern Lake Erie - Lake Erie watershed all have plans in place that establish baseline natural and socio-cultural conditions.

Such plans typically consist of comprehensive plans developed by the various towns or counties along the shoreline, but may also include comprehensive plans or master plans developed by the various incorporated communities (e.g., cities or villages) located along the shoreline. Additionally, a number of communities or locations along the shoreline in the Eastern Lake Erie - Lake Erie watershed have other plans in place to address waterfront development or to manage the various water uses in harbors. These types of plans have typically been developed for shoreline cities in New York that were developed through New York State Department of State's LWRP and consist of LWRP Plans and Harbor Management Plans (HMPs). Additionally, the State of Ohio has issued planning documents through the Ohio Lake Erie Commission.

While the various governmental units may have other plans for the management of natural and socio-cultural features within their boundaries, such as plans for recreation, conservation, etc., the comprehensive/master plans and other Lake Erie shoreline, waterfront, or harbor plans generally present a comprehensive consideration of conditions and uses of the shoreline of the Eastern Lake Erie - Lake Erie watershed. These plans may specifically address the management of many of the named visible and physical natural and socio-cultural features that have been identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed.

In general, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Eastern Lake Erie - Lake Erie watershed would indicate the importance of this shoreline to their respective community characters. These various plans may also recognize the various natural features (e.g., uplands, points, bluffs, coves, beaches, embayments, creeks, streams, and rivers) that physically shape the shoreline and socio-culturally shape the uses of the shoreline for residential, commercial, industrial, recreational, and conservation purposes. These various plans may also recognize various socio-cultural features (i.e., villages, towns, cities, harbors, parks, conservation areas [including nature preserves, wildlife preserves, wildlife management areas and significant coastal fish and wildlife habitats], and residential areas [neighborhoods and hamlets]).

Similarly, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Eastern Lake Erie - Lake Erie watershed would identify common issues or concerns regarding their particular natural and socio-cultural features. The common issues or concerns associated with managing waterfronts or shorelines for water-dependent or water-related uses may consist of, but would not necessarily be limited to:

- Protecting or improving the quality of specific natural features along the shoreline (such as beaches, embayments, marshes, rivers, creeks, and streams);
- Managing or enhancing residential and commercial development along the shoreline;

- Creating or enhancing opportunities for public access to the shoreline, typically for recreational purposes;
- Protecting or developing scenic qualities of the shoreline; and
- Managing or enhancing opportunities for visual access to the shoreline.

Additionally, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Eastern Lake Erie - Lake Erie watershed would identify specific management goals, objectives, or recommendations to address these issues or concerns, and to manage these shorelines for water-dependent or water-related uses. In general, the purpose for managing their respective shorelines would typically, but not necessarily only, be to:

- Acknowledge and promote the character of the communities along the shoreline;
- Enhance the quality of life for permanent residents;
- Enhance the experience of seasonal residents and visitors; and
- Protect, improve, or otherwise support the natural and socio-cultural features that comprise the shoreline of Lake Erie.

F.2.4 Potential Impacts of Introduction and Establishment of Hydrilla on Socio-Cultural Setting of the Eastern Lake Erie - Lake Erie Watershed

This section discusses the potential impacts associated with the introduction and/or establishment of Hydrilla on the socio-cultural setting of the Eastern Lake Erie - Lake Erie watershed. In general, these impacts can be considered in terms of whether they result in:

- Physical changes to natural and/or socio-cultural features identified along the shoreline in the Eastern Lake Erie - Lake Erie watershed;
- Changes to water-dependent or water-related uses of these natural and/or socio-cultural features;
- Changes in perceptions about the features or their uses; and
- Changes in the community character of various locations or focus areas within the watershed.

For the purposes of this impact assessment, water-dependent uses are considered to be facilities or activities that cannot exist without a waterfront location, such as marinas, boat ramps, sewage treatments plants, etc. Water-related uses are considered facilities or activities that increase their value or importance because of their proximity to a shoreline. Frequently, they function as support services for water-dependent uses and could include parks and other recreational facilities, as well as some types of commercial development (Benson 2011).

In general, the changes identified above are considered in terms of whether they would be an impact that is: (1) direct or indirect; (2) temporary or permanent (short-term or long-term); (3) adverse (negative), neutral, or beneficial (positive); and/or (4) cumulative, per changes and impacts associated with other invasive aquatic plant species in the watershed or at a specific focus area and/or per changes and impacts associated with ongoing or emerging socio-cultural trends in the watershed or at a specific focus area.

Impacts on Natural and Socio-Cultural Resources

The introduction and subsequent establishment of Hydrilla within any of the 30 focus areas along the shoreline is likely to result in physical changes to a number of types of natural and socio-cultural features that comprise the socio-cultural setting of these focus areas and of the Eastern Lake Erie - Lake Erie watershed in general. At its most basic level, the introduction of Hydrilla, and its establishment and increasing density over time, in a natural feature (waterbody or marsh or wetland) with suitable environmental conditions would result in direct changes. The changes would occur to the ecological composition of the natural feature, to the appearance (visible and olfactory) of the natural features, and to the socio-cultural features and water-dependent and water-related uses associated with the natural feature. These changes would consist of new and increasingly visible and dense plants or plant mats beneath and at or on the water surface that would change the composition of ecological communities associated with the natural feature and, with regard to human use, would ultimately impede access on or through the water. At its full extent, Hydrilla present in dense mats at or on the water surface would act as a net, capturing floating detritus (natural and man-made) that would detract from the visual and olfactory setting of the waterbodies. Such changes may be small at first, with the introduction of Hydrilla into a suitable waterbody environment, but such changes may increase incrementally in density, visibility, and/or intensity over time until Hydrilla has exploited the maximum extent of available suitable habitat in the waterbody feature.

Physical changes are likely to occur on natural features and on those socio-cultural features that are comprised of, or associated with, natural features. Physical changes are likely to directly and indirectly impact natural and socio-cultural features. Additionally, these physical changes, considered in conjunction with past, present, or reasonably foreseeable future conditions for these natural and socio-cultural features, may have a cumulative impact on these natural and socio-cultural features.

Socio-cultural features that are comprised of, or associated with, natural features are also likely to undergo physical changes from the introduction and subsequent establishment of Hydrilla. These socio-cultural features would typically consist of: (1) public parks or other public facilities; (2) conservation areas; and (3) public or private business enterprises (e.g., marinas, restaurants, and campgrounds) that are located within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed and associated with water-dependent and/or water-related uses. However, other socio-cultural features, comprised of communities, organizations, industrial facilities, and governmental facilities, are often also associated with natural features, such as those identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed. These are attractive locations for seasonal and permanent residences or are specific locations, such as at the mouth of a navigable waterbody, at which a U.S. Coast Guard facility is located, or a shoreline location that provides for specific water intake and discharge capacity for an industrial facility.

Descriptions of the potential impacts on the various types of natural and socio-cultural features identified within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed are presented below. Such impacts are considered primarily with regard to the introduction and establishment of Hydrilla without treatment. Such direct and indirect impacts would likely be considered long-term or permanent impacts and would be perceived as negative impacts by the communities and users of the 30 focus areas along shoreline in the Eastern Lake Erie - Lake Erie watershed.

Dispersal modeling has predicted that approximately 1% of total area of water within the Eastern Lake Erie – Lake Erie watershed may be infested by Hydrilla by 2025 (see Table 3.1.5-1); therefore, it is possible that some of the 30 focus areas would not be affected by Hydrilla, or that impacts resulting from Hydrilla would not affect some or all of the natural and socio-cultural features that collectively comprise the community character of this watershed as described below. Because dispersal modelling does not indicate specific locations within the watershed that would be affected, it is not possible to determine which of the 30 focus areas would be subject to infestation. Additionally, because the results of dispersal modelling extend through the year 2025, it is likely that the impacts discussed below would occur slowly at first, and become increasingly noticeable over time until full exploitation of available suitably habitat has been achieved. Therefore, the impacts of the introduction and establishment of Hydrilla discussed below should be considered representative of the types of impacts that could occur if these, or similar, natural and socio-cultural features are present within or adjacent to the approximately 1% of the total area of water within the entire watershed that may be infested by Hydrilla in 2025.

Impacts on Natural Features

The introduction and establishment of Hydrilla on natural features would result in a number of different impacts on natural features, depending on the type of natural feature. These impacts are both physical ecosystem effects as well as socio-cultural effects associated with impaired public access or reduced recreational usage. The physical ecosystem impacts on these natural features are summarized in this section to provide a context for considering these natural features as the setting for associated socio-cultural features and uses. The socio-cultural impacts associated with these natural features (e.g., impaired public access, and reduced recreational usage) are discussed in detail below as part of the discussion of impacts on socio-cultural features.

Natural features, such as points and islands, are terrestrial natural features that are not likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla. Therefore, the introduction and establishment of Hydrilla is likely to have no impact on these types of natural features, although indirect impacts on socio-cultural features, water-dependent uses, and water-related uses associated with such natural features are likely to occur and are considered below. However, natural features comprised of, or associated with, waterbodies are likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla.

Waterbody features that may be directly impacted by the introduction and establishment of Hydrilla include:

- Shoreline and littoral zone of:
  - Lake Erie and the Niagara River,
  - Beaches, coves, harbors, and bays along the shoreline of the lake, and
  - Outlets or mouths of streams and rivers where they enter the lake or the harbors or bays along the lake shoreline; and
- Marshes or wetlands that are associated with these waterbody features.

Collectively, the 30 focus areas within the Eastern Lake Erie - Lake Erie watershed include shoreline and littoral zone features, although marshes and wetlands may also be present.

The direct impacts on these natural features would result from the introduction and establishment of Hydrilla, and would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of these waterbody features, including changes to water quality (e.g., full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface) and changes to species that are located in, or that otherwise use, these waterbody features (e.g., changes to fish species, aquatic plant species, bird species); and
- Negative because such changes are detrimental to species comprising the ecological systems of these waterbodies.

Waterbody features that may be indirectly impacted by the introduction and establishment of Hydrilla include associated terrestrial features such as points and islands; as well as the shoreline and littoral zone of Lake Erie and the Niagara River; beaches, coves, harbors, and bays along the shoreline of the lake or river;

the outlets or mouths of streams and rivers where they enter Lake Erie or the Niagara River; the harbors or bays along the Lake Erie shoreline; and, if present, marshes and wetlands. Collectively, the 30 focus areas within the Eastern Lake Erie - Lake Erie watershed include all of these natural features except mapped marshes and wetlands (although these natural features may be present in small areas within the focus areas).

Finally, impacts from the introduction and establishment of Hydrilla in these natural features could be cumulative under certain conditions, such that the long-term (permanent), direct, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these natural features from the introduction and establishment of Hydrilla could occur where a waterbody:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil (*Myriophyllum spicatum*); and/or
- Has existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct impacts from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect the waterbodies, resulting in a cumulative impact.

The above impact assessment on natural waterbody features is for the introduction and establishment of Hydrilla, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct, negative impacts on the affected natural features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Impacts on Socio-Cultural Features

The introduction and establishment of Hydrilla on socio-cultural features would result in a number of different impacts, depending on the type of socio-cultural feature. All of the socio-cultural features considered as part of this impact assessment are associated in some way with natural features that are located adjacent to, or are comprised of, waterbodies.

All of the types of socio-cultural features identified within the 30 focus areas along the shoreline of the Eastern Lake Erie - Lake Erie watershed are located along shoreline areas or waterbody features within which Hydrilla is likely to be introduced and established. The impacts on these socio-cultural resources may be direct, where the purpose for, or use of, these socio-cultural features is typically water-dependent, or indirect, where the purpose for, or use of, these socio-cultural features is typically water-related, as discussed below.

The following socio-cultural features may be directly impacted by the introduction and establishment of Hydrilla:

- Private businesses (such as marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas, nature preserves, and wildlife management areas that contain or are located adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g., public boat launches, USCG stations, and harbors).

Collectively, the 30 focus areas within the Eastern Lake Erie - Lake Erie watershed include all of these types of socio-cultural features.

The direct impacts on these socio-cultural features that would result from the introduction and establishment of Hydrilla would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of associated affected waterbody features, such that the purpose for, and use of, these socio-cultural features would be affected. For example, full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface, such that private businesses or governmental facilities such as marinas or harbors could no longer be used by boats; boating or fishing would no longer be desirable or viable activities; use of public parks and beaches along affected waterbodies would no longer be desirable for recreational activities; operation of water intake and discharge systems for industrial facilities would be affected; and
- Negative because the purpose for, or uses of, these socio-cultural features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

The following socio-cultural features may be indirectly impacted by the introduction and establishment of Hydrilla:

- Private businesses such as shoreline restaurants, bars, event sites, camps or retreats, campgrounds, mobile home parks, RV camping, resorts, hotels, bed and breakfasts;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., sunbathing, sightseeing, birding, enjoying scenic views and viewsheds);
- Built resources, particularly where underwater or waterfront setting is an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., birding, wildlife management, enjoying scenic views and viewsheds); and
- Organizations associated with golfing, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

Collectively, the 30 focus areas within the Eastern Lake Erie - Lake Erie watershed include all of these types of socio-cultural features.

The impacts on these socio-cultural features as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the appearance of the setting (visual or olfactory) of these socio-cultural features; and
- Negative, because the intended purpose for, or use of, such features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users, or viable by their owners or managers.

As discussed above for natural features, impacts on these socio-cultural features from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these socio-cultural features from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on socio-cultural features from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these features, resulting in a cumulative impact.

The above impact assessment on socio-cultural features has been for the introduction and establishment of Hydrilla within the 30 focus areas along the shoreline of the Eastern Lake Erie - Lake Erie watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the socio-cultural features that are associated with these natural waterbody or marsh/wetland features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, because their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Impacts on the water-dependent or water-related uses associated with affected waterbodies are discussed in Section F.2.5.

F.2.5 Impacts on Water-Dependent or Water-related Uses of Resources

The introduction and establishment of Hydrilla would result in a number of different impacts on water-dependent or water-related uses within the 30 focus areas along the shoreline within the Eastern Lake Erie - Lake Erie watershed, depending on the type of use and/or the type of natural or socio-cultural feature with which the use is associated. For the purposes of this impact assessment, natural features associated with water-dependent uses include the shoreline and littoral zones of Lake Erie and the Niagara River within the focus areas, such as the following features: coves, harbors, and bays; beaches; outlets or mouths of streams and rivers; and marshes and wetlands. However, all of the natural features identified within the 30 focus areas along the Lake Erie and Niagara River shoreline are associated with water-related uses, including those identified above for water-related uses along with points, bluffs, and islands.

As discussed in Section F.2.4, socio-cultural features associated with water-dependent uses would include:

- Private businesses (such as marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches and other public facilities such as boat ramps that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas, nature preserves, and wildlife management areas that contain or are located in or adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g., public boat launches, USCG stations, and harbors).

Therefore, the introduction and establishment of Hydrilla is likely to have some type of impact on all of the water-dependent uses associated with these natural and socio-cultural features.

The following water-dependent uses may be directly impacted by the introduction and establishment of Hydrilla:

- Swimming;
- Recreational boating;
- Fishing;
- Sailing;
- Policing waterways and waterbodies;
- Power production; and
- Water and sewage treatment.

Similarly, socio-cultural features associated with water-related uses would include:

- Private businesses such as shoreline restaurants, bars, event sites, campgrounds, hotels, and bed and breakfasts;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;

- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, and for enjoying scenic views and viewsheds);
- Built resources (terrestrial and marine), particularly where underwater or waterfront settings are an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, and enjoying scenic views and viewsheds); and
- Organizations associated with yachting, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

The following water-related uses may be indirectly impacted by the introduction and establishment of Hydrilla:

- Dining;
- Drinking;
- Sightseeing;
- Sunbathing;
- Experiencing nature;
- Socializing in large group settings (weddings, picnics, conferences, camps, retreats);
- Vacationing;
- Preserving natural resources;
- Managing natural resources;
- Seasonal (vacation) housing;
- Permanent housing; and
- Commercial and industrial support facilities for recreational, seasonal, and permanent residential activities.

The impacts on the above water-dependent and water-related uses within the 30 focus areas as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), direct and indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it is established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would prevent or impede the water-dependent uses because they could no longer take place;

- Indirect, because the introduction and establishment of Hydrilla would result in changes to the conditions within which such water-dependent uses can occur, such that these water-dependent uses could no longer be conducted or sustained by their users or would no longer be considered viable by their owners or managers; and
- Negative because the introduction and establishment of Hydrilla physically prevents or detrimentally impairs these water-dependent uses or the management of these water-dependent uses.

For example, water-dependent uses such as recreational boating or sailing, and fishing would not be possible or would not be considered desirable water-dependent activities in a waterbody densely infested with Hydrilla. Where such water-dependent uses are reduced, there would be a concurrent reduced need for boat maintenance or storage facilities in the absence of recreational boating, sailing, or fishing. The boating actions associated with policing affected waterbodies or using affected waterbodies that are harbors would be impaired. The use of water intakes and discharge outfalls associated with sewage treatment, water treatment, and power plants would be impeded such that treatment or power production would be impaired.

Similarly, water-related uses would be considered less desirable primarily because of changes to the setting (visual or olfactory) of socio-cultural features that support such activities. Waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing. Similarly, shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing or enjoying nature. Waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities. With changes to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary. Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

As discussed above for natural and socio-cultural features, impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on water-dependent or water-related uses from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these uses, resulting in a cumulative impact.

The above impact assessment on water-dependent or water-related uses has been for the introduction and establishment of Hydrilla within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above for the 30 focus areas are associated with water-dependent uses (e.g., boating and fishing). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, such that their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants or parks). Where the introduction and establishment of Hydrilla would result in impacts on natural or socio-cultural features and/or associated water-dependent or water-related uses, it is likely that perceptions about these features and uses would change. Possible changes to perceptions about the natural or socio-cultural features and their associated water-dependent and water-related uses are considered in Section F.2.6.

F.2.6 Impacts on Community Perceptions of Features and Uses

As noted above in Section F.2.3, counties, towns, cities, and/or other regional entities associated with the 30 focus areas along the shoreline of the Eastern Lake Erie - Lake Erie watershed would manage the natural and socio-cultural features areas located along their respective shorelines or waterfronts to protect, enhance, promote, create, rehabilitate, redevelop, or develop water-dependent and water-related uses. Management would be according to the goals, policies, objectives, or recommendations that are memorialized in management plans that include these areas.

It is likely that natural and socio-cultural features that are located within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed may be specifically identified in such plans, indicating that they would be perceived as locations, features, or attributes that define the local community or governmental unit and that they would be perceived and recognized as worthy of protection or improvement. Similarly, water-dependent and water-related uses associated with these natural and socio-cultural features may also be identified and described, either as part of planning efforts or via zoning ordinances, and discussed in such plans. This would indicate that such uses would be perceived as worthy of protection, management, creation, enhancement, or development.

Such perceptions would generally be expected to be identified or expressed by local individuals and groups that comprise the communities or governmental units responsible for the preparation of such plans and would be inherent in such plans because they were made known via charrettes, questionnaires, and other outreach efforts conducted as part of the preparation of such plans. Such local individuals and groups would be expected to be comprised of local residents, or non-local stakeholders with an interest in specific resources or for specific uses (such as individuals or companies that own and/or manage businesses, organizations, or facilities in an area but do not actually reside there). Additionally, the perceptions of federal, state, or local agencies that fund such planning efforts, or that provide guidance for the preparation of such plans, may also be incorporated into the preparation of such plans, albeit indirectly, via the requirements for the preparation of such plans or via the structure and/or content of meetings and materials included in outreach efforts.

Separately, the perceptions of individuals or groups that have an interest in specific or collective natural or socio-cultural features within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed, or their associated water-dependent or water-related uses, may be lacking from such plans. Such individuals or groups may be seasonal users, state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and special interest groups whose involvement would be at a regional or national scale. For example, the perceptions of individuals or groups that are seasonal users would likely be expressed outside of such plans, by changes to patterns of visiting areas for recreational or other purposes, such as vacationing, camping, fishing, boating, etc. Similarly, the perceptions of state or federal agencies with management responsibilities for specific socio-cultural features located within the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed may also be lacking from such plans. These agencies would be as diverse as the New York State Office of Parks, Recreation, and Historic Preservation or New York State Department of Environmental Conservation, Pennsylvania Historical and Museum Commission, Pennsylvania Department of Conservation and Natural Resources, Ohio State Historic Preservation Office, and Ohio Department of Natural Resources/Division of Parks and Watercraft, that manage parks, historic sites, natural areas, and public access for waterbodies; federal agencies such as the USACE, which manages navigable waterways; and federally recognized Indian tribes with affected lands, such as the Seneca Nation of Indians' Cattaraugus Indian Reservation lands within which a portion of one focus area (Focus Area 21) is located.

Finally, the perceptions of special interest groups that would have a broad or unique interest in natural and socio-cultural features in the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed, and/or their water-dependent or water-related uses, would also be expressed outside of such plans. Such groups, whose primary perceptions would be related to regional, national, or cultural interests in a specific area, feature, or use, may include: additional federally recognized Indian tribes who may have a cultural or historical affiliation with areas that include such features and uses or may have retained treaty rights for use of such areas; or groups such as the Sierra Club, the Nature Conservancy, or Ducks Unlimited, which have national conservation interests that are applied at the local level via ownership of conservation areas or sponsorship for various conservation efforts.

As suggested above in the assessment of water-dependent and water-related uses of natural and socio-cultural features in the 30 focus areas, the potential impacts of the introduction and establishment of Hydrilla would be likely to occur where physical changes would have been made to the features or uses, or where there would be visual or olfactory changes to the setting of such features or uses. For example, the natural or socio-cultural features themselves may no longer be perceived as worthy of being protected, preserved, or managed for their intrinsic natural or socio-cultural values to a community. When changes are made to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary.

Similarly, the water-dependent or water-related uses associated with such features may no longer be perceived as desirable or viable. For example, waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing; shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities (e.g., sightseeing, sunbathing, or enjoying nature); waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities.

Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent and water-related uses within the 30 focus areas as a result of the introduction and establishment of Hydrilla have the potential to be long-term (permanent), direct indirect, and negative. Specifically, these impacts would likely be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because while the introduction and establishment of Hydrilla would result in changes to the conditions of affected features or uses, it is the perceptions of these affected features or uses that could change; and
- Negative where the perceptions of affected features or uses conclude that such features and uses are no longer worthy of protection, management, creation, improvement, enhancement, or development.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent or water-related uses within the 30 focus areas from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on perceptions of affected features or uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the indirect impacts on perceptions of affected features or uses from introduction and establishment of Hydrilla would occur at a faster rate or would be greater, resulting in a cumulative impact.

The above impact assessment for perception of affected natural and socio-cultural features and their associated water-dependent or water-related uses within the 30 focus areas has been for the introduction and establishment of Hydrilla. It is understood that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses associated with affected waterbodies. While it would be unlikely for treatment to completely eliminate or reverse the physical impacts of the introduction and establishment of Hydrilla, treatment would likely receive considerable support by the communities, governmental units, state and federal agencies, stakeholders, special interest groups, and seasonal users in an effort to avoid or minimize impacts on the perceptions of affected features and uses.

F.2.7 Impacts on Community Character of Focus Areas in the Eastern Lake Erie - Lake Erie Watershed

Dispersal modelling suggests that the primary method of introduction of Hydrilla into specific locations is via recreational boat use, such that locations where recreational boaters launch (via public boat launch or private boat launch locations) are most likely to result in the initial introduction of Hydrilla. It follows that the spread of Hydrilla likely would also occur at secondary locations that are accessible by recreational boaters but do not necessarily contain formal public or private boat launching facilities.

Therefore, impacts on community character resulting from the introduction and establishment of Hydrilla are most likely to occur in locations that: (1) have physical features (i.e., boat launch facilities) suitable for the introduction of Hydrilla; (2) have environmental conditions conducive to the establishment of Hydrilla if it is introduced; and (3) whose community character is defined by natural and socio-cultural features and associated water-dependent or water-related uses that would be affected by the introduction and establishment of Hydrilla. The 30 focus areas identified along the shoreline in the Eastern Lake Erie - Lake Erie watershed either meet all of these criteria or, if a focus area lacks a public or private boat launch, meet the second and third criteria.

The potential impacts of the introduction and establishment of Hydrilla on the community character of the 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed correlates to the impact conclusions for natural and socio-cultural features, their associated water-dependent or water-related uses, and the perceptions of such features and use by communities and governmental units, as discussed in Sections F.2.4, F.2.5, and F.2.6. Specifically, the long-term (permanent), direct and/or indirect, and negative impacts of the introduction and establishment of Hydrilla on natural and socio-cultural features, on their associated water-dependent or water-related uses, and on the perceptions of these features and uses, also result in the same type of impacts on the community character of these focus areas. The impacts associated with the treatment of Hydrilla would be the same, as would the potential for cumulative impacts.

It is likely, however, that such impacts on community character would be perceived differently. The local individuals and groups that comprise the communities and governmental units associated with these 30 focus areas likely would consider such impacts differently from seasonal users, from state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and from special interest groups whose involvement would be at a regional or national scale. Additionally, impacts on community character would occur at different rates over time, depending on the nature of the affected individuals, groups, agencies, or users.

For example, local individuals and groups that comprise the communities and governmental units associated with these 30 focus areas likely would recognize the impacts. However, they may be reluctant to accept the changes to their community character and be slow to participate in necessary revisions to the management of affected natural and socio-cultural features and their associated water-dependent or water-related uses that would alter their existing community character.

Conversely, state or federal agencies and special interest groups that operate regionally or nationally likely would recognize the impacts and would accept such changes to the affected features and uses. However, they also may be slow to participate in necessary revisions to the management of affected features and uses for any number of administrative reasons (e.g., limited manpower, limited budget, and limited regulatory authority).

Finally, it is likely that seasonal users may differ greatly from both of these other groups. Seasonal users would be likely to recognize the impacts, and while reluctant to accept the changes to community character, quick to abandon those areas that contain affected natural and socio-cultural features and their associated water-dependent and water-related uses. Changes to their seasonal use of affected areas may be either in favor of other similar areas that remain unaffected by the introduction and establishment of Hydrilla or may represent a greater shift in favor of other areas with features and uses that would never be affected by the introduction and establishment of Hydrilla.

F.2.8 Impacts on the Community Character of the Eastern Lake Erie - Lake Erie Watershed

The 30 focus areas along the shoreline in the Eastern Lake Erie - Lake Erie watershed were selected specifically because they contain conditions that are conducive to the introduction and establishment of Hydrilla. Therefore, the potential impacts on the natural and socio-cultural features and their associated water-dependent and water-related uses that contribute to the community character of these focus areas may appear to be disproportionately emphasized when compared to the potential for similar impacts along the entire Lake Erie shoreline or within the Eastern Lake Erie - Lake Erie watershed.

For the Eastern Lake Erie-Lake Erie watershed as a whole, dispersal modelling predicted that by 2025, approximately 1% of the total waterbody area within the entire watershed would be affected by Hydrilla (see Table 3.1.5-1). Given the overall size of the Eastern Lake Erie - Lake Erie watershed and prevalence of water resources therein, it can be inferred based on these dispersal model results that future (2025) impacts resulting from introduction and establishment of Hydrilla on the overall community character of the watershed may be relatively small when considered for the entire watershed. However, if perchance all future Hydrilla infestations were to occur along the Lake Erie shoreline in one or more of the 30 focus areas evaluated in this analysis, the collective impacts likely would garner more attention and have a greater collective impact, especially if future infestations are concentrated in one or more of the high-use, high-value areas located on the shoreline.

Although this section describes potential future impacts from Hydrilla in focus areas along the Lake Erie shoreline, it is expected that similar impacts from the introduction and establishment of Hydrilla would occur at various locations throughout the interior of the Eastern Lake Erie - Lake Erie watershed. However, it is likely that these impacts would be more localized at or near the point of introduction, and would individually affect a smaller number of natural and socio-cultural features and a smaller number of associated water-dependent or water-related uses. Therefore, perceptions of the impacts on such features and uses, and their overall effect on the community character of the entire watershed would be diluted over a larger area.

As indicated by the above impact analysis, the Lake Erie shoreline represents a distinct component of the community character of the entire Eastern Lake Erie - Lake Erie watershed that differs in size and nature when compared to the smaller and dispersed waterbodies (lakes, ponds, rivers, creeks, and streams) that are located in the interior of this watershed. Thus, it is not unusual for the potential impacts of the introduction and establishment of Hydrilla, with or without treatment to control its spread, to be considered a prominent factor in the future of the Eastern Lake Erie - Lake Erie watershed.

F.2.9 Conclusions and Recommendations

The introduction and establishment of Hydrilla into the Eastern Lake Erie - Lake Erie watershed has the potential to result in long-term (permanent), direct and indirect, negative impacts on natural and socio-cultural features and their associated water-dependent and water-related uses that comprise the socio-cultural setting of this watershed. Similar impacts would be expected on the perceptions of these features and uses. Collectively, these impacts would represent long-term, indirect, negative impacts on the community character of this watershed.

These conclusions were based on the analysis of features and associated uses that were identified from: publicly available databases and planning documents; overlays for Google Earth; 7.5-minute USGS topographic quadrangles; and/or coastal maps maintained in the NOAA’s Office of Coast Survey Historical Map and Chart Collection. These conclusions were also developed considering the management of such features and uses that may be represented in comprehensive plans or master plans for the various counties, towns, and cities located along the shoreline in the Eastern Lake Erie - Lake Erie Watershed and/or identified and discussed in other Lake Erie shoreline-specific management plans, such as the LWRP Plans and HMPs prepared by various communities in New York State through New York State Department of State’s Local Waterfront Revitalization Program or planning documents developed by the Ohio Lake Erie Commission and its member agencies.

These conclusions are based on the analysis of impacts on natural and socio-cultural features and associated water-dependent and water-related uses identified for 30 focus areas that collectively represent approximately 104 miles (38%) of the approximately 276-mile-long shoreline in the Eastern Lake Erie - Lake Erie watershed. However, these conclusions are considered generally representative of potential impacts that would occur in interior areas of this same watershed and would be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

Separately, as discussed in this impact assessment (see Sections F.2 and F.2.6), there are a wide variety of agencies, organizations, and special interest groups, in addition to the many communities and governmental units with authority or jurisdiction over the shoreline in the Eastern Lake Erie - Lake Erie watershed, that may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the watershed. These stakeholders would include, but may not be limited to:

- State agencies such as New York State Office of Parks, Recreation, and Historic Preservation or New York State Department of Environmental Conservation, Pennsylvania Historical and Museum Commission; Pennsylvania Department of Conservation and Natural Resources; Ohio State Historic Preservation Office; and Ohio Department of Natural Resources/Division of Parks and Watercraft, that manage parks, historic sites, natural areas, and public access for waterbodies;
- Federal agencies, such as the USACE, which manages navigable waterways throughout the Eastern Lake Erie - Lake Erie watershed;
- Federally recognized Indian tribes such as the Seneca Nation of Indians because of the location of one focus area (Focus Area 21) within a portion of the Cattaraugus Indian Reservation, and other federally recognized Indian tribes who may have cultural or historical affiliation with various areas in the Eastern Lake Erie - Lake Erie watershed or retain treaty rights to lands, waters, and resources within the Eastern Lake Erie - Lake Erie watershed; and
- Special interest groups, such as The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that may have a broadly defined interest in areas and resources along the shoreline and in interior areas of the Eastern Lake Erie - Lake Erie watershed.

Outreach efforts by the USACE with the various communities and governmental units for all of the counties, towns, cities, and other areas (such as Cattaraugus Indian Reservation) at both the federal (including government-to-government), agency and public level is encouraged in order to collaboratively identify and develop strategies related to raising awareness for, controlling, and jointly managing the introduction and establishment of Hydrilla in this watershed. Similarly, the USACE should consider additional similar outreach efforts with the various stakeholders identified above for the same reasons. Many of these communities, governmental units, and stakeholders already have experience managing invasive aquatic plant species other than Hydrilla, and would likely welcome the opportunity to avoid or minimize the potential for new and/or cumulative impacts on the natural and socio-cultural features and associated water-dependent or water-related uses that they already manage or value.

F.2.10 References

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Attachment F-2

Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie - Lake Erie Watershed

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Niagara Falls National Heritage Area	NY	Niagara	Towns of Porter, Lewiston, and Niagara, Villages of Youngstown and Lewiston, and City of Niagara Falls	Heritage Area	Area designated by US Congress in 2008 to preserve, protect and promote the historic, natural and cultural resources of the 13-mile long area stretching from Niagara Falls to Old Fort Niagara in Youngstown, New York	Multiple (1, 2, 3, 4, 5)
Public Boat Ramps-Lake Ontario	NY	Niagara	Village of Youngstown	boat launch	Two hard surface state boat ramps with parking room for 44 cars and trailers. Confirmed invasive species present include: Eurasian watermilfoil, curly-leaf pondweed, zebra mussel, spiny waterflea, fishhook waterflea	5
Public Boat Ramp-Lower Niagara River	NY	Niagara	Town of Porter	boat launch	Hard surface state boat ramp with parking room for 44 cars and trailers. Confirmed invasive species present include: zebra mussel, and spiny waterflea	5
Riverside Manors	NY	Niagara	Town of Lewiston	Community	Shoreline housing development	1
Public Boat Ramp-Lower Niagara River	NY	Niagara	Village of Lewiston	boat launch	Hard surface municipal boat ramp with parking room for 30 cars and trailers. Confirmed invasive species present include: zebra mussel, and spiny waterflea	5
Earl W. Brydges State Artpark	NY	Niagara	Town of Lewiston	Public Park	108-acre state park established in 1974 that is a venue for summer musical entertainment, also offering picnic tables and pavilions, fishing, hiking, nature trail, a performing arts theater, recreation programs and cross-country skiing	2

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Lower Niagara River Rapids Significant Coastal Fish & Wildlife Habitat	NY	Niagara	City of Niagara Falls and Town of Lewiston	Conservation area	Approximately four and one-half mile segment of river channel, situated in the Niagara Gorge, between the Whirlpool Rapids Bridge and the Lewiston Village Line. This section of the river is very narrow, deep, and fast-flowing, with considerable eddying and crosscurrents and supports a productive coldwater fishery, focused heavily on spawning runs of steelhead (rainbow trout)	2
New York Power Authority Robert Moses Powerplant	NY	Niagara	Town of Lewiston	Industrial facility	Hydroelectric power station, built between 1957 and 1961, owned and operated by New York Power Authority	2
Niagara Power Vista/Niagara Power Project	NY	Niagara	Town of Lewiston	Public facility	Visitor center at NYPA Robert Moses Power Plant with exhibits on history of electricity and power production	2
Buckhorn Island-Goat Island Significant Coastal Fish & Wildlife Habitat	NY	Niagara and Erie	City of Niagara Falls	Conservation area	Approximately 850-acre (State) area located in the Upper Niagara River between Goat Island and Grand Island and is part of one of the most important waterfowl wintering areas and is believed to be a very productive area for fish populations in the upper Niagara River	Multiple (4, 4, 17)
Old Stone Chimney	NY	Niagara	City of Niagara Falls	Built resource	Relocated remnant of 18th century French and British forts built to guard the upper entrance to the portage around Niagara Falls	3
Gill Creek	NY	Niagara	City of Niagara Falls	Natural feature	Tributary of Niagara River	4

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Gill Creek Park	NY	Niagara	City of Niagara Falls	Public park	Small (city) park along Gill Creek, with facilities for picnicking and music concerts	4
Hyde Park	NY	Niagara	City of Niagara Falls	Public park	Park (city) located along Gill Creek, which was dammed to form Hyde Park Lake	4
Tonawanda Channel of Niagara River (east side of Grand Island)	NY	Niagara and Erie	Cities of Niagara Falls and North Tonawanda and Town of Wheatfield in Niagara County; Towns of Tonawanda and Grand Island and City of Tonawanda in Erie County	Natural feature	The northern end of the east passage of the Niagara River where it bifurcates at Grand Island; extends from the south tip of Grand Island, to a point just north of Tonawanda, New York	Multiple (5, 6, 7, 8, 9, 10, 11, 12, 13, 14)
Lasalle Waterfront Park	NY	Niagara	City of Niagara Falls	Public park	State park located along Niagara River at northern end of North Grand Island bridges	5
LaSalle Yacht Club	NY	Niagara	City of Niagara Falls	Organization	Yacht club organized in 1936; facilities include a clubhouse, seawall, dock, and boat slips	5
Bella Vista Ristorante	NY	Niagara	City of Niagara Falls	Private Business	Waterfront restaurant in Four Points by Sheraton Niagara Falls hotel	5
Four Points by Sheraton Niagara Falls	NY	Niagara	City of Niagara Falls	Private Business	Waterfront hotel along Niagara River	5
Little River (by Cayuga Island)	NY	Niagara	City of Niagara Falls	Natural feature	Section of Tonawanda Channel of Niagara River. Flows between Cayuga Island and the New York mainland, within the Niagara River Channel	5
Chute Marine	NY	Niagara	City of Niagara Falls	Private business	Marina that opened in 2002; located off the Cayuga River, which connects to the Niagara River	5

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Cayuga Creek	NY	Niagara	City of Niagara Falls	Natural feature	Tributary to Little River/Niagara River	5
Bergholtz Creek	NY	Niagara	City of Niagara Falls	Natural feature	Tributary to Cayuga Creek	5
Cayuga Island	NY	Niagara	City of Niagara Falls	Natural feature	Small island located in the Tonawanda Channel of the Niagara River, at the mouth of Cayuga Creek	5
Cayuga Island	NY	Niagara	City of Niagara Falls	Community	A residential neighborhood of the City of Niagara Falls	5
Jayne Park	NY	Niagara	City of Niagara Falls	Public park	20-acre waterfront (city) park on Cayuga Island; facilities include renovated playground equipment, new benches, a new trail, and plants	5
Griffon Park	NY	Niagara	City of Niagara Falls	Public park	City park located on the Upper Niagara River in the LaSalle neighborhood of the city of Niagara	5
Public Boat Ramp-Upper Niagara River	NY	Niagara	City of Niagara Falls	boat launch	hard surface boat municipal ramp with parking room for 50 cars and trailers. confirmed invasive species present include: zebra mussel, and spiny waterflea	5
City of North Tonawanda	NY	Niagara	City of North Tonawanda	Community	Originally a village in 1865, which became a city in 1897	Multiple (6, 7)
Lumberjacks Patio and Grill	NY	Niagara	City of North Tonawanda	Private business	Waterfront restaurant	6
Fishermans Park	NY	Niagara	City of North Tonawanda	Public park	Small waterfront park located between River Street and the Niagara River, with a playground, a covered pavilion and water access	7
Turning Basin	NY	Niagara	City of North Tonawanda	Built resource	Located north of Tonawanda Island	7
Tonawanda Island	NY	Niagara	City of North Tonawanda	Natural feature	Located in Tonawanda Channel of Niagara River, at mouth of Erie Canal and Ellicott Creek	7

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Placid Harbor Marina	NY	Niagara	City of North Tonawanda	Private business	Marina	7
The Shores Waterfront Restaurant	NY	Niagara	City of North Tonawanda	Private business	Waterfront restaurant and marina	7
Little River (by Tonawanda Island)	NY	Niagara	City of North Tonawanda	Natural feature	Section of Tonawanda Channel of Niagara River. Flows between Tonawanda Island and the New York mainland, within the Niagara River	7
East Pier Marina	NY	Niagara	City of North Tonawanda	Private business	Marina	7
Bow & Stern Marine	NY	Niagara	City of North Tonawanda	Private business	Boat dealership and marina	7
Niagara River Yacht Club	NY	Niagara	City of North Tonawanda	Organization	Yacht club founded in 1957, with a clubhouse, marina, and bar	7
Winfield Marina, Inc.	NY	Niagara	City of North Tonawanda	Private business	Marina	7
Island Street Boatyard	NY	Niagara	City of North Tonawanda	Private business	Complex for restoring old boats	7
Wardell Boat Yard	NY	Niagara	City of North Tonawanda	Private business	Marina?	7
Erie Canal/Tonawanda Creek	NY	Niagara	City of North Tonawanda	Built/Natural resource	Tonawanda Creek is a tributary to Tonawanda Channel of Niagara River. Western section of Erie Canal joins the creek where it drains into the river	7
City of Tonawanda	NY	Erie	City of Tonawanda	Community	Began as a hamlet in 811, and became a city in 1904	Multiple (7, 8)
Ellicott Creek	NY	Erie	City of Tonawanda	Natural feature	Tributary to Erie Canal/Tonawanda Creek and Tonawanda Channel of Niagara River	7
Nia-Wanda Park	NY	Erie	City of Tonawanda	Public park	Waterfront (city) park with pavilion for events	7
Public Boat Ramp-Upper Niagara River	NY	Erie	City of Tonawanda	boat launch	Hard surface municipal boat ramp with parking room for 32 cars and trailers. Confirmed invasive species present include: zebra mussel, and spiny waterflea	7

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Mississippi Muds	NY	Erie	City of Tonawanda	Private Business	Waterfront restaurant	7
Old Man River	NY	Erie	City of Tonawanda	Private Business	Waterfront restaurant	7
Riverwalk Section of Shoreline Trail	NY	Erie	City and Town of Tonawanda, City of Buffalo	Public park	Continuous multi-use pathway along Lake Erie and the Niagara River, within both Erie and Niagara counties	Multiple (8, 18)
Veterans Memorial Park	NY	Erie	City of Tonawanda	Public park	Waterfront (city) park with picnicking pavilions, playgrounds, and baseball diamonds	8
Twomile Creek	NY	Erie	City of Tonawanda	Natural feature	Tributary to Tonawanda Channel of Niagara River	8
Collins Marine	NY	Erie	Town of Tonawanda	Private business	Boat dealer and marina	9
Erie County Water Authority	NY	Erie	Town of Tonawanda	Municipal facility	Water intake and treatment facility	10
Mid River Marina, Inc.	NY	Erie	Town of Tonawanda	Private business	Boat dealer and marina	10
NRG Huntley Generation Station	NY	Erie	Town of Tonawanda	Industrial facility	Former coal-burning power plant, now closed	10
Small Boat Harbor	NY	Erie	Town of Tonawanda	Governmental -harbor	Municipal park/harbor with boat launching facilities	10
Public (Sheridan) Boat Launch-Upper Niagara River	NY	Erie	Town of Tonawanda	boat launch	Hard surface municipal boat ramp with space for 43 cars and trailers; Confirmed invasive species include zebra mussel and spiny waterflea	10
Aqua Lane Park	NY	Erie	Town of Tonawanda	Public park	Waterfront (town) park with playground and gazebos	10
Clark Craft	NY	Erie	Town of Tonawanda	Private business	Wooden boat building supply center	10
River Grill	NY	Erie	Town of Tonawanda	Private business	Waterfront restaurant and bar	10

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Tonawanda Channel of Niagara River (east side of Grand Island)	NY	Niagara and Erie	Cities of Niagara Falls and North Tonawanda and Town of Wheatfield in Niagara County; Towns of Tonawanda and Grand Island and City of Tonawanda in Erie County	Natural feature	The southern end of the east passage of the Niagara River where it bifurcates at Grand Island; extends from the south tip of Grand Island, to a point just north of Tonawanda, New York	Multiple (5, 6, 7, 8, 9, 10, 11, 12, 13, 14)
Buckhorn Island	NY	Erie	Town of Grand Island	Natural feature	Island located on the north end of Grand Island, where the Tonawanda Channel and the Chippewa Channel of the Niagara River converge	Multiple (11, 17)
Buckhorn Island State Park	NY	Erie	Town of Grand Island	Public park	895-acre state park (state) located on the northern end of Grand Island	Multiple (11, 17)
Buckhorn Island Wetlands Significant Coastal Fish & Wildlife Habitat	NY	Erie	Town of Grand Island	Conservation area	Approximately 500-acre (state) area located in Buckhorn Island State Park at the northern end of Grand Island that provides valuable habitat for a variety of fish and wildlife species	Multiple (11, 17)

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Grand Island Tributaries Significant Coastal Fish & Wildlife Habitat	NY	Erie	Town of Grand Island	Conservation area	Portions of four major tributaries on Grand Island and their associated wetlands: Woods Creek (approximately 2 miles above Buckhorn Island State Park), Gun Creek (lower three-fourths mile), Spicer Creek (lower three-fourths mile), and Big Sixmile Creek (lower one-half mile). Provide important spawning and nursery areas for warm-water fish species, especially northern pike	Multiple, (11, 12, 13, 16)
Woods Creek	NY	Erie	Town of Grand Island	Natural feature	Tributary to Tonawanda Channel of Niagara River. Included in the Grand Island Tributaries Significant Coastal Fish & Wildlife Habitat	11
Sewage Disposal	NY	Erie	Town of Grand Island	Industrial facility	Grand Island Wastewater Treatment Plant	11
Sandy Beach	NY	Erie	Town of Grand Island	Community	Hamlet comprised of homes built in the late 1940s	11
Gun Creek	NY	Erie	Town of Grand Island	Natural feature	Tributary to Tonawanda Channel of Niagara River. Included in the Grand Island Tributaries Significant Coastal Fish & Wildlife Habitat	12
Spicer Creek Wildlife Management Area	NY	Erie	Town of Grand Island	Conservation area	34-acre area established for the permanent preservation of the diverse wetland and for wildlife management, wildlife habitat management, and wildlife-dependent recreation	13

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Spicer Creek	NY	Erie	Town of Grand Island	Natural feature	Tributary to Tonawanda Channel of Niagara River. Included in the Grand Island Tributaries Significant Coastal Fish & Wildlife Habitat	13
Wakiki Watercraft Rentals	NY	Erie	Town of Grand Island	Private business	Jet ski rentals	13
River Oaks Marina, Inc.	NY	Erie	Town of Grand Island	Private business	Marina	13
Buffalo Launch Club	NY	Erie	Town of Grand Island	Organization	Power boat club established in 1903, with marina and clubhouse	14
Anchor Marine	NY	Erie	Town of Grand Island	Private business	Boat dealership and winter storage	14
Ferry Village	NY	Erie	Town of Grand Island	Community	Hamlet on Grand Island, at ferry landing for ferries between Riverside (City of Buffalo) and Grand Island	14
Niagara River Station Fishing Club	NY	Erie	Town of Grand Island	Organization	Fishing club	14
Blue Water Marina	NY	Erie	Town of Grand Island	Private business	Marina	14
Beaver Island State Park	NY	Erie	Town of Grand Island	Public park	950-acre state park located on the southern end of Grand Island	Multiple (14, 15)
Beaver Island Golf Course	NY	Erie	Town of Grand Island	Public (state) golf course	18-hole championship golf course within Beaver Island State Park	Multiple (14, 15)
Boardwalk Bar and Grill	NY	Erie	Town of Grand Island	Public (state) restaurant	Concession inside Beaver Island State Park, along beach	Multiple (14, 15)
Beaver Island Marina	NY	Erie	Town of Grand Island		Marina inside Beaver Island State Park	Multiple (14, 15)
Chippawa Channel of Niagara River (west side of Grand Island)	NY	Erie	Town of Grand Island	Natural feature	"Chippawa Channel" is the river passage on the west side of Grand Island, where the Niagara River bifurcates at the south tip of Grand Island	Multiple (15, 16, 17)
Beaver Island	NY	Erie	Town of Grand Island	Natural feature	Located off the south end of Grand Island; part of Beaver Island State Park	15

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Big Sixmile Creek	NY	Erie	Town of Grand Island	Natural feature	Tributary to Chippewa Channel of Niagara River. Included in the Grand Island Tributaries Significant Coastal Fish & Wildlife Habitat (DOS 2017f)	16
Big Six Mile Creek Marina	NY	Erie	Town of Grand Island	Public (state) facility	Marina with boat launch, slips, gasoline and oil sales, ice cream and pump out service	16
Public Boat Launch-Upper Niagara River	NY	Erie	Town of Grand Island	boat launch	Hard surface municipal boat ramp with space for 10 cars and trailers; Confirmed invasive species include zebra mussel and spiny waterflea	16
Burnt Ship Creek	NY	Erie	Town of Grand Island	Natural feature	Tributary to Chippewa Channel of Niagara River	17
City of Buffalo	NY	Erie	City of Buffalo	Community	City in Western New York; county seat of Erie county. Founded ca. 1804 and became a national industrial center in the 19th and 20th century due to the Erie Canal, railroads, and Lake Erie	Multiple (18, 19)
Harbour Place Marine	NY	Erie	City of Buffalo	Private business	Power boat dealer, marina, and service	18
Acqua	NY	Erie	City of Buffalo	Private business	Waterfront restaurant	18
Tow Path Park	NY	Erie	City of Buffalo	Public park	5-acre waterfront pocket park with passive recreational facilities and access to the Riverwalk in the corridor of the historic Erie Canal's towpath	18
Grand Lady Cruises, Inc.		Erie	City of Buffalo	Private business	Dinner cruise vessel	18
Rich Marine Sales, Inc.	NY	Erie	City of Buffalo	Private business	Boat dealer, marina with over 500 slips, service, and storage	18

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Black Rock Lock	NY	Erie	City of Buffalo	Built resource	Lock along the Erie Canal; built by the Corps of Engineers from 1908 – 1913	18
Black Rock Canal	NY	Erie	City of Buffalo	Built resource	Man-made channel of the Niagara River, extending from the Black Rock Lock of the Erie Canal to Buffalo Harbor	18
Unity/Squaw Island	NY	Erie	City of Buffalo	Natural feature	160-acre island separating the Black Rock Canal from the Niagara River	18
Squaw Island Park	NY	Erie	City of Buffalo	Public park	City park located on north end of Squaw Island; converted landfill that now a waterfront park used for fishing, birdwatching, and picnicking	18
Bird Island Wastewater Treatment Plant	NY	Erie	City of Buffalo	Industrial facility	City of Buffalo water treatment facility on Unity (Squaw) Island	18
Broderick Park	NY	Erie	City of Buffalo	Public park	City park located on the south end of Squaw Island; at historic border crossing for Underground Railroad and at historic location for Black Rock Ferry between Buffalo, New York and Fort Erie, Ontario	18
NASH (harbor tug)	NY	Erie	City of Buffalo	Built resource	World War II U.S. Army Large Tug (LT) class seagoing tugboat. NRHP-listed historic property NR # 91002059; listed on Dec 4, 1991	18
Russ's Bait & Tackle	NY	Erie	City of Buffalo	Private business	Bait and tackle shop	18

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Bird Island Pier	NY	Erie	City of Buffalo	Public park	City park linear in-water navigation structure that establishes the west side of the Black Rock Channel; recreational structure for fishing or walking along the Niagara River. Extends south from southern end of Squaw Island, separating the Black Rock Canal from the Niagara River	18
North Buffalo Harbor Significant Coastal Fish and Wildlife Habitat	NY	Erie	City of Buffalo	Conservation area	Approximately 800-acre area within Lake Erie and the Upper Niagara River, extending from the Peace Bridge to the mouth of the Buffalo River that support valuable fish and wildlife resources	Multiple (18, 19)
Front Park	NY	Erie	City of Buffalo	Public part	Waterfront park designed by Frederick Law Olmsted to focus on views of the Niagara River and Lake Erie. NRHP-listed historic property NR # 82005026; listed on May 26, 1982. Contributing resource to Olmsted Parks and Parkways Thematic Resources	18
West Side Rowing Club	NY	Erie	City of Buffalo	Organization	Rowing club established in 1912	18
Frank Lloyd Wright's Fontana Boathouse	NY	Erie	City of Buffalo	Built resource	Boathouse constructed in 2007, using Frank Lloyd Wright's 1905 plans	18
Buffalo Yacht Club	NY	Erie	City of Buffalo	Organization	Yacht club established in 1860, with a clubhouse and basin with a capacity for over 125 boats	18
Bird Island Reef	NY	Erie	City of Buffalo	Natural feature	Underwater sand and gravel bar near the city of Buffalo, New York	18

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Ward Pumping Station	NY	Erie	City of Buffalo	Industrial facility	Water intake and pumping station constructed in 1915 and still in use	18
Erie Basin	NY	Erie	City of Buffalo	Built resource	A breakwater and commercial slip at the mouth of the Buffalo River at Lake Erie designed to prevent the buildup of sand within the gateway to the Erie Canal and to lessen the impact of storm surges	19
Erie Basin Marina	NY	Erie	City of Buffalo	Private business	Full-service marina and boat launch, with concessions and gardens	19
Templeton Landing Restaurant	NY	Erie	City of Buffalo	Private business	Waterfront restaurant and bar	19
Hatch Restaurant	NY	Erie	City of Buffalo	Private business	Waterfront restaurant and bar	19
Sail Buffalo	NY	Erie	City of Buffalo	Organization	Sailing school	19
Moondance	NY	Erie	City of Buffalo	Private business	Catamaran cruises	19
U.S. Coast Guard Station Buffalo	NY	Erie	City of Buffalo	Government facility	Coast Guard Station along Lake Erie and at the entrance to the Buffalo and Niagara Rivers	19
Buffalo Outer Harbor	NY	Erie	City of Buffalo	Built resource	Manmade harbor along eastern end of Lake Erie at mouth of Buffalo River	19
Times Beach Nature Preserve	NY	Erie	City of Buffalo	Conservation area	City nature preserve along Outer Harbor in downtown Buffalo	19
Times Beach Diked Disposal Site Significant Coastal Fish and Wildlife Habitat	NY	Erie	City of Buffalo	Conservation area	Approximately 55-acre man-made area at Times Beach Nature Preserve that is comprised of partially filled, diked, dredge spoil disposal area that contains a variety of habitats	19
Wilkeson Point	NY	Erie	City of Buffalo	Public park	City park along former pier along Outer Harbor in downtown Buffalo	19

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
RCR Yachts, Inc.	NY	Erie	City of Buffalo	Private business	Boat dealer (power and sail), dockage, mooring, storage, and service	19
Greenway Nature Trail	NY	Erie	City of Buffalo	Public trail	1.2-mile waterfront multi-purpose trail along Outer Harbor in downtown Buffalo	19
Bell Slip	NY	Erie	City of Buffalo	Nature preserve	Sand barren preserve on former slip along Outer Harbor in downtown Buffalo	19
Charlie's Boat Yard (formerly Dug's Dive)	NY	Erie	City of Buffalo	Private business	Waterfront restaurant and bar	19
Buffalo Harbor State Park (NFTA Boat Harbor)	NY	Erie	City of Buffalo	Public park	State park along Outer Harbor in downtown Buffalo, with views of Lake Erie, a 1,000-slip marina, restaurant, boat launches, fishing, and a beach	19
Small Boat Harbor Significant Coastal Fish and Wildlife Habitat	NY	Erie	City of Buffalo	Conservation area	Approximately 165-acre (state) shallow embayment of Lake Erie sheltered by breakwall (i.e., the Small Boat Harbor), which supports a highly productive and diverse littoral community	19
Olson Brothers Marine	NY	Erie	City of Buffalo	Private business	Marina and boat storage	19
Shanty Shack	NY	Erie	City of Buffalo	Private business	waterfront restaurant at Outer Harbor in downtown Buffalo (Buffalo Rising, Inc. 2016)	19
Freedom Boat Club of Buffalo	NY	Erie	City of Buffalo	Organization	Boat club at Outer Harbor in downtown Buffalo offering boat rentals	19
Tifft Nature Preserve	NY	Erie	City of Buffalo	Conservation area	264-acre private conservation area on landfill site along Outer Harbor in downtown Buffalo	19

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Tifft Farm Nature Preserve Significant Coastal Fish and Wildlife Habitat	NY	Erie	City of Buffalo	Conservation area	264-acre private conservation area associated with Tifft Nature Preserve along Outer Harbor in downtown Buffalo that contains a diversity of fish and wildlife habitats, including an approximate 75 acre cattail marsh, small freshwater ponds and old canal remnants, old fields (partly covering a former solid waste transfer site), forested wetland, and shrub-sapling stages of succession	19
Union Canal	NY	Erie	City of Buffalo	Built resource	Industrial waterway dug from 1899-1900 by the Susquehanna Iron Company to provide access for lake freighters to iron ore docks along the Outer Harbor in downtown Buffalo	19
Lackawanna Canal	NY	Erie	City of Lackawanna	Built resource	Industrial waterway dug in 1900 by the Lackawanna Steel Company to provide access for lake freighters to iron ore docks along the Outer Harbor in downtown Buffalo	19
Stony Point	NY	Erie	City of Buffalo	Natural feature	Point along Lake Erie shoreline, at the south end of the Outer Harbor Breakwater	19

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
City of Lackawanna	NY	Erie	City of Lackawanna	Community	Originally part of the Buffalo Creek Reservation, the area was not open to settlement until 1842 when the land was sold by the Seneca Indians. Center of steel manufacture throughout most of the 20th century	19
Sturgeon Point Marina	NY	Erie	Town of Evans	Public park	Marina open to the public with water slips, dry docks, a restaurant, and four boat launches	20
Public Boat Launch-Lake Erie	NY	Erie	Town of Evans	boat launch	Hard surface municipal boat ramp with space for 100 cars and trailers; Confirmed invasive species include zebra mussel and spiny waterflea	20
GR8 Lakes Fishing Adventures	NY	Erie	Town of Evans	Private business	Charter fishing on Lake Erie	20
Sturgeon Point	NY	Erie	Town of Evans	Natural feature	Point along Lake Erie shoreline	20
Cattaraugus Indian Reservation	NY	Erie	Cattaraugus Indian Reservation/Town of Brant	Government	Reservation for the federally recognized Seneca Nation of Indians	21
Cattaraugus Creek	NY	Erie and Chautauqua	Towns of Brant and Hanover	Natural feature	Tributary to Lake Erie	21
Cattaraugus Creek Significant Coastal Fish and Wildlife Habitat	NY	Erie and Chautauqua	Towns of Brant and Hanover	Conservation area	Habitat extends approximately 42 miles from Lake Erie to the Springville Dam with habitat for major spawning runs by salmonids and other lake-based fish populations	21
Hanford Bay	NY	Chautauqua	Town of Hanover	Natural feature	Bay along Lake Erie shoreline	22

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
City of Dunkirk	NY	Chautauqua	City of Dunkirk	Community	Lakeside city settled as early as 1805 and incorporated in 1880. Beginning in the 1980s, the city refocused its economic efforts on revitalizing its pier and fishing, to improve the quality of life for residents and attract more tourists	23
Dunkirk Harbor	NY	Chautauqua	City of Dunkirk	Natural feature	Harbor along Lake Erie shoreline. Also known as Chadwick Bay. Deep draft commercial harbor with protective structures (breakwaters and piers) that supports 24 charter fishing boats and is a harbor of refuge	23
Dunkirk Harbor Significant Coastal Fish and Wildlife Habitat	NY	Chautauqua	City of Dunkirk	Conservation area	Habitat is an approximately 375-acre, shallow, open embayment of Lake Erie. Dunkirk Harbor is the only large, natural embayment in New York's portion of Lake Erie, South of Buffalo. It is one of the few places in the lake that provides substantial protection from wave action for fish, wildlife, and aquatic vegetation. Consequently, this area supports a highly productive and diverse littoral community, and is an important habitat for many fish and wildlife species	23
'Piles'	NY	Chautauqua	City of Dunkirk	Built resource	Man-made features in Dunkirk Harbor	23

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Clarion Hotel & Marina	NY	Chautauqua	City of Dunkirk	Private business	Four-story hotel with 127 guest rooms, nine meeting rooms and over 6,600 square feet of designed meeting space. Other amenities include indoor and outdoor pools, a restaurant and a workout room	23
Dunkirk City Pier	NY	Chautauqua	City of Dunkirk	Public facility	City-owned pier and launching ramps. Amenities include a harbormasters office, restrooms, fish cleaning station and 60 public parking spaces on pier. The facility has three launch ramps and 10 to 12 parking spaces for trailers and tow vehicles	23
Chadwick Bay Marina	NY	Chautauqua	City of Dunkirk	Private business	Privately owned marina built in 1987, with 279 floating aluminum slips, a 20-ton travel lift, fuel (gas and diesel), a pumpout, a mechanic on duty, live bait, showers, restrooms, and a ships store	23
Demetri's on the Lake	NY	Chautauqua	City of Dunkirk	Private business	Waterfront restaurant and bar	23
Memorial Park	NY	Chautauqua	City of Dunkirk	Public park	Waterfront city park along Dunkirk Harbor	23
Dunkirk Yacht Club	NY	Chautauqua	City of Dunkirk	Organization	Privately owned yacht club chartered in 1938, with a clubhouse, 100 fixed wood slips, an additional 3 transient slips able to accommodate up to 35-foot boats, and electric, water, and pumpout facilities	23

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
City of Dunkirk Water Filtration Plant	NY	Chautauqua	City of Dunkirk	Industrial facility	Eight million gallon per day water treatment plant built in 1920. Plant includes: 36-inch intake line extending 5,200 feet into the lake, two-story main building, two external sedimentation basins and a chemical building	23
NRG Energy Coal-fired Power Plant	NY	Chautauqua	City of Dunkirk	Industrial facility	Privately owned 600 MW coal-fired plant in service since 1950. All fuel is brought in by rail from Wyoming, via Chicago and Ashtabula. Generation requires 100 train cars every two days. Coal is stored in an open pile covering about 5 acres, enough for approximately 40 days of operation	23
Boat Ramp	PA	Erie	Town of North East	Built resource	Boat launch offering access to Lake Erie	25
North East Marina	PA	Erie	Town of North East	Private business	Full marina offering storage, fuel, sales, repairs, tackle shop and restaurant on Lake Erie Shore line	25
North East Boat Ramp	PA	Erie	Town of North East	Private business	Boat ramp within North East Marina	25
Light on the Lake	PA	Erie	Town of North East	Private business	Bed and Breakfast on Lake Erie shoreline offering beach-side rentals	25
Shades Beach Park	PA	Erie	Town of Harbor Creek	Public park	Lakeside public park with trails, woodlands, play areas, picnic ground, beach and boat launch and pavilion	26
Shades Beach Boat Ramp	PA	Erie	Town of Harbor Creek	boat launch	Located at mouth of Eightmile Creek	26
Eight Mile Creek	PA	Erie	Town of Harbor Creek	Natural feature	Tributary to Lake Erie	26

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Lawrence Boat Ramp	PA	Erie	Town of Lawrence Park	Public facility	Public boat launch	26
City of Erie	PA	Erie	City of Erie	Community	City in Pennsylvania named for the lake and Native American Tribe, with a population of 101,786 as of 2010	Multiple (26, 27)
East Avenue Boat Launch	PA	Erie	City of Erie	Public facility	Public boat launch	27
Submerged Pier	PA	Erie	City of Erie	Manmade feature	Underwater feature located outside Presque Isle Bay	27
'Shipwreck'??	PA	Erie	City of Erie	Built resource	First of three underwater features located outside Presque Isle Bay	27
'Shipwreck'??	PA	Erie	City of Erie	Built resource	Second of three underwater features located outside Presque Isle Bay	27
'Shipwreck'??	PA	Erie	City of Erie	Built resource	Third of three underwater features located outside Presque Isle Bay	27
Lampe Marina Boat Ramp	PA	Erie	City of Erie	Public facility	Public boat launch	27
Blacktop Charters	PA	Erie	City of Erie	Private business	Fishing charter service offering fishing trips on Lake Erie	27
Capt. John E. Lampe Marina	PA	Erie	City of Erie	Private business	252 slip marina offering floating docks, fuel dock, pump out station, picnic shelters, public launch ramps and 24-hour security	27
Lampe Campground	PA	Erie	City of Erie	Private business	Lakeside campground offering 42 waterfront camping sites, water/electric hookups, picnic tables, fire rings, etc.	27
U.S. Coast Guard	PA	Erie	City of Erie	Governmental facility	Coast Guard Station located on southern end of Presque Isle	27
Presque Isle Bay	PA	Erie	City of Erie	Natural feature	Barrier peninsula off the coast of Erie, PA	27

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Erie-Western PA Port Authority	PA	Erie	City of Erie	Government facility	Erie-Western PA Post Authority Headquarters	27
Harbor Basin	PA	Erie	City of Erie	Built resource	Man-made water feature within Erie Port	27
Approach/Turning Basin	PA	Erie	City of Erie	Built resource	Man-made water feature within Erie Port	27
Public Dock	PA	Erie	City of Erie	Built resource	Man-made water feature within Erie Port	27
Bayfront Maritime Center	PA	Erie	City of Erie	Organization	Maritime themed educational center located on Lake Erie	27
Donjon Shipbuilding and Repair LLC	PA	Erie	City of Erie	Private business	Shipbuilding and repair company located on Lake Erie shoreline	27
Erie Maritime Museum	PA	Erie	City of Erie	Institution	Maritime themed museum focused on the History of Lake Erie and its industry, located on Lake Erie shoreline	27
Rum Runners	PA	Erie	City of Erie	Private business	Located on Public Dock in Presque Isle Bay; maritime themed restaurant and bar	27
Eerie Bayfront Ghost Walks	PA	Erie	City of Erie	Private business	Haunted walking tour business located on public dock on Lake Erie	27
Bayfront Gallery	PA	Erie	City of Erie	Private business	Art gallery on public dock on Lake Erie offering views of the lake from gallery property	27
Smuggler's Wharf, Inc.	PA	Erie	City of Erie	Private business	Located on Public Dock in Presque Isle Bay; Maritime themed restaurant on public dock on Lake Erie	27
Victorian Princess Cruise Line	PA	Erie	City of Erie	Private business	Lake paddleboat offering event space, restaurant, and bar specials by reservation	27
Anchor Marine Ltd.	PA	Erie	City of Erie	Private business	Complete boating/maritime shopping/repair facility	27

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Bicentennial Tower	PA	Erie	City of Erie	Built resource	Observation tower on Lake Erie shoreline offering tours, gift shop, concessions, and public events	27
Small Program Charters – Lake Erie PA Walleye Fishing Charters	PA	Erie	City of Erie	Private business	Fishing charter tours on Lake Erie	27
Rough House Charters	PA	Erie	City of Erie	Private Business	Fishing charter tours on Lake Erie	27
Buckets Fishing Charters	PA	Erie	City of Erie	Private Business	Fishing charter tours on Lake Erie	27
Tiny Tim's Fishing Charters, Inc.	PA	Erie	City of Erie	Private business	Fishing charter tours on Lake Erie	27
Rum Runners Cove	PA	Erie	City of Erie	Private business	Located on Public Dock in Presque Isle Bay; Restaurant and bar with an island/maritime theme	27
Sheraton Erie Bayfront Hotel	PA	Erie	City of Erie	Private business	Located on Public Dock in Presque Isle Bay; Lakeside hotel with waterside restaurant on Lake Erie shoreline	27
Parks	PA	Erie	City of Erie	Public park	Located at Public Dock in Presque Isle Bay	27
Presque Isle Angler Bait and Tackle	PA	Erie	City of Erie	Private business	Bait and tackle shop offering fishing needs and licenses	27
Harbor View Miniature Golf	PA	Erie	City of Erie	Private business	Miniature golf course offering views of Lake Erie	27
U.S.S. Niagara	PA	Erie	City of Erie	Built resource	Located at Public Dock in Presque Isle Bay. NRHP-listed historic property NR # 73001628; listed Apr 11, 1973	27
Bayfront Convention Center	PA	Erie	City of Erie	Private business	Located at Public Dock in Presque Isle Bay; Convention center offering banquet halls and hotels with views of Lake Erie's Presque Isle Bay	27

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Courtyard by Marriott Erie Bayfront	PA	Erie	City of Erie	Private business	Hotel and conference center on Lake Erie Bayfront	27
Presque Isle Yacht Club	PA	Erie	City of Erie	Organization	Located at Public Dock in Presque Isle Bay; Yacht club and marina located on Lake Erie shoreline	27
Fish Hatchery	PA	Erie	City of Erie	Private business	Located in Presque Isle Bay	27
Port Erie Sports	PA	Erie	City of Erie	Private business	Located in Presque Isle Bay; Boat and jet ski rental business as well as tackle shop	27
Bayview Park	PA	Erie	City of Erie	Public park	Located in Presque Isle Bay; public park with Lake Erie views	27
Commodore Perry Yacht Club	PA	Erie	City of Erie	Organization	Located in Presque Isle Bay; Yacht club and marina offering floating docks, social events, clubhouse, picnic shelters, restaurants, etc.	27
Sloppy Duck Saloon	PA	Erie	City of Erie	Private business	Located in Presque Isle Bay; Lakeside restaurant with banquet hall	27
Bay Harbor Marina Services	PA	Erie	City of Erie	Private business	Located in Presque Isle Bay; Marina offering restaurants, docks, ship store, social events	27
Liberty Park	PA	Erie	City of Erie	Public park	Public park on Lake Erie shoreline adjacent to Erie marinas	27
Perry’s Landing Marina	PA	Erie	City of Erie	Private business	Located in Presque Isle Bay; Marina and waterfront club on Lake Erie shoreline	27
RCR Yachts of Erie, Inc.	PA	Erie	City of Erie	Private business	Located in Presque Isle Bay; Boat/Yacht sales business on Lake Erie shoreline	27
Sunrise of Presque Isle Bay	PA	Erie	City of Erie	Community	Retirement community on lake Erie shoreline offering views of Lake Erie	27
West Branch Cascade Creek	PA	Erie	City of Erie	Natural feature	Tributary to Presque Isle Bay	27

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Yacht Basin	PA	Erie	City of Erie	Built resource	Located in Presque Isle Bay	27
Erie Yacht Club	PA	Erie	City of Erie	Organization	Located in Presque Isle Bay; Yacht club and marina offering docks, sailing lessons, banquet hall, bike paths, etc.	27
'Ruins'	PA	Erie	City of Erie	Built resource	Located in Presque Isle Bay	27
Presque Isle State Park	PA	Erie	Town of Mill Creek	Public park	State park off shore of Lake Erie offering multiple beaches, camping areas, historic landmarks and private businesses	27
Presque Isle	PA	Erie	Town of Mill Creek	Natural feature	Peninsula jutting out into Lake Erie	27
Presque Isle Bike Trail	PA	Erie	Town of Mill Creek	Built resource	Bike path along Presque Isle offering trails and views of lake Erie	27
Vista Boat Launch	PA	Erie	Town of Mill Creek	boat launch	Public boat launch on Presque Isle	27
Niagara Boat Launch	PA	Erie	Town of Mill Creek	boat launch	Public boat launch on Presque Isle	27
Yellow Bike Rentals	PA	Erie	Town of Mill Creek	Private business	Bike rental shop offering a wide variety of land and water recreational rentals	27
Big Bend	PA	Erie	Town of Mill Creek	Natural feature	Natural feature along Presque Isle peninsula of Lake Erie	27
Presque Isle Marina Fuel Services	PA	Erie	Town of Mill Creek	Marina	Marina within Presque Isle State Park offering fuel services	27
Marina Lake	PA	Erie	Town of Mill Creek	Natural/built feature	Manmade/natural feature along Presque Isle peninsula of Lake Erie	27
West Pier Boat Ramp	PA	Erie	Town of Mill Creek	boat launch	Public boat launch within Presque Isle state Park	27
Crystal Point	PA	Erie	Town of Mill Creek	Natural feature	Natural feature along Presque Isle peninsula of Lake Erie	27
Perry Monument	PA	Erie	Town of Mill Creek	Built resource	Monument dedicated to Commodore Perry, a prominent naval leader in the war of 1812	27

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Long Pond	PA	Erie	Town of Mill Creek	Natural feature	Waterbody along Presque Isle peninsula of Lake Erie	27
Big Pond	PA	Erie	Town of Mill Creek	Natural feature	Waterbody along Presque Isle peninsula of Lake Erie	27
Old Lagoon Boat Ramp	PA	Erie	Town of Mill Creek	Boat launch	Public boat launch within Presque Isle state Park	27
New Lagoon Boat Ramp	PA	Erie	Town of Mill Creek	Boat launch	Public boat launch within Presque Isle state Park	27
Evening Lagoon By Pontoon	PA	Erie	Town of Mill Creek	Private business	Pontoon charter and guide/tour offering evening wildlife outings	27
Presque Isle Canoe and Boat Livery	PA	Erie	Town of Mill Creek	Private business	Boat and canoe rental service offering tours, food, restrooms, etc.	27
Cranberry Pond	PA	Erie	Town of Mill Creek	Natural feature	Natural water feature along Presque Isle	27
Ridge Pond	PA	Erie	Town of Mill Creek	Natural feature	Natural water feature along Presque Isle	27
Niagara Pond	PA	Erie	Town of Mill Creek	Natural feature	Natural water feature along Presque Isle	27
Misery Bay	PA	Erie	Town of Mill Creek	Natural feature	Natural water feature along Presque Isle	27
Horseshoe Pond	PA	Erie	Town of Mill Creek	Natural feature	Natural water feature along Presque Isle	27
Thompson Bay	PA	Erie	Town of Mill Creek	Natural feature	Natural water feature along Presque Isle	27
Signal Tower	PA	Erie	Town of Mill Creek	Built resource	Located at the end of Presque Isle peninsula	27
Gull Point	PA	Erie	Town of Mill Creek	Natural feature	Viewpoint and hiking area on Presque Isle offering beaches, views, observation deck and hiking trail	27
Presque Isle Light	PA	Erie	Town of Mill Creek	Built resource	NRHP-listed historic property NR # 83002242; listed Aug 4, 1983. Contributing resource to the U.S. Coast Guard Lighthouses and Light States on the Great Lakes Thematic Resources	27
Manchester Beach	PA	Erie	Town of Fairview	Community	Lakefront and beachside community along Lake Erie shoreline	28

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Walnut Creek	PA	Erie	Town of Fairview	Natural feature	Tributary to Lake Erie	28
Walnut Creek Access Area	PA	Erie	Town of Fairview	Boat launch	Public boat launch with ample parking and small marina	28
A&A Fishing Charters	PA	Erie	Town of Fairview	Private business	Fishing charter service offering fishing tours on Lake Erie	28
Conneaut	OH	Ashtabula	City of Conneaut	Community	City in Ohio's northeastern most corner along Lake Erie	29
Conneaut Harbor	OH	Ashtabula	City of Conneaut	Natural/built feature	Harbor within Lake Erie	29
Conneaut Creek	OH	Ashtabula	City of Conneaut	Natural feature	Tributary to Lake Erie	29
Conneaut Boat Club	OH	Ashtabula	City of Conneaut	Organization	Private boat club offering a marina, fueling services and social events	29
Conneaut Port Authority	OH	Ashtabula	City of Conneaut	Government facility	Waterfront agency committed to economic development and recreational activities along the Lake Erie front	29
Port of Conneaut Marine Memorial Park	OH	Ashtabula	City of Conneaut	Public Park	Creekside public park offering picnic areas, fishing access, etc.	29
Snug Harbor Bait and Tackle	OH	Ashtabula	City of Conneaut	Private business	Fishing shop offering equipment and fish cleaning	29
P.C. Queen Perch Fishing Headboat	OH	Ashtabula	City of Conneaut	Private business	Fishing charter service offering fishing trips on Lake Erie	29
Lakeview Park	OH	Ashtabula	City of Conneaut	Public park	Lakefront public park offering Lake Erie views, playground and baseball diamond	29
Conneaut Township Park	OH	Ashtabula	City of Conneaut	Public park	Public park offering public beach, fishing access, concessions, playgrounds, etc.	29
Ashtabula	OH	Ashtabula	City of Ashtabula	Community	City along Lake Erie's shoreline	30

Attachment F-2 Natural and Socio-Cultural Features Along the Shoreline in the Eastern Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Ashtabula Township Park	OH	Ashtabula	Town of Ashtabula and City of Ashtabula	Public park	Public park offering public boat launch, picnic areas, access to fishing, and social events	30
Lake Shore Bait and Tackle	OH	Ashtabula	City of Ashtabula	Private business	Fishing charter service offering fishing trips on Lake Erie, and licenses	30
Pinney Dock	OH	Ashtabula	City of Ashtabula	Built resource	Industrial dock, Located at Ashtabula	30
Union Dock	OH	Ashtabula	City of Ashtabula	Built resource	Located at Ashtabula	30
Ashtabula and Buffalo Dock	OH	Ashtabula	City of Ashtabula	Built resource	Located at Ashtabula along Lake Erie shoreline	30
Ashtabula River	OH	Ashtabula	City of Ashtabula	Natural feature	Tributary to Lake Erie	30

F.3 Potential Socio-Cultural Impacts: Southern Lake Erie Watershed

The Southern Lake Erie watershed is located along the southern side of Lake Erie. Located entirely within northeastern Ohio, it extends over portions of four counties: (from east to west) Ashtabula, Lake, Cuyahoga, and Lorain.

According to modeling conducted for the introduction and establishment of Hydrilla within the larger Great Lakes basin, the Southern Lake Erie watershed is considered to have a high potential for the introduction of Hydrilla, primarily via recreational boating, and a moderate potential for the establishment of Hydrilla in suitable nearshore aquatic habitat if it were to be introduced.

The following impact assessment describes the various features that comprise the existing socio-cultural setting of 17 focus areas along the approximately 107-mile-long shoreline area within the Southern Lake Erie watershed. These 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed were selected for detailed analysis because they include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet, as discussed in Section F.3.1. The following impact assessment considers the potential impacts of the introduction and subsequent establishment of Hydrilla on the various features that collectively represent the community character of these focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. It is recognized that the Southern Lake Erie watershed encompasses additional areas along the shoreline as well as interior areas that are not located along the Lake Erie shoreline. However, the following impact assessment considers the socio-cultural setting and community character of only those counties, townships, villages, towns, and cities where the 17 focus areas are located. This approach was adopted to make the impact assessment more manageable given the total length of the Lake Erie shoreline (107 miles) in the Southern Lake Erie watershed.

Similarly, it is recognized that a wide variety of agencies, organizations, and special interest groups may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the Southern Lake Erie watershed. These stakeholders would consist of the civic and governmental areas with jurisdiction over the areas included in the Southern Lake Erie watershed. Additional stakeholders could include: state agencies (e.g., Ohio State Historic Preservation Office [OSHPO] or Ohio Department of Natural Resources/Division of Parks and Watercraft [ODNR] that manage parks, historic sites, natural areas, and public access for waterbodies); federal agencies (e.g., the USACE, which manages navigable waterways, and the Nuclear Regulatory Commission, which provides regulatory oversight of nuclear power plants); federally recognized Indian tribes that have a cultural or historical affiliation with areas along the Lake Erie shoreline in the Southern Lake Erie watershed or retain treaty rights to lands, waters, and resources along the shoreline of the Southern Lake Erie watershed; or special interest groups (e.g., The Nature Conservancy, The Sierra Club, or Ducks Unlimited) that have a broadly defined interest in areas and resources along the shoreline of the Southern Lake Erie watershed. These additional stakeholders could be involved as part of continued consideration of the potential impacts associated with the introduction and establishment of Hydrilla within the larger Great Lakes basin.

Potential impacts on the socio-cultural setting of shoreline areas of the Southern Lake Erie watershed are discussed in terms of whether they would be: short-term (temporary) or long-term (permanent), direct or indirect, positive (beneficial) or negative (detrimental), and cumulative. Additionally, these impacts are considered with reference to two scenarios: one where Hydrilla is untreated (worst-case scenario) and one where Hydrilla is treated (managed scenario).

It is expected that the results of this assessment of the introduction and subsequent establishment of Hydrilla on the socio-cultural setting and community character of the 17 focus areas along the Lake Erie shoreline within the Southern Lake Erie watershed would be generally representative of potential impacts that would occur in interior areas of this same watershed. The results would also be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

F.3.1 Methodology and Definitions for the Socio-Cultural Impact Assessment for the Southern Lake Erie Watershed

This socio-cultural impact assessment assumes that the introduction and/or establishment of Hydrilla along the shoreline of the Southern Lake Erie watershed will affect the natural and socio-cultural features located in these areas, resulting in changes to the watershed's community character. For the purposes of this impact assessment, natural features are defined as uplands, points, bluffs, coves, beaches, embayments, creeks, streams, rivers, marshes, etc., and socio-cultural features are defined as villages, towns, cities, parks, other residential areas (neighborhoods and hamlets), conservation areas (including nature preserves, wildlife preserves, and wildlife management areas), commercial enterprises, industrial facilities, and cultural and historical sites.

This socio-cultural impact assessment further assumes that these natural and socio-cultural features collectively represent tangible (physical) components of the community character of the Southern Lake Erie watershed. A review of publicly available information for Ohio and Michigan state agencies did not identify specific guidance for defining or assessing impacts on community character. However, Ohio Lake Erie Commission, which, along with its member state agencies, is responsible for actions taken to protect and restore those portions of Lake Erie and its watershed within the state of Ohio, has issued some guidance which addresses those features or qualities that comprise community character (Ohio Lake Erie Commission 2011). In its 2013 *Lake Erie Protection & Restoration Plan*, the Ohio Lake Erie Commission indicated that its mission is "to preserve Lake Erie's natural resources, protect the ecological quality of its watershed, and to promote economic development on the north coast. This is accomplished through coordination and implementation of state policies and programs pertaining to water quality, habitat protection and restoration, recreation and tourism, and resource management within the Lake Erie basin." (Ohio Lake Erie Commission 2013). These features or qualities also contribute to community character at a broad level, when the interaction of natural and socio-cultural features are collectively considered to comprise community character.

Therefore, for the purposes of this impact assessment of the Southern Lake Erie watershed, which lies entirely within Ohio, the concept of community character is modelled on the New York State's guidance for complying with the State Environmental Quality Review Act (SEQR), consistent with other watersheds evaluated as part of this RA. New York State's SEQR guidance notes that:

> Many people define their community's character in very general terms: suburban, rural, urban, quiet, safe, scenic, or friendly are terms often used. Others describe community character only in terms of visual features.
>
> Community character is broader than this however. Community character is defined by all the man-made and natural features of the area. It includes the visual character of a town, village, or city, and its visual landscape; but also includes the buildings and structures and their uses, the natural environment, activities, town services, and local policies that are in place.
>
> These combine to create a sense of place or character that defines the area" (New York State Department of Environmental Conservation [NYSDEC] 2017).

The introduction and establishment of Hydrilla would occur within natural features located along the shoreline of Lake Erie in the Southern Lake Erie watershed. These areas typically are locations recognized and used for water-dependent and water-related uses. The natural and man-made (socio-cultural) features of the watershed as a collective physical representation of the community character of the Southern Lake Erie watershed, as defined above by NYSDEC, appears to provide the most comprehensive consideration of the impacts that the introduction and establishment of Hydrilla would have on the community character of the Southern Lake Erie watershed. However, the definition of community character for this impact assessment has been expanded to include the water-dependent and water-related uses of these natural and man-made or socio-cultural features, which also contribute to community character and are deliberately managed by the communities and governmental units that comprise the Southern Lake Erie watershed.

Due to the large extent of the Lake Erie shoreline in the Southern Lake Erie watershed (approximately 107 miles in length), 17 areas with environmental conditions highly suitable to establishment of Hydrilla were identified within this watershed for an in-depth impact assessment. These 17 areas (henceforth, referred to as focus areas) collectively comprise approximately 26 miles of the Lake Erie shoreline in the Southern Lake Erie watershed. They all contain physical conditions that are conducive to the introduction and establishment of Hydrilla. Table F.3-1 provides a summary description of each of the 17 focus areas identified for the Southern Lake Erie watershed. Section 3.3 describes the criteria used to identify the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie Watershed, which include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet).

Thus, this socio-cultural impact assessment identifies the visible and physical natural and socio-cultural features that represent the attributes and assets of the communities and governmental units associated with the 17 focus areas along the shoreline of Lake Erie in the Southern Lake Erie watershed (see Section F.3.2; see Attachment F-3 for a listing of visible and physical natural and socio-cultural features). This socio-cultural impact assessment considers the management of the visible and physical natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed by the associated counties, towns, and cities or villages (see Section F.3.3). This socio-cultural impact assessment considers the impacts of the introduction and/or establishment of Hydrilla on the natural and socio-cultural features and their associated water-dependent and water-related uses identified for the 17 focus areas in the Southern Lake Erie watershed (see Sections F.3.4 and F.3.5). This assessment also considers the impacts of the introduction and establishment of Hydrilla on perceptions of features and uses and on the community character of the 17 focus areas (see Sections F.3.6 and F.3.7). The results of this impact analysis are considered with regard to their broader applicability to the entire Southern Lake Erie watershed (see Section F.3.8). Finally, conclusions and recommendations regarding the results of this impact assessment are presented in Section F.3.9.

Table F.3-1 Description of Focus Areas in the Southern Lake Erie Watershed

Focus Area Number	Description of Focus Area[1]	County	City or Town	Approximate Length (miles)
1	Lake Erie shoreline at mouth of Red Brook	Ashtabula	Saybrook Township	0.13
2	Lake Erie shoreline within Geneva-On-The-Lake State Park, at mouth of Cowles Creek	Ashtabula	Village of Geneva-On-The-Lake	0.44
3	Lake Erie Shoreline at North Townline Park	Lake	Village of North Perry	0.25
4	Lake Erie Shoreline adjacent to Perry Nuclear Power Plant	Lake	Perry Township and Village of North Perry	0.68

Table F.3-1 Description of Focus Areas in the Southern Lake Erie Watershed

Focus Area Number	Description of Focus Area[1]	County	City or Town	Approximate Length (miles)
5	Shoreline of Fairport Harbor at mouth of Grand River	Lake	Village of Fairport Harbor, City of Painesville, Village of Grand River, Painesville Township, and City of Mentor	1.29
6	Shoreline of Mentor Harbor at mouth of Heisley Creek	Lake	Cities of Mentor, and Mentor-On-The-Lake	3.08
7	Lake Erie shoreline, including the mouths of Chagrin River, and Ward Brook	Lake	City of Eastlake, and Village of Timberlake	0.92
8	Lake Erie shoreline at mouth of Euclid Creek	Cuyahoga	City of Cleveland	0.27
9	Lake Erie shoreline, adjacent to Easterly Wastewater Treatment Plant	Cuyahoga	City of Cleveland, and Village of Bratenahl	1.24
10	Lake Erie shoreline adjacent to the City of Cleveland, including the mouth Cuyahoga River	Cuyahoga	Village of Bratenahl, and City of Cleveland	12.32
11	Lake Erie shoreline at mouth of Rocky River	Cuyahoga	Cities of Lakewood, and Rocky River	0.39
12	Shoreline of unnamed cove along Lake Erie shoreline	Lorain	City of Avon Lake	0.08
13	Lake Erie shoreline including Avon Basin	Lorain	City of Avon Lake	0.87
14	Lake Erie shoreline adjacent to Sheffield Lake	Lorain	City of Sheffield Lake	0.11
15	Lake Erie shoreline at mouth of Black River	Lorain	City of Lorain	2.97
16	Lake Erie shoreline at mouth of Beaver Creek	Lorain	City of Lorain	0.44
17	Lake Erie shoreline near Vermilion-On-The-Lake	Lorain	City of Vermilion	0.06
Total	**N/A**	**N/A**	**N/A**	**25.54**

Notes:
[1] See Section 3.3.1 of the RA for a detailed discussion of the process used to select these focus areas.

Key:
N/A = Not applicable

F.3.2 Natural and Socio-Cultural Features along the Shoreline of the Southern Lake Erie Watershed

Two hundred twelve named natural and socio-cultural features are located within the 17 focus areas along the shoreline of Lake Erie in the Southern Lake Erie watershed. These features were identified primarily from an analysis of information included in overlays for Google Earth and identified on 7.5-minute USGS topographic quadrangles and/or coastal maps maintained in the National Oceanic and Atmospheric Administration's (NOAA's) Office of Coast Survey Historical Map and Chart Collection. Collectively, these 212 named natural and socio-cultural features are physical representations of the community character and the socio-cultural setting of the Lake Erie shoreline in the Southern Lake Erie watershed.

A full listing of the 212 named natural and socio-cultural features identified for the 17 focus areas is included in Attachment F-3. It is noted here that Attachment F-3 is not a definitively complete listing of all the named natural and socio-cultural features in the 17 focus areas or along the entire Lake Erie shoreline in the Southern Lake Erie watershed. While the list in Attachment F-3 is reasonably comprehensive as to the type of natural and socio-cultural features present, it primarily only includes features that are named (e.g., named waterbodies and communities on 7.5-minute USGS topographic quadrangles) and/or that have been identified in databases that comprise the Google Earth overlays.

These 212 named natural and socio-cultural features can be grouped into 10 different categories of resources (see Table F.3-2). These 10 resource categories consist of (in order of predominance from most to fewest): private businesses, public parks and other public facilities, organizations, built resources, communities, natural features, industrial facilities, governmental facilities, conservation areas, and institutions. The types of natural and socio-cultural features located within, or associated with, these 17 focus areas should be considered generally representative of the larger number of natural and socio-cultural features along the Lake Erie shoreline in the Southern Lake Erie watershed.

Table F.3-2 Summary of Natural and Socio-Cultural Features within the 17 Focus Areas along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Resource Category	Description	Total Number in Watershed (% of total)
Private businesses	Private enterprises related to a variety of water-dependent or water-related recreational uses and activities along the shoreline of Lake Erie	60 (28%)
Public parks/facilities	State, county, and town parks and beaches located along the shoreline of Lake Erie	33 (16%)
Organizations	Public or private enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the shoreline of Lake Erie	30 (14%)

Table F.3-2 Summary of Natural and Socio-Cultural Features within the 17 Focus Areas along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Resource Category	Description	Total Number in Watershed (% of total)
Built resources	Specific buildings, structures, objects, or other built features located along the shoreline of Lake Erie	29 (14%)
Communities	Named cities (including named neighborhoods), towns or villages, or hamlets located along the shoreline of Lake Erie	26 (12%)
Natural features	Named natural features located along the shoreline of Lake Erie	13 (6%)
Industrial facilities	Industrial facilities such as power plants or water treatment plants located along the Lake Erie shoreline	11 (5%)
Governmental facilities	Federal, state, or local government facilities located along the shoreline of Lake Erie	6 (3%)
Conservation areas	Federal, state, local, and private natural areas, nature/underwater preserves, and wildlife management areas located along the shoreline of Lake Erie	3 (1%)
Institutions	Educational facilities, such as universities, seminaries, or Chautauqua Institutes, located along the shoreline of Lake Erie	1 (<1%)
Total		**212 (100%)**

Private Businesses (Socio-Cultural Feature)

Sixty private business enterprises were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these 60 private business enterprises represent approximately 28% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These 60 private business enterprises consist of a variety of businesses, primarily related to recreational activities, that all are associated with water-dependent or water-related use of the Lake Erie shoreline. These private businesses were generally identified from overlays in Google Earth. Resources in this category include marinas, campgrounds, RV parks, hotels/inns/bed-and-breakfasts, restaurants, bars, and boating facilities. Resource use may be permanent or seasonal. There are likely to be additional similar private businesses along the Lake Erie shoreline in the Southern Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Public Parks and other Public Facilities (Socio-Cultural Feature)

Thirty-three public parks or other public facilities were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these 33 named public parks represent approximately 16% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These 33 named public parks or other public facilities consist of state, county, and town parks and beaches located along the Lake Erie shoreline as well as numerous public boat ramps. These public parks and other public facilities were identified from USGS 7.5-minute topographic quadrangles and from Google Earth overlays. Resources in this category are primarily developed for active and passive recreational uses of the waterfront (in urban areas) or the shoreline in suburban and rural areas. There are likely to be additional public facilities along the shoreline in the Southern Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Organizations (Socio-Cultural Feature)

Thirty public or private organizations were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these 30 public or private organizations represent approximately 14% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These 30 public or private organizations consist of enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the Lake Erie shoreline. These organizations were generally identified from overlays in Google Earth. Resources in this category include golf courses, yacht clubs, country clubs, and boat clubs. Resources in this category may be owned privately or by non-profit groups. There are likely to be additional similar public or private organizations within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Built Resources (Socio-Cultural Feature)

Twenty-nine specific built resources were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these 29 specific built resources represent approximately 14% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed.

These twenty-nine specific built resources consist of buildings, structures, objects, or other built features located along the Lake Erie shoreline that are recognized for their individual or collective importance at the national, state, or local level (e.g., lighthouses, historical sites, or properties listed in the National Register of Historic Places). Other terrestrial structures consist of industrial docks and commercial piers or landings. Man-made marine features consist of turning basins, harbors, lagoons, breakwalls, aqueducts, and intake tunnels. These specific built resources were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category may or may not be located within communities. Resources in this category may also include, but are not limited to, historic resources.

Communities (Socio-Cultural Feature)

Twenty-six named communities were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these 26 named communities represent approximately 12% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These communities consist of named cities, towns, villages, and hamlets that were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. Resources in this category include variously sized named clusters of residential, commercial, and/or industrial development. With regard to residential development, this may be comprised of owner-occupied or rental units, and may be permanent or seasonal. Resources in this category do not include numerous locations of unnamed shoreline development, although such unnamed shoreline development is also present within many of the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed.

Natural Features

Thirteen named natural features were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these 13 named natural features represent approximately 6% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These 13 named natural features consist of named shoreline or nearshore features (such as rivers, ponds, streams, and marshes) and named terrestrial features (such as islands). These natural features were generally identified from USGS 7.5-minute topographic quadrangles and the NOAA's Office of Coast Survey Historical Map and Chart Collection. Resources in this category do not include unnamed waterbodies and topographic features, although such natural features are also present within some of the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed.

Industrial Facilities (Socio-Cultural Feature)

Eleven industrial facilities were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these 11 industrial facilities represent approximately 5% of the total natural and socio-cultural features within the focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These 11 industrial facilities consist of industrial facilities, such as power plants or water treatment plants, or similar facilities located along the Lake Erie shoreline. Resources in this category may be privately owned or operated by municipalities. These industrial facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There are likely to be additional similar industrial facilities within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Governmental Facilities (Socio-Cultural Feature)

Six governmental facilities were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these six governmental facilities represent 3% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed.

These six governmental facilities consist of federal, state, or local governmental facilities located along the Lake Erie shoreline. Resources in this category include facilities such as USACE and USCG stations or facilities and municipal port authority facilities. These governmental facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. There are likely to be additional similar governmental facilities along the Lake Erie shoreline in the Southern Lake Erie watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Conservation Areas (Socio-Cultural Feature)

Three conservation areas were identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. Collectively, these three conservation areas represent approximately 1% of the total natural and socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These three conservation areas consist of state or municipal nature preserves located along the Lake Erie shoreline. These conservation areas were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category are primarily intended for ecological preservation, although they may also be used for active and/or passive recreational activities. Resources in this category do not include public parks or beaches; these are addressed as a separate resource type.

Institutions (Socio-Cultural Feature)

One institution was identified along the Lake Erie shoreline in the Southern Lake Erie watershed. This one institution represents less than 1% of the total natural and socio-cultural features along the Lake Erie shoreline in the Southern Lake Erie watershed. The one institution consists of the Fairport Harbor Fisheries Research Station. This institutional facility was identified from overlays in Google Earth. There are likely to be additional educational institutions along the Lake Erie shoreline in the Southern Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

F.3.3 Existing Management of Natural and Socio-Cultural Features in the Southern Lake Erie Watershed

Due to the size of the Southern Lake Erie watershed and the length of its shoreline along Lake Erie (approximately 107 miles), the overall nature of development of this watershed varies between highly urbanized areas, such as the city of

Cleveland and the smaller cities adjacent to Cleveland (e.g., the city of Lakewood and the city of Rocky River) in Cuyahoga County, and very rural areas, such as Perry Township in Lake County. Despite the variation in the type and density of development along the Lake Erie shoreline in the Southern Lake Erie watershed, the various governmental units (counties, townships, and incorporated municipalities) along the shoreline of Lake Erie in the Southern Lake Erie watershed have processes in place that consider development in conjunction with natural and socio-cultural conditions under their jurisdiction, whether through the development of specific plans, such as master plans, or through zoning.

Specific plans typically consist of comprehensive plans developed by the various counties, townships, or cities along the shoreline of Lake Erie. Additionally, a number of governmental units may have other plans for the management of natural and socio-cultural features within their boundaries, such as plans for recreation and conservation. These plans may specifically address the management of many of the named visible and physical natural and socio-cultural features that have been identified within the 17 focus areas along the shoreline in the Southern Lake Erie watershed.

The various plans for the communities and governmental units, or for other specific areas, along the Lake Erie shoreline in the Southern Lake Erie watershed would indicate the importance of this shoreline to their respective community character. These various plans may also recognize the various natural features (e.g., uplands, points, bluffs, coves, beaches, embayments, creeks, streams, rivers, and marshes) that physically shape the shoreline of Lake Erie and socio-culturally shape the uses of the shoreline for residential, commercial, industrial, recreational, and conservation purposes. These various plans may also recognize various socio-cultural features (i.e., villages, towns, cities, parks, conservation areas [including nature preserves, wildlife preserves, and wildlife management areas], and residential areas [neighborhoods and hamlets]).

Similarly, the various plans for the communities and governmental units, or for other specific areas along the Lake Erie shoreline in the Southern Lake Erie watershed would identify common issues or concerns regarding their particular natural and socio-cultural features. The common issues or concerns associated with managing waterfronts or shorelines for water-dependent or water-related uses may consist of, but would not necessarily be limited to:

- Protecting or improving the quality of specific natural features along the shoreline (e.g., beaches, embayments, marshes, and streams);
- Managing or enhancing residential and commercial development along the shoreline;
- Creating or enhancing opportunities for public access to the shoreline, typically for recreational purposes;
- Protecting or developing scenic qualities of the shoreline; and

- Managing or enhancing opportunities for visual access to the shoreline.

Additionally, the various plans for the communities and governmental units, or for other specific areas along the Lake Erie shoreline in the Southern Lake Erie watershed would identify specific management goals, objectives, or recommendations to address these issues or concerns, and to manage these shorelines for water-dependent or water-related uses. In general, the purpose for managing their respective shorelines would typically, but not necessarily only, be to:

- Acknowledge and promote the character of the communities along the shoreline;
- Enhance the quality of life for permanent residents;
- Enhance the experience of seasonal residents and visitors; and
- Protect, improve, or otherwise support the natural and socio-cultural features that comprise the shoreline of Lake Erie.

F.3.4 Potential Impacts of Introduction and Establishment of Hydrilla on Socio-Cultural Setting of the Southern Lake Erie Watershed

This section discusses the potential impacts associated with the introduction and/or establishment of Hydrilla on the socio-cultural setting of the Southern Lake Erie watershed. In general, these impacts can be considered in terms of whether they result in:

- Physical changes to natural and/or socio-cultural features identified along the Lake Erie shoreline in the Southern Lake Erie watershed;
- Changes to water-dependent or water-related uses of these natural and/or socio-cultural features;
- Changes in perceptions about the features or their uses; and
- Changes in the community character of various locations or focus areas within the watershed.

For the purposes of this impact assessment, water-dependent uses are facilities or activities that cannot exist without a waterfront location, such as marinas, boat ramps, and sewage treatments plants. Water-related uses are facilities or activities that increase their value or importance because of their proximity to a shoreline. Frequently, they function as support services for water-dependent uses and could include parks and other recreational facilities, as well as some types of commercial development (Benson 2011).

In general, the changes identified above are considered in terms of whether they would be an impact that is: (1) direct or indirect; (2) temporary or permanent (short-term or long-term); (3) adverse (negative), neutral, or beneficial (positive); and/or (4) cumulative, per changes and impacts associated with other invasive aquatic plant species in the watershed or at a specific focus area and/or per changes and impacts associated with ongoing or emerging socio-cultural trends in the watershed or at a specific focus area.

Impacts on Natural and Socio-Cultural Resources

The introduction and subsequent establishment of Hydrilla within any of the 17 focus areas along the shoreline of Lake Erie is likely to result in physical changes to a number of types of natural and socio-cultural features that comprise the socio-cultural setting of these focus areas and of the Southern Lake Erie watershed in general. At its most basic level, the introduction of Hydrilla, and its establishment and increasing density over time, in a natural feature (waterbody or marsh or wetland) with suitable environmental conditions would result in direct changes. The changes would occur to the ecological composition of the natural feature, to the appearance (visible and olfactory) of the natural features, and to the socio-cultural features and water-dependent and water-related uses associated with the natural feature. These changes would consist of new and increasingly visible and dense plants or plant mats beneath and at or on the water surface that would change the composition of ecological communities associated with the natural feature and, with regard to human use, would ultimately impede access on or through the water. At its full extent, Hydrilla present in dense mats at or on the water surface would act as a net, capturing floating detritus (natural and man-made) that would detract from the visual and olfactory setting of the waterbodies. Such changes may be small at first, with the introduction of Hydrilla into a suitable waterbody environment, but such changes may increase incrementally in density, visibility, and/or intensity over time until Hydrilla has exploited the maximum extent of available suitable habitat in the waterbody feature.

Physical changes are likely to occur on natural features and on those socio-cultural features that are comprised of, or associated with, natural features. Physical changes are likely to directly and indirectly impact natural and socio-cultural features. Additionally, these physical changes, considered in conjunction with past, present, or reasonably foreseeable future conditions for these natural and socio-cultural features, may have a cumulative impact on these natural and socio-cultural features.

Socio-cultural features that are comprised of, or associated with, natural features are also likely to undergo physical changes from the introduction and subsequent establishment of Hydrilla. These socio-cultural features would typically consist of: (1) public parks or other public facilities; (2) conservation areas; and (3) public or private business enterprises (e.g., marinas, restaurants, and campgrounds) that are located within the 17 focus areas along the shoreline of Lake Erie in the Southern Lake Erie watershed and associated with water-dependent and/or water-related uses. However, other socio-cultural features, comprised of communities, organizations, industrial facilities, governmental facilities, camps and retreats, and institutions, are often associated with natural features, such as those identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed. These are attractive locations for seasonal and permanent residences or specific locations, such as at the mouth of a navigable waterbody at which a USCG facility is located, or a shoreline location that provides for specific water intake and discharge capacity for an industrial facility.

Descriptions of the potential impacts on the various types of natural and socio-cultural features identified within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed are presented below. Such impacts are considered primarily with regard to the introduction and establishment of Hydrilla without treatment. Such direct and indirect impacts would likely be considered long-term or permanent impacts and would be perceived as negative impacts by the communities and users of the 17 focus areas along Lake Erie shoreline in the Southern Lake Erie watershed.

Dispersal modeling predicted that approximately 3% of total area of water within the Southern Lake Erie watershed may be infested by Hydrilla by 2025 (see Table 3.1.5-1); therefore, it is possible that some of the 17 focus areas would not be affected by Hydrilla, or that impacts resulting from Hydrilla would not affect some or all of the natural and socio-cultural features that collectively comprise the community character of this watershed as described below. Because dispersal modelling does not indicate specific locations within the watershed that would be affected, it is not possible to determine which of the 17 focus areas would be subject to infestation. Additionally, because the results of dispersal modelling extend through the year 2025, it is likely that the impacts discussed in this section would occur slowly at first, and become increasingly noticeable over time until full exploitation of available suitably habitat has been achieved. Therefore, the impacts of the introduction and establishment of Hydrilla should be considered representative of the types of impacts that could occur if these, or similar, natural and socio-cultural features are present within or adjacent to the approximately 3% of the total area of water within the entire watershed that may be infested by Hydrilla in 2025.

Impacts on Natural Features

The introduction and establishment of Hydrilla on natural features would result in a number of different impacts on natural features, depending on the type of natural feature. These impacts are both physical ecosystem effects as well as socio-cultural effects associated with impaired public access or reduced recreational usage. The physical ecosystem impacts on these natural features are summarized in this section to provide a context for considering these natural features as the setting for associated socio-cultural features and uses. The socio-cultural impacts associated with these natural features (e.g., impaired public access and reduced recreational usage) are discussed in detail in the following paragraphs as part of the discussion of impacts on socio-cultural features.

Natural features, such as points, bluffs, and islands, are terrestrial natural features that are not likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla. Therefore, the introduction and establishment of Hydrilla is likely to have no impact on these types of natural features, although indirect impacts on socio-cultural features, water-dependent uses, and water-related uses associated with such natural features are likely to occur and are discussed in this section. However, natural features comprised of, or associated with, waterbodies are likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla.

Waterbody features that may be directly impacted by the introduction and establishment of Hydrilla include:

- Shoreline and littoral zone of:
  - Lake Erie,
  - Beaches, coves, harbors, and bays along the shoreline of the lake, and
  - Outlets or mouths of streams and rivers where they enter the lake or the harbors or bays along the lake shoreline; and
- Marshes or wetlands that are associated with these waterbody features.

Collectively, the 17 focus areas within the Southern Lake Erie watershed include all of these types of natural features.

The direct impacts on these natural features would result from the introduction and establishment of Hydrilla, and would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of these waterbody features, including changes to water quality (e.g., full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface) and changes to species that are located in, or that otherwise use, these waterbody features (e.g., changes to fish species, aquatic plant species, bird species); and
- Negative because such changes are detrimental to species comprising the ecological systems of these waterbodies.

Waterbody features that may be indirectly impacted by the introduction and establishment of Hydrilla include associated terrestrial features such as points, bluffs, and islands, as well as the shoreline and littoral zone of Lake Erie, beaches, and harbors along the shoreline of the lake, the outlets or mouths of streams and rivers where they enter the lake or the harbors along the lake shoreline, and marshes and wetlands. Collectively, the 17 focus areas within the Southern Lake Erie watershed include all of these natural features.

Finally, impacts from the introduction and establishment of Hydrilla in these natural features could be cumulative under certain conditions, such that the long-term (permanent), direct, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these natural features from the introduction and establishment of Hydrilla could occur where a waterbody, marsh, or wetland:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil (*Myriophyllum spicatum*); and/or
- Has existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct impacts from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect the waterbodies, resulting in a cumulative impact.

The above impact assessment on natural waterbody or marsh/wetland features is for the introduction and establishment of Hydrilla, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct, negative impacts on the affected natural features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Impacts on Socio-Cultural Features

The introduction and establishment of Hydrilla on socio-cultural features would result in a number of different impacts on socio-cultural features, depending on the type of socio-cultural feature. All of the socio-cultural features considered as part of this impact assessment are associated in some way with natural features that are located adjacent to, or are comprised of, waterbodies.

For the Southern Lake Erie watershed, the types of socio-cultural features identified within the 17 focus areas along the shoreline of the Southern Lake Erie watershed are located along shoreline areas or waterbody features within which Hydrilla is likely to be introduced and established. The impacts on these socio-cultural resources may be direct, where the purpose for, or use of, these socio-cultural features is typically water-dependent, or indirect, where the purpose for, or use of, these socio-cultural features is typically water-related, as discussed below.

The following socio-cultural features may be directly impacted by the introduction and establishment of Hydrilla:

- Private businesses (e.g., marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including state or municipal nature preserves that contain or are located adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g., public boat launches, USCG stations, and harbors).

Collectively, the 17 focus areas within the Southern Lake Erie watershed include all of these types of socio-cultural features.

The direct impacts on these socio-cultural features that would result from the introduction and establishment of Hydrilla would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of associated affected waterbody features, such that the purpose for, and use of, these socio-cultural features would be affected. For example, full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface, such that private businesses or governmental facilities such as marinas or harbors could no longer be used by boats; boating or fishing would no longer be desirable or viable activities; use of public parks and beaches along affected waterbodies would no longer be desirable for recreational activities; operation of water intake and discharge systems for industrial facilities would be affected; and
- Negative because the purpose for, or uses of, these socio-cultural features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

The following socio-cultural features may be indirectly impacted by the introduction and establishment of Hydrilla:

- Private businesses such as shoreline restaurants, bars, event sites, camps or retreats, campgrounds, mobile home parks, RV camping, resorts, hotels, bed and breakfasts;

- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., sunbathing, sightseeing, birding, enjoying scenic views and viewsheds);
- Built resources, particularly where underwater or waterfront setting is an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., birding, wildlife management, enjoying scenic views, and viewsheds); and
- Organizations associated with golfing, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

Collectively, the 17 focus areas within the Southern Lake Erie watershed include all of these types of socio-cultural features.

The impacts on these socio-cultural features as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the appearance of the setting (visual or olfactory) of these socio-cultural features; and
- Negative because the intended purpose for, or use of, such features would be impaired, impeded, or prevented, such that they no longer would be enjoyable or desirable by their users, or viable by their owners or managers.

As previously discussed for natural features, impacts on these socio-cultural features from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these socio-cultural features from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on socio-cultural features from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these features, resulting in a cumulative impact.

The above impact assessment on socio-cultural features has been for the introduction and establishment of Hydrilla within the 17 focus areas along the shoreline of the Southern Lake Erie watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the socio-cultural features that are associated with these natural waterbody or marsh/wetland features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views because their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Impacts on the water-dependent or water-related uses associated with affected waterbodies are discussed in Section F.3.5.

F.3.5 Impacts on Water-Dependent or Water-related Uses of Resources

The introduction and establishment of Hydrilla would result in a number of different impacts on water-dependent or water-related uses within the 17 focus areas along the Lake Erie shoreline within the Southern Lake Erie watershed, depending on the type of use and/or the type of natural or socio-cultural feature with which the use is associated. For the purposes of this impact assessment, natural features associated with water-dependent uses include the shoreline and littoral zones of Lake Erie within the focus areas, such as the following features: harbors; beaches; outlets or mouths of streams and rivers; and marshes and wetlands. However, all the natural features identified within the 17 focus areas along the Lake Erie shoreline are associated with water-related uses, including those identified above for water-related uses along with bluffs and islands.

As discussed in Section F.3.4, socio-cultural features associated with water-dependent uses would include:

- Private businesses (e.g., marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);

- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas, nature preserves, and wildlife management areas that contain or are located in or adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g., public boat launches, USCG stations, and harbors).

Therefore, the introduction and establishment of Hydrilla is likely to have some type of impact on all of the water-dependent uses associated with these natural and socio-cultural features.

The following water-dependent uses may be directly impacted by the introduction and establishment of Hydrilla:

- Swimming;
- Recreational boating;
- Fishing;
- Sailing;
- Policing waterways and waterbodies;
- Power production; and
- Water and sewage treatment.

Similarly, socio-cultural features associated with water-related uses would include:

- Private businesses such as shoreline restaurants, bars, event sites, camps or retreats, campgrounds, mobile home parks, RV camping, resorts, hotels, bed and breakfasts;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, and for enjoying scenic views and viewsheds);
- Built resources, particularly where underwater or waterfront settings are an important component of the use of, or purpose for, a built resource;

- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, and enjoying scenic views and viewsheds); and
- Organizations associated with golfing, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

The following water-related uses may be indirectly impacted by the introduction and establishment of Hydrilla:

- Dining;
- Drinking;
- Sightseeing;
- Sunbathing;
- Hiking;
- Golfing;
- Camping;
- Experiencing nature;
- Socializing in large group settings (weddings, picnics, conferences, camps, retreats);
- Vacationing;
- Preserving natural resources;
- Managing natural resources;
- Seasonal (vacation) housing;
- Permanent housing; and
- Commercial and industrial support facilities for recreational, seasonal, and permanent residential activities.

The impacts on the above water-dependent and water-related uses within the 17 focus areas as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), direct and indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it becomes established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would prevent or impede the water-dependent uses such that they could no longer take place;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the conditions within which such water-dependent uses can occur, such that these water-dependent uses could no longer be conducted or

sustained by their users or would no longer be considered viable by their owners or managers; and

- Negative where the introduction and establishment of Hydrilla physically prevents or detrimentally impairs these water-dependent uses or the management of these water-dependent uses.

For example, water-dependent uses such as swimming, recreational boating or sailing, and fishing would not be possible or would not be considered desirable water-dependent activities in a waterbody densely infested with Hydrilla. If such water-dependent uses were reduced, there would be a concurrent reduced need for boat maintenance or storage facilities in the absence of recreational boating, sailing, or fishing. The boating actions associated with policing affected waterbodies or using affected waterbodies that are harbors would be impaired. The use of water intakes and discharge outfalls associated with sewage treatment, water treatment, and power plants would be impeded such that treatment or power production would be impaired.

Similarly, water-related uses would be considered less desirable primarily because of changes to the setting (visual or olfactory) of socio-cultural features that support such activities. Waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing. Similarly, shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing, sunbathing, hiking, or enjoying nature. Waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities. With changes to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary. Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

As discussed above for natural and socio-cultural features, impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or

- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on water-dependent or water-related uses from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these uses, resulting in a cumulative impact.

The above impact assessment on water-dependent or water-related uses has been for the introduction and establishment of Hydrilla within the 17 focus areas along the shoreline of Lake Erie in the Southern Lake Erie watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features for the 17 focus areas are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, such that their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Where the introduction and establishment of Hydrilla would result in impacts on natural or socio-cultural features and/or associated water-dependent or water-related uses, it is likely that perceptions about these features and uses would change. Possible changes to perceptions about the natural or socio-cultural features and their associated water-dependent and water-related uses are considered in Section F.3.6.

F.3.6 Impacts on Community Perceptions of Features and Uses

As noted in Section F.3.3, counties, towns, and cities associated with the 17 focus areas along the Lake Erie shoreline of the Southern Lake Erie watershed would manage the natural and socio-cultural features areas located along their respective shorelines or waterfronts to protect, enhance, promote, create, rehabilitate, redevelop, or develop water-dependent and water-related uses. Management would be according to the goals, policies, objectives, or recommendations that are memorialized in management plans that include these areas.

It is likely that natural and socio-cultural features that are located within the 17 focus areas along the shoreline of Lake Erie in the Southern Lake Erie watershed may be specifically identified in such plans, indicating that they would be perceived as locations, features, or attributes that define the local community or governmental unit and that they would be perceived and recognized as worthy of protection or improvement. Similarly, water-dependent and water-related uses associated with these natural and socio-cultural features may also be identified and described, either as part of planning efforts or via zoning ordinances, and discussed in such plans. This would indicate that such uses would be perceived as worthy of protection, management, creation, enhancement, or development.

Such perceptions would generally be expected to be identified or expressed by local individuals and groups that comprise the communities or governmental units responsible for the preparation of such plans and would be inherent in such plans because they were made known via charrettes, questionnaires, and other outreach efforts conducted as part of the preparation of such plans. Such local individuals and groups would be expected to be comprised of local residents, or non-local stakeholders with an interest in specific resources or for specific uses (such as individuals or companies that own and/or manage businesses, organizations, or facilities in an area but do not actually reside there). Additionally, the perceptions of federal, state, or local agencies that fund such planning efforts, or that provide guidance for the preparation of such plans, may also be incorporated into the preparation of such plans, albeit indirectly, via the requirements for the preparation of such plans or via the structure and/or content of meetings and materials included in outreach efforts.

Separately, the perceptions of individuals or groups that have an interest in specific or collective natural or socio-cultural features within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed, or their associated water-dependent or water-related uses, may be lacking from such plans. Such individuals or groups may be seasonal users, state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and special interest groups whose involvement would be at a regional or national scale. For example, the perceptions of individuals or groups that are seasonal users would likely be expressed outside of such plans, by changes to patterns of visiting areas for recreational or other purposes, such as vacationing, camping, fishing, boating, etc. Similarly, the perceptions of state or federal agencies with management responsibilities for specific socio-cultural features located within the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed may also be lacking from such plans. These agencies would be as diverse as the Ohio Department of Natural Resources/Division of Parks and Watercraft, that manage parks, historic sites, natural areas, and public access for waterbodies; the USACE, for navigable waterways; or the Nuclear Regulatory Commission, for the Perry Nuclear Power Plant.

Finally, the perceptions of special interest groups that would have a broad or unique interest in natural and socio-cultural features in the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed, and/or their water-dependent or water-related uses, would also be expressed outside of such plans. Such groups, whose primary perceptions would be related to regional, national, or cultural interests in a specific area, feature, or use, may include: additional federally recognized Indian tribes who may have a cultural or historical affiliation with areas that include such features and uses or may have retained treaty rights for use of such areas; or groups such as the Sierra Club, the Nature Conservancy, or Ducks Unlimited, which have national conservation interests that are applied at the local level via ownership of conservation areas or sponsorship for various conservation efforts.

As suggested above in the assessment of water-dependent and water-related uses of natural and socio-cultural features in the 17 focus areas, the potential impacts of the introduction and establishment of Hydrilla would be likely to occur where physical changes would have been made to the features or uses, or where there would be visual or olfactory changes to the setting of such features or uses. For example, the natural or socio-cultural features themselves may no longer be perceived as worthy of being protected, preserved, or managed for their intrinsic natural or socio-cultural values to a community. When changes are made to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary.

Similarly, the water-dependent or water-related uses associated with such features may no longer be perceived as desirable or viable. For example, waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing; shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities (e.g., sightseeing, sunbathing, hiking, or enjoying nature); waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities.

Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent and water-related uses within the 17 focus areas as a result of the introduction and establishment of Hydrilla have the potential to be long-term (permanent), direct indirect, and negative. Specifically, these impacts would likely be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because, while the introduction and establishment of Hydrilla would result in changes to the conditions of affected features or uses, it is the perceptions of these affected features or uses that could change; and

- Negative where the perceptions of affected features or uses conclude that such features and uses are no longer worthy of protection, management, creation, improvement, enhancement, or development.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent or water-related uses within the 17 focus areas from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on perceptions of affected features or uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the indirect impacts on perceptions of affected features or uses from introduction and establishment of Hydrilla would occur at a faster rate or would be greater, resulting in a cumulative impact.

The above impact assessment for perception of affected natural and socio-cultural features and their associated water-dependent or water-related uses within the 17 focus areas has been for the introduction and establishment of Hydrilla. It is understood that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies. While it would be unlikely for treatment to completely eliminate or reverse the physical impacts of the introduction and establishment of Hydrilla, treatment would likely receive considerable support by the communities, governmental units, state and federal agencies, stakeholders, special interest groups, and seasonal users in an effort to avoid or minimize impacts on the perceptions of affected features and uses.

F.3.7 Impacts on Community Character of Focus Areas in the Southern Lake Erie Watershed

Dispersal modelling suggests that the primary method of introduction of Hydrilla into specific locations is via recreational boat use, such that locations where recreational boaters launch (via public boat launch or private boat launch locations) are most likely to result in the initial introduction of Hydrilla. It follows that the spread of Hydrilla likely would also occur at secondary locations that are accessible by recreational boaters but do not necessarily contain formal public or private boat launching facilities.

Therefore, impacts on community character resulting from the introduction and establishment of Hydrilla are most likely to occur in locations that: (1) have physical features (i.e., boat launch facilities) suitable for the introduction of Hydrilla; (2) have environmental conditions conducive to the establishment of Hydrilla if it is introduced; and (3) have community character defined by natural and socio-cultural features and associated water-dependent or water-related uses that would be affected by the introduction and establishment of Hydrilla. The 17 focus areas identified along the Lake Erie shoreline in the Southern Lake Erie watershed either meet all of these criteria or, if a focus area lacks a public or private boat launch, meet the second and third criteria.

The potential impacts of the introduction and establishment of Hydrilla on the community character of the 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed correlates to the impact conclusions for natural and socio-cultural features, their associated water-dependent or water-related uses, and the perceptions of such features and use by communities and governmental units, as discussed above in Sections F.3.4, F.3.5, and F.3.6. Specifically, the long-term (permanent), direct and/or indirect, and negative impacts of the introduction and establishment of Hydrilla on natural and socio-cultural features, on their associated water-dependent or water-related uses, and on the perceptions of these features and uses, also result in the same type of impacts on the community character of these focus areas. The impacts associated with the treatment of Hydrilla would be the same, as would the potential for cumulative impacts.

It is likely, however, that such impacts on community character would be perceived differently. The local individuals and groups that comprise the communities and governmental units associated with these 17 focus areas likely would consider such impacts differently from seasonal users; from state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and from special interest groups whose involvement would be at a regional or national scale. Additionally, impacts on community character would occur at different rates over time, depending on the nature of the affected individuals, groups, agencies, or users.

For example, local individuals and groups that comprise the communities and governmental units associated with these 17 focus areas likely would recognize the impacts. However, they may be reluctant to accept the changes to their community character and be slow to participate in necessary revisions to the management of affected natural and socio-cultural features and their associated water-dependent or water-related uses that would alter their existing community character.

Conversely, state or federal agencies and special interest groups that operate regionally or nationally likely would recognize the impacts and would accept such changes to the affected features and uses. However, they also may be slow to participate in necessary revisions to the management of affected features and uses for any number of administrative reasons (e.g., limited manpower, limited budget, and limited regulatory authority).

Finally, it is likely that seasonal users may differ greatly from both of these other groups. Seasonal users would be likely to recognize the impacts, and while reluctant to accept the changes to community character, quick to abandon those areas that contain affected natural and socio-cultural features and their associated water-dependent and water-related uses. Changes to their seasonal use of affected areas may be either in favor of other similar areas that remain unaffected by the introduction and establishment of Hydrilla or may represent a greater shift in favor of other areas with features and uses that would never be affected by the introduction and establishment of Hydrilla.

F.3.8 Impacts on the Community Character of the Southern Lake Erie Watershed

The 17 focus areas along the Lake Erie shoreline in the Southern Lake Erie watershed were selected specifically because they contain conditions that are conducive to the introduction and establishment of Hydrilla. Therefore, the potential impacts on the natural and socio-cultural features and their associated water-dependent and water-related uses that contribute to the community character of these focus areas may appear to be disproportionately emphasized when compared to the potential for similar impacts along the entire Lake Erie shoreline or within the Southern Lake Erie watershed.

For the Southern Lake Erie watershed as a whole, dispersal modelling predicted that by 2025, approximately 3% of the total waterbody area within the watershed would be affected by Hydrilla (see Table 3.1.5-1). Given the overall size of the Southern Lake Erie watershed and prevalence of water resources therein, it can be inferred based on the dispersal model results that future (2025) impacts resulting from introduction and establishment of Hydrilla on the overall community character of the watershed may be relatively small when considered for the entire watershed. However, if perchance all future Hydrilla infestations were to occur along the Lake Erie shoreline in one or more of the 17 focus areas evaluated in this analysis, the collective impacts likely would garner more attention and have a greater collective impact, especially if future infestations are concentrated in one or more of the high-use, high-value areas located on the shoreline.

Although this section describes potential future impacts from Hydrilla in focus areas along the Lake Erie shoreline, it is expected that similar impacts from the introduction and establishment of Hydrilla would occur at various locations throughout the interior of the Southern Lake Erie watershed. However, it is likely that these impacts would be more localized at or near the point of introduction, and would individually affect a smaller number of natural and socio-cultural features and a smaller number of associated water-dependent or water-related uses. Therefore, perceptions of the impacts on such features and uses, and their overall effect on the community character of the entire watershed would be diluted over a larger area.

As indicated by the above impact analysis, the Lake Erie shoreline represents a distinct component of the community character of the entire Southern Lake Erie watershed that differs in size and nature when compared to the smaller and dispersed waterbodies (lakes, ponds, rivers, creeks, and streams) that are located in the interior of this watershed. Thus, it is not unusual that the potential impacts of the introduction and establishment of Hydrilla, with or without treatment to control its spread, would be considered a prominent factor in the future of the Southern Lake Erie watershed.

F.3.9 Conclusions and Recommendations

The introduction and establishment of Hydrilla into the Southern Lake Erie watershed has the potential to result in long-term (permanent), direct and indirect, negative impacts on natural and socio-cultural features and their associated water-dependent and water-related uses that comprise the socio-cultural setting of this watershed. Similar impacts would be expected on the perceptions of these features and uses. Collectively, these impacts would represent long-term, indirect, negative impacts on the community character of this watershed.

These conclusions were based on the analysis of features and associated uses that were identified from: publicly available databases and planning documents; overlays for Google Earth; 7.5-minute USGS topographic quadrangles; and/or coastal maps maintained in the NOAA's Office of Coast Survey Historical Map and Chart Collection. These conclusions were also developed considering the management of such features and uses that may be represented in comprehensive plans or master plans for the various counties, towns, and cities located along the Lake Erie shoreline in the Southern Lake Erie Watershed and/or identified and discussed in other Lake Erie shoreline-specific management plans, such as the planning documents developed by the Ohio Lake Erie Commission and its member agencies.

These conclusions are based on the analysis of impacts on natural and socio-cultural features and associated water-dependent and water-related uses identified for 17 focus areas that collectively represent approximately 26 miles (24%) of the approximately 107-mile-long Lake Erie shoreline in the Southern Lake Erie watershed. However, these conclusions are considered generally representative of potential impacts that would occur in interior areas of this same watershed and would be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

Separately, as discussed in this impact assessment (see Sections F.3 and F.3.6), there are a wide variety of agencies, organizations, and special interest groups, in addition to the many communities and governmental units with authority or jurisdiction over the Lake Erie shoreline in the Southern Lake Erie watershed, that may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the watershed. These stakeholders would include, but may not be limited to:

- State agencies such as Ohio State Historic Preservation Office (OSHPO) and Ohio Department of Natural Resources/Division of Parks and Watercraft, that manage parks, historic sites, natural areas, and public access for waterbodies;
- Federal agencies such as the USACE, which manages navigable waterways throughout the Southern Lake Erie watershed, and the Nuclear Regulatory Commission, that provides regulatory oversight of the nuclear power plants along the Lake Erie shoreline in the Southern Lake Erie watershed;
- Federally recognized Indian tribes that may have cultural or historical affiliation with various areas in the Southern Lake Erie watershed or retain treaty rights to lands, waters, and resources within the Southern Lake Erie watershed;
- Institutions that conduct ecological research in or along the shores of Lake Erie or in other waterbodies in the Southern Lake Erie watershed, such as the Fairport Harbor Fisheries Research Station; and
- Special interest groups, such as The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that have a broadly defined interest in areas and resources along the shoreline and in interior areas of the Southern Lake Erie watershed.

Outreach efforts by the USACE with the various communities and governmental units for all of the counties, towns, cities, and other areas at both the agency and public level is encouraged in order to collaboratively identify and develop strategies related to raising awareness for, controlling, and jointly managing the introduction and establishment of Hydrilla in this watershed. Similarly, the USACE should consider additional similar outreach efforts with the various stakeholders identified above for the same reasons. Many of these communities, governmental units, and stakeholders already have experience managing invasive aquatic plant species other than Hydrilla, and would likely welcome the opportunity to avoid or minimize the potential for new and/or cumulative impacts on the natural and socio-cultural features and associated water-dependent or water-related uses that they already manage or value.

F.3.10 References

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Attachment F-3

Natural and Socio-Cultural Features Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Redbrook Boat Club	OH	Ashtabula	Saybrook Township	Organization	Marina and clubhouse offering docks, fuel, fish cleaning, etc.	1
Red Brook	OH	Ashtabula	Saybrook Township	Natural feature	Tributary to Lake Erie	1
Cowles Creek	OH	Ashtabula	Village of Geneva-on-the-Lake	Natural feature	Tributary to Lake Erie	2
Geneva Marina	OH	Ashtabula	Village of Geneva-on-the-Lake	Private business	Marina and charter service offering dock rentals, marine shop, and water sports rentals	2
Walleye Encounters	OH	Ashtabula	Village of Geneva-on-the-Lake	Private business	Fishing charter service offering fishing trip on Lake Erie	2
Best Coast Water Sports	OH	Ashtabula	Village of Geneva-on-the-Lake	Private business	Watersports rental service	2
Privateer Sport Fishing	OH	Ashtabula	Village of Geneva-on-the-Lake	Private business	Fishing charter service offering fishing trip on Lake Erie	2
The North Coast Outpost	OH	Ashtabula	Village of Geneva-on-the-Lake	Private business	Watersports rental service	2
Great Lakes Charters	OH	Ashtabula	Village of Geneva-on-the-Lake	Private business	Fishing charter service offering fishing trips on Lake Erie	2
Geneva State Park	OH	Ashtabula	Village of Geneva-on-the-Lake	Public Park	Public state park near Lake Erie shoreline offering hiking trails, fishing, hunting, lodging, etc.	2
North Townline Park	OH	Lake	Village of North Perry	Public park	Public park along the Lake Erie shoreline offering boat ramp, fishing piers, sports fields, community center, etc.	3
Perry Nuclear Power Plant	OH	Lake	Perry Township, and Village of North Perry	Industrial Facility	Nuclear power plant along the Lake Erie shoreline	4
Tartan Yachts	OH	Lake	Village of Fairport Harbor	Private business	Boat building company	5

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Harbortowne Point Condominiums	OH	Lake	Village of Fairport Harbor	Community	Lakefront condominium complex	5
Fairport Harbor	OH	Lake	Village of Fairport Harbor	Community	Lakefront community along Lake Erie	5
Sunset Harbor Bar and Grille	OH	Lake	Village of Fairport Harbor	Private business	Lakefront restaurant within marina	5
HTP Rack & Marina	OH	Lake	Village of Fairport Harbor	Private business	Marina offering immediate access to Lake Erie, breakwall, sea wall protection, etc.	5
Aqueducts	OH	Lake	Village of Fairport Harbor	Built resource	Aqueduct in Lake Erie	5
Fairport Lakehouse Rental	OH	Lake	Village of Fairport Harbor	Private business	Vacation home rental agency along Lake Erie shores	5
Fairport memorial park	OH	Lake	Village of Fairport Harbor	Public park	Public park near lake Erie shoreline	5
Fairport Harbor Port Authority	OH	Lake	Village of Fairport Harbor	Government facility	Agency responsible for watercraft activity of Fairport Harbor	5
Fairport Harbor Lakefront Park	OH	Lake	Village of Fairport Harbor	Public Park	Lakefront public park offering public beach, trails, fishing, swimming, etc.	5
Fairport Marine Museum and Lighthouse	OH	Lake	Village of Fairport Harbor	Museum	First lighthouse marine museum in the United States, offers special events and gift shop	5
Fairport Water Works	OH	Lake	Village of Fairport Harbor	Industrial facility	Water utility company	5
Fairport Harbor Pier	OH	Lake	Village of Fairport Harbor	Built resource	Public pier offering access to Lake Erie and lake activities	5
Steve’s Bait Shop	OH	Lake	Village of Fairport Harbor	Private business	Bait and tackle shop along Grand River	5
Grand River	OH	Lake	Village of Fairport Harbor	Natural feature	Tributary to Lake Erie	5
Great Lakes Boat Works	OH	Lake	Village of Fairport Harbor	Private Business	Marine and boating supplies store along Grand River	5
Windsurf Ohio	OH	Lake	Village of Fairport Harbor	Private business	Windsurf lesson and kayak/paddleboard rental shop	5
Grand River Marine, Inc.	OH	Lake	Village of Fairport Harbor	Private business	Full-service marina on Grand River	5

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Highwater Tavern	OH	Lake	Village of Fairport Harbor	Private business	Bar and grill along Grand River	5
Fairport Harbor Yacht Club	OH	Lake	Village of Fairport Harbor	Organization	Marine club offering marina, watercraft storage, docks, restaurant and bar, social events, etc.	5
Fairport Harbor Fisheries Research Station	OH	Lake	Village of Fairport Harbor	Institution	Fisheries research facility along Grand River	5
Fairport Harbor Rod and Reel Association	OH	Lake	Village of Fairport Harbor	Organization	Fishing club located along Grand River	5
Hidden Harbor Marina and Storage LLC	OH	Lake	Village of Fairport Harbor	Private business	Marina and storage facility located along Grand River	5
River's Edge Yacht Club	OH	Lake	Village of Fairport Harbor	Organization	Marine club offering clubhouse, social events, marina, etc.	5
Hidden Harbor Estates	OH	Lake	Village of Fairport Harbor	Community	Riverside condominium complex	5
Western Reserve Yacht Club	OH	Lake	Village of Fairport Harbor	Organization	Marine club offering clubhouse, social events, marina, etc.	5
Grand River Landing Park	OH	Lake	Village of Fairport Harbor	Public park	Riverside public park offering access to Grand River, fishing, and picnic areas	5
Painesville Water Pollution Control Plant	OH	Lake	City of Painesville	Industrial facility	Water pollution control facility located along Grand River	5
Windjammer Court Condominiums	OH	Lake	City of Painesville	Community	Riverside condominium complex	5
Harbor Bait and Tackle	OH	Lake	City of Painesville	Private business	Bait and tackle shop near Grand River	5
Richlawn Acres apartments	OH	Lake	Village of Grand River	Community	Apartment complex along Grand River	5
Grand Harbor Condominiums	OH	Lake	Village of Grand River	Community	Riverside condominium complex	5
Grand Key Condominium	OH	Lake	Village of Grand River	Community	Riverside condominium complex	5
Grand River Yacht Club	OH	Lake	Village of Grand River	Organization	Marine club offering clubhouse, social events, marina, etc.	5

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Pickle Bills Lobster House	OH	Lake	Village of Grand River	Private business	Maritime themed seafood restaurant located on Grand River	5
Brennans Fish House	OH	Lake	Village of Grand River	Private business	Maritime themed seafood restaurant located near Grand River	5
Osborne Concrete & Stone	OH	Lake	Village of Grand River	Private business	Asphalt contractor located along Grand River	5
Carmeuse	OH	Lake	Painesville Township	Private business	Lime and limestone manufacturer and distributor located along Grand River	5
Morton Salt	OH	Lake	Painesville Township	Corporation	Salt manufacturer and distributor located along Grand River	5
U.S. Coast Guard	OH	Lake	Painesville Township	Government facility	U.S. Coast Guard station located at the mouth of Grand River	5
Headland Dunes State Nature Preserve	OH	Lake	Painesville Township	Conservation area	Nature preserve located at the mouth of Grand River and Lake Erie	5
Headlands Beach State Park	OH	Lake	Painesville Township, and Mentor	Public Park	Lakefront beach park offering access to Lake Erie, fishing, picnic areas, walking trails, swimming, etc.	5
Shipman Pond	OH	Lake	City of Mentor	Natural feature	Pond located within Mentor Marsh State Nature Preserve	5
Mentor Marsh State Nature Preserve	OH	Lake	City of Mentor	Conservation area	Aquatic nature preserve located near Lake Erie shores	5
Mentor Lagoons Nature Preserve & Marina	OH	Lake	City of Mentor	Conservation area	Marina and Nature preserve offering docks, floating docks, direct access to lake Erie	6
Mentor Lagoons Yacht Club	OH	Lake	City of Mentor	Organization	Private club and marina offering docks, social events, etc.	6
Heisley Creek	OH	Lake	City of Mentor	Natural feature	Tributary to Lake Erie and Mentor Harbor	6
Gary L. Kron Water Reclamation Facility	OH	Lake	City of Mentor	Industrial facility	Wastewater treatment facility located near marsh creek and Mentor Marsh	6

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Mentor Harbor	OH	Lake	City of Mentor	Community	Lakeside community near Lake Erie	6
Harbor Creek Condominiums	OH	Lake	City of Mentor-on-the-Lake	Community	Condominium complex near Lake Erie shore	6
Villas at Mentor on the Lake Condominiums	OH	Lake	City of Mentor-on-the-Lake	Community	Condominium complex near Lake Erie shore	6
Mentor Harbor Yachting Club	OH	Lake	City of Mentor-on-the-Lake	Organization	Yacht club and marina offering docks, access to Lake Erie, clubhouse, social events, etc.	6
Mentor Beach Park	OH	Lake	City of Mentor-on-the-Lake	Public Park	Public lakeside park offering beach area, ball fields, and rentable shelters/pavilions	6
Mentor-on-the-Lake	OH	Lake	City of Mentor-on-the-Lake	Community	Lakeside community near Lake Erie shoreline including many condominium complexes and smaller neighborhoods	6
Brookside Condominiums	OH	Lake	City of Eastlake	Community	Condominium complex near Lake Erie shoreline	7
Marina Park Condominiums	OH	Lake	City of Eastlake	Community	Condominium complex near Lake Erie shoreline	7
Lake Property Management	OH	Lake	City of Eastlake	Private business	Vacation home rental agency offering lakeside rentals	7
Chagrin River	OH	Lake	City of Eastlake	Natural feature	Tributary to Lake Erie	7
Chagrin River Bait and Tackle	OH	Lake	City of Eastlake	Private business	Bait and tackle shop near Chagrin River	7
Chagrin Marine	OH	Lake	City of Eastlake	Private business	Full service marina and service facility	7
Lake County Yacht Club	OH	Lake	City of Eastlake	Organization	Yacht club offering marina, docks, clubhouse and social events	7
Deck Lounge	OH	Lake	City of Eastlake	Private business	Bar and grill located within marina geared towards boaters	7
Fishers of Men	OH	Lake	City of Eastlake	Private business	Online fishing blog	7
Ward Brook	OH	Lake	City of Eastlake	Natural feature	Tributary to Chagrin River	7

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Chagrin River Park	OH	Lake	City of Eastlake	Public Park	Riverside park offering access to Chagrin River, fishing, boating, hiking, horseback riding, ball fields/courts, etc.	7
Smuggler’s Cove Condominiums	OH	Lake	City of Eastlake	Community	Condominium complex near Chagrin River shore	7
Mitchell Field	OH	Lake	City of Eastlake	Public Park	Fishing area along banks of Chagrin River	7
Garrett’s Cove	OH	Lake	City of Eastlake	Community	Lakeside community near banks of Chagrin River	7
Chagrin River	OH	Lake	City of Eastlake	Community	Lakeside community near banks of Chagrin River	7
Yachtsman’s Cove	OH	Lake	City of Eastlake	Community	Lakeside community near banks of Chagrin River	7
Hartford	OH	Lake	City of Eastlake	Community	Lakeside community near banks of Chagrin River	7
Trader Jacks Riverside Grille	OH	Lake	City of Eastlake	Private business	Restaurant and Bar offering seafood menu, riverside seating, event rooms and reservations	7
South Shore Yacht Supply	OH	Lake	City of Eastlake	Private business	Boat repair business/facility	7
West Channel Yacht Club Inc	OH	Lake	City of Eastlake	Organization	Yacht club and marina offering boat storage, fuel, clubhouse, restaurants, social events, etc.	7
Chagrin River Canoe and Kayak Livery	OH	Lake	City of Eastlake	Private business	Kayak and paddleboard rental shop near Chagrin River offering easy access/launch	7
Chagrin Lagoons Yacht Club	OH	Lake	City of Eastlake	Organization	Marina and yacht club offering clubhouse, dockage, pool, restaurants, fuel, etc.	7
Village of Timberlake	OH	Lake	Village of Timberlake	Community	Lakeside community near Lake Erie shoreline	7
Eastlake	OH	Lake	City of Eastlake	Community	Lakeside community with multiple shoreline neighborhoods and condominiums	7

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Wildwood Park and Euclid Creek Reservation	OH	Cuyahoga	City of Cleveland	Public Park	Lakefront and creek-side public park near Lake Erie and Euclid Creek offering fishing, hiking trails, marina, picnic areas, etc.	8
Wildwood Marina and Fishing Charters	OH	Cuyahoga	City of Cleveland	Private business	Marina and water activities charters offering fishing trips, scuba diving charters, sightseeing tours ad kayak and canoe rentals	8
Boat Ramp	OH	Cuyahoga	City of Cleveland	boat launch	Public boat launch within wildwood park and marina	8
Euclid Creek	OH	Cuyahoga	City of Cleveland	Natural resource	Tributary to Lake Erie	8
Cleveland Script Sign	OH	Cuyahoga	City of Cleveland	Built resource	"Cleveland" script sign near Lake Erie Shoreline, with city skyline in background offering photographic opportunities	8
Easterly Wastewater Treatment Plant	OH	Cuyahoga	City of Cleveland	Industrial facility	Wastewater treatment facility located along Lake Erie shoreline	9
White City Park	OH	Cuyahoga	Village of Bratenahl	Fairground	Lakefront site of the old historic White City Amusement Park	9
Bratenahl	OH	Cuyahoga	Village of Bratenahl	Community	Lakefront community in Cleveland, OH, bordering Lake Erie shoreline	9, 10
Cleveland Lakefront State Park	OH	Cuyahoga	City of Cleveland	Public Park	Lakefront state park offering access to Lake Erie, hiking trails, picnic areas, lakefront views, etc.	10
Boat Ramp	OH	Cuyahoga	City of Cleveland	boat launch	Public boat launch offering access to Lake Erie	10
Intercity Yacht Club	OH	Cuyahoga	City of Cleveland	Organization	Yacht club and marina offering clubhouse, banquet hall, and social events	10

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Gordon Park	OH	Cuyahoga	City of Cleveland	Public park	Public park near Lake Erie shoreline, offering ball fields/courts, views of Lake Erie, picnic areas, etc.	10
Lakefront Reservation E 72nd Fishing Area	OH	Cuyahoga	City of Cleveland	Public park	Public fishing area located along Lake Erie shoreline within Lakefront State Park	10
Rockefeller Park	OH	Cuyahoga	City of Cleveland	Public park	Creekside public park with multicultural gardens along Doan Creek	10
East 55th Street Marina	OH	Cuyahoga	City of Cleveland	Marina	Marina located along Lake Erie shoreline, offering fishing piers and park areas	10
Universal Terminal Company Dock and Warehouse	OH	Cuyahoga	City of Cleveland	Built resource	NRHP-listed built resource along Lake Erie shoreline; NPS # 83001954	10
Sailing Inc.	OH	Cuyahoga	City of Cleveland	Private business	Boat repair and sales shop located on Lake Erie shoreline	10
Forest City Yacht Club	OH	Cuyahoga	City of Cleveland	Organization	Yacht club along Lake Erie shoreline offering clubhouse, marina, picnic areas, etc.	10
Lakeside Yacht Club	OH	Cuyahoga	City of Cleveland	Organization	Yacht club along Lake Erie shoreline offering clubhouse, marina, restaurant, social events, etc.	10
East Basin	OH	Cuyahoga	City of Cleveland	Natural/built feature	Basin along Lake Erie within breakwater wall	10
Cleveland Harbor	OH	Cuyahoga	City of Cleveland	Natural/built feature	Harbor within breakwater wall, leads to Cuyahoga River	10
Burke Lakefront Airport	OH	Cuyahoga	City of Cleveland	Airport	Lakefront airport located along the southern shore of Lake Erie in downtown Cleveland	10
LeanDog	OH	Cuyahoga	City of Cleveland	Private business	Software company located on a barge within Cleveland Harbor	10

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
USS Cod Submarine Memorial	OH	Cuyahoga	City of Cleveland	Built resource	NRHP listed resource; Marine museum dedicated to the USS Cod Submarine; NPS # 86000088	10
US Army Corps of Engineers	OH	Cuyahoga	City of Cleveland	Government facility	USACE office located on Cleveland Harbor	10
Goodtime III	OH	Cuyahoga	City of Cleveland	Private business	Charter yacht offering reservations for private events, public events, tours, etc.	10
Nuevo Modern Mexican & Tequila Bar	OH	Cuyahoga	City of Cleveland	Private business	Waterfront Mexican restaurant and bar	10
Voinovich Bicentennial Park	OH	Cuyahoga	City of Cleveland	Public park	Waterfront park on Cleveland harbor	10
Rock and Roll Hall of Fame	OH	Cuyahoga	City of Cleveland	Museum	Lakefront music museum	10
Great Lakes Science Center	OH	Cuyahoga	City of Cleveland	Museum	Lakefront museum offering history and education about the Great Lakes	10
Steamship William G Mather	OH	Cuyahoga	City of Cleveland	Museum	Great Lakes freighter museum offering tours of a historic freighter	10
Cleveland-Cuyahoga County Port	OH	Cuyahoga	City of Cleveland	Built resource	Great Lakes port, whose mission is to spur job creation and economic vitality	10
First Energy Stadium	OH	Cuyahoga	City of Cleveland	Built resource	Lakefront professional football stadium where Cleveland Browns play	10
Cleveland East Pierhead Light	OH	Cuyahoga	City of Cleveland	Built resource	NRHP-listed resource; Light at point of east breakwater wall, NPS # 91001855	10
Cleveland West Pierhead Lighthouse	OH	Cuyahoga	City of Cleveland	Built resource	NRHP-listed resource; Lighthouse at point of west breakwater wall, NPS # 83001950	10
Cuyahoga River	OH	Cuyahoga	City of Cleveland	Natural Feature	Tributary to Lake Erie	10

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Cleveland Harbor Station, U.S. Coast Guard	OH	Cuyahoga	City of Cleveland	Government facility	NRHP Listed resource; U.S. Coast Guard station at the mouth of Cuyahoga River; NPS # 76001390	10
Shooters on the Water	OH	Cuyahoga	City of Cleveland	Private business	Riverfront restaurant offering riverside seating and views of the Cuyahoga River	10
Great Lakes Water Sports	OH	Cuyahoga	City of Cleveland	Private business	Riverside watersports rental company offering canoe, kayak, and jet ski rentals	10
Main Avenue Viaduct	OH	Cuyahoga	City of Cleveland	Built resource	Bridge spanning the Cuyahoga river	10
Old River Road Historic District	OH	Cuyahoga	City of Cleveland	Built resource	NRHP-listed resource; Riverfront historic district; NPS # 05001574	10
Nautica Queen	OH	Cuyahoga	City of Cleveland	Private Business	Boat tour agency offering dining cruises and private events	10
Settler's Landing Park	OH	Cuyahoga	City of Cleveland	Public Park	Riverfront park along Cuyahoga river, offering river views, and dog park	10
Lorenzo Carter Cabin	OH	Cuyahoga	City of Cleveland	Built resource	Home of Cleveland's first permanent resident, located along Cuyahoga River	10
Detroit Superior High Level Bridge	OH	Cuyahoga	City of Cleveland	Built resource	NRHP-listed resource; Bridge spanning Cuyahoga River; NPS # 74001437	10
Superior Avenue Viaduct	OH	Cuyahoga	City of Cleveland	Built resource	NRHP-listed resource; Bridge spanning Cuyahoga River; NPS # 78002043	10
Cleveland Rowing Foundation	OH	Cuyahoga	City of Cleveland	Organization	Rowing club located in downtown Cleveland along the Cuyahoga River	10
Rivergate Park	OH	Cuyahoga	City of Cleveland	Public park	Riverfront public park including playground and skatepark	10

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Cleveland Dragon boat Association	OH	Cuyahoga	City of Cleveland	Organization	Non-profit organization promoting dragon boat racing, and Asian culture awareness while also raising money through racing	10
Heritage Park	OH	Cuyahoga	City of Cleveland	Public Park	Riverfront public park offering picnic areas, live music events, views of skyline and Cuyahoga River	10
Jacobs Pavilion at Nautica	OH	Cuyahoga	City of Cleveland	Private business	Waterfront concert venue along Cuyahoga River	10
Greater Cleveland Aquarium	OH	Cuyahoga	City of Cleveland	Built resource	Riverfront aquarium offering many exhibits including species native to Ohio and Lake Erie	10
Lafarge North America	OH	Cuyahoga	City of Cleveland	Private Business	Construction material supplier located along Cuyahoga River	10
Ontario Stone Corporation	OH	Cuyahoga	City of Cleveland	Private Business	Crushed limestone products distributor located along Cuyahoga River	10
The Great Lakes Towing Company	OH	Cuyahoga	City of Cleveland	Private business	Full service marine transportation organization located along Old River	10
Division Avenue Pumping Station	OH	Cuyahoga	City of Cleveland	Industrial facility	NRHP Listed building NPS # 74007438	10
Channel Park Marina	OH	Cuyahoga	City of Cleveland	Private business	Full-service marina and boat repair shop offering docking, fuel, picnic areas, etc.	10
Olde River Yacht Club	OH	Cuyahoga	City of Cleveland	Organization	Private yacht club on Old River, offering clubhouse, full service marina, restaurant, etc.	10
Cargill	OH	Cuyahoga	City of Cleveland	Private business	Salt/deicing supplier and exporter located on Cuyahoga River	10
Whiskey Island	OH	Cuyahoga	City of Cleveland	Natural feature	Industrial island between west basin and Old River	10

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Wendy Park	OH	Cuyahoga	City of Cleveland	Public Park	Lakefront public park offering volleyball courts, live music events, Lake Erie views	10
Whiskey Island Still and Eatery	OH	Cuyahoga	City of Cleveland	Private Business	Lakefront restaurant and bar offering live music and outdoor seating	10
West Basin	OH	Cuyahoga	City of Cleveland	Natural/built feature	Basin located between West breakwater wall and whiskey Island/mainland	10
Pennsylvania Railway Ore Dock	OH	Cuyahoga	City of Cleveland	Built resource	NRHP Listed Ore dock; NPS # 95000492	10
West Breakwater Wall	OH	Cuyahoga	City of Cleveland	Built resource	Man-made water control feature in Lake Erie	10
Intake Tunnel	OH	Cuyahoga	City of Cleveland	Built resource	Built intake feature within Lake Erie	10
Westerly Wastewater Treatment Plant	OH	Cuyahoga	City of Cleveland	Industrial facility	Wastewater treatment facility located along Lake Erie shoreline	10
Edgewater Marina	OH	Cuyahoga	City of Cleveland	Marina	Public marina along Lake Erie shoreline offering docking, access to Lake Erie, etc.	10
Edgewater public boat ramp	OH	Cuyahoga	City of Cleveland	Boat launch	Public boat launch offering access to Lake Erie	10
Cleveland Marine Towing	OH	Cuyahoga	City of Cleveland	Private business	Marine towing business located on Lake Erie shoreline	10
Edgewater Yacht Club, Inc.	OH	Cuyahoga	City of Cleveland	Organization	Private yacht club and marina offering docking, clubhouse, restaurant, social events, etc.	10
The Clifton Club	OH	Cuyahoga	City of Lakewood	Organization	Country club near Lake Erie shore offering event venue, private beach, ball courts, golf course, restaurant, etc.	11
Clifton Lagoon	OH	Cuyahoga	City of Lakewood	Natural/built feature	Lagoon near the mouth of Rocky river	11
Rocky River	OH	Cuyahoga	City of Lakewood	Natural feature	Tributary to lake Erie	11

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Clifton Pointe Luxury Ecohomes	OH	Cuyahoga	City of Lakewood	Condominium Complex	Riverfront condominium complex offering views of Rocky River	11
Harborview Associates	OH	Cuyahoga	City of Lakewood	Apartment complex	Riverfront apartment building offering views of Rocky River	11
Emerald Necklace Marina	OH	Cuyahoga	City of Lakewood	Marina	Park and marina offering docking, restaurant, riverfront views	11
Freedom Boat Club	OH	Cuyahoga	City of Lakewood	Organization	Riverfront boating community offering docking, social events, etc.	11
Boat Ramp	OH	Cuyahoga	City of Lakewood	Boat launch	Public boat launch offering access to Rocky River	11
Lakewood Wastewater Treatment	OH	Cuyahoga	City of Lakewood	Industrial facility	Water treatment facility located on the banks of Rocky River	11
Eleven River Luxury Townhomes	OH	Cuyahoga	City of Rocky River	Condominium complex	Riverfront condominium complex offering views of Rocky River	11
Rocky River Marina	OH	Cuyahoga	City of Rocky River	Private business	Boat and marine sports shop	11
Detroit Avenue Bridge	OH	Cuyahoga	City of Rocky River	Built resource	NRHP-listed bridge spanning Rocky River; NPS # 73001428	11
Westlake Condominium	OH	Cuyahoga	City of Rocky River	Built resource	NRHP-listed riverfront condominium complex offering views of Rocky River and a marina; NPS # 83004278	11
The Marina at the Westlake	OH	Cuyahoga	City of Rocky River	Marina	Marina behind the historic Westlake Condos, offering powered pedestal docking, picnic areas, private event space, etc.	11
Cleveland Yacht Club	OH	Cuyahoga	City of Rocky River	Organization	Private yacht club and marina offering docking, clubhouse, restaurant, banquet events	11
Oakwood Beach	OH	Cuyahoga	City of Rocky River	Private Park	Private beach park open to residents of Beach Cliff, offering access to Lake Erie	11

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Avon Lake	OH	Lorain	City of Avon Lake	Community	Lakefront community along Lake Erie shoreline	12, 13
NRG Energy, Inc.	OH	Lorain	City of Avon Lake	Industrial facility	Power plant located on the Lake Erie shoreline	13
Avon Basin	OH	Lorain	City of Avon Lake	Natural/built Feature	Basin created from aqueducts behind NRG Power Plant	13
Beachpark Tower	OH	Lorain	City of Avon Lake	Apartment building	Apartment complex located near the Lake Erie shoreline	13
Miller Road Park	OH	Lorain	City of Avon Lake	Public Park	Lakefront park offering fishing piers, boat launch, playgrounds, picnic areas	13
Peter Miller House Museum	OH	Lorain	City of Avon Lake	Built resource	NRHP-listed house of the first permanent settler of Avon Lake; NPS # 78002106	13
Sheffield Lake	OH	Lorain	City of Sheffield Lake	Community	Lakefront community near Lake Erie shoreline	14
Sheffield Lake Public Boat Ramp and Beach	OH	Lorain	City of Sheffield Lake	boat launch	Boat launch offering access to Lake Erie	14
Express Marin	OH	Lorain	City of Lorain	Private business	Boat repair and water sports shop	15
Lakeside Landing	OH	Lorain	City of Lorain	Public park	Lakefront park offering access to Lake Erie, fishing, beach area, etc.	15
Jackalope Lakeside	OH	Lorain	City of Lorain	Private business	Lakefront seafood restaurant offering outdoor seating and views of Lake Erie and marina	15
Spitzer Lakeside and Riverside Marina	OH	Lorain	City of Lorain	Marina	Marinas located at the mouth of Black River and Lake Erie, and along Black River offering docking, experienced staff, picnic areas, restaurants, social events, etc.	15
Mile Long Pier	OH	Lorain	City of Lorain	Public Park	Local pier offering access to lake Erie, fishing, marina, etc.	15

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Lorain Sailing and Yacht Club	OH	Lorain	City of Lorain	Organization	Yacht club and marina offering floating docks, clubhouse, social events, etc.	15
U.S. Coast Guard	OH	Lorain	City of Lorain	Government facility	U.S. Coast Guard station on black river	15
Black River	OH	Lorain	City of Lorain	Natural Feature	Tributary to Lake Erie	15
Riverside Park	OH	Lorain	City of Lorain	Public park	Park on the banks of Black River offering access to Black River, docking, playground, fishing, etc.	15
Gene's Marina Sales & Service LLC	OH	Lorain	City of Lorain	Private business	Marina and boat sales and service shop located on Black River	15
Westlake Yachting club	OH	Lorain	City of Lorain	Organization	Yacht club offering clubhouse and social events	15
Black River Landing	OH	Lorain	City of Lorain	Built resource	Riverfront events venue offering views of Black River, playground, stage, concessions, etc.	15
Lorain Port Authority	OH	Lorain	City of Lorain	Government facility	Agency located on Black River whose goal is promoting waterborne commerce, economic development opportunities, enhancing public access to waterways, etc.	15
Charles Berry Bridge	OH	Lorain	City of Lorain	Built resource	Bridge spanning Black River	15
Lorain Water Department	OH	Lorain	City of Lorain	Industrial facility	Water utilities agency involved in purification and wastewater treatment	15
Hot Waters Boat Ramp	OH	Lorain	City of Lorain	Boat launch	Public boat launch offering access to Lake Erie	15
Lorain Harbor Lighthouse	OH	Lorain	City of Lorain	Built resource	Lighthouse and NRHP listed building on Lake Erie; NPS # 78002108	15
Harmon's Beach	OH	Lorain	City of Lorain	Public Park	Beach park located on Lake Erie shoreline	15

Attachment F-3 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Southern Lake Erie Watershed

Feature or Resource Name	State	County	City/Town	Type of Feature or Resource	Description	Focus Area Number*
Lakeview Park	OH	Lorain	City of Lorain	Public park	Lakefront beach park offering beach area, swimming, bathhouse, historic rose garden, event space, café, etc.	15
Beacon B&B	OH	Lorain	City of Lorain	Private business	Bed and Breakfast located across from Lakeview Park, offering access to park and Lake Erie views	15
Copper Kettle Marina	OH	Lorain	City of Lorain	Private business	Marina and boat supply store on Beaver Creek	16
Beaver Creek Boat Club	OH	Lorain	City of Lorain	Organization	Yacht/boat club on beaver creek offering clubhouse, playground, docks, picnic areas, etc.	16
Beaver Park Marina	OH	Lorain	City of Lorain	Private business	Full service marina and boat supply and sales store	16
Beaver Park North, Inc.	OH	Lorain	City of Lorain	Marina	Marina on Beaver Creek offering rack storage and water docks	16
Beaver Park Yacht Club	OH	Lorain	City of Lorain	Organization	Private yacht club located on Beaver creek	16
Beaver Creek	OH	Lorain	City of Lorain	Natural feature	Tributary to Lake Erie	16
Snack Shack	OH	Lorain	City of Lorain	Private business	Restaurant within public marina located on Lake Erie shoreline	16
Fox Creek Golf and racquet Club	OH	Lorain	City of Lorain	Private business	Golf course located on banks of Beaver Creek	16

*The following focus area did not have any specific natural or cultural features, communities, etc.: 17.

F.4 Potential Socio-Cultural Impacts: Western Lake Erie Watershed

The Western Lake Erie watershed is located at the western end of Lake Erie. Located within northwestern Ohio and southeastern Michigan, it extends over portions of five counties: (from east to northwest) Erie, Lucas, Ottawa, and Sandusky counties, Ohio; and Monroe County, Michigan.

According to modeling conducted for the introduction and establishment of Hydrilla within the larger Great Lakes basin, the Western Lake Erie watershed is considered to have a high potential for the introduction of Hydrilla, primarily via recreational boating, and a moderate potential for the establishment of Hydrilla in suitable nearshore aquatic habitat if it were to be introduced.

The following impact assessment describes the various features that comprise the existing socio-cultural setting of 49 focus areas along the approximately 295-mile-long shoreline area within the Western Lake Erie watershed. These 49 focus areas along the shoreline in the Western Lake Erie watershed were selected for detailed analysis because they include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet (see Section F.4.1). The following impact assessment considers the potential impacts of the introduction and subsequent establishment of Hydrilla on the various features that collectively represent the community character of these focus areas along the shoreline in the Western Lake Erie watershed. The Western Lake Erie watershed encompasses additional areas along the shoreline as well as interior areas that are not located along the shoreline. However, the following impact assessment considers the socio-cultural setting and community character of only those counties, townships, villages, towns, and cities within which the 49 focus areas are located. This approach was adopted to make the impact assessment more manageable given the total length of the Lake Erie shoreline (295 miles) in the Western Lake Erie watershed.

Similarly, it is recognized that a wide variety of agencies, organizations, and special interest groups may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the Western Lake Erie watershed. These stakeholders would consist of the civic and governmental areas with jurisdiction over the areas included in the Western Lake Erie watershed and additional stakeholders that could include: state agencies (e.g., the Ohio State Historic Preservation Office, Ohio Department of Natural Resources/Division of Parks and Watercraft, Michigan State Historic Preservation Office, and Michigan Department of Natural Resources) that manage parks, historic sites, natural areas, and public access for waterbodies; federal agencies (e.g., USACE, which manages navigable waterways, the USFWS, which manages national wildlife refuges, and the U.S. Nuclear Regulatory Commission, which manages nuclear power plants such as the Enrico Fermi Nuclear Power Plant); federally recognized Indian tribes that have a cultural or historical affiliation with areas along the shoreline in the Western Lake Erie watershed or retain treaty rights to lands, waters, and resources along the shoreline of the Western Lake Erie watershed; or special interest groups (e.g., The Nature Conservancy, The Sierra Club, or Ducks Unlimited) that may have a broadly defined interest in areas and resources along the shoreline of the Western Lake Erie watershed. These additional stakeholders could be involved as part of continued consideration of the potential impacts associated with the introduction and establishment of Hydrilla within the larger Great Lakes basin.

Potential impacts on the socio-cultural setting of shoreline areas of the Western Lake Erie watershed are discussed in terms of whether they would be: short-term (temporary) or long-term (permanent): direct or indirect, positive (beneficial) or negative (detrimental), and cumulative. Additionally, these impacts are considered with reference to two scenarios: one where Hydrilla is untreated (worst-case scenario), and one where Hydrilla is treated (managed scenario).

It is expected that the results of this assessment of the introduction and subsequent establishment of Hydrilla on the socio-cultural setting and community character of the 49 focus areas along the shoreline within the Western Lake Erie watershed would be generally representative of potential impacts that would occur in interior areas of this same watershed. The results would also be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

F.4.1 Methodology and Definitions for the Socio-Cultural Impact Assessment for the Western Lake Erie Watershed

This socio-cultural impact assessment assumes that the introduction and/or establishment of Hydrilla along the shoreline of the Western Lake Erie watershed will affect the natural and socio-cultural features located in the 49 focus areas, resulting in changes to the watershed's community character. For the purposes of this impact assessment, natural features are defined as uplands, points, bluffs, coves, beaches, embayments, creeks, streams, rivers, marshes, etc., and socio-cultural features are defined as villages, towns, cities, parks, other residential areas (neighborhoods and hamlets), conservation areas (including nature preserves, wildlife preserves, and wildlife management areas), commercial enterprises, industrial facilities, and cultural and historical sites.

This socio-cultural impact assessment further assumes that these natural and socio-cultural features collectively represent tangible (physical) components of the community character of the Western Lake Erie watershed. A review of publicly available information for Ohio and Michigan state agencies did not identify specific guidance for defining, or assessing impacts on, community character. However, Ohio Lake Erie Commission, which, along with its member state agencies, is responsible for actions taken to protect and restore those portions of Lake Erie and its watershed within the state of Ohio, has issued some guidance which addresses those features or qualities that comprise community character (Ohio Lake Erie Commission 2013). In its 2013 *Lake Erie Protection & Restoration Plan*, the Ohio Lake Erie Commission indicated that its mission is “to preserve Lake Erie's natural resources, protect the ecological quality of its watershed, and to promote economic development on the north coast. This is accomplished through coordination and implementation of state policies and programs pertaining to water quality, habitat protection and restoration, recreation and tourism, and resource management within the Lake Erie basin." (Ohio Lake Erie Commission 2013). Additionally, Michigan's Natural Resources and Environmental Protection Act, Act 451 of 1994, was passed to protect the environment and natural resources of the State of Michigan. While this act does not specifically address community character, many sections of this state law require project proponents to consider the impacts of their actions on the aesthetic, recreational, and economic aspects of natural resources (State of Michigan Legislative Council 2017). Collectively, these features, qualities, or aspects also contribute to community character at a broad level, when the interaction of natural and socio-cultural features are collectively considered to comprise community character.

Therefore, for the purposes of this impact assessment of the Western Lake Erie watershed, which lies entirely within portions of Ohio and Michigan, the concept of community character is modelled on New York State's guidance for complying with its State Environmental Quality Review Act (SEQR), consistent with other watersheds evaluated as part of this RA. New York State's SEQR guidance notes that:

> Many people define their community's character in very general terms: suburban, rural, urban, quiet, safe, scenic, or friendly are terms often used. Others describe community character only in terms of visual features.
>
> Community character is broader than this however. Community character is defined by all the man-made and natural features of the area. It includes the visual character of a town, village, or city, and its visual landscape; but also includes the buildings and structures and their uses, the natural environment, activities, town services, and local policies that are in place.
>
> These combine to create a sense of place or character that defines the area" (New York State Department of Environmental Conservation 2017).

The introduction and establishment of Hydrilla would occur within natural features located along the shoreline in the Western Lake Erie watershed. These areas typically are locations recognized and used for water-dependent and water-related uses. The natural and man-made (socio-cultural) features of the watershed as a collective physical representation of the community character of the Western Lake Erie watershed, as defined above by NYSDEC, appears to provide the most comprehensive consideration of the impacts that the introduction and establishment of Hydrilla would have on the community character of the Western

Lake Erie watershed. However, the definition of community character for this impact assessment has been expanded to include the water-dependent and water-related uses of these natural and man-made or socio-cultural features, which also contribute to community character and are deliberately managed by the communities and governmental units that comprise the Western Lake Erie watershed.

Due to the large extent of the shoreline in the Western Lake Erie watershed (approximately 295 miles in length), 49 areas with environmental conditions highly suitable to establishment of Hydrilla were identified within this watershed for an in-depth impact assessment. These 49 areas (henceforth, referred to as focus areas) collectively intersect with approximately 6.25 miles of the shoreline in the Western Lake Erie watershed[1]. They all contain physical conditions that are conducive to the introduction and establishment of Hydrilla. Table F.4-1 provides a summary description of each of the 49 focus areas identified for the Western Lake Erie watershed. Section 3.3 describes the criteria used to identify the 49 focus areas along the Lake Erie shoreline in the Western Lake Erie watershed, which include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet).

Thus, this socio-cultural impact assessment identified the visible and physical natural and socio-cultural features that represent the attributes and assets of the communities and governmental units associated with the 49 focus areas along the shoreline in the Western Lake Erie watershed (see Section F.4.2: see also Attachment F-4 for a listing of these visible and physical natural and socio-cultural features). This socio-cultural impact assessment also considers the management of the visible and physical natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed by the associated counties, towns, and cities or villages (see Section F.4.3). This socio-cultural impact assessment considers the impacts of the introduction and/or establishment of Hydrilla on the natural and socio-cultural features and their associated water-dependent and water-related uses identified for the 49 focus areas in the Western Lake Erie watershed (see Sections F.4.4 and F.4.5). This assessment also considers the impacts of the introduction and establishment of Hydrilla on perceptions of features and uses and on the community character of the 49 focus areas (see Sections F.4.6 and F.4.7). The results of this impact analysis are considered with regard to their broader applicability to the entire Western Lake Erie watershed (see Section F.4.8). Finally, conclusions and recommendations regarding the results of this impact assessment are presented in Section F.4.9.

[1] Given the nature of the topography of the lakeshore within this watershed, this appears to comprise a small percentage of the Lake Erie shoreline within this watershed. However, the majority of these 49 focus areas include relatively large areas of waterbodies that are interior, or on the landside of the shoreline, rather than right along the shoreline.

Table F.4-1 Description of Focus Areas in the Western Lake Erie Watershed

Focus Area Number	Description of Focus Area	State	County	City or Township	Approximate Length (miles)
1	Shoreline of Lake Erie and Vermilion River	OH	Erie	City of Vermilion	0.83
2	Shoreline of Lake Erie at mouths of two unnamed intermittent tributaries, between Beulah Beach and Heidelberg Beach	OH	Erie	Vermilion Township	0.23
3	Shoreline of Lake Erie at mouths of Cranberry Creek and two other unnamed intermittent tributaries, at Ruggles Beach	OH	Erie	Berlin Township	0.07
4	Shoreline of Lake Erie and outlet of Old Woman Creek near Oberlin Beach	OH	Erie	Berlin Township	0.30
5	Shoreline of Lake Erie, Huron River, and Mud Brook	OH	Erie	City of Huron	1.54
6	Shoreline of Lake Erie at mouth of Sawmill Creek	OH	Erie	Huron Township	0.11
7	Shoreline of Sandusky Bay	OH	Erie	Huron Township and City of Sandusky	10.85
8	Shoreline of Sandusky Bay	OH	Erie	City of Sandusky	0.16
9	Shoreline of marsh complex on Sandusky Bay, south of City of Bayview	OH	Erie	Margaretta Township	5.01
10	Shoreline of Sandusky Bay, east of City of Bayview	OH	Erie	Margaretta Township	0.25
11	Shoreline of marsh complex at Willow Point, near Springbrook and the Ohio Agricultural Experimental Station (North Central Substation)	OH	Erie	Margaretta Township	1.51
12	Shoreline of Sandusky Bay at Bay Harbor Marina near Whites Landing	OH	Erie	Margaretta Township	0.10
13	Shoreline of lowlying channelizeded area within Pickerel Creek State Wildlife Management Area	OH	Sandusky	Townsend Township	1.88
14	Shoreline of marshy area of Muddy Creek Bay (off of Sandusky Bay) between Peach Island and Graveyard Island	OH	Sandusky	Riley Township	0.42

Table F.4-1 Description of Focus Areas in the Western Lake Erie Watershed

Focus Area Number	Description of Focus Area	State	County	City or Township	Approximate Length (miles)
15	Shoreline of The Bogs, a marshy area of Muddy Creek Bay (off of Sandusky Bay) between Hickory Island and Peach and Graveyard Islands	OH	Sandusky	Riley Township	1.06
16	Shoreline of Muddy Creek Bay, including marshy areas at the mouths of South Creek, Sandusky River, Little Muddy Creek, and Muddy Creek	OH	Sandusky and Ottawa	Riley and Rice Townships (Sandusky County) and Bay Township (Ottawa County)	9.10
17	Shoreline of channelized, lowlying and marshy area off Sandusky Bay, near Port Clinton	OH	Ottawa	Bay and Portage Townships	0.99
18	Shoreline of quarried areas off of Sandusky Bay near Gypsum	OH	Ottawa	Portage Township	0.58
19	Shoreline of channelized areas off of Sandusky Bay near Danbury	OH	Ottawa	Danbury Township	0.51
20	Shoreline of channelized areas off of Sandusky Bay near Danbury	OH	Ottawa	Danbury Township	0.60
21	Shoreline of Sandusky Bay, near Zellers Beach Park	OH	Ottawa	Danbury Township	0.65
22	Shorelines of Sandusky Bay and Meadow Brook	OH	Ottawa	Danbury Township	1.12
23	Shoreline of Sandusky Bay, near Mineyahta-on-the-Bay	OH	Ottawa	Danbury Township	0.82
24	Shoreline of Bay Point Marina on Sandusky Bay	OH	Ottawa	Danbury Township	0.61
25	Shoreline of marina on Johnson Island, in Sandusky Bay	OH	Ottawa	Danbury Township	0.51
26	Shoreline of interior ponds or lakes or reclaimed quarries within Lakeside Daisy State Nature Preserve	OH	Ottawa	Danbury Township	0.80
27	Shoreline of Lake Erie at the U.S. Coast Guard Station in Marblehead	OH	Ottawa	Danbury Township	0.09
28	Shoreline of Put-in-Bay on South Bass Island in Lake Erie	OH	Ottawa	South Bass Island	1.79

Table F.4-1 Description of Focus Areas in the Western Lake Erie Watershed

Focus Area Number	Description of Focus Area	State	County	City or Township	Approximate Length (miles)
29	Shoreline of East Harbor and Middle Harbor near Lakeside and partially within East Harbor State Park	OH	Ottawa	Danbury Township	2.99
30	Shoreline of West Harbor, including portions of East Harbor State Park and Catawba Island	OH	Ottawa	Danbury Township and Catawba Island	7.61
31	Unnamed marina at Catawba Island Club along west side of Catawba Island, north end of Sugar Rock	OH	Ottawa	Catawba Island	0.23
32	Channels and coves at Catawba Island Marina South, along west side of Catawba Island, south of Sugar Rock	OH	Ottawa	Catawba Island	0.38
33	Shoreline of Lake Erie on west side of Catawba Island, at Northwest Catawba Island Marina	OH	Ottawa	Catawba Island	0.24
34	Shoreline of Lake Erie, east of Port Clinton	OH	Ottawa	Portage Township	0.81
35	Shoreline of mouth of Portage River, before it empties into Lake Erie at Port Clinton	OH	Ottawa	City of Port Clinton and Erie Township	2.30
36	Marshy areas at the mouth of Toussaint River, at the noncontiguous Ottawa National Wildlife Refuge	OH	Ottawa	Erie and Carroll Townships	1.81
37	Marshy areas associated with Turtle Creek Bay, Turtle Creek Lake Area, Big Sand Bay, Turtle Creek, Crane Creek, and Wards Canal, at the noncontiguous Ottawa National Wildlife Refuge, Magee Marsh Wildlife Area, Crane State Park the Metzger Marsh Wildlife Area	OH	Ottawa and Lucas	Carroll and Benton Townships (Ottawa County) and Jerusalem Township (Lucas County)	6.33

Table F.4-1 Description of Focus Areas in the Western Lake Erie Watershed

Focus Area Number	Description of Focus Area	State	County	City or Township	Approximate Length (miles)
38	Interior marshy and channelized lowlying areas associated with Williams Ditch, Wolf Creek Pond, Suzar Bay, Lacourse Pond, Back of Howells Pond, Pintail Pond, Widgeon Pond, Cedar Creek Pond, Long Pond, Outlet Pond, and Carrington Pond, at the Cedar Point National Wildlife Reserve	OH	Lucas	Jerusalem Township	5.42
39	Shorelines of Lake Erie, including tidal flat at outlet of Berger Ditch and Inland Lake, at Maumee Beach State Park	OH	Lucas	Jerusalem Township	0.42
40	Shorelines of Maumee Bay and Maumee River	OH	Lucas	City of Toledo	4.05
41	Shorelines of North Maumee Bay, Ottawa River, and Halfway Creeks	OH and MI	Lucas (OH and Monroe (MI)	City of Toledo and Washington Township (Lucas County) and Erie Township (Monroe County)	6.86
42	Shoreline of Allens Cove, including Marsh Areas behind Toledo Beach and the outlets of Muddy Creek and Sulphur Creek	MI	Monroe	City of Luna Pier	1.53
43	Shoreline of Otter Creek where it drains into Lake Erie	MI	Monroe	La Salle Township	0.36
44	Shoreline of La Plaisance Creek where it drains into La Plaissance Bay near Bolles Harbor	MI	Monroe	Monroe Township	0.45
45	Shorelines of Plum Creek, River Raisin, and other interior waterbodies formed at the outlets of Mason Run, Dubois Drain, Stonecrusher Drain, and Sandy Creek	MI	Monroe	Monroe Township and City of Monroe	4.34
46	Shoreline of Stony Creek where it drains into Brest Bay	MI	Monroe	Frenchtown Township	0.24

Table F.4-1 Description of Focus Areas in the Western Lake Erie Watershed

Focus Area Number	Description of Focus Area	State	County	City or Township	Approximate Length (miles)
47	Interior manmade waterbodies south of Enrico Fermi Nuclear Powerplant that drain into Lake Erie	MI	Monroe	Frenchtown Township	0.49
48	Interior shoreline of Swan Creek where it drains into Lake Erie	MI	Monroe	Frenchtown and Berlin Townships	1.69
49	Shorelines of open water and marshy areas associated with Mouilles Marsh, including East Lead, West Lead, Langton Drain, Mouilles Creek, and Laudenschlager Drain	MI	Monroe	Berlin Township	4.78
Total	**N/A**	**N/A**	**N/A**	**N/A**	**95.82**

Key:
N/A = Not applicable

F.4.2 Natural and Socio-Cultural Features along the Shoreline of the Western Lake Erie Watershed

Three hundred thirty-nine named natural and socio-cultural features are located within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These features were identified primarily from an analysis of information included in overlays for Google Earth and identified on 7.5-minute USGS topographic quadrangles and/or coastal maps maintained in the National Oceanic and Atmospheric Administration's (NOAA's) Office of Coast Survey Historical Map and Chart Collection. Collectively, these 339 named natural and socio-cultural features are physical representations of the community character and the socio-cultural setting of the shoreline in the Western Lake Erie watershed.

A full listing of the 339 named natural and socio-cultural features identified for the 49 focus areas is included in Attachment F-4. It is noted here that Attachment F-4 is not a definitive and complete listing of all the named natural and socio-cultural features in the 49 focus areas or along the entire shoreline in the Western Lake Erie watershed. While the list in Attachment F-4 is reasonably comprehensive as to the type of natural and socio-cultural features present, it primarily only includes features that are named (e.g., named waterbodies and communities on 7.5-minute USGS topographic quadrangles) and/or that have been identified in databases that comprise the Google Earth overlays.

These 339 named natural and socio-cultural features can be grouped into 10 different categories of resources (see Table F.4-2). These 10 resource categories consist of (in order of predominance from most to fewest): private businesses, natural features, organizations, public parks and other public facilities, communities, built resources, conservation areas, industrial facilities, governmental facilities, and institutions. The types of natural and socio-cultural features located within, or associated with, these 49 focus areas should be considered generally representative of the larger number of natural and socio-cultural features along the shoreline in the Western Lake Erie watershed.

Table F.4-2 Summary of Natural and Socio-Cultural Features within the 49 focus Areas along the Shoreline in the Western Lake Erie Watershed

Resource Category	Description	Total Number in Watershed (% of total)
Private businesses	Private enterprises related to a variety of water-dependent or water-related recreational uses and activities along the shoreline of Lake Erie	146 (43%)
Natural features	Named natural features located along the shoreline of Lake Erie	63 (19%)
Organizations	Public or private enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the shoreline of Lake Erie	28 (8%)
Public parks/facilities	State, county, and town parks and beaches located along the shoreline of Lake Erie	27 (8%)
Communities	Named cities (including named neighborhoods), towns or villages, or hamlets located along the shoreline of Lake Erie	26 (8%)
Built resources	Specific buildings, structures, objects, or other built features located along the shoreline of Lake Erie	19 (6%)
Conservation areas	Federal, state, local, and private natural areas, nature/underwater preserves, and wildlife management areas located along the shoreline of Lake Erie	17 (5%)
Industrial facilities	Industrial facilities such as power plants or water treatment plants located along the Lake Erie shoreline	9 (3%)
Governmental facilities	Federal, state, or local government facilities located along the shoreline of Lake Erie	3 (1%)
Institutions	Educational facilities, such as universities, seminaries, or Chautauqua Institutes, located along the shoreline of Lake Erie	1 (<1%)
Total		**339 (100%)**

Private Businesses (Socio-Cultural Feature)

One hundred forty-six private business enterprises were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these 146 private business enterprises represent approximately 43% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. The 146 private business enterprises consist of a variety of businesses, primarily related to recreational activities, that all are associated with water-dependent or water-related use of the Lake Erie shoreline. These private businesses were generally identified from overlays in Google Earth. Resources in this category include marinas, charter fishing companies, campgrounds, hotels/inns/bed-and-breakfasts, restaurants, bars, and boating facilities, and their use may be permanent or seasonal. There are likely to be additional similar private businesses along the shoreline in the Western Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Natural Features

Sixty-three named natural features were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these 63 named natural features represent approximately 19% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These 63 named natural features consist of named shoreline or nearshore features (such as rivers, creeks, bays, streams, ditches, lakes, ponds, and bogs) and named terrestrial features (such as points and islands). These natural features were generally identified from USGS 7.5-minute topographic quadrangles and the NOAA's Office of Coast Survey Historical Map and Chart Collection. Resources in this category do not include unnamed waterbodies and topographic features, although such natural features are also present within many of the 49 focus areas along the shoreline in the Western Lake Erie watershed.

Organizations (Socio-Cultural Feature)

Twenty-eight public or private organizations were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these 28 public or private organizations represent approximately 8% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These 28 public or private organizations consist of enterprises related to water-dependent or water-related recreational activities associated with the use of the Lake Erie shoreline. These organizations were generally identified from overlays in Google Earth. Resources in this category primarily consist of yacht clubs, boat clubs, country clubs, or golf courses. Resources in this category may be owned privately or by non-profit groups. There are likely to be additional similar public or private organizations within the 49 focus areas along the shoreline in the Western Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Public Parks and Other Public Facilities (Socio-Cultural Feature)

Twenty-seven public parks or other public facilities were identified within the 49 focus areas along the Shoreline in the Western Lake Erie watershed. Collectively, these 27 public parks or other public facilities represent approximately 8% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These 27 named public parks or other public facilities consist of state, county, township, or municipal parks and beaches located along the Lake Erie shoreline as well as numerous public boat ramps. These public parks and other public facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. Resources in this category are primarily developed for active and passive recreational uses of the waterfront (in urban areas) or the shoreline in suburban and rural areas. There are likely to be additional public facilities along the shoreline in the Western Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Communities (Socio-Cultural Feature)

Twenty-six named communities were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these 26 named communities represent approximately 8% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These 26 communities consist of named cities, towns, villages, and hamlets that were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. Resources in this category also include variously sized named clusters of residential, commercial, and/or industrial development. With regard to residential development, this may be comprised of owner-occupied or rental units, and may be permanent or seasonal. Resources in this category do not include numerous locations of unnamed shoreline development, although such unnamed shoreline development is also present within many of the 49 focus areas along the shoreline in the Western Lake Erie watershed.

Built Resources (Socio-Cultural Feature)

Nineteen specific built resources were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these 19 specific built resources represent approximately 6% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These 19 specific built resources consist of man-made terrestrial and marine features. Man-made terrestrial built resources consist of buildings, structures, objects, or other built features located along the Lake Erie shoreline. Some of these terrestrial buildings or structures are recognized for their individual or collective historic importance at the national, state, or local level (e.g., lighthouses, historical sites, or properties listed in the National Register of Historic Places). Other terrestrial structures consist of industrial docks. Man-made marine features consist of channelized areas within rivers or harbors, including canals and locks, channels, turning basins, and harbors. These specific built resources were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category may or may not be located within communities. Resources in this category may also include, but are not limited to, historic resources.

Conservation Areas (Socio-Cultural Feature)

Seventeen conservation areas were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these 17 conservation areas represent approximately 5% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These 17 conservation areas consist of federal, state, local, or private natural areas, nature preserves, and wildlife management areas located along the Lake Erie shoreline. These conservation areas were identified from

USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category are primarily intended for ecological preservation, although they may also be used for active and/or passive recreational activities. Resources in this category do not include public parks or beaches; these are addressed as a separate resource type.

Industrial Facilities (Socio-Cultural Feature)

Nine industrial facilities were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these nine industrial facilities represent approximately 3% of the total natural and socio-cultural features within the focus areas along the shoreline in the Western Lake Erie watershed. These nine industrial facilities consist of power plants, water treatment plants, sewage, or wastewater treatment plants, or similar facilities located along the shoreline. Resources in this category may be privately owned or operated by municipalities. These industrial facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There may be additional similar industrial facilities within the 49 focus areas along the shoreline in the Western Lake Erie watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Governmental Facilities (Socio-Cultural Feature)

Three governmental facilities were identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. Collectively, these three governmental facilities represent 1% of the total natural and socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed. The three governmental facilities consist of federal governmental facilities located along the Lake Erie shoreline. Resources in this category include facilities such as USACE and USCG stations or facilities. These governmental facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. There are likely to be additional similar governmental facilities along the shoreline in the Western Lake Erie watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Institutions (Socio-cultural Feature)

One institution was identified along the Lake Erie shoreline in the Western Lake Erie watershed. This one institution represents less than 1% of the total natural and socio-cultural features along the Lake Erie shoreline in the Western Lake Erie watershed. This one institution consists of the Ohio State University's Franz Theodore Stoen Laboratory at Put-in-Bay on South Bass Island, north of Port Clinton. This institutional facility was identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There are likely to be additional educational institutions along the Lake Erie shoreline in the Western Lake Erie watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

F.4.3 Existing Management of Natural and Socio-Cultural Features in the Western Lake Erie Watershed

Due to the size of the Western Lake Erie watershed and the length of its shoreline (approximately 295 miles), the overall nature of development of this watershed varies between highly urbanized areas, such as the cities of Huron, Sandusky, and Toledo in Ohio, and the city of Monroe in Michigan, and very rural areas in between these cities. Despite the variation in the type and density of development along the shoreline in the Western Lake Erie watershed, the majority of the various governmental units (counties, townships, and incorporated municipalities) along the shoreline in the Western Lake Erie watershed have processes in place that consider development in conjunction with natural and socio-cultural conditions under their jurisdiction, whether through the development of specific plans, such as master plans, or through zoning.

Specific plans typically consist of comprehensive or master plans developed by the various counties, townships, or cities along the shoreline of Lake Erie. Additionally, a number of governmental units may have other plans for the management of natural and socio-cultural features within their boundaries, such as plans for recreation and conservation. These plans may specifically address the management of many of the named visible and physical natural and socio-cultural features that have been identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed.

The various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Western Lake Erie watershed would indicate the importance of this shoreline to their respective community characters. These various plans may also recognize the various natural features (e.g., points, coves, beaches, embayments, creeks, streams and ditches, and rivers) that physically shape the shoreline and socio-culturally shape the uses of the shoreline for residential, commercial, industrial, recreational, and conservation purposes. These various plans may also recognize various socio-cultural features (i.e., villages, towns, cities, harbors, parks, conservation areas [including nature preserves, wildlife preserves, wildlife management areas and significant coastal fish and wildlife habitats], and residential areas [neighborhoods and hamlets]).

Similarly, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Western Lake Erie watershed would identify common issues or concerns regarding their particular natural and socio-cultural features. The common issues or concerns associated with managing waterfronts or shorelines for water-dependent or water-related uses may consist of, but would not necessarily be limited to:

- Protecting or improving the quality of specific natural features along the shoreline (e.g., beaches, embayments, marshes, rivers, creeks, and streams);

- Managing or enhancing residential and commercial development along the shoreline;
- Creating or enhancing opportunities for public access to the shoreline, typically for recreational purposes;
- Protecting or developing scenic qualities of the shoreline; and
- Managing or enhancing opportunities for visual access to the shoreline.

Additionally, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Western Lake Erie watershed would identify specific management goals, objectives, or recommendations to address these issues or concerns, and to manage these shorelines for water-dependent or water-related uses. In general, the purpose for managing their respective shorelines would typically, but not necessarily only, be to:

- Acknowledge and promote the character of the communities along the shoreline;
- Enhance the quality of life for permanent residents;
- Enhance the experience of seasonal residents and visitors; and
- Protect, improve, or otherwise support the natural and socio-cultural features that comprise the shoreline of Lake Erie.

F.4.4 Potential Impacts of Introduction and Establishment of Hydrilla on Socio-Cultural Setting of the Western Lake Erie Watershed

This section discusses the potential impacts associated with the introduction and/or establishment of Hydrilla on the socio-cultural setting of the Western Lake Erie watershed. In general, these impacts can be considered in terms of whether they result in:

- Physical changes to natural and/or socio-cultural features identified along the shoreline in the Western Lake Erie watershed;
- Changes to water-dependent or water-related uses of these natural and/or socio-cultural features;
- Changes in perceptions about the features or their uses; and
- Changes in the community character of various locations or focus areas within the watershed.

For the purposes of this impact assessment, water-dependent uses are facilities or activities that cannot exist without a waterfront location, such as marinas, boat ramps, and sewage treatments plants. Water-related uses are facilities or activities that increase their value or importance because of their proximity to a shoreline. Frequently, they function as support services for water-dependent uses and could include parks and other recreational facilities, as well as some types of commercial development (Benson 2011).

In general, the changes identified above are considered in terms of whether they would be an impact that is: (1) direct or indirect; (2) temporary or permanent (short-term or long-term); (3) adverse (negative), neutral, or beneficial (positive); and/or (4) cumulative, per changes and impacts associated with other invasive aquatic plant species in the watershed or at a specific focus area and/or per changes and impacts associated with ongoing or emerging socio-cultural trends in the watershed or at a specific focus area.

Impacts on Natural and Socio-Cultural Resources

The introduction and subsequent establishment of Hydrilla within any of the 49 focus areas along the shoreline is likely to result in physical changes to a number of types of natural and socio-cultural features that comprise the socio-cultural setting of these focus areas and of the Western Lake Erie watershed in general. At its most basic level, the introduction of Hydrilla and its establishment and increasing density over time in a natural feature (waterbody or marsh or wetland) with suitable environmental conditions would result in direct changes. The changes would occur to the ecological composition of the natural feature, to the appearance (visible and olfactory) of the natural features, and to the socio-cultural features and water-dependent and water-related uses associated with the natural feature. These changes would consist of new and increasingly visible and dense plants or plant mats beneath and at or on the water surface that would change the composition of ecological communities associated with the natural feature and, with regard to human use, would ultimately impede access on or through the water. At its full extent, Hydrilla present in dense mats at or on the water surface would act as a net, capturing floating detritus (natural and man-made) that would detract from the visual and olfactory setting of the waterbodies. Such changes may be small at first, with the introduction of Hydrilla into a suitable waterbody environment, but such changes may increase incrementally in density, visibility, and/or intensity over time until Hydrilla has exploited the maximum extent of available suitable habitat in the waterbody feature.

Physical changes are likely to occur on natural features and on those socio-cultural features that are comprised of, or associated with, natural features. Physical changes are likely to directly and indirectly impact natural and socio-cultural features. Additionally, these physical changes, considered in conjunction with past, present, or reasonably foreseeable future conditions for these natural and socio-cultural features, may have a cumulative impact on these natural and socio-cultural features.

Socio-cultural features that are comprised of, or associated with, natural features are also likely to undergo physical changes from the introduction and subsequent establishment of Hydrilla. These socio-cultural features would typically consist of: (1) public parks or other public facilities; (2) conservation areas; and (3) public or private business enterprises (e.g., marinas, restaurants, and campgrounds) that are located within the 49 focus areas along the shoreline in the Western Lake Erie watershed and associated with water-dependent and/or water-related uses. However, other socio-cultural features, comprised of communities, organizations, industrial facilities, and governmental facilities, are often associated with natural features, such as those identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed. These are attractive locations for seasonal and permanent residences or are specific locations, such as at the mouth of a navigable waterbody, at which a USCG facility is located, or a shoreline location that provides for specific water intake and discharge capacity for an industrial facility.

Descriptions of the potential impacts on the various types of natural and socio-cultural features identified within the 49 focus areas along the shoreline in the Western Lake Erie watershed are presented below. Such impacts are considered primarily with regard to the introduction and establishment of Hydrilla without treatment. Such direct and indirect impacts would likely be considered long-term or permanent impacts and would be perceived as negative impacts by the communities and users of the 49 focus areas along shoreline in the Western Lake Erie watershed.

Dispersal modeling predicted that approximately 4% of total area of water within the Western Lake Erie watershed may be infested by Hydrilla by 2025 (see Table 3.1.5-1 in the risk assessment); therefore, it is possible that some of the 49 focus areas would not be affected by Hydrilla, or that impacts resulting Hydrilla would not affect some or all of the natural and socio-cultural features that collectively comprise the community character of this watershed as described below. Because dispersal modelling does not indicate specific locations within the watershed that would be affected, it is not possible to determine which of the 49 focus areas would be subject to infestation. Additionally, because the results of dispersal modelling extend through the year 2025, it is likely that the impacts discussed in this section would occur slowly at first, and become increasingly noticeable over time until full exploitation of available suitably habitat has been achieved. Therefore, the impacts of the introduction and establishment of Hydrilla should be considered representative of the types of impacts that could occur if these, or similar, natural and socio-cultural features are present within or adjacent to the approximately 4% of the total area of water within the entire watershed that would be infested by Hydrilla in 2025.

Impacts on Natural Features

The introduction and establishment of Hydrilla on natural features would result in a number of different impacts on natural features, depending on the type of natural feature. These impacts are both physical ecosystem effects as well as socio-cultural effects associated with impaired public access or reduced recreational usage. The physical ecosystem impacts on these natural features are summarized in this section to provide a context for considering these natural features as the setting for associated socio-cultural features and uses. The socio-cultural impacts associated with these natural features (e.g., impaired public access, and reduced recreational usage) are discussed in detail in the following paragraphs as part of the discussion of impacts on socio-cultural features.

Natural features, such as points and islands, are terrestrial natural features that are not likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla. Therefore, the introduction and establishment of Hydrilla is likely to have no impact on these types of natural features, although indirect impacts on socio-cultural features, water-dependent uses, and water-related uses associated with such natural features are likely to occur and are discussed in this section. However, natural features comprised of, or associated with, waterbodies are likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla.

Waterbody features that may be directly impacted by the introduction and establishment of Hydrilla include:

- Shoreline and littoral zone of:
  - Lake Erie and the Niagara River,
  - Beaches, coves, harbors, and bays along the shoreline of the lake, and
  - Outlets or mouths of streams and rivers where they enter the lake or the harbors or bays along the lake shoreline; and
- Marshes or wetlands that are associated with these waterbody features.

Collectively, the 49 focus areas within the Western Lake Erie watershed include shoreline and littoral zone features, although marshes and wetlands may also be present.

The direct impacts on these natural features would result from the introduction and establishment of Hydrilla, and would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of these waterbody features, including changes to water quality (e.g., full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface) and changes to species that are located in, or that otherwise use, these waterbody features (e.g., changes to fish species, aquatic plant species, bird species); and
- Negative because such changes are detrimental to species comprising the ecological systems of these waterbodies.

Waterbody features that may be indirectly impacted by the introduction and establishment of Hydrilla include associated terrestrial features such as: points and islands, as well as the shoreline and littoral zone of Lake Erie; beaches, harbors, and bays along the shoreline of the lake, the outlets or mouths of streams and rivers where they enter Lake Erie; the harbors or bays along the Lake Erie shoreline; and, if present, marshes and wetlands. Collectively, the 49 focus areas within the Western Lake Erie watershed include all of these natural features.

Finally, impacts from the introduction and establishment of Hydrilla in these natural features could be cumulative under certain conditions, such that the long-term (permanent), direct, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these natural features from the introduction and establishment of Hydrilla could occur where a waterbody:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil (*Myriophyllum spicatum*); and/or
- Has existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct impacts from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect the waterbodies, resulting in a cumulative impact.

The above impact assessment on natural waterbody features is for the introduction and establishment of Hydrilla, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct, negative impacts on the affected natural features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Impacts on Socio-Cultural Features

The introduction and establishment of Hydrilla on socio-cultural features would result in a number of different impacts, depending on the type of socio-cultural feature. All of the socio-cultural features considered as part of this impact assessment are associated in some way with natural features that are located adjacent to, or are comprised of, waterbodies.

All of the types of socio-cultural features identified within the 49 focus areas along the shoreline of the Western Lake Erie watershed are located along shoreline areas or waterbody features within which Hydrilla is likely to be introduced and established. The impacts on these socio-cultural resources may be direct, where the purpose for, or use of, these socio-cultural features is typically water-dependent, or indirect, where the purpose for, or use of, these socio-cultural features is typically water-related, as discussed below.

The following socio-cultural features may be directly impacted by the introduction and establishment of Hydrilla:

- Private businesses (e.g., marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas, nature preserves, and wildlife management areas that contain or are located adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g, public boat launches, USCG stations, and harbors).

Collectively, the 49 focus areas within the Western Lake Erie watershed include all of these types of socio-cultural features.

The direct impacts on these socio-cultural features that would result from the introduction and establishment of Hydrilla would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of associated affected waterbody features, such that the purpose for, and use of, these socio-cultural features would be affected. For example, full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface, such that private businesses or governmental facilities such as marinas or harbors could no longer be used by boats; boating or fishing would no longer be desirable or viable activities; use of public parks and beaches along affected waterbodies would no longer be desirable for recreational activities; operation of water intake and discharge systems for industrial facilities would be affected; and
- Negative because the purpose for, or uses of, these socio-cultural features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

The following socio-cultural features may be indirectly impacted by the introduction and establishment of Hydrilla:

- Private businesses such as shoreline restaurants, bars, event sites, camps or retreats, campgrounds, mobile home parks, RV camping, resorts, and hotels;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, for enjoying scenic views and viewsheds);
- Built resources, particularly where underwater or waterfront setting is an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, enjoying scenic views and viewsheds); and
- Organizations associated with golfing, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

Collectively, the 49 focus areas within the Western Lake Erie watershed include all of these types of socio-cultural features.

The impacts on these socio-cultural features as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the appearance of the setting (visual or olfactory) of these socio-cultural features; and
- Negative because the intended purpose for, or use of, such features would be impaired, impeded, or prevented, such that they no longer would be enjoyable or desirable by their users or viable by their owners or managers.

As previously discussed for natural features, impacts on these socio-cultural features from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these socio-cultural features from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on socio-cultural features from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these features, resulting in a cumulative impact.

The above impact assessment on socio-cultural features has been for the introduction and establishment of Hydrilla within the 49 focus areas along the shoreline of the Western Lake Erie watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the socio-cultural features that are associated with these natural waterbody or marsh/wetland features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views because their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Impacts on the water-dependent or water-related uses associated with affected waterbodies are discussed in Section F.4.5.

F.4.5 Impacts on Water-Dependent or Water-related Uses of Resources

The introduction and establishment of Hydrilla would result in a number of different impacts on water-dependent or water-related uses within the 49 focus areas along the shoreline within the Western Lake Erie watershed, depending on the type of use and/or the type of natural or socio-cultural feature with which the use is associated. For the purposes of this impact assessment, natural features associated with water-dependent uses include the shoreline and littoral zones of Lake Erie and the Niagara River within the focus areas, such as the following features: coves, harbors, and bays; beaches; outlets or mouths of streams and rivers; and marshes and wetlands. However, all the natural features identified within the 49 focus areas along the Lake Erie and Niagara River shoreline are associated with water-related uses, including those identified above for water-related uses along with points and islands.

As discussed in Section F.4.4, socio-cultural features associated with water-dependent uses would include:

- Private businesses (e.g., marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches and other public facilities, such as boat ramps that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas, nature preserves, and wildlife management areas that contain or are located in or adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., power plants, sewage treatment plants, or water treatment plants); and
- Governmental facilities (e.g., public boat launches, USCG stations, and harbors).

Therefore, the introduction and establishment of Hydrilla is likely to have some type of impact on all of the water-dependent uses associated with these natural and socio-cultural features.

The following water-dependent uses may be directly impacted by the introduction and establishment of Hydrilla:

- Swimming;
- Recreational boating;
- Fishing;
- Sailing;
- Policing waterways and waterbodies;
- Power production; and
- Water and sewage treatment.

Similarly, socio-cultural features associated with water-related uses would include:

- Private businesses such as shoreline restaurants, bars, event sites, campgrounds, hotels, and bed and breakfasts;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, and for enjoying scenic views and viewsheds);

- Built resources (terrestrial and marine), particularly where underwater or waterfront settings are an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, and enjoying scenic views and viewsheds); and
- Organizations associated with yachting, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

The following water-related uses may be indirectly impacted by the introduction and establishment of Hydrilla:

- Dining;
- Drinking;
- Sightseeing;
- Sunbathing;
- Experiencing nature;
- Socializing in large group settings (weddings, picnics, conferences, camps, retreats);
- Vacationing;
- Preserving natural resources;
- Managing natural resources;
- Seasonal (vacation) housing;
- Permanent housing; and
- Commercial and industrial support facilities for recreational, seasonal, and permanent residential activities.

The impacts on the above water-dependent and water-related uses within the 49 focus areas as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), direct and indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it becomes established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would prevent or impede the water-dependent uses such that they could no longer take place;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the conditions within which such water-dependent uses can occur, such that these water-dependent uses could no longer be conducted or

sustained by their users or would no longer be considered viable by their owners or managers; and

- Negative where the introduction and establishment of Hydrilla physically prevents or detrimentally impairs these water-dependent uses or the management of these water-dependent uses.

For example, water-dependent uses such as recreational boating or sailing, and fishing would not be possible or would not be considered desirable water-dependent activities in a waterbody densely infested with Hydrilla. If such water-dependent uses were reduced, there would be a concurrent reduced need for boat maintenance or storage facilities in the absence of recreational boating, sailing, or fishing. The boating actions associated with policing affected waterbodies or using affected waterbodies that are harbors would be impaired. The use of water intakes and discharge outfalls associated with sewage treatment, water treatment, and power plants would be impeded such that treatment or power production would be impaired.

Similarly, water-related uses would be considered less desirable primarily because of changes to the setting (visual or olfactory) of socio-cultural features that support such activities. Waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing. Similarly, shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing or enjoying nature. Waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities. With changes to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary. Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

As discussed above for natural and socio-cultural features, impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or

- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on water-dependent or water-related uses from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these uses, resulting in a cumulative impact.

The above impact assessment on water-dependent or water-related uses has been for the introduction and establishment of Hydrilla within the 49 focus areas along the shoreline in the Western Lake Erie watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features for the 49 focus areas are associated with water-dependent uses (e.g., boating and fishing). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, such that their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants or parks). Where the introduction and establishment of Hydrilla would result in impacts on natural or socio-cultural features and/or associate water-dependent or water-related uses, it is likely that perceptions about these features and uses would change. Possible changes to perceptions about the natural or socio-cultural features and their associated water-dependent and water-related uses are considered in Section F.3.6.

F.4.6 Impacts on Community Perceptions of Features and Uses

As noted in Section F.4.3, counties, towns, and cities associated with the 49 focus areas along the shoreline of the Western Lake Erie watershed would manage the natural and socio-cultural features areas located along their respective shorelines or waterfronts to protect, enhance, promote, create, rehabilitate, redevelop, or develop water-dependent and water-related uses. Management would be according to the goals, policies, objectives, or recommendations that are memorialized in management plans that include these areas.

It is likely that natural and socio-cultural features that are located within the 49 focus areas along the shoreline in the Western Lake Erie watershed may be specifically identified in such plans, indicating that they would be perceived as locations, features, or attributes that define the local community or governmental unit and that they would be perceived and recognized as worthy of protection or improvement. Similarly, water-dependent and water-related uses associated with these natural and socio-cultural features may also be identified and described, either as part of planning efforts or via zoning ordinances, and discussed in such plans. This would indicate that such uses would be perceived as worthy of protection, management, creation, enhancement, or development.

Such perceptions would generally be expected to be identified or expressed by local individuals and groups that comprise the communities or governmental units responsible for the preparation of such plans and would be inherent in such plans because they were made known via charrettes, questionnaires, and other outreach efforts conducted as part of the preparation of such plans. Such local individuals and groups would be expected to be comprised of local residents, or non-local stakeholders with an interest in specific resources or for specific uses (such as individuals or companies that own and/or manage businesses, organizations, or facilities in an area but do not actually reside there). Additionally, the perceptions of federal, state, or local agencies that fund such planning efforts, or that provide guidance for the preparation of such plans, may also be incorporated into the preparation of such plans, albeit indirectly, via the requirements for the preparation of such plans or via the structure and/or content of meetings and materials included in outreach efforts.

Separately, the perceptions of individuals or groups that have an interest in specific or collective natural or socio-cultural features within the 49 focus areas along the shoreline in the Western Lake Erie watershed, or their associated water-dependent or water-related uses, may be lacking from such plans. Such individuals or groups may be seasonal users, state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and special interest groups whose involvement would be at a regional or national scale. For example, the perceptions of individuals or groups that are seasonal users would likely be expressed outside of such plans, by changes to patterns of visiting areas for recreational or other purposes, such as vacationing, camping, fishing, boating, etc. Similarly, the perceptions of state or federal agencies with management responsibilities for specific socio-cultural features located within the 49 focus areas along the shoreline in the Western Lake Erie watershed may also be lacking from such plans. These agencies would be as diverse as the Ohio State Historic Preservation Office, Ohio Department of Natural Resources/Division of Parks and Watercraft, Michigan State Historic Preservation Office, and Michigan Department of Natural Resources that manage parks, historic sites, natural areas, and public access for waterbodies; federal agencies such as the USACE, which manages navigable waterways, the USFWS, which manages national wildlife refuges, and the U.S. Nuclear Regulatory Commission, which manages nuclear power plants such as the Enrico Fermi Nuclear Power Plant.

Finally, the perceptions of special interest groups that would have a broad or unique interest in natural and socio-cultural features in the 49 focus areas along the shoreline in the Western Lake Erie watershed, and/or their water-dependent or water-related uses, would also be expressed outside of such plans. Such groups, whose primary perceptions would be related to regional, national, or cultural interests in a specific area, feature, or use, may include: additional federally recognized Indian tribes who may have a cultural or historical affiliation with areas that include such features and uses or may have retained treaty rights for use of such areas; or groups such as the Sierra Club, the Nature Conservancy, or Ducks Unlimited, which have national conservation interests that are applied at the local level via ownership of conservation areas or sponsorship for various conservation efforts.

As suggested above in the assessment of water-dependent and water-related uses of natural and socio-cultural features in the 49 focus areas, the potential impacts of the introduction and establishment of Hydrilla would be likely to occur where physical changes would have been made to the features or uses, or where there would be visual or olfactory changes to the setting of such features or uses. For example, the natural or socio-cultural features themselves may no longer be perceived as worthy of being protected, preserved, or managed for their intrinsic natural or socio-cultural values to a community. When changes are made to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary.

Similarly, the water-dependent or water-related uses associated with such features may no longer be perceived as desirable or viable. For example, waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing; shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities (e.g., sightseeing, sunbathing, or enjoying nature); waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities.

Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent and water-related uses within the 49 focus areas as a result of the introduction and establishment of Hydrilla have the potential to be long-term (permanent), direct indirect, and negative. Specifically, these impacts would likely be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;

- Indirect because while the introduction and establishment of Hydrilla would result in changes to the conditions of affected features or uses, it is the perceptions of these affected features or uses that could change; and
- Negative where the perceptions of affected features or uses conclude that such features and uses are no longer worthy of protection, management, creation, improvement, enhancement, or development.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent or water-related uses within the 49 focus areas from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on perceptions of affected features or uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality.

These conditions would tend to result in similar physical changes to waterbodies, such that the indirect impacts on perceptions of affected features or uses from introduction and establishment of Hydrilla would occur at a faster rate or would be greater, resulting in a cumulative impact.

The above impact assessment for perception of affected natural and socio-cultural features and their associated water-dependent or water-related uses within the 49 focus areas has been for the introduction and establishment of Hydrilla. It is understood that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies. While it would be unlikely for treatment to completely eliminate or reverse the physical impacts of the introduction and establishment of Hydrilla, treatment would likely receive considerable support by the communities, governmental units, state and federal agencies, stakeholders, special interest groups, and seasonal users in an effort to avoid or minimize impacts on the perceptions of affected features and uses.

F.4.7 Impacts on Community Character of Focus Areas in the Western Lake Erie Watershed

Dispersal modelling suggests that the primary method of introduction of Hydrilla into specific locations is via recreational boat use, such that locations where recreational boaters launch (via public boat launch or private boat launch locations) are most likely to result in the initial introduction of Hydrilla. It follows that the spread of Hydrilla likely would also occur at secondary locations that are accessible by recreational boaters but do not necessarily contain formal public or private boat launching facilities.

Therefore, impacts on community character resulting from the introduction and establishment of Hydrilla are most likely to occur in locations that: (1) have physical features (i.e., boat launch facilities) suitable for the introduction of Hydrilla; (2) have environmental conditions conducive to the establishment of Hydrilla if it is introduced; and (3) have community character defined by natural and socio-cultural features and associated water-dependent or water-related uses that would be affected by the introduction and establishment of Hydrilla. The 49 focus areas identified along the shoreline in the Western Lake Erie watershed either meet all of these criteria or, if a focus area lacks a public or private boat launch, meet the second and third criteria.

The potential impacts of the introduction and establishment of Hydrilla on the community character of the 49 focus areas along the shoreline in the Western Lake Erie watershed correlates to the impact conclusions for natural and socio-cultural features, their associated water-dependent or water-related uses, and the perceptions of such features and use by communities and governmental units, as discussed above in Sections F.4.4, F.4.5, and F.4.6. Specifically, the long-term (permanent), direct and/or indirect, and negative impacts of the introduction and establishment of Hydrilla on natural and socio-cultural features, on their associated water-dependent or water-related uses, and on the perceptions of these features and uses, also result in the same type of impacts on the community character of these focus areas. The impacts associated with the treatment of Hydrilla would be the same, as would the potential for cumulative impacts.

It is likely, however, that such impacts on community character would be perceived differently. The local individuals and groups that comprise the communities and governmental units associated with these 49 focus areas likely would consider such impacts differently from seasonal users, from state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and from special interest groups whose involvement would be at a regional or national scale. Additionally, impacts on community character would occur at different rates over time, depending on the nature of the affected individuals, groups, agencies, or users.

For example, local individuals and groups that comprise the communities and governmental units associated with these 49 focus areas likely would recognize the impacts. However, they may be reluctant to accept the changes to their community character and be slow to participate in necessary revisions to the management of affected natural and socio-cultural features and their associated water-dependent or water-related uses that would alter their existing community character.

Conversely, state or federal agencies and special interest groups that operate regionally or nationally likely would recognize the impacts and would accept such changes to the affected features and uses. However, they also may be slow to participate in necessary revisions to the management of affected features and uses for any number of administrative reasons (e.g., limited manpower, limited budget, and limited regulatory authority).

Finally, it is likely that seasonal users may differ greatly from both of these other groups. Seasonal users would be likely to recognize the impacts, and while reluctant to accept the changes to community character, quick to abandon those areas that contain affected natural and socio-cultural features and their associated water-dependent and water-related uses. Changes to their seasonal use of affected areas may be either in favor of other similar areas that remain unaffected by the introduction and establishment of Hydrilla or may represent a greater shift in favor of other areas with features and uses that would never be affected by the introduction and establishment of Hydrilla.

F.4.8 Impacts on the Community Character of the Western Lake Erie Watershed

The 49 focus areas along the shoreline in the Western Lake Erie watershed were selected specifically because they contain conditions that are conducive to the introduction and establishment of Hydrilla. Therefore, the potential impacts on the natural and socio-cultural features and their associated water-dependent and water-related uses that contribute to the community character of these focus areas may appear to be disproportionately emphasized when compared to the potential for similar impacts along the entire Lake Erie shoreline or within the Western Lake Erie watershed.

For the Western Lake Erie watershed as a whole, dispersal modelling predicted that by 2025, approximately 4% of the total waterbody area within the watershed would be affected by Hydrilla (see Table 3.1.5-1 in the risk assessment). Given the overall size of the Western Lake Erie watershed and prevalence of water resources, it can be inferred based on the dispersal model results that future (2025) impacts from the introduction and establishment of Hydrilla on the overall community character of the watershed would be relatively small when considered for the entire watershed. However, if perchance all future Hydrilla infestations were to occur along the Lake Erie shoreline in one or more of the 49 focus areas evaluated in this analysis, the collective impacts likely would garner more attention and have a greater collective impact, especially if future infestations are concentrated in one or more of the high-use, high-value areas located on the shoreline, such as Sandusky Bay.

Although this section describes potential future impacts from Hydrilla in focus areas along the Lake Erie shoreline, it is expected that similar impacts from the introduction and establishment of Hydrilla would occur at various locations throughout the interior of the Western Lake Erie watershed. However, it is likely that these impacts would be more localized at or near the point of introduction, and would individually affect a smaller number of natural and socio-cultural features and a smaller number of associated water-dependent or water-related uses. Therefore, perceptions of the impacts on such features and uses, and their overall effect on the community character of the entire watershed would be diluted over a larger area.

As indicated by the above impact analysis, the Lake Erie shoreline represents a distinct component of the community character of the entire Western Lake Erie watershed that differs in size and nature when compared to the smaller and dispersed waterbodies (lakes, ponds, rivers, creeks, and streams) that are located in the interior of this watershed. Thus, it is not unusual that the potential impacts of the introduction and establishment of Hydrilla, with or without treatment to control its spread, would be considered a prominent factor in the future of the Western Lake Erie watershed.

F.4.9 Conclusions and Recommendations

The introduction and establishment of Hydrilla into the Western Lake Erie watershed has the potential to result in long-term (permanent), direct and indirect, negative impacts on natural and socio-cultural features and their associated water-dependent and water-related uses that comprise the socio-cultural setting of this watershed. Similar impacts would be expected on the perceptions of these features and uses. Collectively, these impacts would represent long-term, indirect, negative impacts on the community character of this watershed.

These conclusions were based on the analysis of features and associated uses that were identified from: publicly available databases and planning documents; overlays for Google Earth; 7.5-minute USGS topographic quadrangles; and/or coastal maps maintained in the NOAA’s Office of Coast Survey Historical Map and Chart Collection. These conclusions were also developed considering the management of such features and uses that may be represented in comprehensive plans or master plans for the various counties, towns, and cities located along the shoreline in the Western Lake Erie Watershed and/or identified and discussed in other Lake Erie shoreline-specific management plans, such as planning documents developed by the Ohio Lake Erie Commission and its member agencies.

These conclusions are based on the analysis of impacts on natural and socio-cultural features and associated water-dependent and water-related uses identified for 49 focus areas that collectively represent approximately 95.8 miles (32%) of the approximately 295-mile-long shoreline in the Western Lake Erie watershed. However, these conclusions are considered generally representative of potential impacts that would occur in interior areas of this same watershed and would be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

Separately, as discussed in this impact assessment (see Sections F.4 and F.4.6), there are a wide variety of agencies, organizations, and special interest groups, in addition to the many communities and governmental units with authority or jurisdiction over the shoreline in the Western Lake Erie watershed, that may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the watershed. These stakeholders would include, but may not be limited to:

- State agencies such as Ohio State Historic Preservation Office, Ohio Department of Natural Resources/Division of Parks and Watercraft, Michigan State Historic Preservation Office, and Michigan Department of Natural Resources that manage parks, historic sites, natural areas, and public access for waterbodies;
- Federal agencies such as the USACE, which manages navigable waterways throughout the Western Lake Erie watershed, the USFWS, which manages national wildlife refuges, and the U.S. Nuclear Regulatory Commission, which manages nuclear power plants such as the Enrico Fermi Nuclear Power Plant;
- Federally recognized Indian tribes that have a cultural or historical affiliation with various areas in the Western Lake Erie watershed or retain treaty rights to lands, waters, and resources within the Western Lake Erie watershed; and,
- Special interest groups ,such as The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that may have a broadly defined interest in areas and resources along the shoreline and in interior areas of the Western Lake Erie watershed.

Outreach efforts by the USACE with the various communities and governmental units for all of the counties, towns, cities, and other areas (such as Cattaraugus Indian Reservation) at both the federal (including government-to-to-government), agency and public level is encouraged in order to collaboratively identify and develop strategies related to raising awareness for, controlling, and jointly managing the introduction and establishment of Hydrilla in this watershed. Similarly, the USACE should consider additional similar outreach efforts with the various stakeholders identified above for the same reasons. Many of these communities, governmental units, and stakeholders already have experience managing invasive aquatic plant species other than Hydrilla, and would likely welcome the opportunity to avoid or minimize the potential for new and/or cumulative impacts on the natural and socio-cultural features and associated water-dependent or water-related uses that they already manage or value.

F.4.10 References

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Attachment F-4

Natural and Socio-Cultural Features Along the Shoreline in the Western Lake Erie Watershed

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Vermilion	OH	Erie	City of Vermilion	Community	Lakefront community located on the Lake Erie shores and Vermilion River	1
Vermilion River	OH	Erie	City of Vermilion	Natural feature	Tributary to Lake Erie	1
Vermilion Yacht Club	OH	Erie	City of Vermilion	Organization	Yacht club and marina on Vermilion River, offering access to the River and Lake Erie as well as facilities and social events	1
Vermilion Power Boats	OH	Erie	City of Vermilion	Organization	Yacht club and marina on Vermilion River, offering access to the River and Lake Erie as well as facilities and social events	1
Trolling Eye Charters	OH	Erie	City of Vermilion	Private business	Fishing charter service offering walleye fishing trips on Lake Erie	1
Romp's Water Port Marina	OH	Erie	City of Vermilion	Organization	Yacht club and marina on Vermilion River, offering access to the River and Lake Erie as well as facilities and social events	1
Key Harbour Marina	OH	Erie	City of Vermilion	Private business	Full service marina on Vermilion River offering access to the River and Lake Erie as well as facilities and social events	1
Valley Harbor Marina	OH	Erie	City of Vermilion	Private business	Full service marina on Vermilion River offering access to the River and Lake Erie as well as facilities and social events	1
Vermilion Boat Launch	OH	Erie	City of Vermilion	Boat Launch	Public boat launch on Vermilion River offering access to the river and Lake Erie	1
Vermilion Wastewater Treatment	OH	Erie	City of Vermilion	Industrial facility	Wastewater treatment utility facility located on Vermilion River	1

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Lucky Duck Charters	OH	Erie	City of Vermilion	Private business	Fishing charter service offering walleye and perch fishing trips on Lake Erie	1
West River Paddling Co.	OH	Erie	City of Vermilion	Private business	Watersports rental shop offering kayak, canoe, and paddleboard rentals, as well as lessons and tours	1
Mega Bites	OH	Erie	City of Vermilion	Private business	Fishing charter service offering walleye and perch fishing trips on Lake Erie	1
Just One More Lake Erie Fishing Charters	OH	Erie	City of Vermilion	Private business	Fishing charter service offering walleye and perch fishing trips on Lake Erie	1
Don Parsons Inc.	OH	Erie	City of Vermilion	Private business	Private marina and boat repair shop located on Vermilion River	1
Moes Marine Service	OH	Erie	City of Vermilion	Private business	Marine sports/boat repair and sales shop located on Vermilion River	1
Vermilion Boat Club	OH	Erie	City of Vermilion	Organization	Private boat club located on Vermilion river, offering facilities, swimming pool, dockage, social events, etc.	1
Sail Loft	OH	Erie	City of Vermilion	Built resource	NRHP Listed structure; NPS # 79003927	1
Steamboat Hotel	OH	Erie	City of Vermilion	Built resource	NRHP Listed structure; NPS # 79003947	1
Kishman Fish Company Buildings	OH	Erie	City of Vermilion	Built resource	NRHP Listed structure; NPS # 79003959	1
Vermilion Municipal Docks	OH	Erie	City of Vermilion	Built resource	Public docks available along Vermilion River offering access to historic Main Street from river	1
Ruggles Beach	OH	Erie	Berlin Township	Community	Beachfront community along Lake Erie shoreline	3

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Cranberry Creek	OH	Erie	Berlin Township	Natural feature	Tributary to Lake Erie	3
Cranberry Creek Marina	OH	Erie	Berlin Township	Private business	Marina, bait and tackle shop, and repair service business located along Lake Erie shores and Cranberry Creek	3
Reeltime Cottages	OH	Erie	Berlin Township	Private business	Vacation home rental agency located along Lake Erie shoreline	3
Old Woman Creek	OH	Erie	Berlin Township	Natural Feature	Tributary to lake Erie	4
Old Woman Creek National Estuarine Research Reserve	OH	Erie	Berlin Township	Conservation area	Wildlife and nature reserve located along Lake Erie shoreline and Old Woman Creek	4
Huron	OH	Erie	City of Huron	Community	Lakefront city along Lake Erie with a population of 7,149 as of 2010.	5
Nickel Plate Beach	OH	Erie	City of Huron	Public park	Beach and park along lake Erie shoreline offering beach area, swimming, playgrounds, ball fields/courts, etc.	5
Light	OH	Erie	City of Huron	Built resource	Light at the end of fishing pier within Lake Erie	5
Huron Range	OH	Erie	City of Huron	Natural feature	Water feature at the mouth of Huron River	5
Huron River	OH	Erie	City of Huron	Natural Feature	Tributary to lake Erie	5
Huron Lime Co (Mississippi Lime)	OH	Erie	City of Huron	Private business	Lime/limestone supplier using Huron River and Lake Erie for transport	5
Huron Boat Ramp	OH	Erie	City of Huron	Boat Launch	Public boat launch located on Huron River	5
Huron Lagoons Marina	OH	Erie	City of Huron	Private business	Marina, boat sales, storage and repair facilities offering sales, dockage, restaurant, etc.	5

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Mud Brook	OH	Erie	City of Huron	Natural feature	Tributary to Huron River	5
Holiday Harbor Marina	OH	Erie	City of Huron	Private business	Marina and boat repair services located along Mud Brook	5
Harbor North	OH	Erie	City of Huron	Private Business	Boat dealer located along Huron River	5
Huron Yacht Club	OH	Erie	City of Huron	Organization	Yacht club, marina, boat sales, and boat repair services located along Huron River	5
Huron Boat Basin	OH	Erie	City of Huron	Public facility	Public docking area within Huron River	5
Comfort Inn River's Edge	OH	Erie	City of Huron	Private business	Riverside hotel/motel located along Huron River, offering riverfront views	5
Harbor House Bar and Grill	OH	Erie	City of Huron	Private Business	Bar/Grill located along the Huron River, offering outdoor seating along the river and docking for customers	5
Old Fish House	OH	Erie	City of Huron	Private business	Café/Bar located at the mouth of Huron River, offering riverfront views	5
Huron Rotary Centennial Park	OH	Erie	City of Huron	Public park	River/lakefront public park offering fishing pier, lighthouse, beach area, etc.	5
Nickel Plate Beach Fishing Pier	OH	Erie	City of Huron	Public park	Fishing pier located at the mouth of Huron River, on Lake Erie; offering fishing access on Lake Erie	5
Sawmill Creek	OH	Erie	Huron Township	Natural feature	Tributary to Lake Erie	6
Sawmill Creek Resort	OH	Erie	Huron Township	Private business	Lakefront resort offering event center, catering hall, full service marina, golf course, restaurants, shops, beach area, lodging, etc.	6

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Sheldon Marsh State Nature Preserve	OH	Erie	Huron Township	Conservation area	Lakefront marsh nature preserve offering hiking trails, beach area, marsh ecosystem preservation, birding, etc.	7
Sandusky	OH	Erie	City of Sandusky	Community	Historic lakefront city with many lakefront neighborhoods, population of approximately 25,000	7
Griffing Sandusky Airport	OH	Erie	City of Sandusky	Airport	Lakefront airport offering charters, tours and flying lessons	7
Bayshore Estate MHC	OH	Erie	City of Sandusky	Community	Bayfront mobile home park offering bay-front living, and views of Sandusky Bay	7
Castaway Bay	OH	Erie	City of Sandusky	Natural Feature	Bay within Sandusky bay fed by Pipe Creek	7
Pipe Creek	OH	Erie	City of Sandusky	Natural feature	Tributary to Castaway Bay	7
Marina Villa Condominium	OH	Erie	City of Sandusky	Community	Condominium complex located on Castaway bay offering bay views and community center	7
Harbour Homeowners Association	OH	Erie	City of Sandusky	Organization	Community organization governing the 188 properties that make up the Harbour community	7
Castaway Bay Marina	OH	Erie	City of Sandusky	Private business	Marina and docks connected with Castaway Bay Hotel and Waterpark	7
Castaway Bay (Hotel)	OH	Erie	City of Sandusky	Private business	Hotel connected to Castaway Bay Waterpark	7
Castaway Bay	OH	Erie	City of Sandusky	Private business	Island-themed waterpark located on Castaway Bay, with lodging	7
WWW Boat Services Inc.	OH	Erie	City of Sandusky	Private business	Boat dealer located on Castaway Bay	7

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Pipe Creek Marina Bait and Tackle	OH	Erie	City of Sandusky	Private business	Marina service, docking, bait and tackle shop, and fishing charter service located on Castaway Bay	7
Pipe Creek Wildlife Area	OH	Erie	City of Sandusky	Conservation area	Lakefront (bay-front) wildlife park offering walking trails and access to Sandusky Bay	7
Water Treatment Plant	OH	Erie	City of Sandusky	Industrial facility	Water treatment/filtration facility located in Sandusky Bay	7
Firelands Canvas	OH	Erie	City of Sandusky	Private business	Boat canopy and custom interior service	7
Venetian Marina	OH	Erie	City of Sandusky	Private business	Full service marina offering service center, dockage, pool, picnic area, etc.	7
Lyman Harbor	OH	Erie	City of Sandusky	Private business	Catering hall, event/conference center, pub and marina located in Sandusky Bay	7
Son Rise Marina	OH	Erie	City of Sandusky	Private business	Full service marina offering service center, dockage, pool, picnic area, etc.	7
Cedar Point	OH	Erie	City of Sandusky	Natural Feature	Barrier peninsula of the coast of Sandusky, OH	7
Cedar Point	OH	Erie	City of Sandusky	Private business	Amusement park located on Cedar Point, including multiple lakefront restaurants (Bay Harbour, Famous Dave's BBQ), lodging, campgrounds, historic landmarks and rides, marinas	7
Great American Racing Derby	OH	Erie	City of Sandusky	Built resource	NRHP listed amusement park ride, NPS # 90000626	7
Muller, Daniel C., Carousel	OH	Erie	City of Sandusky	Built resource	NRHP listed amusement park ride, NPS # 82001426	7

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Dentzel, William H., 1924 Carousel	OH	Erie	City of Sandusky	Built resource	NRHP listed amusement park ride, NPS # 90000625	7
Coliseum	OH	Erie	City of Sandusky	Built resource	NRHP listed resource, NPS # 82001385	7
Cedar Point Light	OH	Erie	City of Sandusky	Built resource	NRHP listed resource, NPS # 84003667	7
Sandusky Harbor Lighthouse	OH	Erie	City of Sandusky	Built resource	Historic lighthouse located off of Cedar Point within Lake Erie	7
U.S. Coast Guard Building	OH	Erie	City of Sandusky	Government facility	NRHP listed resource, NPS # 82001449	7
Dentzel, William H., 1921 Carousel	OH	Erie	City of Sandusky	Built resource	Historic amusement park ride, NPS # 90000627	7
Cross View Marine Services	OH	Erie	City of Sandusky	Private business	Indoor marine storage facility	7
Marine Discounters	OH	Erie	City of Sandusky	Private business	Marine parts and services warehouse	7
Cove Dwellers Vacation Rentals	OH	Erie	City of Sandusky	Private business	Vacation home rental agency in the 'Cove District' of Sandusky	7
Geno's Holiday Charters	OH	Erie	City of Sandusky	Private business	Walleye and Perch fishing charters offering fishing trips on Lake Erie	7
Dockside Accommodatio ns	OH	Erie	City of Sandusky	Private business	Vacation home rental agency in the offering lakeside "Florida Keys themed" rentals	7
Sandusky Bay Marine Restoration	OH	Erie	City of Sandusky	Private business	Full-service marine repair and restoration shop in Sandusky Bay	7
Cove Carry-Out	OH	Erie	City of Sandusky	Private business	Gas dock and dockside convenience store located in Sandusky bay	7
Sandusky Sailing Club	OH	Erie	City of Sandusky	Organization	Boating club on Sandusky bay, offering sailing lessons, races, community events, etc.	7
Meigs Street pier	OH	Erie	City of Sandusky	Built resource	Pier in Sandusky Bay offering fishing access	7

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Battery Park Marina	OH	Erie	City of Sandusky	Private business	Marina offering 600+ slips, 5 acre park (Battery Park), shopping, facilities, etc.	7
Sandusky Yacht Club	OH	Erie	City of Sandusky	Organization	Marina and yacht club on Sandusky Bay offering docking, clubhouse, event space, restaurant, etc.	7
Shoreline Park	OH	Erie	City of Sandusky	Public Park	Lakeside park offering bike rentals, lake views, concessions, etc.	7
New Sandusky Fish Company	OH	Erie	City of Sandusky	Private business	Fish and seafood restaurant located on Sandusky Bay	7
Erie Shore Hookers Bait and Tackle	OH	Erie	City of Sandusky	Private business	Bait and tackle shop located on Sandusky bay, offering licenses, charters, etc.	7
Viewpoint Apartments	OH	Erie	City of Sandusky	Apartment Complex	Senior living apartments offering views of Lake Erie and Sandusky Harbor	7
West Marine	OH	Erie	City of Sandusky	Private business	Marine supply store offering boating and fishing needs, located along Sandusky Harbor	7
Dock of the Bay Marina	OH	Erie	City of Sandusky	Private business	Full service marina locate in Downtown Sandusky along Sandusky harbor	7
Jet Express	OH	Erie	City of Sandusky	Private business	Ferry service offering lake transportation to multiple different ports in OH	7
Goodtime Lake Erie Island Cruises	OH	Erie	City of Sandusky	Private business	Events cruise line offering party cruises, family cruises, private events, etc.	7
Chesapeake Lofts	OH	Erie	City of Sandusky	Apartment building	Lakefront apartment complex offering views of Sandusky Bay	7
Ohio Lake Erie Commission	OH	Erie	City of Sandusky	Organization	Lake Erie environmental conservation advocate organization	7

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Dockside Café	OH	Erie	City of Sandusky	Private business	Restaurant offering docking and waterfront dining on Lake Erie/Sandusky Bay	7
Boeckling, G.A., (side-paddlewheel steamboat)	OH	Erie	City of Sandusky	Built resource	NRHP Listed steamboat in Sandusky Bay; NPS # 83001959	7
Sandusky Boat Basin	OH	Erie	City of Sandusky	Public facility	Public marina on Sandusky Bay offering overnight docking and floating docks	7
Paper District Marina	OH	Erie	City of Sandusky	Public facility	Public marina on Sandusky Bay offering floating docks, facilities, etc.	7
Deep Water Marina	OH	Erie	City of Sandusky	Public facility	Public marina on Sandusky Bay offering a crane boat hoist	7
City of Sandusky Boat Launch	OH	Erie	City of Sandusky	Boat Launch	Large, public boat launch/ramp offering access to Lake Erie/Sandusky Bay, and a small park	7
Sandusky Wastewater Treatment	OH	Erie	City of Sandusky	Industrial facility	Wastewater treatment facility located on Sandusky Bay	7
Craft Marine	OH	Erie	City of Sandusky	Private business	Winter boat storage warehouse/facility on Sandusky Bay	7
Sandusky Harbor Marina	OH	Erie	City of Sandusky	Public facility	Public marina on Sandusky Bay offering access to Lake Erie, fishing, boat storage, etc.	8
Lagoon Deer Park	OH	Erie	Margaretta Township	Private business	Park and petting zoo offering a variety of tamed animals, fishing, gift shop	9
Bay View Boat and RV Storage	OH	Erie	Margaretta Township	Private business	Boat and RV storage facility located on Sandusky Bay	9
Clemons Boats	OH	Erie	Margaretta Township	Private business	Boat dealership and rental service located on Sandusky bay	10

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Driftwood Cottages	OH	Erie	Margaretta Township	Private business	Vacation home rental agency offering lakeside cottages	10
Badman Charter	OH	Erie	Margaretta Township	Private business	Fishing boat charter service, offering fishing trips on Lake Erie	10
Willow Point Wildlife Area	OH	Erie	Margaretta Township	Conservation area	Wildlife area offering views of Lake Erie, wetland ecosystems, birding and other wildlife siting, etc.	11
Ohio Agricultural Experimental Station (North Central Substation)	OH	Erie	Margaretta Township	Conservation area	Wildlife area offering views of Lake Erie, wetland ecosystems, birding and other wildlife siting, etc.	11
Bay Harbor Marina	OH	Erie	Margaretta Township	Private business	Marina offering seasonal dockage, ramping, fuel, and storage services	12
Pickerel Creek Wildlife Area	OH	Sandusky	Townsend Township	Conservation area	Wildlife area offering birding, hunting, hiking trails, etc.	12
The Bogs	OH	Sandusky	Riley Township	Natural feature	Unique ecosystem and water feature in Muddy Creek Bay	15
Muddy Creek Bay	OH	Sandusky	Riley Township	Natural feature	Bay at western end of Sandusky bay, feeding Sandusky River and Muddy Creek	16
South Creek	OH	Sandusky	Riley Township	Natural feature	Tributary to Muddy bay creek	16
Hickory Island	OH	Sandusky	Riley Township	Natural feature	Island within “The Bogs” in Muddy Creek Bay	16
Squaw Island	OH	Sandusky	Riley Township	Natural feature	Island within Muddy Creek Bay	16
Green Creek	OH	Sandusky	Riley Township	Natural feature	Tributary to Muddy Bay Creek	16
Sandusky River	OH	Sandusky	Riley Township	Natural feature	Tributary to Muddy Bay Creek	16
Redhead Cove	OH	Sandusky	Rice Township	Natural feature	Cove at the mouth of Muddy Creek	16
Muddy Creek	OH	Sandusky	Rice Township	Natural feature	Tributary to Muddy Bay Creek	16

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Horseshoe Island	OH	Ottawa	Bay Township	Natural feature	Island within Muddy Creek Bay	16
Willow Bend Resort	OH	Ottawa	Danbury Township	Campground	Campground and RV park offering community activities, electric hookups, facilities, etc. Located on Sandusky Bay	16
Danbury	OH	Ottawa	Danbury Township	Community	Lakefront community located on Sandusky Bay	17
Kamp Kozy	OH	Ottawa	Danbury Township	Retreat	Lakefront campgrounds and cottage rentals located on Sandusky bay offering docking, marina, access to Lake Erie, etc.	17
Zeller's Beach Park	OH	Ottawa	Danbury Township	Retreat	Campground and beach club offering swimming, camping, access to Lake Erie, located on Sandusky Bay	18
Plymouth Shore on the Bay	OH	Ottawa	Danbury Township	Retreat	RV park offering marina, beach area, pool, fishing, etc.	19
Meadow Brook	OH	Ottawa	Danbury Township	Natural feature	Tributary to Sandusky bay	19
South Beach Resort	OH	Ottawa	Danbury Township	Private business	Lakefront hotel and condominium rental service offering access to Lake Erie, marina, beach area, fishing, etc.	19
Bay Willo Lodges	OH	Ottawa	Danbury Township	Private business	Vacation home rental agency located on Sandusky Bay	19
Castaway Harbor	OH	Ottawa	Danbury Township	Campground	Campground, marina and mobile home park located on Sandusky Bay	20
Avalon on the Bay Waterfront Cottage	OH	Ottawa	Danbury Township	Private business	Lake cottage rental located on Sandusky Bay	20

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Mineyahta on-the-Bay	OH	Ottawa	Danbury Township, and Village of Marblehead	Community	Lakefront neighborhood on Sandusky Bay	20
Johnson's Island	OH	Ottawa	Village of Marblehead	Community	Island neighborhood within Sandusky Bay	21
Bay Point Shoal	OH	Ottawa	Village of Marblehead	Community	Lakefront neighborhood on peninsula within Sandusky Bay	22
Bay Point Marina	OH	Ottawa	Village of Marblehead	Private business	Marina located in Sandusky Bay	22
Boat Ramp	OH	Ottawa	Village of Marblehead	boat launch	Boat launch on Bay Point Shoal offering access to Lake Erie	22
Kaspar's Lake Breeze Cabins	OH	Ottawa	Village of Marblehead	Private business	Lakefront cottage rental agency offering rentals on Lake Erie shores	23
Lake Point Park	OH	Ottawa	Village of Marblehead	Public park	Lakefront park offering playground, lake, fishing, grills, etc.	23
Lakeside Daisy State Nature Preserve	OH	Ottawa	Village of Marblehead	Conservation area	Nature preserve located on Marblehead in an old Limestone quarry	23
U.S. Coast Guard	OH	Ottawa	Village of Marblehead	Government facility	U.S. Coast Guard station along Lake Erie shoreline	24
Lakeside	OH	Ottawa	Danbury Township	Community	Lakefront community on Marblehead peninsula	25
Mazurik Boat Access	OH	Ottawa	Danbury Township	Boat launch	Public boat launch offering access to Lake Erie	25
Shrock's Marina	OH	Ottawa	Danbury Township	Private business	Marina and restaurant/bar located on Lake Erie shoreline	25
Hidden Beach Bar	OH	Ottawa	Danbury Township	Private business	Restaurant and bar offering outdoor seating, Lake Erie views, Lake Erie fish, etc.	25
Marblehead Harbor Marina	OH	Ottawa	Danbury Township	Private business	Marina offering dockage and direct access to Lake Erie and seasonal camping	25

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Lakevue Marina	OH	Ottawa	Danbury Township	Private business	Marina and watersports rental service offering drive up docks, kayak sales and rentals, etc.	25
East Harbor	OH	Ottawa	Danbury Township	Natural feature	Natural water inlet and harbor on Lake Erie	25
Channel Grove Marina	OH	Ottawa	Danbury Township	Private business	Full service marina on East Harbor offering docking, access to Lake Erie fishing	25
Mar-Lu Marina	OH	Ottawa	Danbury Township	Private business	Fishing resort offering cottage rentals, marina, fish cleaning services, etc.	25
Skippers Marina and Resort	OH	Ottawa	Danbury Township	Private business	Lakefront resort offering cottage rentals waterfront views, etc.	25
Harbor Winds RV Park and Marina	OH	Ottawa	Danbury Township	Campground	RV Park and Marina offering RV and mobile home lots, and access to Lake Erie	25
Rock Harbor Cottage & Reef Bobber Charters	OH	Ottawa	Danbury Township	Private business	Lakefront resort offering lakeside cottages and fishing charter services	25
Tibbels Marina & Fishing Charter Service	OH	Ottawa	Danbury Township	Private business	Fishing charter service offering fishing trips on Lake Erie as well as fishing gear, licenses, etc.	25
Skipper Bud's	OH	Ottawa	Danbury Township	Private business	Marina and boat dealer located on East Harbor in Lake Erie	25
Bass Haven Marina	OH	Ottawa	Danbury Township	Private business	Full service marina offering docking, cranes, picnic shelters, bait and tackle shop, storage facility, etc.	25
Harbor's Edge	OH	Ottawa	Danbury Township	Private business	Lakefront resort offering mobile home and RV lots, cabin rentals, marina and docking, boat repairs, etc.	25

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
East Harbor State Park	OH	Ottawa	Danbury Township	Public Park	Recreation area on the shores of Lake Erie with scenic wetlands, wildlife, a beach & camping.	25
Woody's Boathouse and Gifts	OH	Ottawa	Portage Township	Private business	Lakefront gift shop offering maritime themed items	26
Fort Firelands	OH	Ottawa	Danbury Township	Retreat	RV resort and campground offering lake Erie views and access, flea market, restaurant, etc.	26
Great Egret Marsh Nature Preserve	OH	Ottawa	Danbury Township	Conservation area	Large wetland/marsh ecosystem preserve and park offering wildlife viewing, etc.	26
West harbor Marina	OH	Ottawa	Danbury Township	Private business	Marina and condominiums offering docking and condo sales/rentals along Lake Erie shores	26
East Harbor State Park Marina	OH	Ottawa	Danbury Township	Public facility	Marina offering docking, restaurant, facilities, etc.	26
Crabby Joe's Dockside	OH	Ottawa	Danbury Township	Private business	Lakefront restaurant offering Lake Erie views and seafood	26
Anchors Away marina	OH	Ottawa	Danbury Township	Private business	Marina offering seasonal docking, access to Lake Erie, facilities, storage, etc.	26
Eye-Catcher Charters	OH	Ottawa	Danbury Township	Private business	Fishing charter offering fishing trips on Lake Erie	26
West Harbor	OH	Ottawa	Catawba Island Township, Danbury Township	Natural/Built feature	Harbor and inlet adjacent to Lake Erie containing many marinas and docks, etc.	26
Gem Beach and Marina	OH	Ottawa	Catawba Island Township	Organization	Beach and boat club offering memberships, docking, access to Lake Erie and club house	26

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Nor' Easter Club	OH	Ottawa	Catawba Island Township	Organization	Private beach/boat club offering clubhouse, pool, marina, catering hall, private event space, etc.	26
Foxhaven Marina	OH	Ottawa	Catawba Island Township	Private business	Full service marina offering over 500 docks, fueling, pump out, etc.	26
Pier 53 Marina	OH	Ottawa	Catawba Island Township	Private business	Marina and boat dealership offering dockage and new and used boats for sale	26
Catawba Moorings	OH	Ottawa	Catawba Island Township	Private business	Marina and boat dealership offering dockage and new and used boats for sale	26
Catawba Landing Marina	OH	Ottawa	Catawba Island Township	Private business	Full service marina offering pump out, fueling, docking, storage and repair facilities	26
MarineMax	OH	Ottawa	Catawba Island Township	Private business	Boat dealership located on West Harbor off Lake Erie	26
Boat Ramp	OH	Ottawa	Catawba Island Township	Boat Launch	Public boat launch offering access to West Harbor and Lake Erie	26
Erie Express Fishing Charters	OH	Ottawa	Catawba Island Township	Private business	Fishing charter service offering Lake Erie fishing trips	26
Midway Marina	OH	Ottawa	Port Clinton	Private Business	Full service marina and plaza offering docking, storage facility, shopping plaza, pool, picnic pavilion, etc.	26
South Bass Island	OH	Ottawa	Put-in-Bay Township, and Village of Put-in-Bay	Natural feature	Island in Lake Erie	27
Gibraltar Island	OH	Ottawa	Put-in-Bay Township	Natural feature	Island in Lake Erie within Pu-in-Bay	27
Put-in-Bay	OH	Ottawa	Put-in-Bay Township, and Village of Put-in-Bay	Natural feature	Bay along South Bass Island	27

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Put-in-Bay	OH	Ottawa	Put-in-Bay Township, and Village of Put-in-Bay	Community	Island community on South Bass Island	27
Inselruhe	OH	Ottawa	Village of Put-in-Bay	Built resource	NRHP listed mansion on South Bass Island; NPS # 76001506	27
Perry's Victory & International Peace Memorial	OH	Ottawa	Village of Put-in-Bay	Public park	NRHP Listed Public park along Put-in-Bay and Lake Erie shores; NPS # 66000118	27
The Keys	OH	Ottawa	Village of Put-in-Bay	Private business	Lakefront island-themed restaurant and bar, offering outdoor seating, Lake Erie views, live music, social events, etc.	27
Park Place Boat Club	OH	Ottawa	Village of Put-in-Bay	Organization	Marina and boat club offering preferred docking, facilities, Put-in-Bay community benefits, etc.	27
Perry Park	OH	Ottawa	Village of Put-in-Bay	Public park	Lakefront park offering Lake Erie views	27
Put-in-Bay Parasail	OH	Ottawa	Village of Put-in-Bay	Private business	Parasailing ours and stand-up paddle board rentals on Lake Erie	27
The Boardwalk	OH	Ottawa	Village of Put-in-Bay	Private business(es)	Lakefront business complex offering multiple seafood restaurants, bars, and live music events, Lake Erie views, etc.	27
Miller Boat Line	OH	Ottawa	Village of Put-in-Bay	Private business	Water taxi/ferry service offering transport from South Bass Island to Mainland OH	27
Miller Marina	OH	Ottawa	Put-in-Bay Township	Private business	Marina offering dockage for South Bass Island and access to Lake Erie	27
Kayak the Bay, Ltd.	OH	Ottawa	Put-in-Bay Township	Private business	Kayak rental service along Pu-in-Bay offering kayak tours, etc.	27

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Oak Point State Park	OH	Ottawa	Put-in-Bay Township	Public Park	Lakefront state park offering access to Lake Erie, fishing, picnic areas	27
Aquatic Visitors Center	OH	Ottawa	Put-in-Bay Township	Museum	Educational center focused on Lake Erie aquatic science	27
Peach Orchard Point	OH	Ottawa	Put-in-Bay Township	Natural feature	Lookout point on Lake Erie at northern tip of South Bass Island	27
Franz Theodore Stoen Laboratory	OH	Ottawa	Put-in-Bay Township	Institution	Laboratory/Hall part of Ohio State University, focused in biology, freshwater ecology and other natural science studies	27
Cooke, Jay, House	OH	Ottawa	Put-in-Bay Township	Built resource	NRHP Listed built resource; NPS # 66000620	27
Catawba Island	OH	Ottawa	Catawba Island Township	Natural feature	Island on Lake Erie shoreline	26, 28, 29, 30
Catawba Island	OH	Ottawa	Catawba Island Township	Community	Island community on Lake Erie shoreline	26, 28, 29, 30
Catawba Island Club	OH	Ottawa	Catawba Island Township	Organization	Country club and boat club offering marina, club house, private event space, catering hall, charter yachts, etc.	31, 32
Island Yacht Sales	OH	Ottawa	Catawba Island Township	Private business	Yacht dealership located on Catawba Island	32
Le Marin Club	OH	Ottawa	Catawba Island Township	Community	Lakefront condominium complex offering Lake Erie views, marina, clubhouse, ball courts, etc.	32
Northwest Catawba Marina	OH	Ottawa	Port Clinton	Private business	Marina offering 150 docks, electric, swimming pool, bathhouse, etc.	33
Knecht’s Beach and Marina	OH	Ottawa	Portage Township	Campground	Campground, mobile home park and marina on Lake Erie shoreline	34

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Port Clinton	OH	Ottawa	City of Port Clinton	Community	Lakefront, boating community along Lake Erie shoreline	35
Waterworks Park	OH	Ottawa	City of Port Clinton	Public park	Lakefront park offering beach area, access to Lake Erie, picnic areas, trails, historic Port Clinton Light House, etc.	35
Portage River	OH	Ottawa	City of Port Clinton	Natural resource	Tributary to Lake Erie	35
Bootlegger Waterfront Grille and Bar	OH	Ottawa	City of Port Clinton	Private business	Waterfront restaurant offering outdoor seating, Lake Erie views	35
Port Clinton Yacht Club	OH	Ottawa	City of Port Clinton	Organization	Sailing club located along Portage River and Lake Erie offering memberships, sailing events and races, lessons, clubhouse, etc.	35
Fisherman's Wharf	OH	Ottawa	City of Port Clinton	Private business	Bait and tackle shop, also offering fishing charter services, located along Portage River	35
Waterfront Condominium	OH	Ottawa	City of Port Clinton	Community	Lakefront condominium offering Lake Erie views, beach area, pool, etc. located on Lake Erie shoreline	35
Jet Express	OH	Ottawa	City of Port Clinton	Private business	Lake Erie Ferry service offering transport to mainland OH and multiple lake islands	35
Shore Nuf Charters	OH	Ottawa	City of Port Clinton	Private business	Fishing charter service offering fishing trips on Lake Erie, gift and bait and tackle shop	35
Beachfront Resort	OH	Ottawa	City of Port Clinton	Private business	Beachfront hotel/motel and resort offering private beach area, private event space, dining, etc.	35

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Dock's Beach House Bar and Grille	OH	Ottawa	City of Port Clinton	Private business	Lakefront eatery and bar offering Lake Erie views, outdoor seating, tiki/island themed	35
Brand's Marina	OH	Ottawa	City of Port Clinton	Private business	Marina and dry storage facility, maintenance and parts shop, located along Lake Erie shoreline	35
Condo Port Clinton	OH	Ottawa	City of Port Clinton	Condominium	Riverfront condominium complex offering views of Portage River and docking	35
Coastal Marine II	OH	Ottawa	City of Port Clinton	Private business	Full service marina, boat sales, and repair service located along Portage River	35
Clinton Reef Club	OH	Ottawa	City of Port Clinton	Community	Riverfront condominium complex offering clubhouse, marina, waterfront views	35
Lakecraft Corporation	OH	Ottawa	Erie Township	Corporation	Manufacturer of custom dike pumps and other water tech, located along Portage River	35
Angel Bay Marina	OH	Ottawa	Erie Township	Private business	Marina on Portage River offering dockage and access to Lake Erie	35
Outboard Motor Service	OH	Ottawa	Erie Township	Private business	Boat repair service located along Portage River	35
Sunset Shore Campground	OH	Ottawa	Erie Township	Campground	Lakefront campgrounds offering beach area, RV lots, etc.	35
Lakefront Marina	OH	Ottawa	Erie Township	Organization	Marina on Lake Erie shoreline offering variety of amenities including a swimming pool, grills, picnic pavilion, bathhouse, laundry, etc.	35

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Boat Ramp	OH	Ottawa	Erie Township	boat launch	Boat launch offering access Portage River and Lake Erie	35
Toussaint River	OH	Ottawa	Carroll Township	Natural feature	Tributary to Lake Erie	36
Beef Creek Marina	OH	Ottawa	Carroll Township	Private business	Marina located on Toussaint River offering access to river and Lake Erie	36
Toussaint River Marina	OH	Ottawa	Carroll Township	Private business	Marina located on Toussaint River offering access to river and Lake Erie	36
X-Ta-Sea Charter	OH	Ottawa	Carroll Township	Private business	Fishing charter service on Toussaint River	36
Locust Point	OH	Ottawa	Carroll Township	Community	Riverfront community along Toussaint River	37
Turtle Creek	OH	Ottawa	Carroll Township	Natural feature	Tributary to Lake Erie	37
Turtle Point Marina	OH	Ottawa	Carroll Township	Private business	Marina, campgrounds, bait and tackle shop, and fishing access located along Turtle Creek	37
Fisherman's Cove Marina	OH	Ottawa	Carroll Township	Private business	Marina, campgrounds, bait and tackle shop, and fishing access located along Turtle Creek	37
Turtle Creek Marina & Campground	OH	Ottawa	Carroll Township	Private business	Campground and Marina offering docking, fishing, camping, etc., along Turtle Creek	37
Summer Break Charters	OH	Ottawa	Carroll Township	Private business	Fishing charter service offering fishing trips on Lake Erie	37
Magee East Marina and Campground	OH	Ottawa	Carroll Township	Private business	Campground and Marina offering docking, fishing, camping, etc., along Turtle Creek	37
Magee Marsh Wildlife Area	OH	Ottawa	Carroll Township	Conservation area	Wildlife management area offering fishing and hunting, walking trails, birding, etc.	37

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Crane Creek Wildlife Research	OH	Ottawa	Benton Township	Conservation area	Nature preserve offering wildlife viewing, birding, etc.	37
Big Sand Bay	OH	Ottawa	Benton Township	Natural feature	Natural water feature within Crane Creek	37
Ottawa National Wildlife Refuge	OH	Ottawa	Benton Township	Conservation area	Swamp, Forest, and grassland refuge offering hiking trails, wildlife viewing, etc.	37
Crane Creek	OH	Lucas	Jerusalem Township	Natural feature	Tributary to Lake Erie	37
Metzger Marsh Wildlife Area	OH	Lucas	Jerusalem Township	Conservation area	Wildlife area offering hunting, fishing, birding and hiking	37
Lakemont Landing	OH	Lucas	Jerusalem Township	Community	Lakeshore community along Lake Erie shoreline	38
Cedar Creek	OH	Lucas	Jerusalem Township	Natural feature	Tributary to Lake Erie	38
Wolf Creek	OH	Lucas	Jerusalem Township	Natural feature	Tributary to Lake Erie	38
Anchor Pointe Boat-A-Minium	OH	Lucas	Jerusalem Township	Private business	500 slip marina located on Cooley Canal, offering seasonal docking, pool, bathhouse, etc.	38
Boat Ramp	OH	Lucas	Jerusalem Township	Boat launch	Public boat launch offering access to creek and Lake Erie	38
Meinke Marina Laraine's Landing & Gas Docks	OH	Lucas	Jerusalem Township	Private business	Marina and campgrounds resort offering docking, camping, RV space, fishing charters, etc.	38
Cedar Point National Wildlife Refuge	OH	Lucas	Jerusalem Township	Conservation area	Wetland wildlife refuge on Lake Erie shoreline offering birding, hiking trails, etc.	38
Wolf Creek Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Lacourse Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Suzar Bay	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Back of Howell's Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Pintail Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Widgeon Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Cedar Creek Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Long Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Outlet Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Carrington Pond	OH	Lucas	Jerusalem Township	Natural feature	Water feature within Cedar Point Wildlife Refuge	38
Maumee Bay State Park Lodge and Conference Center	OH	Lucas	Jerusalem Township, and Oregon Township	Convention Center	Lakefront lodge and convention center, offering hotel rooms, private event space, convention event space, golf course, beach area, etc.	39
Maumee Bay State Park	OH	Lucas	Jerusalem Township, and Oregon Township	Public Park	Expansive lakefront state park offering beach, fishing, golf course, hiking trails, bike paths, lodging, camping, etc.	39
Inland Lake	OH	Lucas	Jerusalem Township and City of Toledo	Built resource	Manmade waterbody near outlet of Berger Ditch	39
Tidal Flat	OH	Lucas	Jerusalem Township	Natural resource	Tidal flat at outlet of Berger Ditch	39
Maumee Bay Docks	OH	Lucas	Jerusalem Township	Private business	Marina	39
Harbor View	OH	Lucas	Oregon Township	Community	Lakefront village outside of Toledo, OH	40

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Harbor View Yacht Club	OH	Lucas	Oregon Township	Organization	Yacht club along Maumee Bay offering docking, winter storage, fuel, etc.	40
Maumee Bay	OH	Lucas	Oregon Township	Natural feature	Bay within Lake Erie, bordering city of Toledo	40
Toledo Iron Dock	OH	Lucas	Oregon Township	Industrial facility	Marina/dock for large freightliners or barge ships	40
Otter Creek	OH	Lucas	Oregon Township	Natural feature	Tributary to Maumee Bay/Lake Erie	40
Presque Isle	OH	Lucas	Oregon Township	Natural feature	Industrial Isle jutting into Maumee River/Maumee Bay	40
Maumee River	OH	Lucas	Oregon Township, and City of Toledo	Natural feature	Tributary to Lake Erie	40
Midwest Terminals – Toledo International	OH	Lucas	City of Toledo	Corporation	Full service cargo facility and shipping port along Maumee River	40
Geo. Gradel Co.	OH	Lucas	City of Toledo	Private business	Site development and marine contractor located on Maumee River shoreline, offering marine construction/excavation including dredging	40
Arc (Toledo Terminal)	OH	Lucas	City of Toledo	Corporation	Gasoline/oil products distribution center along Maumee River, utilizes River/Lakes for transport and delivery	40
Brenner 75 at Harrison Marina	OH	Lucas	City of Toledo	Private business	Full service marina, marine/boat, parts, and accessories store, boat maintenance, storage, etc.	40
Toledo Division of Water Reclamation	OH	Lucas	City of Toledo	Industrial facility	Water treatment facility located on Maumee River	40
Bay View Retirees Golf Course	OH	Lucas	City of Toledo	Golf Course	Riverfront golf course offering views of Maumee River/Bay	40

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Toledo Yacht Club	OH	Lucas	City of Toledo	Organization	NRHP Listed resource Yacht club and marina located at the mouth of Maumee River, offering large clubhouse, private event space, docking, social events, etc.; NPS # 76001476	40
US Army Corps of Engineers	OH	Lucas	City of Toledo	Government facility	USACE office located at the mouth of Maumee River	40
Bayview Park	OH	Lucas	City of Toledo	Public Park	Riverfront/Lakefront public park offering views of Maumee River and Lake Erie, walking trails, wildlife viewing, fishing, etc.	40
Bay View Yacht Club	OH	Lucas	City of Toledo	Organization	Yacht club and marina located at the mouth of Maumee River, offering clubhouse, private event space, docking, social events, etc.	40
U.S. Coast Guard	OH	Lucas	City of Toledo	Government facility	Coast Guard base located at the mouth of Maumee River	40
Cullen Park	OH	Lucas	City of Toledo	Public park	Lakefront park offering boat launch, birding, docks, etc.	40
Ottawa River	OH	Lucas	City of Toledo	Natural feature	Tributary to Lake Erie	41
Spot and Spam's Bait and Tackle	OH	Lucas	City of Toledo	Private business	Bait and tackle shop on Ottawa River offering fish cleaning, bait, etc.	41
Chet's Marine	OH	Lucas	City of Toledo	Private business	Marina and maintenance shop located on Ottawa River, offering docking, repairs, etc.	41

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Ottawa River Yacht Club	OH	Lucas	City of Toledo	Organization	Boat club and marina on Ottawa River, offering clubhouse, private event space, docking, social events, etc.	41
Point Place Boat Club	OH	Lucas	City of Toledo	Organization	Marina and boat club offering floating docks, bathhouse facilities, picnic areas, etc.	41
Jolly Roger Sailing Club	OH	Lucas	City of Toledo	Organization	Sailing club on Ottawa River offering docking, sailing lessons, etc.	41
Riverview Yacht Club	OH	Lucas	City of Toledo	Organization	Boat club and marina offering membership, docking, clubhouse, private event space, etc.	41
Jockett's Marina	OH	Lucas	City of Toledo	Private business	Riverfront marina offering new floating docks, boat hoist on site, etc.	41
River Café & Marina	MI	Monroe	Erie Township	Private business	Restaurant and marina on Ottawa River offering seafood, and docking for customers	41
Webber's Waterfront Restaurant	MI	Monroe	Erie Township	Private business	Riverfront restaurant offering seafood fare, live music, outdoor seating	41
Lost Peninsula Marina	MI	Monroe	Erie Township	Private business	Large bay-front marina offering floating docks, access to North Maumee Bay and Lake Erie, etc.	41
Halfway Creek	MI	Monroe	Erie Township	Natural feature	Tributary to Lake Erie	41
North Maumee Bay	MI	Monroe	Erie Township	Natural feature	Bay at the mouth of Ottawa River, and Halfway Creek, off of Lake Erie	41
Indian Island	MI	Monroe	Erie Township	Natural feature	Island within North Maumee Bay	41
Gard Island	MI	Monroe	Erie Township	Natural feature	Island within North Maumee Bay	41

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Fishermans Cave Bait and Tackle	MI	Monroe	Erie Township	Private business	Bait and tackle shop offering live bait, Michigan and Ohio licenses, boat rentals, etc.	41
Boat Ramp	MI	Monroe	Erie Township	Boat launch	Public boat launch offering access to Halfway creek, North Maumee Bay, Lake Erie	41
John Fisher's Marina	MI	Monroe	Erie Township	Private business	Boat sales, repair and maintenance service located on North Maumee Bay	41
Woodtick Peninsula	MI	Monroe	Erie Township	Natural feature	Peninsula jutting out into Lake Erie, separating Lake Erie from North Maumee Bay	41
Michigan DNR Public Hunting Area	MI	Monroe	Erie Township	Conservation area	Public hunting lands within North Maumee Bay, comprised of mainly marsh and wetland, with walking trails	41
JR Whiting Power Plant	MI	Monroe	Erie Township	Industrial facility	Electric generating station located at the Northern tip of North Maumee Bay	41
Erie Rd. Public Beach Access	MI	Monroe	Erie Township	Public park	Access to public beach area on Lake Erie shoreline	41
Allens Cove	MI	Monroe	City of Luna Pier, La Salle Township	Natural feature	Natural water feature along Lake Erie shoreline	42
Reed Yacht Sales	MI	Monroe	La Salle Township	Private business	Yacht and boat sales located on Lake Erie shoreline offering wide variety of new and used boats	42
Toledo Beach Marina	MI	Monroe	La Salle Township	Private business	Marina on Lake Erie shoreline offering docks/slips, storage, café (Sandbar Grille), repair services	42

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
North Cape Yacht Club	MI	Monroe	La Salle Township	Organization	Sailing club offering memberships, sailing lessons, racing, social events, etc.	42
Grand View	MI	Monroe	La Salle Township	Community	Lakeside community along Lake Erie shoreline	42
Otter Creek	MI	Monroe	La Salle Township	Natural feature	Tributary to Lake Erie	43
Otter Creek Marina Inc.	MI	Monroe	La Salle Township	Private business	Marina located on Otter Creek offering docking and access to Lake Erie	43
La Plaisance Creek	MI	Monroe	Monroe Charter Township	Natural feature	Tributary to Lake Erie	44
Trout's Yacht Basin LLC	MI	Monroe	Monroe Charter Township	Private business	Marina, boat accessories, and repair services offering docking, storage, and access to La Plaisance Creek and Lake Erie	44
Talon Charters	MI	Monroe	Monroe Charter Township	Private business	Fishing charter service offering fishing trips on Lake Erie and Lake Michigan	44
Monroe Yacht Club	MI	Monroe	Monroe Charter Township	Organization	Boat club and marina located on La Plaisance Creek offering docking, clubhouse, memberships, social events, and access to Lake Erie	44
Harbor Marine	MI	Monroe	Monroe Charter Township	Private business	Marina, warehouse, and boat sales offering docking on La Plaisance Creek, winter storage, maintenance, etc.	44
La Chasseur Lake Erie Sport Fishing Charters	MI	Monroe	Monroe Charter Township	Private business	Fishing charter service offering fishing trips on Lake Erie	45
Anglers Fish Camp	MI	Monroe	Monroe Charter Township	Private business	Bait and tackle shop offering licenses, and fishing charters	45

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Bolles Harbor Boat Launch	MI	Monroe	Monroe Charter Township	Boat launch	Public boat launch offering access to La Plaisance Creek and Lake Erie	45
Plum Creek	MI	Monroe	Monroe Charter Township, and	Natural feature	Tributary to Lake Erie	45
Foleys Island	MI	Monroe	City of Monroe	Natural feature	Island within Plum Creek	45
River Raisin	MI	Monroe	City of Monroe	Natural feature	Tributary to Lake Erie	45
Port of Monroe	MI	Monroe	City of Monroe	Built resource	Industrial, commercial, and recreational "gateway" to the city of Monroe	45
Riverfront Marina	MI	Monroe	City of Monroe	Private business	Marina and storage facility offering rack and launch, indoor and outdoor storage, repairs, etc.	45
River Raisin Marina and Campground	MI	Monroe	City of Monroe	Retreat	Marina and campground resort located on River Raisin, offering camping, marina/docking, sailing, fishing, etc.	45
William C. Sterling State Park	MI	Monroe	Frenchtown Charter Township	Public Park	Lakefront state park offering large campgrounds, beach area, swimming, hunting, fishing, etc.	45
Boat Ramp	MI	Monroe	Frenchtown Charter Township	Boat launch	Public boat launch offering access to Lake Erie	45
Detroit Beach	MI	Monroe	Frenchtown Charter Township	Community	Lakefront beach community on Lake Erie shoreline	45
Detroit Beach Boat Club	MI	Monroe	Frenchtown Charter Township	Organization	Boat club and marina offering access to Lake Erie, docking, clubhouse, social events, etc.	45
Stony Creek	MI	Monroe	Frenchtown Charter Township	Natural feature	Tributary to Lake Erie	46

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Brest Bay Marina	MI	Monroe	Frenchtown Charter Township	Private business	Full service marina offering dockage, rack and launch, winter storage, ship store, bait and tackle, etc.	46
Enrico Fermi II Nuclear Power Plant	MI	Monroe	Frenchtown Charter Township	Industrial facility	Nuclear power plant located along the Lake Erie shoreline, training facility on location	47
Swan Creek	MI	Monroe	Frenchtown Charter Township, and Berlin Charter Township	Natural feature	Tributary to Lake Erie	48
Swan Boat Club	MI	Monroe	Berlin Charter Township	Organization	Boat club and marina offering dockage on Swan Creek, access to Lake Erie, memberships, social events, etc.	48
Detroit River International Wildlife Refuge, Brancheau Unit	MI	Monroe	Berlin Charter Township	Conservation area	Wildlife refuge along Swan Creek and Lake Erie, offering trails, wildlife sighting, etc.	48
Swan Yacht Basin	MI	Monroe	Berlin Charter Township	Private business	Full service marina on Swan Creek offering dockage, rack and launch, repair services, storage facilities, etc.	48
Detroit River International Wildlife Refuge, Strong Unit	MI	Monroe	Berlin Charter Township	Conservation area	Wildlife refuge along Lake Erie, offering trails, wildlife sighting, etc.	48
Pointe Mouillee State Game Area	MI	Monroe	Berlin Charter Township	Conservation area	State park and game area offering wildlife viewing, birding, fishing, hiking trails, canoeing and kayaking, hunting, etc.	49
Detroit River International Wildlife Refuge, Taylor Unit	MI	Monroe	Berlin Charter Township	Conservation area	Wildlife refuge along Lake Erie, offering trails, wildlife sighting, etc.	49

Attachment F-4 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Erie Shoreline in the Western Lake Erie Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number *
Mouillee Creek	MI	Monroe	Berlin Charter Township	Natural feature	Tributary to Lake Erie	49

*The following focus areas did not have any specific natural or cultural features, communities, etc.: 3, 14.

F.5 Potential Socio-Cultural Impacts: Southwestern Lake Huron Watershed

The SW Lake Huron watershed is located at the eastern end of Lake Huron. Located entirely within eastern Michigan, it extends over portions of six counties: (from east to west) Sanilac, Huron, Tuscola, Bay, Arenac, and Iosco.

According to modeling conducted for the introduction and establishment of Hydrilla within the larger Great Lakes basin, the SW Lake Huron watershed is considered to have a medium potential for the introduction of Hydrilla, primarily via recreational boating, and a low potential for the establishment of Hydrilla in suitable nearshore aquatic habitat if it were to be introduced.

The following impact assessment describes the various features that comprise the existing socio-cultural setting of 52 focus areas along the approximately 462-mile-long shoreline area within the SW Lake Huron watershed. These 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed were selected for detailed analysis because they include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet, as discussed in greater detail in Section 3.3.5.1. The following impact assessment then considers the potential impacts of the introduction and subsequent establishment of Hydrilla on the various features that collectively represent the community character of these focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. It is recognized that the SW Lake Huron watershed encompasses additional areas along the shoreline as well as interior areas that are not located along the Lake Huron shoreline. However, the following impact assessment considers the socio-cultural setting and community character of only those counties, townships, villages, towns, and cities within which the 52 focus areas are located. This approach was adopted to make the impact assessment more manageable given the total length of the Lake Ontario shoreline (462 miles) in the SW Lake Huron watershed.

Similarly, it is recognized that a wide variety of agencies, organizations, and special interest groups may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the SW Lake Huron watershed. These stakeholders would consist of the civic and governmental areas with jurisdiction over the areas included in the SW Lake Huron watershed and additional stakeholders that could include: state agencies (e.g., Michigan State Historic Preservation Office [MSHPO] or Michigan Department of Natural Resources [MDNR]) that manage parks, historic sites, natural areas, and public access for waterbodies; federal agencies (e.g., the U.S. Army Corps of Engineers, which manages navigable waterways); federally recognized Indian tribes that have a cultural or historical affiliation with areas along the Lake Huron shoreline in the SW Lake Huron watershed or retain treaty rights to lands, waters, and resources along the shoreline of the SW Lake Huron watershed; or special interest groups (e.g., The Nature Conservancy, The Sierra Club, or Ducks Unlimited) that may have a broadly defined interest in areas and resources along the shoreline of the SW Lake Huron watershed. These additional stakeholders could be involved as part of continued consideration of the potential impacts associated with the introduction and establishment of Hydrilla within the larger Great Lakes basin.

Potential impacts on the socio-cultural setting of shoreline areas of the SW Lake Huron watershed are discussed in terms of whether they would be: short-term (temporary) or long-term (permanent): direct or indirect, positive (beneficial) or negative (detrimental), and cumulative. Additionally, these impacts are considered with reference to two scenarios: one where Hydrilla is untreated (worst-case scenario) and one where Hydrilla is treated (managed scenario).

It is expected that the results of this assessment of the introduction and subsequent establishment of Hydrilla on the socio-cultural setting and community character of the 52 focus areas along the Lake Huron shoreline within the SW Lake Huron watershed would be generally representative of potential impacts that would occur in interior areas of this same watershed. The results would also be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

F.5.1 Methodology and Definitions for the Socio-Cultural Impact Assessment for the Southwestern Lake Huron Watershed

This socio-cultural impact assessment assumes that the introduction and/or establishment of Hydrilla along the shoreline of the SW Lake Huron watershed will affect the natural and socio-cultural features located in these areas, resulting in changes to the watershed's community character. For the purposes of this impact assessment, natural features are defined as uplands, points, bluffs, coves, beaches, embayments, creeks, rivers, marshes, etc., and socio-cultural features are defined as villages, towns, cities, parks, conservation areas (including nature preserves), commercial enterprises, industrial facilities, and cultural and historical sites.

This socio-cultural impact assessment further assumes that these natural and socio-cultural features collectively represent tangible (physical) components of the community character of the SW Lake Huron watershed. A review of publicly available information for Michigan state agencies did not identify specific guidance for defining, or assessing impacts on, community character. However, Michigan's Natural Resources and Environmental Protection Act, Act 451 of 1994, was passed to protect the environment and natural resources of the State of Michigan. While this act does not specifically address community character, many sections of this state law require project proponents to consider the impacts of their actions on the aesthetic, recreational, and economic aspects of natural resources (State of Michigan Legislative Council 2017).

In the absence of specific state-level guidance for defining community character and assessing impacts on community character, this impact assessment for the SW Lake Huron watershed, which lies entirely within Michigan, uses the concept of community character that is modelled on New York State's guidance for complying with its State Environmental Quality Review Act (SEQR), consistent with other watershed evaluated as part of this RA. New York State's SEQR guidance notes that:

> Many people define their community's character in very general terms: suburban, rural, urban, quiet, safe, scenic, or friendly are terms often used. Others describe community character only in terms of visual features.
>
> Community character is broader than this however. Community character is defined by all the man-made and natural features of the area. It includes the visual character of a town, village, or city, and its visual landscape; but also includes the buildings and structures and their uses, the natural environment, activities, town services, and local policies that are in place.
>
> These combine to create a sense of place or character that defines the area" (New York State Department of Environmental Conservation [NYSDEC] 2017).

The introduction and establishment of Hydrilla would occur within natural features located along the shoreline of Lake Huron in the SW Lake Huron watershed. These areas typically are locations recognized and used for water-dependent and water-related uses. The natural and man-made (socio-cultural) features of the watershed as a collective physical representation of the community character of the SW Lake Huron watershed, as defined by the NYSDEC, appears to provide the most comprehensive consideration of the impacts that the introduction and establishment of Hydrilla would have on the community character of the SW Lake Huron watershed. However, the definition of community character for this impact assessment has been expanded to include the water-dependent and water-related uses of these natural and man-made or socio-cultural features, which also contribute to community character and are deliberately managed by the communities and governmental units that comprise the SW Lake Huron watershed.

Due to the large extent of the Lake Huron shoreline in the SW Lake Huron watershed (approximately 462 miles in length), 52 areas with environmental conditions highly suitable to establishment of Hydrilla were identified within this watershed for an in-depth impact assessment. These 52 areas (henceforth, referred to as focus areas) collectively comprise approximately 124 miles of the Lake Huron shoreline in the SW Lake Huron watershed. They all contain physical conditions that are conducive to the introduction and establishment of Hydrilla. Table F.5-1, provides a summary description of each of the 52 focus areas identified for the SW Lake Huron watershed. Section 3.3 describes the criteria used to identify the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed, which include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet).

Thus, this socio-cultural impact assessment identified the visible and physical natural and socio-cultural features that represent the attributes and assets of the communities and governmental units associated with the 52 focus areas along the shoreline of Lake Huron in the SW Lake Huron watershed (see Section F.5.2: see also Attachment F-5 for a listing of these visible and physical natural and socio-cultural features). This socio-cultural impact assessment also considers the management of the visible and physical natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed by the associated counties, towns, and cities or villages (see Section F.5.3), This socio-cultural impact assessment considers the impacts of the introduction and/or establishment of Hydrilla on the natural and socio-cultural features and their associated water-dependent and water-related uses identified for the 52 focus areas in the SW Lake Huron watershed (see Sections F.5.4 and F.5.5) and considers the impacts of the introduction and establishment of Hydrilla on perceptions of features and uses and on the community character of the 52 focus areas (see Section F.5.6 and F.5.7). The results of this impact analysis are considered with regard to their broader applicability to the entire SW Lake Huron watershed (see Section F.5.8). Finally, conclusions and recommendations regarding the results of this impact assessment are presented in Section F.5.9.

Table F.5-1 Description of Focus Areas in the Southwestern Lake Huron Watershed

Focus Area Number[1]	Description of Focus Area[2]	County	City or Town	Approximate Length (miles)
1	Lake Huron shoreline along Lexington State Harbor	Sanilac	Village of Lexington	0.26
2	Lake Huron shoreline along Port Sanilac Harbor	Huron	Village of Port Sanilac	0.46
3	Shoreline of unnamed cove at mouth of White Rock Creek	Huron	Sherman Township	0.45
4	Lake Huron shoreline along Harbor Beach and Harbor of Refuge	Huron	City of Harbor Beach	3.23
5	Shoreline of unnamed cove	Huron	City of Harbor Beach	1.68
6	Lake Huron shoreline at Village of Port Hope along unnamed cove	Huron	Village of Port Hope	0.23
7	Lake Huron shoreline along Whiskey Harbor	Huron	Gore Township	1.82

Table F.5-1 Description of Focus Areas in the Southwestern Lake Huron Watershed

Focus Area Number[1]	Description of Focus Area[2]	County	City or Town	Approximate Length (miles)
8	Lake Huron shoreline at mouth of Willow Creek	Huron	Port Austin Township	0.93
9	Shoreline of unnamed harbor	Huron	Port Austin Township	0.71
10	Shoreline of Eagle Bay and Burnt Cabin Point	Huron	Port Austin Township	1.05
11	Shoreline of unnamed marsh along Lake Huron shore	Huron	Pointe Aux Barques Township	0.59
12	Shoreline of Port Austin Harbor	Huron	Village of Port Austin	0.50
13	Lake Huron shoreline	Huron	Port Austin Township	0.22
14	Lake Huron shoreline at mouth of Pinnebog River	Huron	Hume Township	3.02
15	Shoreline of inland Rush Lake	Huron	Lake Township	2.38
16	Shoreline of inland Oak Point Lake, Little Doerr Lake and Doerr Lake	Huron	Caseville Township	2.02
17	Shoreline of Pigeon River	Huron	City of Caseville	1.96
18	Inland harbor along Sand Point	Huron	Caseville Township	5.21
19	Inland harbor along Sand Point	Huron	Caseville Township	4.09
20	Shoreline of Wild Fowl Bay	Huron	Caseville Township and McKinley Township	1.70
21	Shoreline of unnamed harbor along Wild Fowl Bay	Huron	McKinley Township	0.98
22[1]	Shoreline of unnamed harbor along Wild Fowl Bay and Wild Fowl Point	Huron	Fairhaven Township	1.04
24[1]	Lake Huron shoreline along Saginaw Bay	Huron	Fairhaven Township	2.46
25	Shoreline of unnamed harbor along Saginaw Bay	Huron	Fairhaven Township	1.43
26	Shoreline of unnamed residential basin/canal	Huron	Fairhaven Township	1.14
27	Shoreline of unnamed, inland, manmade lakes	Huron	Sebawaing Township	1.96

Table F.5-1 Description of Focus Areas in the Southwestern Lake Huron Watershed

Focus Area Number[1]	Description of Focus Area[2]	County	City or Town	Approximate Length (miles)
28	Shoreline of Sebawaing River and unnamed harbors	Huron	Village of Sebawaing	1.73
29	Shoreline of unnamed marsh along Saginaw Bay and Fish Point	Tuscola	Akron Township	2.23
30	Shoreline of unnamed harbor along Saginaw Bay	Tuscola	Akron Township	0.78
31	Shoreline of Saginaw Bay	Tuscola	Wisner Township	1.54
32	Shoreline of Saginaw Bay at mouth of Quanicasse	Tuscola	Wisner Township	1.47
33	Shoreline of Saginaw River and Saginaw Bay	Bay	City of Essexville and Bangor Charter Township	7.48
34	Shorelines of Kawkawlin River, unnamed harbor, and Saginaw Bay	Bay	Bangor Charter Township	3.00
35	Shoreline of Tobico Lagoon	Bay	Bangor Charter Township	0.43
36	Shoreline of Tobico Marsh	Bay	Bangor Charter Township, and Kawkawlin Township	3.79
37	Shoreline of unnamed harbor along Saginaw Bay	Bay	Kawkawlin Township	0.60
38	Shorelines of Saginaw Bay, unnamed marsh, Lengsville Point, Mallard Point, and Nayanquing Point	Bay	Fraser Township	6.71
39	Shoreline of unnamed harbor and Saginaw Bay near mouth of Pinconning River	Bay	Pinconning Township	1.46
40	Shoreline of private marina along Saginaw Bay	Arenac	Standish Township	1.19
41	Shoreline of Pine River	Arenac	Standish Township	2.17
42	Shoreline of Wigwam Bay	Arenac	Standish Township, and Arenac Township	2.36
43	Shoreline along Rifle River	Arenac	Arenac Township	1.73

Table F.5-1 Description of Focus Areas in the Southwestern Lake Huron Watershed

Focus Area Number[1]	Description of Focus Area[2]	County	City or Town	Approximate Length (miles)
44	Shoreline along unnamed marsh within Saginaw Bay	Arenac	Arenac Township	1.39
45	Shoreline along residential basin/canal	Arenac	Au Gres Township	3.26
46	Shorelines of Au Gres River and Saginaw Bay	Arenac	City of Au Gres	4.99
47	Shoreline of Saginaw Bay and private marina	Arenac	Sims Township	0.88
48	Shorelines of inland Cranberry Lake and unnamed lake	Arenac	Whitney Township	2.18
49	Shoreline of filled in manmade quarry	Iosco	Alabaster Township	5.63
50	Shorelines of Tawas River and Tawas Bay	Iosco	Tawas City	1.59
51	Shoreline of unnamed harbor within Tawas Bay	Iosco	City of East Tawas	0.24
52	Shoreline of inland Lake Solitude	Iosco	Baldwin Township	3.02
53	Shorelines of unnamed marsh and inland Spencer Lake	Iosco	Baldwin Township	1.57
Total	**N/A**	**N/A**	**N/A**	**104.98**

Notes:
[1] Due to a numbering oversight, there is no Focus Area Number 23.
[2] See Section 3.3 of the RA for a detailed discussion of the process used to select these focus areas.

Key:
N/A = Not applicable

F.5.2 Natural and Socio-Cultural Features along the Shoreline of the Southwestern Lake Huron Watershed

One hundred thirty-seven named natural and socio-cultural features are located within the 52 focus areas along the shoreline of Lake Huron in the SW Lake Huron watershed. These features were identified primarily from an analysis of information included in overlays for Google Earth and identified on 7.5-minute USGS topographic quadrangles and/or coastal maps maintained in the National Oceanic and Atmospheric Administration's (NOAA's) Office of Coast Survey Historical Map and Chart Collection. Collectively, these 137 named natural and socio-cultural features are physical representations of the community character and the socio-cultural setting of the Lake Huron shoreline in the SW Lake Huron watershed.

A full listing of the 137 named natural and socio-cultural features identified for the 52 focus areas is included in Attachment F-5. It is noted here that Attachment F-5 is not a definitive and complete listing of all the named natural and socio-cultural features in the 52 focus areas or along the entire Lake Huron shoreline in the SW Lake Huron watershed. While the list in Attachment F-5 is reasonably comprehensive as to the type of natural and socio-cultural features present, it primarily only includes features that are named (e.g., named waterbodies and communities on 7.5-minute USGS topographic quadrangles) and/or that have been identified in databases that comprise the Google Earth overlays.

These 137 named natural and socio-cultural features can be grouped into eight different categories of resources (see Table F.5-2). These eight resource categories consist of (in order of predominance from most to fewest): private businesses, natural features, public parks and other public facilities, communities, built resources, conservation areas, organizations, industrial facilities, and government facilities. The types of natural and socio-cultural features located within, or associated with, these 52 focus areas should be considered generally representative of the larger number of natural and socio-cultural features along the Lake Huron shoreline in the SW Lake Huron watershed.

Table F.5-2 Summary of Natural and Socio-Cultural Features within the 52 Focus Areas along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Resource Category	Description	Total Number in Watershed (% of total)
Private businesses	Private enterprises related to a variety of water-dependent or water-related recreational uses and activities along the shoreline of Lake Huron.	38 (28%)
Natural features	Named natural features located along the shoreline of Lake Huron.	37 (27%)
Public parks/facilities	State, county, and town parks and beaches located along the shoreline of Lake Huron.	21 (15%)
Communities	Named cities (including named neighborhoods), towns or villages, or hamlets located along the shoreline of Lake Huron.	17 (12%)
Built resources	Specific buildings, structures, objects, or other built features located along the shoreline of Lake Huron.	11 (8%)
Conservation areas	Federal, state, local, and private natural areas, nature/underwater preserves, and wildlife management areas located along the shoreline of Lake Huron.	7 (5%)
Organizations	Public or private enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the shoreline of Lake Huron.	5 (4%)
Governmental facilities	Federal, state, or local government facilities located along the shoreline of Lake Huron.	1 (1%)
Total		**137 (100%)**

Private Businesses (Socio-Cultural Feature)

Thirty-eight private business enterprises were identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, these 38 private business enterprises represent approximately 28% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These 38 private business enterprises consist of a variety of businesses, primarily related to recreational activities, that all are associated with water-dependent or water-related use of the Lake Huron shoreline. These private businesses were generally identified from overlays in Google Earth. Resources in this category include marinas, campgrounds, RV parks, hotels/resorts, restaurants, and boating facilities, and their use may be permanent or seasonal. There are likely to be additional similar private businesses along the Lake Huron shoreline in the SW Lake Huron watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Natural Features

Thirty-seven named natural features were identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, these 37 named natural features represent approximately 27% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These 37 named natural features consist of named shoreline or nearshore features (such as rivers, bays, harbors, lagoons, lakes, creeks, and marshes) and named terrestrial features (such as points and islands). These natural features were generally identified from USGS 7.5-minute topographic quadrangles and the NOAA's Office of Coast Survey Historical Map and Chart Collection. Resources in this category do not include unnamed waterbodies and topographic features, although such natural features are also present within many of the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed.

Public Parks and Other Public Facilities (Socio-Cultural Feature)

Twenty-one public parks and other public facilities (such as public boat launches or ramps) were identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, these 21 named public parks and other public facilities represent approximately 8% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These 21 named public parks and other public parks consist of state, county, and township parks located along the Lake Huron shoreline. These public parks and other public facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category are primarily developed for active and passive recreational uses of the shoreline. Resources in this category do not include nature preserves; these are addressed as a separate type of resource.

Communities (Socio-Cultural Feature)

Seventeen named communities were identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, these 17 named communities represent approximately 12% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These 17 named communities consist of named cities, towns, villages, and hamlets that were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. Resources in this category include variously sized named clusters of residential, commercial, and/or industrial development. With regard to residential development, this may be comprised of owner-occupied or rental units, and may be permanent or seasonal. Resources in this category do not include numerous locations of unnamed shoreline development, although such unnamed shoreline development is also present within some of the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed.

Built Resources (Socio-Cultural Feature)

Eleven specific built resources were identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, these 11 specific built resources represent approximately 8% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These 11 specific built resources consist of buildings, structures, objects, or other built features located along the Lake Huron shoreline that are recognized for their individual or collective importance at the national, state, or local level (e.g., lighthouses, historical sites, or properties listed in the National Register of Historic Places). These specific built resources were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category may or may not be located within communities. Resources in this category may also include, but are not limited to, historic resources.

Conservation Areas (Socio-Cultural Feature)

Seven conservation areas were identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, these seven conservation areas represent approximately 5% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These seven conservation areas consist of state, local, or private natural areas or nature preserves or wildlife management areas located along the Lake Huron shoreline. These conservation areas were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category are primarily intended for ecological preservation, they may also be used for active and/or passive recreational activities. Resources in this category do not include public parks or beaches; these are addressed as a separate resource type.

Organizations (Socio-Cultural Feature)

Five public or private organizations were identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, these five public or private organizations represent approximately 4% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These five public or private organizations consist of enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the Lake Huron shoreline. These organizations were generally identified from overlays for Google Earth. Resources in this category include yacht clubs and boat clubs. Resources in this category may be owned privately or by non-profit groups. There are likely to be additional similar public or private organizations within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Governmental Facilities (Socio-Cultural Feature)

One governmental facility was identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. Collectively, this governmental facility represents approximately 1% of the total natural and socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. This governmental facility consists of a U.S. Coast Guard station located along the Lake Huron shoreline. This governmental facility was identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. There are likely to be additional similar governmental facilities along the Lake Huron shoreline in the SW Lake Huron watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

F.5.3 Existing Management of Natural and Socio-Cultural Features in the SW Lake Huron Watershed

Due to the size of the SW Lake Huron watershed and the length of its shoreline along Lake Huron (approximately 462 miles), the overall nature of development of this watershed varies between relatively urbanized areas, such as the city of Essexville and the towns/cities adjacent to the city (e.g., Bangor Charter Township and Bay City) in Bay County or Tawas City in Iosco, and very rural areas, such as Standish Township in Arenac County or Sherman Township in Huron County and others. Despite the variation in the type and density of development along the Lake Huron shoreline in the SW Lake Huron watershed, the various governmental units (counties, townships, and incorporated municipalities) along the shoreline of Lake Huron in the SW Lake Huron watershed have processes in place that consider development in conjunction with natural and socio-cultural conditions under their jurisdiction, whether through the development of specific plans, such as master plans, or through zoning.

Specific plans typically consist of comprehensive or master plans developed by the various counties, townships, or cities along the shoreline of Lake Huron. Additionally, a number of governmental units may have other plans for the management of natural and socio-cultural features within their boundaries, such as plans for recreation, and conservation. These plans may specifically address the management of many of the named visible and physical natural and socio-cultural features that have been identified within the 52 focus areas along the shoreline in the SW Lake Huron watershed.

The various plans for the communities and governmental units, or for other specific areas, along the shoreline in the SW Lake Huron watershed would indicate the importance of this shoreline to their respective community characters. These various plans may also recognize the various natural features (e.g., points, beaches, embayments, creeks, and rivers) that physically shape the shoreline and socio-culturally shape the uses of the shoreline for residential, commercial, recreational, and conservation purposes. These various plans may also recognize various socio-cultural features (i.e., villages, towns, cities, harbors, parks, conservation areas [including nature preserves and wildlife management areas], and residential areas [unincorporated communities and hamlets]).

Similarly, the various plans for the communities and governmental units, or for other specific areas such as Saginaw Bay, along the Lake Huron shoreline in the SW Lake Huron watershed would identify common issues or concerns regarding their particular natural and socio-cultural features. The common issues or concerns associated with managing waterfronts or shorelines for water-dependent or water-related uses may consist of, but would not necessarily be limited to:

- Protecting or improving the quality of specific natural features along the shoreline (e.g., embayments, marshes, and creeks);
- Managing or enhancing residential and commercial development along the shoreline;
- Creating or enhancing opportunities for public access to the shoreline, typically for recreational purposes;
- Protecting or developing scenic qualities of the shoreline; and
- Managing or enhancing opportunities for visual access to the shoreline.

Additionally, the various plans for the communities and governmental units, or for other specific areas such as Saginaw Bay, along the Lake Huron shoreline in the SW Lake Huron watershed would identify specific management goals, objectives, or recommendations to address these issues or concerns, and to manage these shorelines for water-dependent or water-related uses. In general, the purpose for managing their respective shorelines would typically, but not necessarily only, be to:

- Acknowledge and promote the character of the communities along the shoreline;
- Enhance the quality of life for permanent residents;
- Enhance the experience of seasonal residents and visitors; and
- Protect, improve, or otherwise support the natural and socio-cultural features that comprise the shoreline of Lake Huron.

F.5.4 Potential Impacts of Introduction and Establishment of Hydrilla on Socio-Cultural Setting of the Southwestern Lake Huron Watershed

This section discusses the potential impacts associated with the introduction and/or establishment of Hydrilla on the socio-cultural setting of the SW Lake Huron watershed. In general, these impacts can be considered in terms of whether they result in:

- Physical changes to natural and/or socio-cultural features identified along the Lake Huron shoreline in the SW Lake Huron watershed;
- Changes to water-dependent or water-related uses of these natural and/or socio-cultural features;
- Changes in perceptions about the features or their uses; and
- Changes in the community character of various locations or focus areas within the watershed.

For the purposes of this impact assessment, water-dependent uses are considered to be facilities or activities that cannot exist without a waterfront location, such as marinas or boat ramps. Water-related uses are considered facilities or activities that increase their value or importance because of their proximity to a shoreline. Frequently, they function as support services for water-dependent uses and could include parks and other recreational facilities, as well as some types of commercial development (Benson 2011).

In general, the changes identified above are considered in terms of whether they would be an impact that is: (1) direct or indirect; (2) temporary or permanent (short-term or long-term); (3) adverse (negative), neutral, or beneficial (positive); and/or (4) cumulative, per changes and impacts associated with other invasive aquatic plant species in the watershed or at a specific focus area and/or per changes and impacts associated with ongoing or emerging socio-cultural trends in the watershed or at a specific focus area.

Impacts on Natural and Socio-Cultural Resources

The introduction and subsequent establishment of Hydrilla within any of the 52 focus areas along the shoreline of Lake Huron is likely to result in physical changes to a number of types of natural and socio-cultural features that comprise the socio-cultural setting of these focus areas and of the SW Lake Huron watershed in general. At its most basic level, the introduction of Hydrilla, and its establishment and increasing density over time, in a natural feature (waterbody or marsh or wetland) with suitable environmental conditions would result in direct changes to the ecological composition of the natural feature, to the appearance (visible and olfactory) of the natural features, and to the socio-cultural features and water-dependent and water-related uses associated with the natural feature. These changes would consist of new and increasingly visible and dense plants or plant mats beneath and at or on the water surface that would change the composition of ecological communities associated with the natural feature and, with regard to human use, would ultimately impede access on or through the water. At its full extent, Hydrilla present in dense mats at or on the water surface would act as a net, capturing floating detritus (natural and man-made) that would detract from the visual and olfactory setting of the waterbodies. Such changes may be small at first, with the introduction of Hydrilla into a suitable waterbody environment, but such changes may increase incrementally in density, visibility, and/or intensity over time until Hydrilla has exploited the maximum extent of available suitable habitat in the waterbody feature.

Physical changes are likely to occur on natural features and on those socio-cultural features that are comprised of, or associated with, natural features. Physical changes are likely to directly and indirectly impact natural and socio-cultural features. Additionally, these physical changes, considered in conjunction with past, present, or reasonably foreseeable future conditions for these natural and socio-cultural features, may have a cumulative impact on these natural and socio-cultural features.

Socio-cultural features that are comprised of, or associated with, natural features are also likely to undergo physical changes from the introduction and subsequent establishment of Hydrilla. These socio-cultural features would typically consist of: (1) public parks; (2) conservation areas; and (3) public or private business enterprises (e.g., marinas, restaurants, and campgrounds) that are located within the 52 focus areas along the shoreline of Lake Huron in the SW Lake Huron watershed and associated with water-dependent and/or water-related uses. However, other socio-cultural features, comprised of communities, organizations, and governmental facilities, are often also associated with natural features, such as those identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed. These are attractive locations for seasonal and permanent residences or specific locations, such as at the mouth of a navigable waterbody at which a U.S. Coast Guard facility is located.

Descriptions of the potential impacts on the various types of natural and socio-cultural features identified within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed are presented below. Such impacts are considered primarily with regard to the introduction and establishment of Hydrilla without treatment, such direct and indirect impacts would likely be considered long-term or permanent impacts and would also be perceived as negative impacts by the communities and users of the 52 focus areas along Lake Huron shoreline in the SW Lake Huron watershed.

Dispersal modeling predicted that approximately less than 1% (0.7) of total area of water within the SW Lake Huron watershed may be infested by Hydrilla by 2025 (see Table 3.1.5-1 in the risk assessment); therefore, it is possible that some of the 52 focus areas would not be affected by Hydrilla, or that impacts resulting from Hydrilla would not affect some or all of the natural and socio-cultural features that collectively comprise the community character of this watershed as described below. Because dispersal modelling does not indicate specific locations within the watershed that would be affected, it is not possible to determine which of the 52 focus areas would be subject to infestation. Additionally, because the results of dispersal modelling extend through the year 2025, it is likely that the impacts discussed in this section would occur slowly at first, and become increasingly noticeable over time until full exploitation of available suitably habitat has been achieved. Therefore, the impacts of the introduction and establishment of Hydrilla discussed below should be considered representative of the types of impacts that could occur if these, or similar, natural and socio-cultural features are present within or adjacent to the approximately less than 1% of the total area of water within the entire watershed that may be infested by Hydrilla in 2025.

Impacts on Natural Features

The introduction and establishment of Hydrilla on natural features would result in a number of different impacts on natural features, depending on the type of natural feature. These impacts are both physical ecosystem effects as well as socio-cultural effects associated with impaired public access or reduced recreational usage. The physical ecosystem impacts on these natural features are summarized in this section to provide a context for considering these natural features as the setting for associated socio-cultural features and uses. The socio-cultural impacts associated with these natural features (e.g., impaired public access and reduced recreational usage) are discussed in greater the following paragraphs as part of the discussion of impacts on socio-cultural features.

Natural features, such as points and islands, are terrestrial natural features that are not likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla. Therefore, the introduction and establishment of Hydrilla is likely to have no impact on these types of natural features, although indirect impacts on socio-cultural features, water-dependent uses, and water-related uses associated with such natural features are likely to occur and are discussed in this section. However, natural features comprised of, or associated with, waterbodies are likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla.

Waterbody features that may be directly impacted by the introduction and establishment of Hydrilla include:

- Shoreline and littoral zone of:
    - Lake Huron,
    - Beaches, inland lakes, harbors, and bays along the shoreline of the lake, and
    - Outlets or mouths of creeks and rivers where they enter the lake or the harbors or bays along the lake shoreline; and
- Marshes or wetlands that are associated with these waterbody features.

Collectively, the 52 focus areas within the SW Lake Huron watershed include all of these types of natural features.

The direct impacts on these natural features would result from the introduction and establishment of Hydrilla, and would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of these waterbody features, including changes to water quality (e.g., full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface) and changes to species that are located in, or that otherwise use, these waterbody features (e.g., changes to fish species, aquatic plant species, bird species); and
- Negative because such changes are detrimental to species comprising the ecological systems of these waterbodies.

Waterbody features that may be indirectly impacted by the introduction and establishment of Hydrilla include associated terrestrial features such as points and islands, as well as the shoreline and littoral zone of Lake Huron, beaches, interior lakes, harbors, and bays along the shoreline of the lake, the outlets or mouths of creeks and rivers where they enter the lake or the harbors or bays along the lake shoreline, and marshes and wetlands. Collectively, the 52 focus areas within the SW Lake Huron watershed include all of these natural features.

Finally, impacts from the introduction and establishment of Hydrilla in these natural features could be cumulative under certain conditions, such that the long-term (permanent), direct, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these natural features from the introduction and establishment of Hydrilla could occur where a waterbody, marsh, or wetland:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil (*Myriophyllum spicatum*); and/or

- Has existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct impacts from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect the waterbodies, resulting in a cumulative impact.

The above impact assessment on natural waterbody or marsh/wetland features is for the introduction and establishment of Hydrilla, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct, negative impacts on the affected natural features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Impacts on Socio-Cultural Features

The introduction and establishment of Hydrilla on socio-cultural features would result in a number of different impacts on socio-cultural features, depending on the type of socio-cultural feature. All of the socio-cultural features considered as part of this impact assessment are associated in some way with natural features that are located adjacent to, or are comprised of, waterbodies.

All of the types of socio-cultural features identified within the 52 focus areas along the shoreline of the SW Lake Huron watershed are located along shoreline areas or waterbody features within which Hydrilla is likely to be introduced and established. The impacts on these socio-cultural resources may be direct, where the purpose for, or use of, these socio-cultural features is typically water-dependent, or indirect, where the purpose for, or use of, these socio-cultural features is typically water-related, as discussed below.

The following socio-cultural features may be directly impacted by the introduction and establishment of Hydrilla:

- Private businesses (e.g., marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including state, county, or private natural areas, nature preserves, and wildlife management areas that contain or are located adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);

- Governmental facilities (e.g., public boat launches, U.S. Coast Guard stations, and harbors).

Collectively, the 52 focus areas within the SW Lake Huron watershed include all of these types of socio-cultural features.

The direct impacts on these socio-cultural features that would result from the introduction and establishment of Hydrilla would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of associated affected waterbody features, such that the purpose for, and use of, these socio-cultural features would be affected. For example, full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface, such that private businesses or governmental facilities such as marinas or harbors could no longer be used by boats; boating or fishing would no longer be desirable or viable activities; use of public parks and beaches along affected waterbodies would no longer be desirable for recreational activities; operation of water intake and discharge systems for industrial facilities would be affected; and
- Negative because the purpose for, or uses of, these socio-cultural features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

The following socio-cultural features may be indirectly impacted by the introduction and establishment of Hydrilla:

- Private businesses such as shoreline restaurants, campgrounds, mobile home parks, RV camping, resorts, and hotels;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, for enjoying scenic views and viewsheds);
- Built resources, particularly where underwater or waterfront setting is an important component of the use of, or purpose for, a built resource; and
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, enjoying scenic views and viewsheds).

Collectively, the 52 focus areas within the SW Lake Huron watershed include all of these types of socio-cultural features.

The impacts on these socio-cultural features as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the appearance of the setting (visual or olfactory) of these socio-cultural features; and
- Negative, because the intended purpose for, or use of, such features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

As previously discussed for natural features, impacts on these socio-cultural features from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these socio-cultural features from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on socio-cultural features from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these features, resulting in a cumulative impact.

The above impact assessment on socio-cultural features has been for the introduction and establishment of Hydrilla within the 52 focus areas along the shoreline of the SW Lake Huron watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the socio-cultural features that are associated with these natural waterbody or marsh/wetland features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views because their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Impacts on the water-dependent or water-related uses associated with affected waterbodies are discussed in Section F.5.5.

F.5.5 Impacts on Water-Dependent or Water-related Uses of Resources

The introduction and establishment of Hydrilla would result in a number of different impacts on water-dependent or water-related uses within the 52 focus areas along the Lake Huron shoreline within the SW Lake Huron watershed, depending on the type of use and/or the type of natural or socio-cultural feature with which the use is associated. For the purposes of this impact assessment, natural features associated with water-dependent uses include the shoreline and littoral zones of Lake Huron within the focus areas, such as the following features: harbors and bays; beaches; outlets or mouths of creeks and rivers; and marshes and wetlands. However, all the natural features identified within the 52 focus areas along the Lake Huron shoreline are associated with water-related uses, including those identified above for water-related uses along with points and islands.

As discussed above in Section F.5.4, socio-cultural features associated with water-dependent uses would include:

- Private businesses (e.g., boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including state, county, or private natural areas, nature preserves, and wildlife management areas that contain or are located in or adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, sportfishing clubs); and
- Governmental facilities (e.g., public boat launches, U.S. Coast Guard stations, and harbors).

Therefore, the introduction and establishment of Hydrilla is likely to have some type of impact on all of the water-dependent uses associated with these natural and socio-cultural features.

The following water-dependent uses may be directly impacted by the introduction and establishment of Hydrilla:

- Swimming;
- Recreational boating;
- Fishing;
- Sailing; and
- Policing waterways and waterbodies.

Similarly, socio-cultural features associated with water-related uses would include:

- Private businesses such as shoreline restaurants, campgrounds, mobile home parks, RV camping, resorts, and hotels;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., for sunbathing, sightseeing, birding, and for enjoying scenic views and viewsheds);
- Built resources, particularly where underwater or waterfront settings are an important component of the use of, or purpose for, a built resource; and
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., for birding, wildlife management, and enjoying scenic views and viewsheds).

The following water-related uses may be indirectly impacted by the introduction and establishment of Hydrilla:

- Dining;
- Drinking;
- Sightseeing;
- Sunbathing;
- Hiking;
- Camping;
- Experiencing nature;
- Vacationing;
- Preserving natural resources;

- Managing natural resources;
- Seasonal (vacation) housing;
- Permanent housing; and
- Commercial and industrial support facilities for recreational, seasonal, and permanent residential activities.

The impacts on the above water-dependent and water-related uses within the 52 focus areas as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), direct and indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it becomes established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would prevent or impede the water-dependent uses such that they could no longer take place;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the conditions within which such water-dependent uses can occur, such that these water-dependent uses could no longer be conducted or sustained by their users or would no longer be considered viable by their owners or managers; and
- Negative where the introduction and establishment of Hydrilla physically prevents or detrimentally impairs these water-dependent uses or the management of these water-dependent uses.

For example, water-dependent uses such as swimming, recreational boating or sailing, and fishing would not be possible or would not be considered desirable water-dependent activities in a waterbody densely infested with Hydrilla. If such water-dependent uses were reduced, there would be a concurrent reduced need for boat maintenance or storage facilities in the absence of recreational boating, sailing, or fishing. The boating actions associated with policing affected waterbodies or using affected waterbodies that are harbors would be impaired. The use of water intakes and discharge outfalls associated with sewage treatment and water treatment would be impeded such that treatment or power production would be impaired.

Similarly, water-related uses would be considered less desirable primarily because of changes to the setting (visual or olfactory) of socio-cultural features that support such activities. Waterfront or shoreline restaurants would no longer be perceived as attractive places for dining, drinking, and socializing. Similarly, shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing, sunbathing, hiking, or enjoying nature. With changes to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary. Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

As discussed above for natural and socio-cultural features, impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could occur where associated waterbodies or marshes or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on water-dependent or water-related uses from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these uses, resulting in a cumulative impact.

The above impact assessment on water-dependent or water-related uses has been for the introduction and establishment of Hydrilla within the 52 focus areas along the shoreline of Lake Huron in the SW Lake Huron watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above for the 52 focus areas are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, such that their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants, campgrounds, or parks). Where the introduction and establishment of Hydrilla would result in impacts on natural or socio-cultural features and/or associate water-dependent or water-related uses, it is likely that perceptions about these features and uses would change. Possible changes to perceptions about the natural or socio-cultural features and their associated water-dependent and water-related uses are considered in Section F.5.6.

F.5.6 Impacts on Community Perceptions of Features and Uses

As noted above in Section F.5.3, counties, towns, and cities associated with the 52 focus areas along the Lake Huron shoreline of the SW Lake Huron watershed would manage the natural and socio-cultural features areas located along their respective shorelines or waterfronts to protect, enhance, promote, create, rehabilitate, redevelop, or develop water-dependent and water-related uses. Management would be according to the goals, policies, objectives, or recommendations that are memorialized in management plans that include these areas.

It is likely that natural and socio-cultural features that are located within the 52 focus areas along the shoreline of Lake Huron in the SW Lake Huron watershed may be specifically identified in such plans, indicating that they would be perceived as locations, features, or attributes that define the local community or governmental unit and that they would be perceived and recognized as worthy of protection or improvement. Similarly, water-dependent and water-related uses associated with these natural and socio-cultural features may also be identified and described, either as part of planning efforts or via zoning ordinances, and discussed in such plans. This would indicate that such uses would be perceived as worthy of protection, management, creation, enhancement, or development.

Such perceptions would generally be expected to be identified or expressed by local individuals and groups that comprise the communities or governmental units responsible for the preparation of such plans and would be inherent in such plans because they were made known via charrettes, questionnaires, and other outreach efforts conducted as part of the preparation of such plans. Such local individuals and groups would be expected to be comprised of local residents, or non-local stakeholders with an interest in specific resources or for specific uses (such as individuals or companies that own and/or manage businesses, organizations, or facilities in an area but do not actually reside there). Additionally, the perceptions of federal, state, or local agencies that fund such planning efforts, or that provide guidance for the preparation of such plans, may also be incorporated into the preparation of such plans, albeit indirectly, via the requirements for the preparation of such plans or via the structure and/or content of meetings and materials included in outreach efforts.

Separately, the perceptions of individuals or groups that have an interest in specific or collective natural or socio-cultural features within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed, or their associated water-dependent or water-related uses, may be lacking from such plans. Such individuals or groups may be seasonal users, state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and special interest groups whose involvement would be at a regional or national scale. For example, the perceptions of individuals or groups that are seasonal users would likely be expressed outside of such plans, by changes to patterns of visiting areas for recreational or other purposes, such as vacationing, camping, fishing, boating, etc. Similarly, the perceptions of state or federal agencies with management responsibilities for specific socio-cultural features located within the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed may also be lacking from such plans. These agencies would be as diverse as the Michigan Department of Natural Resources and Michigan State Historic Preservation Office, that manage parks, historic sites, natural areas, and public access for waterbodies; and federal agencies such as the U.S. Army Corps of Engineers, which manages navigable waterways.

Finally, the perceptions of special interest groups that would have a broad or unique interest in natural and socio-cultural features in the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed, and/or their water-dependent or water-related uses, would also be expressed outside of such plans. Such groups, whose primary perceptions would be related to regional, national, or cultural interests in a specific area, feature, or use, may include: federally recognized Indian tribes who may have a cultural or historical affiliation with areas that include such features and uses or may have retained treaty rights for use of such areas; or groups such as the Sierra Club, the Nature Conservancy, or Ducks Unlimited, which have national conservation interests that are applied at the local level via ownership of conservation areas or sponsorship for various conservation efforts.

As suggested above in the assessment of water-dependent and water-related uses of natural and socio-cultural features in the 52 focus areas, the potential impacts of the introduction and establishment of Hydrilla would be likely to occur where e physical changes would have been made to the features or uses, or where there would be visual or olfactory changes to the setting of such features or uses. For example, the natural or socio-cultural features themselves may no longer be perceived as worthy of being protected, preserved, or managed for their intrinsic natural or socio-cultural values to a community. When changes are made to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary.

Similarly, the water-dependent or water-related uses associated with such features may no longer be perceived as desirable or viable. For example, waterfront or shoreline restaurants would no longer be perceived as attractive places for dining, drinking, and socializing; or shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing, sunbathing, hiking, or enjoying nature.

Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent and water-related uses within the 52 focus areas as a result of the introduction and establishment of Hydrilla have the potential to be long-term (permanent), direct indirect, and negative. Specifically, these impacts would likely be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the conditions of affected features or uses, it is the perceptions of these affected features or uses that could change; and
- Negative where the perceptions of affected features or uses conclude that such features and uses are no longer worthy of protection, management, creation, improvement, enhancement, or development.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent or water-related uses within the 52 focus areas from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on perceptions of affected features or uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the indirect impacts on perceptions of affected features or uses from introduction and establishment of Hydrilla would occur at a faster rate or would be greater, resulting in a cumulative impact.

The above impact assessment for perception of affected natural and socio-cultural features and their associated water-dependent or water-related uses within the 52 focus areas has been for the introduction and establishment of Hydrilla. It is understood that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies While it would be unlikely for treatment to completely eliminate or reverse the physical impacts of the introduction and establishment of Hydrilla, treatment would likely receive considerable support by the communities, governmental units, state and federal agencies, stakeholders, special interest groups, and seasonal users in an effort to avoid or minimize impacts on the perceptions of affected features and uses.

F.5.7 Impacts on Community Character of Focus Areas in the Southwestern Lake Huron Watershed

Dispersal modelling suggests that the primary method of introduction of Hydrilla into specific locations is via recreational boat use, such that locations where recreational boaters launch (via public boat launch or private boat launch locations) are most likely to result in the initial introduction of Hydrilla. It follows that the spread of Hydrilla likely would also occur at secondary locations that are accessible by recreational boaters but do not necessarily contain formal public or private boat launching facilities.

Therefore, impacts on community character resulting from the introduction and establishment of Hydrilla are most likely to occur in those locations: (1) that have physical features (i.e., boat launch facilities) by which Hydrilla would become introduced; (2) that have environmental conditions conducive to the establishment of Hydrilla if it is introduced; and (3) whose community character is defined by natural and socio-cultural features and associated water-dependent or water-related uses that would be affected by the introduction and establishment of Hydrilla. In general, the 52 focus areas identified along the Lake Huron shoreline in the SW Lake Huron watershed either meet all of these criteria or, if a focus area lacks a public or private boat launch, meet the second and third criteria.

The potential impacts of the introduction and establishment of Hydrilla on the community character of the 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed correlates to the impact conclusions for natural and socio-cultural features, their associated water-dependent or water-related uses, and the perceptions of such features and use by communities and governmental units, as discussed above in Sections F.5.4, F.5.5, and F.5.6. Specifically, the long-term (permanent), direct and/or indirect, and negative impacts of the introduction and establishment of Hydrilla on natural and socio-cultural features, on their associated water-dependent or water-related uses, and on the perceptions of these features and uses, also result in the same type of impacts on the community character of these focus areas. The impacts associated with the treatment of Hydrilla would be the same, as would the potential for cumulative impacts.

It is likely, however, that such impacts on community character would be perceived differently. The local individuals and groups that comprise the communities and governmental units associated with these 52 focus areas likely would consider such impacts differently from seasonal users, from state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and from special interest groups whose involvement would be at a regional or national scale. Additionally, impacts on community character would occur at different rates over time, depending on the nature of the affected individuals, groups, agencies, or users.

For example, local individuals and groups that comprise the communities and governmental units associated with these 52 focus areas likely would recognize the impacts. However, they may be reluctant to accept the changes to their community character and be slow to participate in necessary revisions to the management of affected natural and socio-cultural features and their associated water-dependent or water-related uses that would alter their existing community character.

Conversely, state or federal agencies and special interest groups that operate regionally or nationally likely would recognize the impacts and would accept such changes to the affected features and uses. However, they also may be slow to participate in necessary revisions to the management of affected features and uses for any number of administrative reasons (e.g., limited manpower, limited budget, and limited regulatory authority).

Finally, it is likely that seasonal users may differ greatly from both of these other groups. Seasonal users would be likely to recognize the impacts, and while reluctant to accept the changes to community character, quick to abandon those areas that contain affected natural and socio-cultural features and their associated water-dependent and water-related uses. Changes to their seasonal use of affected areas may be either in favor of other similar areas that remain unaffected by the introduction and establishment of Hydrilla or may represent a greater shift in favor of other areas with features and uses that would never be affected by the introduction and establishment of Hydrilla.

F.5.8 Impacts on the Community Character of the Southwestern Lake Huron Watershed

The 52 focus areas along the Lake Huron shoreline in the SW Lake Huron watershed were selected specifically because they contain conditions that are conducive to the introduction and establishment of Hydrilla. Therefore, the potential impacts on the natural and socio-cultural features and their associated water-dependent and water-related uses that contribute to the community character of these focus areas may appear to be disproportionately emphasized when compared to the potential for similar impacts along the entire Lake Huron shoreline or within the SW Lake Huron watershed.

For the SW Lake Huron watershed as a whole, dispersal modelling predicted that by 2025, approximately less than 1% (0.7) of the total waterbody area within the watershed would be affected by Hydrilla (see Table 3.1.5-1 in the risk assessment). Given the overall size of the SW Lake Huron watershed and prevalence of water resources therein, it can be inferred on the dispersal model results that future (2025) impacts resulting from introduction and establishment of Hydrilla on the overall community character of the watershed may be relatively small when considered for the entire watershed. However, if perchance all future Hydrilla infestations were to occur along the Lake Huron shoreline in one or more of the 52 focus areas evaluated in this analysis, the collective impacts likely would garner more attention and have a greater collective impact, especially if future infestations are concentrated in one or more of the high-use, high-value areas located on the shoreline, such as Saginaw Bay.

Although this section describes potential future impacts from Hydrilla in focus areas along the Lake Huron shoreline, it is expected that similar impacts from the introduction and establishment of Hydrilla would occur at various locations throughout the interior of the SW Lake Huron watershed. However, it is likely that these impacts would be more localized at or near the point of introduction, and would individually affect a smaller number of natural and socio-cultural features and a smaller number of associated water-dependent or water-related uses. Therefore, perceptions of the impacts on such features and uses, and their overall effect on the community character of the entire watershed would be diluted over a larger area.

As indicated by the above impact analysis, the Lake Huron shoreline represents a distinct component of the community character of the entire SW Lake Huron watershed that differs in size and nature when compared to the smaller and dispersed waterbodies (lakes, ponds, rivers, and creeks) that are located in the interior of this watershed. Thus, it is not unusual that the potential impacts of the introduction and establishment of Hydrilla, with or without treatment to control its spread, would be considered a prominent factor in the future of the SW Lake Huron watershed.

F.5.9 Conclusions and Recommendations

The introduction and establishment of Hydrilla into the SW Lake Huron watershed has the potential to result in long-term (permanent), direct and indirect, negative impacts on natural and socio-cultural features and their associated water-dependent and water-related uses that comprise the socio-cultural setting of this watershed. Similar impacts would be expected on the perceptions of these features and uses. Collectively, these impacts would represent long-term, indirect, negative impacts on the community character of this watershed.

These conclusions were based on the analysis of features and associated uses that were identified from: publicly available databases and planning documents; overlays for Google Earth; 7.5-minute USGS topographic quadrangles; and/or coastal maps maintained in the NOAA's Office of Coast Survey Historical Map and Chart Collection. These conclusions were also developed considering the management of such features and uses that may be represented in comprehensive plans or master plans for the various counties, towns, and cities located along the Lake Huron shoreline in the SW Lake Huron Watershed and/or planning documents developed by the Michigan Department of Natural Resources and its member agencies.

These conclusions are based on the analysis of impacts on natural and socio-cultural features and associated water-dependent and water-related uses identified for 52 focus areas that collectively represent approximately 105 miles (23%) of the approximately 462-mile-long Lake Huron shoreline in the SW Lake Huron watershed. However, these conclusions are considered generally representative of potential impacts that would occur in interior areas of this same watershed and would be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

Separately, as discussed in this impact assessment (see Sections F.5.5 and F.5.6), there are a wide variety of agencies, organizations, and special interest groups, in addition to the many communities and governmental units with authority or jurisdiction over the Lake Huron shoreline in the SW Lake Huron watershed, that may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the watershed. These stakeholders would include, but may not be limited to:

- State agencies such as Michigan State Historic Preservation Office or Michigan Department of Natural Resources that manage parks, historic sites, natural areas, and public access for waterbodies;
- Federal agencies such as the U.S. Army Corps of Engineers, which manages navigable waterways throughout the SW Lake Huron watershed;
- Federally recognized Indian tribes who may have cultural or historical affiliation with various areas in the SW Lake Huron watershed or retain treaty rights to lands, waters, and resources within the SW Lake Huron watershed;
- Special interest groups such as or The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that have a broadly defined interest in areas and resources along the shoreline and in interior areas of the SW Lake Huron watershed.

Outreach efforts by the USACE with the various communities and governmental units for all of the counties, towns, cities, and other areas at both the agency and public level is encouraged in order to collaboratively identify and develop strategies related to raising awareness for, controlling, and jointly managing the introduction and establishment of Hydrilla in this watershed. Similarly, the USACE should consider additional similar outreach efforts with the various stakeholders identified above for the same reasons. Many of these communities, governmental units, and stakeholders already have experience managing invasive aquatic plant species other than Hydrilla, and would likely welcome the opportunity to avoid or minimize the potential for new and/or cumulative impacts on the natural and socio-cultural features and associated water-dependent or water-related uses that they already manage or value.

F.5.10 References

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Attachment F-5

Natural and Socio-Cultural Features Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Lexington	MI	Sanilac	Village of Lexington	Community	Lakefront town along Lake Huron, including a historic Main Street and Harbor/Beach area.	1
Lexington State Harbor	MI	Sanilac	Village of Lexington	Harbor	State-run harbor and marina offering docking, access to Lake Huron, fishing, etc.	1
Oldford's Lexington Marina	MI	Sanilac	Village of Lexington	Marina	Lakefront marina offering 71 slips, ice cream shop, bathhouse facilities, access to Lake Huron, etc.	1
Port Sanilac	MI	Huron	Village of Port Sanilac	Community	Lakefront town along Lake Huron, including a historic Main Street and Harbor/Beach area. Population was 623 at the 2010 census	2
Port Sanilac Light Station	MI	Huron	Village of Port Sanilac	Built resource	NRHP Listed lighthouse on Lake Huron shoreline; NPS # 84001842	2
Port Sanilac Marina	MI	Huron	Village of Port Sanilac	Private business	Full service marina within Port Sanilac Harbor, offering docking and storage, maintenance and repairs, boat sales, sailing club, towing service, etc.	2
The great Lakes Diver	MI	Huron	Village of Port Sanilac	Private business	Scuba diving shop along Lake Huron shoreline	2
Port Sanilac Boat Launch	MI	Huron	Village of Port Sanilac	Public facility	Public boat launch offering access to Lake Huron, public park, bathroom facilities, etc.	2
White Rock	MI	Huron	Village of Port Sanilac	Community	Lakefront community along Lake Huron shoreline	2
White Rock Creek	MI	Huron	Sherman Township	Natural feature	Tributary to Lake Huron	3

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Harbor Beach	MI	Huron	City of Harbor Beach	Community	Lakefront community along Lake Huron shoreline. Population of 1,703 at 2010 census	4
Judge James H. Lincoln Memorial Park	MI	Huron	City of Harbor Beach	Public park	Beachfront public park offering sandy swimming beach, playground, picnic shelter, lengthy pier, etc.	4
Harbor Beach Lighthouse	MI	Huron	City of Harbor Beach	Built resource	NRHP Listed lighthouse in Harbor Beach Harbor; NPS # 83000850	4
Navigation Structures at Harbor Beach Harbor	MI	Huron	City of Harbor Beach	Built resource	NRHP Listed navigation structures within Harbor Beach Harbor; NPS # 97000972	4
Off Shore Marina	MI	Huron	City of Harbor Beach	Private business	Marina and campgrounds on Lake Huron shoreline, offering views of Lake Huron, camping, fishing, etc.	4
Waterworks Park	MI	Huron	City of Harbor Beach	Public park	Waterfront park offering fishing, picnic areas, and four rental cottages	4
Harbor Beach Marina	MI	Huron	City of Harbor Beach	Public facility	Public marina offering 114 boat slips, restroom facilities, fuel, fish cleaning station, playground, etc.	4
Port Hope	MI	Huron	Village of Port Hope	Community	Lakefront community along Lake Huron shoreline. Population of 267 at 2010 census	6
Stafford, W. R., Saw Mill Site	MI	Huron	Village of Port Hope	Built Resource	NRHP Listed site in Port Hope along Lake Huron coast; NPS# 87001959	6
Port Hope Chimney	MI	Huron	Village of Port Hope	Built resource	State of Michigan Historical Marker, part of the W. R. Stafford Sawmill site	6

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Stafford County Park	MI	Huron	Village of Port Hope	Public Park	Lakefront park on Lake Huron shoreline, offering camping, camper cabins for rent, ball fields/courts, boat launch, etc.	6
Whiskey Harbor	MI	Huron	Gore Township	Natural feature	Bay along the coast of Lake Huron	7
Willow Creek	MI	Huron	Port Austin Township	Natural feature	Tributary to Lake Huron	8
Huron City	MI	Huron	Port Austin Township	Community	Small lakefront community/village along Lake Huron shoreline	8
Grind Stone City	MI	Huron	Port Austin Township	Community	Small fishing community near Lake Huron shoreline	9
Grindstone County Park	MI	Huron	Port Austin Township	Public park	Lakefront park offering access to Lake Huron, fishing, Lake Huron views, etc.	9
Whalen's Grindstone Shores Inc.	MI	Huron	Port Austin Township	Private business	Lakefront campground and resort on Lake Huron shoreline offering camping sites, cabin rentals, fishing and boat access, fish cleaning, fishing charter services, etc.	9
Stormy Chinook Fishing Charters	MI	Huron	Port Austin Township	Private business	Fishing charter service offering fishing trips on Lake Huron	9
Captain Morgan's Grindstone Resort	MI	Huron	Port Austin Township	Private business	Restaurant and resort on Lake Huron shores, offering rooms/cabins for rent, boat docks, access to Lake Huron and fishing, fishing charter service, lakeside restaurant, etc.	9
Fin-Lander Sport Fishing Charters	MI	Huron	Port Austin Township	Private business	Fishing charter service offering fishing trips on Lake Huron	9

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Burnt Cabin Point	MI	Huron	Port Austin Township	Natural feature	Cape at the northern end of Port Austin within Lake Huron	10
Eagle Bay	MI	Huron	Port Austin Township	Natural feature	Bay along the Lake Huron coast near northern end of Port Austin	10
Port Austin	MI	Huron	Village of Port Austin	Community	Lakefront village in Huron County. Population was 664 at the 2010 census	12
Bird Creek	MI	Huron	Village of Port Austin	Natural feature	Tributary to Lake Huron	12
Port Austin Kayak	MI	Huron	Village of Port Austin	Private business	Kayak and paddleboard rental and tour service offering watersport rentals, tours to Turnip Rock, bike rentals, and beer garden	12
Bird Creek Park	MI	Huron	Village of Port Austin	Public park	Beachfront park along Lake Huron coast, offering a long boardwalk, picnic spots, restrooms, access to Lake Huron and fishing, rentable pavilion	12
Port Austin State Harbor	MI	Huron	Village of Port Austin	Public Park	Lakefront park along Lake Huron shoreline, offering boat launch, docks, picnic tables, access to Lake Huron, beach area, grills, etc.	12
Port Austin Breakwater	MI	Huron	Village of Port Austin	Built resource	Breakwater wall and walk containing Port Austin Harbor in Lake Huron, offering fishing and Lake Huron views	12
Light	MI	Huron	Village of Port Austin	Built resource	Light at the end of Port Austin breakwater wall for guiding boaters	12

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Port Crescent State Park	MI	Huron	Hume Township	Public Park	Beachfront state park along Lake Huron shoreline offering beach area, swimming, hiking trails, boardwalk, fishing, hunting, birding, cabin rentals and camping, etc.	14
Pinnebog River	MI	Huron	Hume Township	Natural feature	Tributary to Lake Huron	14
Tip-A-Thumb Canoe and Kayak Rental	MI	Huron	Hume Township	Private business	Canoe and kayak rental service along Pinnebog River	14
Sleeper State Park	MI	Huron	Lake Township	Public park	State park offering lakefront beach area, swimming, hiking trails, boardwalk, hunting, fishing, camping, cabin rentals, etc.	15
Rush Lake	MI	Huron	Lake Township	Natural feature	Inland lake near the Lake Huron shoreline	15
Oak Point Lake	MI	Huron	Caseville Township	Natural feature	Inland lake near the Lake Huron shoreline	16
Little Doerr Lake	MI	Huron	Caseville Township	Natural feature	Inland lake near the Lake Huron shoreline	16
Doerr Lake	MI	Huron	Caseville Township	Natural feature	Inland lake near the Lake Huron shoreline	16
Caseville	MI	Huron	City of Caseville	Community	Lakefront city in Huron County, along Lake Huron shoreline, population of 777 at the 2010 census	17
Pigeon River	MI	Huron	City of Caseville	Natural feature	Tributary to Lake Huron	17
Caseville Resort and Marina	MI	Huron	City of Caseville	Private business	Marina and Charter House Inn along Pigeon River offering lodging, camping, docking, clubhouse, pool, etc.	17
Caseville Marina	MI	Huron	City of Caseville	Private business	Marina on Pigeon River offering access to river and Lake Huron, docking, boat launch, fuel pumps, picnic areas, etc.	17

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Mariner's Cove Marina	MI	Huron	City of Caseville	Private business	Mobile home park and marina offering access to Pigeon River, docking, mobile home plots, etc.	17
Key North Surf Shop	MI	Huron	City of Caseville	Private business	Surf/gift/novelty shop along Pigeon River in Caseville	17
Mud Lake	MI	Huron	Caseville Township	Natural feature	Inland lake near the Lake Huron shoreline	18
Sand Point	MI	Huron	Caseville Township	Community	Small lakefront community located on a peninsula jutting into Lake Huron, separating Wild Fowl Bay from Lake Huron	18
Boat Ramp	MI	Huron	Caseville Township	Public facility	Boat launch offering access to Wild Fowl Bay and Lake Huron	18
Beadle Bay Marina & Campground	MI	Huron	Caseville Township	Private business	Summer lake resort offering campsites, RV sites, docking, kayak rentals, marina, etc.	18
Charity Island Excursions	MI	Huron	Caseville Township	Private business	Ferry and cruise service to Charity Island, offering dinner cruises, tours, private event space on Charity Island, etc.	18
Sand Point	MI	Huron	Caseville Township	Natural feature	Cape at the end of Sand Point Peninsula jutting into Lake Huron and Wild Fowl Bay	19
Sand Point Nature Preserve	MI	Huron	Caseville Township, and McKinley Township	Conservation area	Private lakefront nature preserve along Lake Huron shoreline, offering hiking trails, picnic spots, wildlife viewing, etc.	20
Wild Fowl Bay	MI	Huron	Caseville Township, and McKinley Township	Natural feature	Bay south of Sand Point in Lake Huron	20

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Bayshore Marina	MI	Huron	McKinley Township	Private business	Campground and marina on Wild Fowl Bay, offering docking, campsites, access to fishing, fueling, etc.	21
Bay Port	MI	Huron	Fairhaven Township	Community	Lakefront community along Wild Fowl Bay	22
Bay Port Historic Commercial Fishing District	MI	Huron	Fairhaven Township	Built resource	NRHP listed fishing district along Lake Huron shoreline; NPS # 77000714	22
Bay Port Fish	MI	Huron	Fairhaven Township	Private business	Fresh Lake Huron fish market located on Wild Fowl Bay, offering fresh, frozen, and smoked fish	22
Boat Ramp	MI	Huron	Fairhaven Township	Public facility	Public boat launch offering access to Wild Fowl Bay and Lake Huron	22
Wild Fowl Point	MI	Huron	Fairhaven Township	Natural feature	Cape at the western end of Wild Fowl Bay	22
Wild Fowl Bay State Wildlife Area	MI	Huron	Fairhaven Township	Conservation area	Expansive state wildlife area including multiple marsh island within Saginaw Bay, offering wildlife viewing, birding, hunting, fishing, boat access, etc.	24, 25, 26, 27
Rose Island	MI	Huron	Fairhaven Township	Community	Small lakeside town along Saginaw Bay	25
Sebewaing	MI	Huron	Village of Sebewaing	Community	Lakefront village along Saginaw Bay in Huron County. Population of 1,759 at 2010 census	28
Sebewaing County Park	MI	Huron	Village of Sebewaing	Public Park	Lakefront public park offering available campsites, wildlife viewing, fishing dock, etc.	28
Sebewaing River	MI	Huron	Village of Sebewaing	Natural feature	Tributary to Lake Huron	28

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Sebewaing River Campground	MI	Huron	Village of Sebewaing	Private business	Campground and marina offering rustic and modern campsites, boat ramp for access to Lake Huron, cabin rentals, etc.	28
Sebewaing Harbor Marina LLC	MI	Huron	Village of Sebewaing	Private business	Marina located along Sebewaing River offering docking, access to Lake Huron, Bait and Tackle shop, etc.	28
Fish Point State Wildlife Area	MI	Tuscola	Akron Township	Conservation area	Wildlife area along Saginaw Bay offering hiking trails, birding, wildlife viewing, fishing, canoeing/kayaking	29, 30, 31
Sunset Bay Marina	MI	Tuscola	Akron Township	Private business	Marina and campground offering access to Lake Huron, docking, fishing, etc.	30
Boat Ramp	MI	Tuscola	Akron Township	Public facility	Public boat launch offering access to Lake Huron	30
Quanicassee River	MI	Tuscola	Wisner Township	Natural feature	Tributary to Lake Huron	32
Fresh Water Boats	MI	Tuscola	Wisner Township	Private business	Boat sales business located along Quanicassee River	32
Boat Ramp	MI	Tuscola	Wisner Township	Public facility	Public boat launch offering access to Lake Huron, and fishing	32
Essesville	MI	Bay	City of Essexville	Community	Riverfront town, part of Bay City, along Saginaw River. Population of 3,478 at 2010 census	33
Bangor	MI	Bay	Bangor Township	Community	Riverfront/Lakefront town, part of Bay City, along Saginaw River. Population of 14,641 at 2010 census	33, 34

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Saginaw River	MI	Bay	Hampton Township, City of Essexville, Bangor Township	Natural feature	Tributary to Lake Huron	33
Saginaw Bay	MI	Bay	Hampton Township, City of Essexville, Bangor Township, Kawkawlin Township	Natural feature	Bay at the mouth of Saginaw River	33
U.S. Coast Guard	MI	Bay	Hampton Township	Government facility	Coast guard station located along Saginaw River	33
Saginaw Bay Yacht Club	MI	Bay	Hampton Township	Organization	Yacht club and marina along Saginaw River, offering memberships, clubhouse and social events, dining and lounge facilities, etc.	33
Bay Aggregates, Inc.	MI	Bay	Bangor Charter Township	Private business	Sand, gravel, concrete, aggregate distributor located along Saginaw river, utilizing river and Lake Huron for transport	33
Bay Harbor Marina	MI	Bay	Bangor Charter Township	Organization	Marina and boat club located on Saginaw River offering docking, storage, fueling, party store (beer and wine), ship store, bathhouses, etc.	33
Saginaw River Light Station	MI	Bay	Bangor Charter Township	Built resource	NRHP Listed lighthouse/light station; NPS # 84001373	33
DNR Launch	MI	Bay	Bangor Charter Township	Public facility	Public boat launch near mouth of Saginaw River offering access to Saginaw Bay/River and lake Huron	33

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Bay City Yacht Club	MI	Bay	Bangor Charter Township	Organization	Marina and boat club located on Saginaw River offering docking, storage, fueling, bathhouses, etc.	33
Sunset Shores Yacht Club, Inc.	MI	Bay	Bangor Charter Township	Organization	Boat club located on Saginaw River offering marina and docking, access to Lake Huron, community room, picnic areas, bathhouse facilities, etc.	33
Lagoon Beach	MI	Bay	Bangor Charter Township	Community	Lakefront community along Lake Huron shoreline	34
Kawkawlin River	MI	Bay	Bangor Charter Township	Natural feature	Tributary to Lake Huron	34
Castaways	MI	Bay	Bangor Charter Township	Private business	Riverside bar and grill offering docking for customers, live music, boater friendly, etc.	34
Tobico Lagoon	MI	Bay	Bangor Charter Township	Natural feature	Water body fed by Lake Huron, harbored inland by barrier beach	35
Tobico Marsh & Frank N. Andersen Nature Trail	MI	Bay	Bangor Charter Township	Conservation area	Nature park and trail system within the Bay City State Recreation Area near Lake Huron shoreline, offering hiking trails	35, 36
Tobico Marsh	MI	Bay	Bangor Charter Township, and Kawkawlin Township	Natural feature	Natural marsh land protected by a beach barrier, near Lake Huron shoreline	36
Tobico Marsh Nature Area	MI	Bay	Bangor Charter Township, and Kawkawlin Township	Conservation area	Natural wildlife area offering hiking trails, hunting, canoeing, birding, etc.	36

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Linwood Beach Marina and Campground	MI	Bay	Kawkawlin Township	Private business	Marina located along Saginaw Bay shoreline offering docking, boat sales and repair shop, campground, fishing, etc.	37
Lengsville Point	MI	Bay	Fraser Township	Natural feature	Cape jutting south into Saginaw Bay	38
Mallard Point	MI	Bay	Fraser Township	Natural feature	Cape jutting south into Saginaw Bay	38
Nayanquing Point	MI	Bay	Fraser Township	Natural feature	Cape jutting south into Saginaw Bay	38
Nayaquing Point State Wildlife Area	MI	Bay	Fraser Township	Conservation area	Wetland nature park and wildlife area offering hiking, birding, fishing, hunting, wildlife viewing, etc.	38
Pinconning River	MI	Bay	Pinconning Township	Natural feature	Tributary to Lake Huron	39
Bay County Pinconning Park	MI	Bay	Pinconning Township	Public Park	Lakefront public park offering beach area, swimming, playground, campsites, cabins for rent, pavilion/gazebo for rent, and a boat ramp	39
Eagle Bay Marina	MI	Arenac	Standish Township	Private business	Full service marina on Lake Huron offering floating docks, access to Lake Huron, watercraft rentals, storage, fueling, bathhouse facilities, etc.	40
Pine River	MI	Arenac	Standish Township	Natural feature	Tributary to Lake Huron	41
Pine River Access	MI	Arenac	Standish Township	Public facility	Public boat launch on Pine River offering access to river, Lake Huron, and fishing	41
Wigwam Bay	MI	Arenac	Standish Township, and Arenac Township	Natural feature	Bay/Harbor within Lake Huron	42
Rifle River	MI	Arenac	Arenac Township	Natural feature	Tributary to Lake Huron	43
Greens Point	MI	Arenac	Arenac Township	Natural feature	Marshy cape at northern edge of Wigwam Bay	44

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Boat Ramp	MI	Arenac	City of Au Gres	Public facility	Public boat launch offering access to Saginaw Bay and Lake Huron	46
Au Gres River	MI	Arenac	City of Au Gres	Natural feature	Tributary to Lake Huron	46
Au Gres Yacht Club	MI	Arenac	City of Au Gres	Organization	Marina and boat club offering docking, clubhouse, social events, fueling and marine store	46
Sleepy Oaks RV Campground	MI	Arenac	City of Au Gres	Private business	Lakefront campground offering RV sites, tent sites, clubhouse, laundry and bathhouse facilities, access to Lake Huron, fishing, etc.	46
Northport Station LLC	MI	Arenac	Sims Township	Private business	Public marina offering docking and access to Lake Huron	47
Northport Campground	MI	Arenac	Sims Township	Private business	Lakefront mobile home park offering RV and mobile home plots, in-ground pool, docking and access to Lake Huron	47
Northport Marine	MI	Arenac	Sims Township	Private business	Boat storage and service business offering indoor and outdoor summer and winter storage, maintenance, etc.	47
Cranberry Lake	MI	Arenac	Whitney Township	Natural feature	Inland lake near Lake Huron shoreline	48
Alabaster Historic District	MI	Iosco	Alabaster Township	Built resource	NRHP Listed District near Lake Huron shoreline; NPS # 77000715	49
United States Gypsum	MI	Iosco	Alabaster Township	Industrial facility	Gypsum/stone quarry near Lake Huron shoreline	49
Young’s Getaway Beachfront Resort	MI	Iosco	Tawas City	Private business	Vacation home rental agency offering beachfront cottages	50

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Tawas Bay Condominium Marina	MI	Iosco	Tawas City	Private business	Private marina offering access to Lake Huron, clubhouse, 129 available slips, bathhouse facilities, etc.	50
Tawas River	MI	Iosco	Tawas City	Natural feature	Tributary to Lake Huron	50
Boat Ramp	MI	Iosco	Tawas City	Public facility	Public boat launch along Tawas River offering access to river and Lake Huron	50
Gateway Park	MI	Iosco	Tawas City	Public park	Lakefront park offering beach area, pavilion, lake swimming, walking paths, fishing, etc.	50
Surfside Motel Marina Resort	MI	Iosco	Tawas City	Private business	Riverfront/Lakefront motel and marina offering waterfront room rentals, docking, access to Tawas River and Lake Huron	50
Tawas City	MI	Iosco	Tawas City	Community	Lakefront city along Tawas Bay/Lake Huron coastline. Population of 1,827 at 2010 census	50
Tawas Bay	MI	Iosco	Tawas City	Natural feature	Bay with Lake Huron, bordering Tawas City and Tawas Point	50
East Tawas Dock	MI	Iosco	City of East Tawas	Private business	State run marina offering docking, boat launch, access to Lake Huron, playground and park, fueling, etc.	51
Bikini's Beach Bar	MI	Iosco	City of East Tawas	Private business	Beachfront restaurant and bar offering outdoor seating, private beach, jet ski rentals, beach volleyball, etc.	51

Attachment F-5 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Huron Shoreline in the Southwestern Lake Huron Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number*
Tawas Bay Beach Resort	MI	Iosco	City of East Tawas	Private business	Beachfront hotel/resort offering waterfront rooms, Lake Huron views, private beach and swimming area, restaurant, private event space, watercraft rentals, etc.	51
East Tawas DNR Boat Launch	MI	Iosco	City of East Tawas	Public facility	Public boat launch along Tawas Bay offering access to Lake Huron	51
Lake Solitude	MI	Iosco	Baldwin Township	Natural feature	Inland lake near Lake Huron shoreline	52
Spencer Lake	MI	Iosco	Baldwin Township	Natural feature	Inland lake near Lake Huron shoreline	533

* The following focus areas do not have any specific natural or cultural features, communities, etc.: 5, 11, 13, and 45. Additionally, due to a numbering oversight, there is no Focus Area Number 23.

F.6 Potential Socio-Cultural Impacts: Southwestern Lake Michigan 2 Watershed

The Southwestern Lake Michigan 2 watershed is located at the southern end of Lake Michigan. Located within portions of southwestern Michigan, northwestern Indiana, and northeastern Illinois, it extends over portions of five counties: (from east to west) Berrien Count, Michigan; La Porte, Porter, and Lake counties, Indiana; and Cook County, Illinois.

According to modeling conducted for the introduction and establishment of Hydrilla within the larger Great Lakes basin, the Southwestern Lake Michigan 2 watershed is considered to have a medium potential for the introduction of Hydrilla, primarily via recreational boating, and a moderate potential for the establishment of Hydrilla in suitable nearshore aquatic habitat if it were to be introduced.

The following impact assessment describes the various features that comprise the existing socio-cultural setting of 26 focus areas along the approximately 148-mile-long shoreline area within the Southwestern Lake Michigan 2 watershed. These 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed were selected for detailed analysis because they include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet, as discussed in greater detail in Section F.6.1. The following impact assessment then considers the potential impacts of the introduction and subsequent establishment of Hydrilla on the various features that collectively represent the community character of these focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. It is recognized that the Southwestern Lake Michigan 2 watershed encompasses additional areas along the shoreline as well as interior areas that are not located along the shoreline. However, the following impact assessment considers the socio-cultural setting and community character of only those counties, townships, villages, towns, and cities within which the 26 focus areas are located. This approach was adopted to make the impact assessment more manageable given the total length of the Lake Michigan shoreline (148 miles) in the Southwestern Lake Michigan 2 watershed.

Similarly, it is recognized that a wide variety of agencies, organizations, and special interest groups may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the Southwestern Lake Michigan 2 watershed. These stakeholders would consist of the civic and governmental areas with jurisdiction over the areas included in the Southwestern Lake Michigan 2 watershed. Additional stakeholders could include: state agencies such as Michigan State Historic Preservation Office, Michigan Department of Natural Resources, Indiana Department of Natural Resources, and Illinois Department of Natural Resources, that respectively manage parks, historic sites, natural areas, and public access for waterbodies in the states of Michigan, Indiana, and Illinois; federal agencies such as the U.S. Army Corps of Engineers, which manages navigable waterways and the U.S. National Park Service, which manages the Indiana Dunes National Lakeshores;

federally recognized Indian tribes that have a cultural or historical affiliation with areas along the shoreline in the Southwestern Lake Michigan 2 watershed or retain treaty rights to lands, waters, and resources along the shoreline of the Southwestern Lake Michigan 2 watershed; or special interest groups such as The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that may have a broadly defined interest in areas and resources along the shoreline of the Southwestern Lake Michigan 2 watershed. These additional stakeholders could be involved as part of continued consideration of the potential impacts associated with the introduction and establishment of Hydrilla within the larger Great Lakes basin.

Potential impacts on the socio-cultural setting of shoreline areas of the Southwestern Lake Michigan 2 watershed are discussed in terms of whether they would be: short-term (temporary) or long-term (permanent): direct or indirect, positive (beneficial) or negative (detrimental), and cumulative. Additionally, these impacts are considered with reference to two scenarios: one where Hydrilla is untreated (worst-case scenario) and one where Hydrilla is treated (managed scenario).

It is expected that the results of this assessment of the introduction and subsequent establishment of Hydrilla on the socio-cultural setting and community character of the 26 focus areas along the shoreline within the Southwestern Lake Michigan 2 watershed would be generally representative of potential impacts that would occur in interior areas of this same watershed. The results would also be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

F.6.1 Methodology and Definitions for the Socio-Cultural Impact Assessment for the Southwestern Lake Michigan 2 Watershed

This socio-cultural impact assessment assumes that the introduction and/or establishment of Hydrilla along the shoreline of the Southwestern Lake Michigan 2 watershed will affect the natural and socio-cultural features located in the 26 focus areas, resulting in changes to the watershed's community character. For the purposes of this impact assessment, natural features are defined as uplands, points, bluffs, coves, beaches, embayments, creeks, streams, rivers, marshes, etc., and socio-cultural features are defined as villages, towns, cities, parks, other residential areas (neighborhoods and hamlets), conservation areas (including nature preserves, wildlife preserves, and wildlife management areas), commercial enterprises, industrial facilities, and cultural and historical sites.

This socio-cultural impact assessment further assumes that these natural and socio-cultural features collectively represent tangible (physical) components of the community character of the Southwestern Lake Michigan 2 watershed. A review of publicly available information for Michigan, Indiana, and Illinois state agencies did not identify specific guidance for defining, or assessing impacts on, community character. However, Michigan's Natural Resources and

Environmental Protection Act, Act 451 of 1994, was passed to protect the environment and natural resources of the State of Michigan. While this act does not specifically address community character, many sections of this state law require project proponents to consider the impacts of their actions on the aesthetic, recreational, and economic aspects of natural resources (State of Michigan Legislative Council 2017). Similarly, Illinois Department of Natural Resources' guidance for the agency's Comprehensive Environmental Review Process (CERP) notes that for projects considered under CERP, an impact would be considered significant if it: affects a listed species, natural area or nature preserve; causes significant alterations to lakes or streams; affects NRHP-eligible historic properties, or substantially affects an importing aesthetic feature of the area within which the project is located (Illinois Department of Natural Resources 2017). Collectively, these aspects or features also contribute to community character at a broad level, when the interaction of natural and socio-cultural features are collectively considered to comprise community character.

Separately, both the Illinois and Indiana Departments of Transportation's provide guidance on the methodology for identifying the characteristics of communities (Illinois Department of Transportation 2007, Indiana Department of Transportation 2012). In general, this guidance considers socioeconomic characteristics when defining communities (such as population size, density, average age, and average household income). However, this guidance does acknowledge that definitions of community include the interaction of people with their physical environment, and maintaining, enhancing, or improving the relationships of individuals in a community with their physical environment is part of the assessment of impacts on the character of those communities.

In the absence of specific state-level guidance for defining community character and assessing impacts on community character, this impact assessment for the Southwestern Lake Michigan 2 watershed, which lies entirely within portions of Ohio and Michigan, uses the concept of community character that is modelled on New York State's guidance for complying with its State Environmental Quality Review Act (SEQR), consistent with other watersheds evaluated as part of this RA. New York State's SEQR guidance notes that:

> Many people define their community's character in very general terms: suburban, rural, urban, quiet, safe, scenic, or friendly are terms often used. Others describe community character only in terms of visual features.
>
> Community character is broader than this however. Community character is defined by all the man-made and natural features of the area. It includes the visual character of a town, village, or city, and its visual landscape; but also includes the buildings and structures and their uses, the natural environment, activities, town services, and local policies that are in place.

> These combine to create a sense of place or character that defines the area" (New York State Department of Environmental Conservation 2017).

The introduction and establishment of Hydrilla would occur within natural features located along the shoreline in the Southwestern Lake Michigan 2 watershed. These areas typically are locations recognized and used for water-dependent and water-related uses. The natural and man-made (socio-cultural) features of the watershed as a collective physical representation of the community character of the Southwestern Lake Michigan 2 watershed, as defined above by the NYSDEC, appears to provide the most comprehensive consideration of the impacts that the introduction and establishment of Hydrilla would have on the community character of the Southwestern Lake Michigan 2 watershed. However, the definition of community character for this impact assessment has been expanded to include the water-dependent and water-related uses of these natural and man-made or socio-cultural features, which also contribute to community character and are deliberately managed by the communities and governmental units that comprise the Southwestern Lake Michigan 2 watershed.

Due to the large extent of the shoreline in the Southwestern Lake Michigan 2 watershed (approximately 148 miles in length), 26 areas with environmental conditions highly suitable to establishment of Hydrilla were identified within this watershed for an in-depth impact assessment. These 26 areas (henceforth, referred to as focus areas) collectively comprise approximately 91 miles of the shoreline in the Southwestern Lake Michigan 2 watershed. They all contain physical conditions that are conducive to the introduction and establishment of Hydrilla. Table F.6-1, provides a summary description of each of the 26 focus areas identified for the Southwestern Lake Michigan 2 watershed. Section 3.3 in the risk assessment describes the criteria used to identify the 26 focus areas along the shoreline in this watershed, which include environmental conditions such as the presence of marinas, sheltered and calm waters, and water depths of less than 20 feet).

Thus, this socio-cultural impact assessment identifies the visible and physical natural and socio-cultural features that represent the attributes and assets of the communities and governmental units associated with the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed (see Section F.6.2: see also Attachment F-6 for a listing of these visible and physical natural and socio-cultural features). This socio-cultural impact assessment also considers the management of the visible and physical natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed by the associated counties, towns, and cities or villages (see Section F.6.3). This socio-cultural impact assessment considers the impacts of the introduction and/or establishment of Hydrilla on the natural and socio-cultural features and their associated water-dependent and water-related uses identified for the 26 focus areas in the Southwestern Lake Michigan 2 watershed (see Sections F.6.4 and F.6.5) and considers the impacts of the introduction and establishment of Hydrilla on perceptions of features and uses and on the community character of the 26 focus areas (see Section F.6.6 and F.6.7). The results of this impact analysis are considered with regard to their broader applicability to the entire Southwestern Lake Michigan 2 watershed (see Section F.6.8). Finally, conclusions and recommendations regarding the results of this impact assessment are presented in Section F.6.9.

Table F.6-1 Description of Focus Areas in the Southwestern Lake Michigan 2 Watershed

Focus Area Number	Description of Focus Area[1]	State	County	City or Township	Approximate Length (miles)
1	Shoreline of Lake Michigan and inland Grand Mere Lakes within Grand Mere State Park	MI	Berrien	Lincoln Township	8.48
2	Shoreline of unnamed inland lake within Lost Dunes Golf Club	MI	Berrien	Lake Charter Township	1.03
3	Shorelines of Lake Michigan at mouth of Galien River, Galien River, and multiple harbors/marinas	MI	Berrien	City of New Buffalo	6.47
4	Shoreline of inland Clare Lake within Long Beach Country Club	IN	La Porte	Town of Long Beach	3.58
5	Shoreline of unnamed, inland, manmade lake	IN	La Porte	Michigan City	0.79
6	Shorelines of Lake Michigan at Michigan City Harbor and mouth of Trail Creek, as well as Trail Creek	IN	La Porte	Michigan City	2.56
7	Shorelines of Lake Michigan and Burns International Harbor	IN	Porter	Town of Burns Harbor, and Portage Township	3.63
8	Shorelines of Long Lake and unnamed marsh within Indiana Dunes National Lakeshore	IN	Porter, and Lake	Portage Township (Porter County), and City of Gary (Lake County)	2.11
9	Shorelines of Grand Calumet River and unnamed marsh complex within Indiana Dunes National Lakeshore	IN	Lake	City of Gary	4.49

Table F.6-1 Description of Focus Areas in the Southwestern Lake Michigan 2 Watershed

Focus Area Number	Description of Focus Area[1]	State	County	City or Township	Approximate Length (miles)
10	Shorelines of Lake Michigan, Gary Harbor, and manmade industrial canal	IN	Lake	City of Gary	4.94
11	Shorelines of Lake Michigan at Buffington Harbor, and unnamed, inland lake	IN	Lake	City of East Chicago	1.60
12	Shorelines of Lake Michigan at unnamed harbor, East Chicago Marina, Indiana Harbor, and Indiana Harbor Canal	IN	Lake	City of East Chicago	8.34
13	Shorelines of inland Wolf Lake, and Lake George	IN, IL	Lake, and Cook	City of Hammond (Lake County), and City of Chicago (Cook County)	11.82
14	Shoreline of Lake Michigan at unnamed harbor/marina	IL	Cook	City of Chicago	0.89
15	Shorelines of Lake Michigan at Calumet Harbor, Calumet River, and multiple boat slips	IL	Cook	City of Chicago	9.43
16	Shorelines of Yacht Harbor, and South Lagoon within Jackson Park	IL	Cook	City of Chicago	1.72
17	Shorelines of Lake Michigan at 59th Street Harbor, East Lagoon and West Lagoon within Jackson Park	IL	Cook	City of Chicago	2.84
18	Shoreline Lake Michigan at 31st St Harbor	IL	Cook	City of Chicago	0.56
19	Shorelines of Lake Michigan at Burnham Harbor and unnamed, inland lake at Northerly Island	IL	Cook	City of Chicago	2.03
20	Shorelines of Lake Michigan at Chicago Harbor (Monroe Harbor) including multiple piers, and Chicago River	IL	Cook	City of Chicago	4.50
21	Shorelines of Diversey Harbor, South Lagoon, and North and South Ponds within Lincoln Park	IL	Cook	City of Chicago	4.36

Table F.6-1 Description of Focus Areas in the Southwestern Lake Michigan 2 Watershed

Focus Area Number	Description of Focus Area[1]	State	County	City or Township	Approximate Length (miles)
22	Shoreline of Belmont Harbor along Lake Michigan	IL	Cook	City of Chicago	1.61
23	Shoreline Montrose Harbor along Lake Michigan	IL	Cook	City of Chicago	1.10
24	Shorelines of Lake Michigan at unnamed harbor and Church St Boat Ramp, as well as Arrington Lagoon at Dawes Park	IL	Cook	City of Evanston	0.35
25	Shoreline of unnamed harbor along Lake Michigan within Northwestern University campus	IL	Cook	City of Evanston	1.00
26	Shoreline of Wilmette Harbor	IL	Cook	Village of Wilmette	0.73
Total	**N/A**		**N/A**	**N/A**	**90.97**

Notes:
[1] See Section 3.3 of the RA for a detailed discussion of the process used to select these focus areas.

Key:
N/A = Not applicable

F.6.2 Natural and Socio-Cultural Features along the Shoreline of the Southwestern Lake Michigan 2 Watershed

One hundred forty named natural and socio-cultural features are located within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These features were identified primarily from an analysis of information included in overlays for Google Earth and identified on 7.5-minute USGS topographic quadrangles and/or coastal maps maintained in the National Oceanic and Atmospheric Administration's (NOAA's) Office of Coast Survey Historical Map and Chart Collection. Collectively, these 140 named natural and socio-cultural features are a physical representation of the community character and the socio-cultural setting of the shoreline in the Southwestern Lake Michigan 2 watershed.

A full listing of the 140 named natural and socio-cultural features identified for the 26 focus areas is included in Attachment F-6. It is noted here that Appendix A is not a definitively complete listing of all the named natural and socio-cultural features in the 26 focus areas or along the entire shoreline in the Southwestern Lake Michigan 2 watershed. While the list in Attachment F-6 is reasonably comprehensive as to the type of natural and socio-cultural features present, it primarily only includes features that are named (e.g., named waterbodies and communities on 7.5-minute USGS topographic quadrangles) and/or that have been identified in databases that comprise the Google Earth overlays.

These 140 named natural and socio-cultural features can be grouped into 10 different categories of resources (see Table F.6-2). These 10 resource categories consist of (in order of predominance from most to fewest): private businesses, public parks and other public facilities, built resources, organizations, natural features, communities, industrial facilities, governmental facilities, conservation areas, and institutions. The types of natural and socio-cultural features located within, or associated with, these 26 focus areas should be considered generally representative of the larger number of natural and socio-cultural features along the shoreline in the Southwestern Lake Michigan 2 watershed.

Table F.6-2 Summary of Natural and Socio-Cultural Features within the 26 focus Areas along the Shoreline in the Southwestern Lake Michigan 2 Watershed

Resource Category	Description	Total Number in Watershed (% of total)
Private businesses	Private enterprises related to a variety of water-dependent or water-related recreational uses and activities along the shoreline of Lake Michigan.	31 (22%)
Public parks/facilities	State, county, and town parks and beaches located along the shoreline of Lake Michigan.	28 (20%)
Built resources	Specific buildings, structures, objects, or other built features located along the shoreline of Lake Michigan.	25 (18%)
Organizations	Public or private enterprises related to a variety of water-dependent or water-related recreational activities associated with the use of the shoreline of Lake Michigan.	23 (17%)
Natural features	Named natural features located along the shoreline of Lake Michigan.	14 (10%)
Communities	Named cities (including named neighborhoods), towns or villages, or hamlets located along the shoreline of Lake Michigan.	6 (4%)
Industrial facilities	Industrial facilities such as power plants or water treatment plants located along the Lake Michigan shoreline.	6 (4%)
Governmental facilities	Federal, state, or local government facilities located along the shoreline of Lake Michigan.	3 (2%)
Conservation areas	Federal, state, local, and private natural areas, nature/underwater preserves, and wildlife management areas located along the shoreline of Lake Michigan.	2 (1%)
Institutions	Educational facilities, such as universities, seminaries, or Chautauqua Institutes, located along the shoreline of Lake Michigan.	2 (1%)
Total		**140 (100%)**

Private Businesses (Socio-Cultural Feature)

Thirty-one private business enterprises were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these 31 private business enterprises represent approximately 22% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These 31 private business enterprises consist of a variety of businesses, primarily related to recreational activities, that all are associated with water-dependent or water-related use of the Lake Michigan shoreline. These private businesses were generally identified from overlays in Google Earth. Resources in this category include marinas, charter fishing companies, hotels, casinos, cruise ships, water taxis, restaurants, bars, and boating facilities. Resource use may be permanent or seasonal. There are likely to be additional similar private businesses along the shoreline in the Southwestern Lake Michigan 2 watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Public Parks and Other Public Facilities (Socio-Cultural Feature)

Twenty-eight public parks or other public facilities were identified within the 26 focus areas along the Shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these 28 public parks or other public facilities represent approximately 20% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These 28 named public parks or other public facilities consist of state, county, township, or municipal parks and beaches located along the Lake Michigan shoreline as well as numerous public boat ramps. These public parks and other public facilities were identified from USGS 7.5-minute topographic quadrangles and from Google Earth overlays. Resources in this category are primarily developed for active and passive recreational uses of the waterfront (in urban areas) or the shoreline in suburban and rural areas. There are likely to be additional public facilities along the shoreline in the Southwestern Lake Michigan 2 watershed that have not been identified for this assessment because they were not included in the databases used to generate Google Earth overlays.

Built Resources (Socio-Cultural Feature)

Twenty-five specific built resources were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these 25 specific built resources represent approximately 18% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These 25 specific built resources consist of manmade terrestrial and marine features. Manmade terrestrial built resources consist of buildings, structures, objects, or other built features located along the Lake Michigan shoreline. Some of these terrestrial buildings or structures are recognized for their individual or collective historic importance at the national, state, or local level (e.g., lighthouses, historical sites, or properties listed in the National Register of Historic Places). Other terrestrial structures consist of industrial docks. Manmade marine features consist of channelized areas within rivers or harbors, including canals, channels, and breakwalls. These specific built resources were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. Resources in this category may or may not be located within communities. Resources in this category may also include, but are not limited to, historic resources.

Organizations (Socio-Cultural Feature)

Twenty-three public or private organizations were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these 23 public or private organizations represent approximately 17% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These 23 public or private organizations consist of enterprises related to water-dependent or water-related recreational activities associated with the use of the Lake Michigan shoreline. These organizations were generally identified from overlays for Google Earth. Resources in this category primarily consist of yacht clubs, boat clubs, or golf clubs, but also include museums and aquariums with a specific water-related focus. Resources in this category may be owned privately or by non-profit groups. There are likely to be additional similar public or private organizations within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed that have not been identified for this assessment because they were not included in the databases used to generate overlays for Google Earth.

Natural Features

Fourteen named natural features were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these 14 named natural features represent approximately 10% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These 14 named natural features consist of named shoreline or nearshore features (such as rivers, creeks, bays, creeks, lagoons, and inland lakes) and named terrestrial features that are islands. These natural features were generally identified from USGS 7.5-minute topographic quadrangles and the NOAA's Office of Coast Survey Historical Map and Chart Collection. Resources in this category do not include unnamed waterbodies and topographic features, although such natural features are also present within many of the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed.

Communities (Socio-Cultural Feature)

Six named communities were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these six named communities represent approximately 4% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These six named communities consist primarily of named cities (and named neighborhoods within cities), towns, villages, and hamlets. These named communities were identified from USGS 7.5-minute topographic quadrangles and from overlays in Google Earth. Resources in this category also include variously sized named clusters of residential, commercial, and/or industrial development. With regard to residential development, this may be comprised of owner-occupied or rental units, and may be permanent or seasonal. Resources in this category do not include numerous locations of unnamed shoreline development, although such unnamed shoreline development is also present within some of the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed.

Industrial Facilities (Socio-Cultural Feature)

Six industrial facilities were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these six industrial facilities represent approximately 4% of the total natural and socio-cultural features within the focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These six industrial facilities consist of water treatment plants and manufacturing facilities located along the Lake Michigan shoreline. Resources in this category may be privately owned or operated by municipalities. These industrial facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There may be additional similar industrial facilities within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Governmental Facilities (Socio-Cultural Feature)

Three governmental facilities were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these three governmental facilities represent 2% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These three governmental facilities consist of federal governmental facilities located along the Lake Michigan shoreline. Resources in this category include facilities such as U.S. Coast Guard stations and municipal harbors and wharves. These governmental facilities were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. There are likely to be additional similar governmental facilities along the shoreline in the Southwestern Lake Michigan 2 watershed that have not been identified for this assessment because they were not identified on USGS 7.5-minute topographic quadrangles and were not included in the databases used to generate overlays for Google Earth.

Conservation Areas (Socio-Cultural Feature)

Two conservation areas were identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. Collectively, these two conservation areas represent approximately 1% of the total natural and socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These two conservation areas consist of federal or private natural areas or nature preserves located along the Lake Michigan shoreline. These conservation areas were identified from USGS 7.5-minute topographic quadrangles and from overlays for Google Earth. Resources in this category are primarily intended for ecological preservation, although they may also be used for active and/or passive recreational activities. Resources in this category do not include public parks or beaches; these are addressed as a separate resource type.

Institutions (Socio-Cultural Feature)

Two institutions was identified along the Lake Michigan shoreline in the Southwestern Lake Michigan 2 watershed. These two institutions represents approximately 1% of the total natural and socio-cultural features along the Lake Michigan shoreline in the Southwestern Lake Michigan 2 watershed. These two institutions consist of the Environmental Education Center in the City of Hammond, within Wolf Lake Memorial Park, and Northwestern University in the City of Evanston, north of Chicago. These institutional facilities were identified from USGS 7.5-minute topographic quadrangles and from Google Earth overlays. There are likely to be additional educational institutions along the Lake Michigan shoreline in the Southwestern Lake Michigan 2 watershed that have not been identified for this assessment because they were not included in the databases used to generate Google Earth overlays.

F.6.3 Existing Management of Natural and Socio-Cultural Features in the Southwestern Lake Michigan 2 Watershed

Due to the size of the Southwestern Lake Michigan 2 watershed and the length of its shoreline (approximately 148 miles), the overall nature of development of this watershed varies between highly urbanized areas, such as the greater metropolitan area surrounding the city of Chicago, Illinois (extending approximately from Gary, Indiana, west along the Lake Michigan shoreline to Evanston, Illinois), smaller urban areas such as Michigan City in Indiana, and relatively rural areas along the western side of Lake Michigan within this watershed. Despite the variation in the type and density of development along the shoreline in the Southwestern Lake Michigan 2 watershed, the majority of the various governmental units (cities, counties, townships, and other incorporated municipalities) along the shoreline in the Southwestern Lake Michigan 2 watershed have processes in place that consider development in conjunction with natural and socio-cultural conditions under their jurisdiction, whether through the development of specific plans, such as master plans, or through zoning.

Specific plans typically consist of comprehensive or master plans developed by the various cities, counties, or townships along the shoreline of Lake Michigan. Additionally, a number of governmental units may have other plans for the management of natural and socio-cultural features within their boundaries, such as plans for recreation, conservation, etc. These plans may specifically address the management of many of the named visible and physical natural and socio-cultural features that have been identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed.

In general, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Southwestern Lake Michigan 2 watershed would indicate the importance of this shoreline to their respective community characters. These various plans may also recognize the various natural features (e.g., rivers, creeks, bays, creeks, lagoons, and inland lakes) that physically shape the shoreline and socio-culturally shape the uses of the shoreline for residential, commercial, industrial, recreational, and conservation purposes. These various plans may also recognize various socio-cultural features (i.e., cities, towns, harbors, parks, conservation areas [including nature preserves, wildlife preserves, wildlife management areas and significant coastal fish and wildlife habitats], and residential areas [neighborhoods and unincorporated hamlets]).

Similarly, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Southwestern Lake Michigan 2 watershed would identify common issues or concerns regarding their particular natural and socio-cultural features. The common issues or concerns associated with managing waterfronts or shorelines for water-dependent or water-related uses may consist of, but would not necessarily be limited to:

- Protecting or improving the quality of specific natural features along the shoreline (such as beaches, embayments, marshes, rivers, creeks, and lagoons);
- Managing or enhancing residential and commercial development along the shoreline;
- Creating or enhancing opportunities for public access to the shoreline, typically for recreational purposes;
- Protecting or developing scenic qualities of the shoreline; and
- Managing or enhancing opportunities for visual access to the shoreline.

Additionally, the various plans for the communities and governmental units, or for other specific areas, along the shoreline in the Southwestern Lake Michigan 2 watershed would identify specific management goals, objectives, or recommendations to address these issues or concerns, and to manage these shorelines for water-dependent or water-related uses. In general, the purpose for managing their respective shorelines would typically, but not necessarily only, be to:

- Acknowledge and promote the character of the communities along the shoreline;
- Enhance the quality of life for permanent residents;
- Enhance the experience of seasonal residents and visitors; and
- Protect, improve, or otherwise support the natural and socio-cultural features that comprise the shoreline of Lake Michigan.

F.6.4 Potential Impacts of Introduction and Establishment of Hydrilla on Socio-Cultural Setting of the Southwestern Lake Michigan 2 Watershed

This section discusses the potential impacts associated with the introduction and/or establishment of Hydrilla on the socio-cultural setting of the Southwestern Lake Michigan 2 watershed. In general, these impacts can be considered in terms of whether they result in:

- Physical changes to natural and/or socio-cultural features identified along the shoreline in the Southwestern Lake Michigan 2 watershed;
- Changes to water-dependent or water-related uses of these natural and/or socio-cultural features;
- Changes in perceptions about the features or their uses; and
- Changes in the community character of various locations or focus areas within the watershed.

For the purposes of this impact assessment, water-dependent uses are considered to be facilities or activities that cannot exist without a waterfront location, such as marinas, boat ramps, water treatments plants, etc., as well as some types of commercial development, such as floating hotels and casinos, cruise lines, and water taxis. Water-related uses are considered facilities or activities that increase their value or importance because of their proximity to a shoreline. Frequently, they function as support services for water-dependent uses and could include parks and other recreational facilities, as well as some types of commercial development (Benson 2011).

In general, the changes identified above are considered in terms of whether they would be an impact that is: (1) direct or indirect; (2) temporary or permanent (short-term or long-term); (3) adverse (negative), neutral, or beneficial (positive); and/or (4) cumulative, per changes and impacts associated with other invasive aquatic plant species in the watershed or at a specific focus area and/or per changes and impacts associated with ongoing or emerging socio-cultural trends in the watershed or at a specific focus area.

Impacts on Natural and Socio-Cultural Resources

The introduction and subsequent establishment of Hydrilla within any of the 26 focus areas along the shoreline is likely to result in physical changes to a number of types of natural and socio-cultural features that comprise the socio-cultural setting of these focus areas and of the Southwestern Lake Michigan 2 watershed in general. At its most basic level, the introduction of Hydrilla, and its establishment and increasing density over time, in a natural feature (waterbody or marsh or wetland) with suitable environmental conditions would result in direct changes to the ecological composition of the natural feature, to the appearance (visible and olfactory) of the natural features, and to the socio-cultural features and water-dependent and water-related uses associated with the natural feature.

These changes would consist of new and increasingly visible and dense plants or plant mats beneath and at or on the water surface that would change the composition of ecological communities associated with the natural feature and, with regard to human use, would ultimately impede access on or through the water. At its full extent, Hydrilla present in dense mats at or on the water surface would act as a net, capturing floating detritus (natural and man-made) that would detract from the visual and olfactory setting of the waterbodies. Such changes may be small at first, with the introduction of Hydrilla into a suitable waterbody environment, but such changes may increase incrementally in density, visibility, and/or intensity over time until Hydrilla has exploited the maximum extent of available suitable habitat in the waterbody feature.

Physical changes are likely to occur on natural features and on those socio-cultural features that are comprised of, or associated with, natural features. Physical changes are likely to directly and indirectly impact natural and socio-cultural features. Additionally, these physical changes, considered in conjunction with past, present, or reasonably foreseeable future conditions for these natural and socio-cultural features, may have a cumulative impact on these natural and socio-cultural features.

Socio-cultural features that are comprised of, or associated with, natural features are also likely to undergo physical changes from the introduction and subsequent establishment of Hydrilla. These socio-cultural features would typically consist of: (1) public parks or other public facilities; (2) conservation areas; and (3) public or private business enterprises (e.g., marinas, restaurants, floating hotels and casinos, cruise lines, and water taxis) that are located within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed and associated with water-dependent and/or water-related uses. However, other socio-cultural features, comprised of communities, organizations, industrial facilities, and governmental facilities, are often also associated with natural features, such as those identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed. These are attractive locations for seasonal and permanent residences or are specific locations, such as at the mouth of a navigable waterbody, at which a U.S. Coast Guard facility is located, or a shoreline location that provides for specific water intake and discharge capacity for an industrial facility.

Descriptions of the potential impacts on the various types of natural and socio-cultural features identified within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed are presented below. Such impacts are considered primarily with regard to the introduction and establishment of Hydrilla without treatment. Such direct and indirect impacts would likely be considered long-term or permanent impacts and would also be perceived as negative impacts by the communities and users of the 26 focus areas along shoreline in the Southwestern Lake Michigan 2 watershed.

Dispersal modeling predicted that approximately 1% of total area of water within the Southwestern Lake Michigan 2 watershed may be infested by Hydrilla by 2025 (see Table 3.1.5-1 in the risk assessment); therefore, it is possible that some of the 26 focus areas would not be affected by Hydrilla, or that impacts resulting Hydrilla would not affect some or all of the natural and socio-cultural features that collectively comprise the community character of this watershed as described below. Because dispersal modelling does not indicate specific locations within the watershed that would be affected, it is not possible to determine which of the 26 focus areas would be subject to infestation. Additionally, because the results of dispersal modelling extend through the year 2025, it is likely that the impacts discussed below would occur slowly at first, and become increasingly noticeable over time until full exploitation of available suitably habitat has been achieved. Therefore, the impacts of the introduction and establishment of Hydrilla discussed below should be considered representative of the types of impacts that could occur if these, or similar, natural and socio-cultural features are present within or adjacent to the approximately 1% of the total area of water within the entire watershed that may be infested by Hydrilla in 2025.

Impacts on Natural Features

The introduction and establishment of Hydrilla on natural features would result in a number of different impacts on natural features, depending on the type of natural feature. These impacts are both physical ecosystem effects as well as socio-cultural effects associated with impaired public access or reduced recreational usage. The physical ecosystem impacts on these natural features are summarized in this section to provide a context for considering these natural features as the setting for associated socio-cultural features and uses. The socio-cultural impacts associated with these natural features (e.g., impaired public access and reduced recreational usage) are discussed in greater detail below as part of the discussion of impacts on socio-cultural features.

Natural features such as islands are not likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla. Therefore, the introduction and establishment of Hydrilla is likely to have no impact on this types of natural feature, although indirect impacts on socio-cultural features, water-dependent uses, and water-related uses associated with this natural feature are likely to occur and are considered below. However, natural features comprised of, or associated with, waterbodies are likely to undergo direct physical changes from the introduction and subsequent establishment of Hydrilla.

Waterbody features that may be directly impacted by the introduction and establishment of Hydrilla include:

- Shoreline and littoral zone of:
  - Lake Michigan,
  - Beaches, harbors, and bays along the shoreline of the lake, and

  - Outlets or mouths of streams and rivers where they enter the lake or the harbors or bays along the lake shoreline; and

- Marshes or wetlands that are associated with these waterbody features.

Collectively, the 26 focus areas within the Southwestern Lake Michigan 2 watershed include all of these types of natural features.

The direct impacts on these natural features would result from the introduction and establishment of Hydrilla, and would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of these waterbody features, including changes to water quality (e.g., full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface) and changes to species that are located in, or that otherwise use, these waterbody features (e.g., changes to fish species, aquatic plant species, bird species); and
- Negative because such changes are detrimental to species comprising the ecological systems of these waterbodies.

Waterbody features that may be indirectly impacted by the introduction and establishment of Hydrilla include associated terrestrial features such as: islands and the shoreline and littoral zone of Lake Michigan; beaches, harbors, and bays along the shoreline of the lake, the outlets or mouths of streams and rivers where they enter Lake Michigan; the harbors or bays along the Lake Michigan shoreline; inland lakes; and, where present, marshes and wetlands. Collectively, the 26 focus areas within the Southwestern Lake Michigan 2 watershed include all of these natural features.

Finally, impacts from the introduction and establishment of Hydrilla in these natural features could be cumulative under certain conditions, such that the long-term (permanent), direct, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these natural features from the introduction and establishment of Hydrilla could occur where a waterbody:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil (*Myriophyllum spicatum*); and/or
- Has existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct impacts from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect the waterbodies, resulting in a cumulative impact.

The above impact assessment on natural waterbody features is for the introduction and establishment of Hydrilla, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct, negative impacts on the affected natural features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Impacts on Socio-Cultural Features

The introduction and establishment of Hydrilla on socio-cultural features would result in a number of different impacts, depending on the type of socio-cultural feature. All of the socio-cultural features considered as part of this impact assessment are associated in some way with natural features that are located adjacent to, or are comprised of, waterbodies.

All of the types of socio-cultural features identified within the 26 focus areas along the shoreline of the Southwestern Lake Michigan 2 watershed are located along shoreline areas or waterbody features within which Hydrilla is likely to be introduced and established. The impacts on these socio-cultural resources may be direct, where the purpose for, or use of, these socio-cultural features is typically water-dependent, or indirect, where the purpose for, or use of, these socio-cultural features is typically water-related, as discussed below.

The following socio-cultural features may be directly impacted by the introduction and establishment of Hydrilla:

- Private businesses (such as marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas and nature preserves that contain or are located adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, and sportfishing clubs);
- Industrial facilities (e.g., water treatment plants or manufacturing facilities); and
- Governmental facilities (such as public boat launches, U.S. Coast Guard stations, and harbors).

Collectively, the 26 focus areas within the Southwestern Lake Michigan 2 watershed include all of these types of socio-cultural features.

The direct impacts on these socio-cultural features that would result from the introduction and establishment of Hydrilla would be considered long-term (permanent), direct, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would represent a physical change in the conditions of associated affected waterbody features, such that the purpose for, and use of, these socio-cultural features would be affected. For example, full growth and expansion of Hydrilla would result in dense stands of plants in the water and floating vegetation mats at or on the water surface, such that private businesses or governmental facilities such as marinas or harbors could no longer be used by boats; cruises, boating or fishing would no longer be desirable or viable activities; use of public parks and beaches along affected waterbodies would no longer be desirable for recreational activities; operation of water intake and discharge systems for industrial facilities would be affected; and
- Negative because the purpose for, or uses of, these socio-cultural features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

The following socio-cultural features may be indirectly impacted by the introduction and establishment of Hydrilla:

- Private businesses such as shoreline restaurants, bars, event sites, resorts, casinos, and hotels;
- Communities (hamlets, villages, and cities) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., sunbathing, sightseeing, birding, for enjoying scenic views and viewsheds);
- Built resources, particularly where waterfront setting is an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., birding, wildlife management, enjoying scenic views and viewsheds); and
- Organizations associated with golfing, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

Collectively, the 26 focus areas within the Southwestern Lake Michigan 2 watershed include all of these types of socio-cultural features.

The impacts on these socio-cultural features as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the appearance of the setting (visual or olfactory) of these socio-cultural features; and
- Negative, because the intended purpose for, or use of, such features would be impaired, impeded, or prevented, such that they no longer would be considered enjoyable or desirable by their users or viable by their owners or managers.

As discussed above for natural features, impacts on these socio-cultural features from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these socio-cultural features from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues blooms.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on socio-cultural features from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these features, resulting in a cumulative impact.

The above impact assessment on socio-cultural features has been for the introduction and establishment of Hydrilla within the 26 focus areas along the shoreline of the Southwestern Lake Michigan 2 watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the socio-cultural features that are associated with these natural waterbody or marsh/wetland features, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above are associated with water-dependent uses (e.g., fishing, boating, and swimming). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, because their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants or parks). Impacts on the water-dependent or water-related uses associated with affected waterbodies are discussed in Section F.6.5.

F.6.5 Impacts on Water-Dependent or Water-related Uses of Resources

The introduction and establishment of Hydrilla would result in a number of different impacts on water-dependent or water-related uses within the 26 focus areas along the shoreline within the Southwestern Lake Michigan 2 watershed, depending on the type of use and/or the type of natural or socio-cultural feature with which the use is associated. For the purposes of this impact assessment, natural features associated with water-dependent uses include the shoreline and littoral zones of Lake Michigan and the Niagara River within the focus areas, such as the following features: harbors, bays, and inland lakes; beaches; outlets or mouths of streams and rivers; and marshes and wetlands. However, of all the natural features identified within the 26 focus areas along the Lake Michigan shoreline are associated with water-related uses, including those identified above for water-related uses along with islands.

As discussed in Section F.6.4, socio-cultural features associated with water-dependent uses would include:

- Private businesses (such as marinas, boating-related businesses, and fishing-related businesses [charters or bait-stores]);
- Public parks or public beaches and other public facilities such as boat ramps that contain or are located along affected waterbody features and where use is water-dependent for activities such as swimming or boating;
- Conservation areas (including federal, state, or private natural areas and nature preserves that contain or are located in or adjacent to affected waterbody features);
- Organizations (e.g., yacht clubs, boat clubs, sportfishing clubs);
- Industrial facilities (e.g., water treatment plants or manufacturing facilities); and
- Governmental facilities (e.g., public boat launches, U.S. Coast Guard stations, and harbors).

Therefore, the introduction and establishment of Hydrilla is likely to have some type of impact on all of the water-dependent uses associated with these natural and socio-cultural features.

The following water-dependent uses may be directly impacted by the introduction and establishment of Hydrilla:

- Swimming;
- Recreational boating;
- Fishing;
- Sailing;
- Policing waterways and waterbodies; and
- Water treatment.

Similarly, socio-cultural features associated with water-related uses would include:

- Private businesses such as shoreline restaurants, bars, event sites, hotels, and casinos;
- Communities (cities, towns, and hamlets) with waterfront property that is publicly accessible and/or developed for residential, recreational, commercial, and industrial purposes;
- Public parks and beaches that contain or are located along affected waterbody features and where usage is water-related (e.g., sunbathing, sightseeing, birding, and for enjoying scenic views and viewsheds);
- Built resources (terrestrial and marine), particularly where waterfront settings are an important component of the use of, or purpose for, a built resource;
- Conservation areas that contain, or are located along, affected waterbody features and where usage is water-related (e.g., birding, ecological preservation, enjoying scenic views and viewsheds); and
- Organizations associated with yachting, where shoreline or waterfront setting is an important component of the use of, or purpose for, the organization.

The following water-related uses may be indirectly impacted by the introduction and establishment of Hydrilla:

- Dining;
- Drinking;
- Sightseeing;
- Sunbathing;
- Experiencing nature;
- Socializing in large group settings (weddings, picnics, conferences);
- Vacationing;

- Preserving natural resources;
- Managing natural resources;
- Seasonal (vacation) housing;
- Permanent housing; and
- Commercial and industrial support facilities for recreational, seasonal, and permanent residential activities.

The impacts on the above water-dependent and water-related uses within the 26 focus areas as a result of the introduction and establishment of Hydrilla would be considered long-term (permanent), direct and indirect, and negative. Specifically, these impacts would be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it is established in a conducive environment;
- Direct because the introduction and establishment of Hydrilla would prevent or impede the water-dependent uses because they could no longer take place;
- Indirect because the introduction and establishment of Hydrilla would result in changes to the conditions within which such water-dependent uses can occur, such that these water-dependent uses could no longer be conducted or sustained by their users or would no longer be considered viable by their owners or managers; and
- Negative because the introduction and establishment of Hydrilla physically prevents or detrimentally impairs these water-dependent uses or the management of these water-dependent uses.

For example, water-dependent uses such as commercial boating, recreational boating or sailing, and fishing would not be possible or would not be considered desirable water-dependent activities in a waterbody densely infested with Hydrilla. Where such water-dependent uses are reduced, there would be a concurrent reduced need for boat maintenance or storage facilities in the absence of commercial or recreational boating, sailing, or fishing. The boating actions associated with policing affected waterbodies or using affected waterbodies that are harbors would be impaired. The use of water intakes and discharge outfalls associated with sewage treatment, water treatment, and power plants would be impeded such that treatment or power production would be impaired.

Similarly, water-related uses would be considered less desirable primarily because of changes to the setting (visual or olfactory) of socio-cultural features that support such activities. Waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing. Similarly, shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing or enjoying nature. Waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities. With changes to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary. Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

As discussed above for natural and socio-cultural features, impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), direct or indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on these water-dependent or water-related uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contains other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the direct or indirect impacts on water-dependent or water-related uses from introduction and establishment of Hydrilla would occur at a faster rate or would similarly affect these uses, resulting in a cumulative impact.

The above impact assessment on water-dependent or water-related uses has been for the introduction and establishment of Hydrilla within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed, given the understanding that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies, but is unlikely to completely eliminate or reverse such impacts, once Hydrilla has become established.

Many of the natural and socio-cultural features discussed above for the 26 focus areas are associated with water-dependent uses (e.g., boating and fishing). Similarly, many of the natural and socio-cultural features discussed above are also recognized for their scenic value and views, such that their locations and/or settings contribute to water-related uses, such as permanent or seasonal residential development and/or private business enterprises (e.g., restaurants or parks). Where the introduction and establishment of Hydrilla would result in impacts on natural or socio-cultural features and/or associate water-dependent or water-related uses, it is likely that perceptions about these features and uses would change. Possible changes to perceptions about the natural or socio-cultural features and their associated water-dependent and water-related uses are considered in Section F.6.6.

F.6.6 Impacts on Community Perceptions of Features and Uses

As noted above in Section F.6.3, cities, townships, and counties associated with the 26 focus areas along the shoreline of the Southwestern Lake Michigan 2 watershed would manage the natural and socio-cultural features areas located along their respective shorelines or waterfronts to protect, enhance, promote, create, rehabilitate, redevelop, or develop water-dependent and water-related uses. Management would be according to the goals, policies, objectives, or recommendations that are memorialized in management plans that include these areas.

It is likely that natural and socio-cultural features that are located within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed may be specifically identified in such plans, indicating that they would be perceived as locations, features, or attributes that define the local community or governmental unit and that they would be perceived and recognized as worthy of protection or improvement. Similarly, water-dependent and water-related uses associated with these natural and socio-cultural features may also be identified and described, either as part of planning efforts or via zoning ordinances, and discussed in such plans. This would indicate that such uses would be perceived as worthy of protection, management, creation, enhancement, or development.

Such perceptions would generally be expected to be identified or expressed by local individuals and groups that comprise the communities or governmental units responsible for the preparation of such plans and would be inherent in such plans because they were made known via charrettes, questionnaires, and other outreach efforts conducted as part of the preparation of such plans. Such local individuals and groups would be expected to be comprised of local residents, or non-local stakeholders with an interest in specific resources or for specific uses (such as individuals or companies that own and/or manage businesses, organizations, or facilities in an area but do not actually reside there). Additionally, the perceptions of federal, state, or local agencies that fund such planning efforts, or that provide guidance for the preparation of such plans, may also be incorporated into the preparation of such plans, albeit indirectly, via the requirements for the preparation of such plans or via the structure and/or content of meetings and materials included in outreach efforts.

Separately, the perceptions of individuals or groups that have an interest in specific or collective natural or socio-cultural features within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed, or their associated water-dependent or water-related uses, may be lacking from such plans. Such individuals or groups may be seasonal users, state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and special interest groups whose involvement would be at a regional or national scale. For example, the perceptions of individuals or groups that are seasonal users would likely be expressed outside of such plans, by changes to patterns of visiting areas for recreational or other purposes, such as vacationing, fishing, boating, etc. Similarly, the perceptions of state or federal agencies with management responsibilities for specific socio-cultural features located within the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed may also be lacking from such plans. These agencies would be as diverse as the Michigan State Historic Preservation Office, Michigan Department of Natural Resources, Indiana Department of Natural Resources, and Illinois Department of Natural Resources, that respectively manage parks, historic sites, natural areas, and public access for waterbodies within the states of Michigan, Indiana, and Illinois; and federal agencies such as the U.S. Army Corps of Engineers, which manages navigable waterways, and the U.S. National Park Service, which manages the Indiana Dunes National Lakeshore.

Finally, the perceptions of special interest groups that would have a broad or unique interest in natural and socio-cultural features in the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed, and/or their water-dependent or water-related uses, would also be expressed outside of such plans. Such groups, whose primary perceptions would be related to regional, national, or cultural interests in a specific area, feature, or use, may include: federally recognized Indian tribes who may have a cultural or historical affiliation with areas that include such features and uses or may have retained treaty rights for use of such areas; or groups such as the Sierra Club, the Nature Conservancy, or Ducks Unlimited, which have national conservation interests that are applied at the local level via ownership of conservation areas or sponsorship for various conservation efforts.

As suggested above in the assessment of water-dependent and water-related uses of natural and socio-cultural features in the 26 focus areas, the potential impacts of the introduction and establishment of Hydrilla would be likely to occur where there would be physical changes to the features or uses, or where there would be visual or olfactory changes to the setting of such features or uses. For example, the natural or socio-cultural features themselves may no longer be perceived as worthy of being protected, preserved, or managed for their intrinsic natural or socio-cultural values to a community: with changes to the setting of natural areas, conservation and preservation of the resources associated with such areas may no longer be considered appropriate or necessary.

Similarly, the water-dependent or water-related uses associated with such features may no longer be perceived as desirable or viable. For example, waterfront or shoreline restaurants and bars would no longer be perceived as attractive places for dining, drinking, and socializing; shoreline or waterfront public parks and beaches would no longer be perceived as attractive places for recreational activities such as sightseeing, sunbathing, or enjoying nature; waterfront or shoreline locations for group events would no longer be perceived as attractive places for weddings, conferences, meetings, concerts, or other large-group activities.

Finally, shoreline and waterfront locations that are developed for seasonal and/or permanent residences primarily because of their setting would no longer be perceived as attractive locations and could see a decline in usage (in the case of seasonal [vacation] housing) or value (of both seasonal and permanent residential housing). Where declines in the usage or value of seasonal and/or permanent housing are experienced, there would be a concurrent decline on the commercial and industrial support facilities.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent and water-related uses within the 26 focus areas as a result of the introduction and establishment of Hydrilla have the potential to be long-term (permanent), direct indirect, and negative. Specifically, these impacts would likely be:

- Long-term (permanent) because it is unlikely that Hydrilla could be completely eradicated once it became established in a conducive environment;
- Indirect because while the introduction and establishment of Hydrilla would result in changes to the conditions of affected features or uses, it is the perceptions of these affected features or uses that could change; and
- Negative where the perceptions of affected features or uses conclude that such features and uses are no longer worthy of protection, management, creation, improvement, enhancement, or development.

The impacts on perceptions of affected natural and socio-cultural features and associated water-dependent or water-related uses within the 26 focus areas from the introduction and establishment of Hydrilla could be cumulative under certain conditions, such that the long-term (permanent), indirect, negative impacts would be exaggerated or exacerbated. Cumulative impacts on perceptions of affected features or uses from the introduction and establishment of Hydrilla could occur where associated waterbodies, marshes, or wetlands:

- Already contain other established invasive or alien aquatic plant species, such as Eurasian watermilfoil or spiked water-milfoil; and/or
- Have existing water quality issues.

These conditions would tend to result in similar physical changes to waterbodies, such that the indirect impacts on perceptions of affected features or uses from introduction and establishment of Hydrilla would occur at a faster rate or would be greater, resulting in a cumulative impact.

The above impact assessment for perception of affected natural and socio-cultural features and their associated water-dependent or water-related uses within the 26 focus areas has been for the introduction and establishment of Hydrilla. It is understood that once introduced and established, the growth of Hydrilla in areas with conducive conditions would expand until the entire extent of suitable habitat has been colonized. Considering a scenario where treatment to control the growth of Hydrilla occurs, it is unlikely that Hydrilla could be removed completely from suitable habitat, once it has become established. Therefore, treatment to control the growth of Hydrilla would likely serve to minimize or control the long-term (permanent), direct or indirect, negative impacts on the water-dependent or water-related uses that are associated with affected waterbodies. While it would be unlikely for treatment to completely eliminate or reverse the physical impacts of the introduction and establishment of Hydrilla, treatment would likely receive considerable support by the communities, governmental units, state and federal agencies, stakeholders, special interest groups, and seasonal users in an effort to avoid or minimize impacts on the perceptions of affected features and uses.

F.6.7 Impacts on Community Character of Focus Areas in the Southwestern Lake Michigan 2 Watershed

Dispersal modelling suggests that the primary method of introduction of Hydrilla into specific locations is via recreational boat use, such that locations where recreational boaters launch (via public boat launch or private boat launch locations) are most likely to result in the initial introduction of Hydrilla. It follows that the spread of Hydrilla likely would also occur at secondary locations that are accessible by recreational boaters but do not necessarily contain formal public or private boat launching facilities.

Therefore, impacts on community character resulting from the introduction and establishment of Hydrilla are most likely to occur in locations that: (1) have physical features (i.e., boat launch facilities) by which Hydrilla would become introduced; (2) have environmental conditions conducive to the establishment of Hydrilla if it is introduced; and (3) whose community character is defined by natural and socio-cultural features and associated water-dependent or water-related uses that would be affected by the introduction and establishment of Hydrilla. The 26 focus areas identified along the shoreline in the Southwestern Lake Michigan 2 watershed either meet all of these criteria or, if a focus area lacks a public or private boat launch, meet the second and third criteria.

The potential impacts of the introduction and establishment of Hydrilla on the community character of the 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed correlates to the impact conclusions for natural and socio-cultural features, their associated water-dependent or water-related uses, and the perceptions of such features and use by communities and governmental units, as discussed above in Sections F.6.4, F.6.5, and F.6.6. Specifically, the long-term (permanent), direct and/or indirect, and negative impacts of the introduction and establishment of Hydrilla on natural and socio-cultural features, on their associated water-dependent or water-related uses, and on the perceptions of these features and uses, also result in the same type of impacts on the community character of these focus areas. The impacts associated with the treatment of Hydrilla would be the same, as would the potential for cumulative impacts.

It is likely, however, that such impacts on community character would be perceived differently. The local individuals and groups that comprise the communities and governmental units associated with these 26 focus areas likely would consider such impacts differently from seasonal users, from state or federal agencies with regulatory oversight or management responsibilities for specific features or uses; and from special interest groups whose involvement would be at a regional or national scale. Additionally, impacts on community character would occur at different rates over time, depending on the nature of the affected individuals, groups, agencies, or users.

For example, local individuals and groups that comprise the communities and governmental units associated with these 26 focus areas likely would recognize the impacts. However, they may be reluctant to accept the changes to their community character and be slow to participate in necessary revisions to the management of affected natural and socio-cultural features and their associated water-dependent or water-related uses that would alter their existing community character.

Conversely, state or federal agencies and special interest groups that operate regionally or nationally likely would recognize the impacts and would accept such changes to the affected features and uses. However, they also may be slow to participate in necessary revisions to the management of affected features and uses for any number of administrative reasons (e.g., limited manpower, limited budget, and limited regulatory authority).

Finally, it is likely that seasonal users may differ greatly from both of these other groups. Seasonal users would be likely to recognize the impacts, and while reluctant to accept the changes to community character, quick to abandon those areas that contain affected natural and socio-cultural features and their associated water-dependent and water-related uses. Changes to their seasonal use of affected areas may be either in favor of other similar areas that remain unaffected by the introduction and establishment of Hydrilla or may represent a greater shift in favor of other areas with features and uses that would never be affected by the introduction and establishment of Hydrilla.

F.6.8 Impacts on the Community Character of the Southwestern Lake Michigan 2 Watershed

The 26 focus areas along the shoreline in the Southwestern Lake Michigan 2 watershed were selected specifically because they contain conditions that are conducive to the introduction and establishment of Hydrilla. Therefore, the potential impacts on the natural and socio-cultural features and their associated water-dependent and water-related uses that contribute to the community character of these focus areas may appear to be disproportionately emphasized when compared to the potential for similar impacts along the entire Lake Michigan shoreline or within the Southwestern Lake Michigan 2 watershed.

For the Southwestern Lake Michigan 2 watershed as a whole, dispersal modelling predicted that by 2025, approximately 1% of the total waterbody area within the watershed would be affected. Given the overall size of the Southwestern Lake Michigan 2 watershed and prevalence of water resources therein, it can be inferred based on the dispersal model results that future (2025) impacts resulting from introduction and establishment of Hydrilla on the overall community character of the watershed may be relatively small when considered for the entire watershed. However, if perchance all future Hydrilla infestations were to occur along the Lake Michigan shoreline in one or more of the 26 focus areas evaluated in this analysis, the collective impacts likely would garner more attention and have a greater collective impact, especially if future infestations are concentrated in one or more of the high-use, high-value areas located on the shoreline, such as Chicago Bay.

Although this section describes potential future impacts from Hydrilla in focus areas along the Lake Michigan shoreline, it is expected that similar impacts from the introduction and establishment of Hydrilla would occur at various locations throughout the interior of the Southwestern Lake Michigan 2 watershed. However, it is likely that these impacts would be more localized at or near the point of introduction, and would individually affect a smaller number of natural and socio-cultural features and a smaller number of associated water-dependent or water-related uses. Therefore, perceptions of the impacts on such features and uses, and their overall effect on the community character of the entire watershed would be diluted over a larger area.

As indicated by the above impact analysis, the Lake Michigan shoreline represents a distinct component of the community character of the entire Southwestern Lake Michigan 2 watershed that differs in size and nature when compared to the smaller and dispersed waterbodies (lakes, ponds, rivers, creeks, and streams) that are located in the interior of this watershed. Thus, it is not unusual for the potential impacts of the introduction and establishment of Hydrilla, with or without treatment to control its spread, to be considered a prominent factor in the future of the Southwestern Lake Michigan 2 watershed.

F.6.9 Conclusions and Recommendations

The introduction and establishment of Hydrilla into the Southwestern Lake Michigan 2 watershed has the potential to result in long-term (permanent), direct and indirect, negative impacts on natural and socio-cultural features and their associated water-dependent and water-related uses that comprise the socio-cultural setting of this watershed. Similar impacts would be expected on the perceptions of these features and uses. Collectively, these impacts would represent long-term, indirect, negative impacts on the community character of this watershed.

These conclusions were based on the analysis of features and associated uses that were identified from: publicly available databases and planning documents; overlays for Google Earth; 7.5-minute USGS topographic quadrangles; and/or coastal maps maintained in the NOAA's Office of Coast Survey Historical Map and Chart Collection. These conclusions were also developed considering the management of such features and uses that may be represented in comprehensive plans or master plans for the various counties, towns, and cities located along the shoreline in the Southwestern Lake Michigan 2 Watershed and/or identified and discussed in other Lake Michigan shoreline-specific regional management plans.

These conclusions are based on the analysis of impacts on natural and socio-cultural features and associated water-dependent and water-related uses identified for 26 focus areas that collectively represent approximately 91 miles (61%) of the approximately 148-mile-long shoreline in the Southwestern Lake Michigan 2 watershed. However, these conclusions are considered generally representative of potential impacts that would occur in interior areas of this same watershed and would be generally representative of potential impacts that would occur in other watersheds in the Great Lakes Basin that have a similar potential for the introduction and establishment of Hydrilla.

Separately, as discussed in this impact assessment (see Sections F.6 and F.6.6), there are a wide variety of agencies, organizations, and special interest groups, in addition to the many communities and governmental units with authority or jurisdiction over the shoreline in the Southwestern Lake Michigan 2 watershed, that may be considered stakeholders with a particular interest in the management of invasive aquatic plant species such as Hydrilla within the watershed. These stakeholders would include, but may not be limited to:

- State agencies such as Michigan State Historic Preservation Office, Michigan Department of Natural Resources, Indiana Department of Natural Resources, and Illinois Department of Natural Resources, that respectively manage parks, historic sites, natural areas, and public access for waterbodies in the states of Michigan, Indiana, and Illinois;
- Federal agencies such as the U.S. Army Corps of Engineers, which manages navigable waterways throughout the Southwestern Lake Michigan 2 watershed, and the U.S. National Park Service, which manages Indiana Dunes National Lakeshore;
- Federally recognized Indian tribes that have a cultural or historical affiliation with various areas in the Southwestern Lake Michigan 2 watershed or retain treaty rights to lands, waters, and resources within the Southwestern Lake Michigan 2 watershed; and,
- Special interest groups such as or The Nature Conservancy, The Sierra Club, or Ducks Unlimited, that may have a broadly defined interest in areas and resources along the shoreline and in interior areas of the Southwestern Lake Michigan 2 watershed.

Outreach efforts by the U.S. Army Corps of Engineers with the various communities and governmental units for all of the counties, towns, cities, and other areas at both the federal (including government-to-to-government), agency and public level is encouraged in order to collaboratively identify and develop strategies related to raising awareness for, controlling, and jointly managing the introduction and establishment of Hydrilla in this watershed. Similarly, the USACE should consider additional similar outreach efforts with the various stakeholders identified above for the same reasons. Many of these communities, governmental units, and stakeholders already have experience managing invasive aquatic plant species other than Hydrilla, and would likely welcome the opportunity to avoid or minimize the potential for new and/or cumulative impacts on the natural and socio-cultural features and associated water-dependent or water-related uses that they already manage or value.

F.6.10 References

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Attachment F-6

Natural and Socio-Cultural Features Along the Shoreline in the Southwestern Lake Michigan 2 Watershed

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Grand Mere Lakes	MI	Berrien	Lincoln Township	Natural feature	String of inland lakes protected by barrier beach land, near Lake Michigan shoreline	1
North Lake Park	MI	Berrien	Lincoln Township	Public park	Lakefront park offering shelter and picnic areas and fishing	1
Sports Widow Fishing Charters	MI	Berrien	Lincoln Township	Private business	Fishing charter service offering fishing trips on Lake Michigan	1
Grand Mere State Park	MI	Berrien	Lincoln Township	Public Park	Lakefront state park offering Lake Michigan beaches, lake swimming, hiking trails, picnic areas, hunting, etc.	1
Lost Dunes Golf Club	MI	Berrien	Lake Charter Township	Organization	Golf course and country club near Lake Michigan shoreline, offering full golf course, clubhouse with lounge and restaurant, and cabins available for rent	2
New Buffalo	MI	Berrien	City of New Buffalo	Community	Lakefront community/city along Lake Michigan shoreline	3
New Buffalo Beach & Boat Ramp	MI	Berrien	City of New Buffalo	Public Park	Beachfront park and boat launch offering swimming, beach area, playground, boat launch and access to Lake Michigan and Galien River	3
Lake Michigan Yacht Club	MI	Berrien	City of New Buffalo	Organization	Boat club and marina located at the mouth of Galien River offering membership, docking, access to Lake Michigan, clubhouse, restaurant, etc.	3
Marina Grand Resort	MI	Berrien	City of New Buffalo	Resort	Marina and Harbor resort offering hotel rooms, private event space, harbor views, restaurant and bar, bike rentals, etc.	3

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
New Buffalo Yacht Club	MI	Berrien	City of New Buffalo	Organization	Boat club and marina offering memberships, docking, clubhouse, private event space, etc.	3
Harbor Grand Hotel	MI	Berrien	City of New Buffalo	Private business	Marina and Harbor hotel offering hotel rooms, private event space, harbor views, restaurant and bar, etc.	3
New Buffalo Marina	MI	Berrien	City of New Buffalo	Private business	Marina and boat launch offering docking, electric, fueling, picnic areas, access to Lake Michigan, etc.	3
Third Coast Paddling	MI	Berrien	New Buffalo Township	Private business	Kayaking and Stand-Up Paddleboarding rental service located on Galien River	3
Galien River County Park	MI	Berrien	New Buffalo Township	Public park	Marsh and river park offering boardwalk through the woods and river overlook points.	3
Long Beach	IN	La Porte	Town of Long Beach	Community	Lakefront community locate along Lake Michigan shoreline, population of 1,179 at the 2010 census	4
Clare Lake	IN	La Porte	Town of Long Beach	Natural feature	Inland Lake near Lake Michigan shoreline	4
Long Beach Country Club	IN	La Porte	Town of Long Beach	Organization	Country club and golf course offering memberships, full golf course, clubhouse with dining and private event space, etc.	4
Long Beach Cove Villas	IN	La Porte	Town of Long Beach	Community	Lakefront condominium complex along Clare Lake	4
Beachwalk Vacation Rentals	IN	La Porte	Michigan City	Private business	Vacation home rental agency offering lakeside rental cabins, communal playground and fishing pier, etc.	5

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Michigan City	IN	La Porte	Michigan City	Community	Lakefront city along Michigan Lake shoreline, population of 31,157	6
Washington Park Beach	IN	La Porte	Michigan City	Public park	Beachfront park on Lake Michigan offering beach area, swimming, etc.	6
Michigan City East Pierhead Light Tower and Elevated Walk	IN	La Porte	Michigan City	Built resource	NRHP Listed lighthouse and pier walk; NPS # 88000069	6
Michigan City Port Authority	IN	La Porte	Michigan City	Government facility	Agency overseeing marinas and ports within Michigan City. Office located along Lake Michigan coastline	6
US Coast Guard	IN	La Porte	Michigan City	Government facility	Coast guard station along Trail Creek	6
Trail Creek	IN	La Porte	Michigan City	Natural feature	Tributary to Lake Michigan	6
Old Lighthouse Museum	IN	La Porte	Michigan City	Organization	Riverfront museum focused on the Michigan City lighthouse, Michigan City History, Great Lakes History, etc.	6
Michigan City Lighthouse	IN	La Porte	Michigan City	Built resource	NRHP Listed lighthouse along Trail Creek; NPS # 74000023	6
Bridges Waterside Grille	IN	La Porte	Michigan City	Private business	Riverside restaurant and bar offering docking and outdoor riverfront seating	6
Michigan City Fishing Charters	IN	La Porte	Michigan City	Private business	Fishing charter service offering fishing trips on Lake Michigan	6
Blue Chip Casino Hotel and Spa	IN	La Porte	Michigan City	Private business	Riverfront hotel and spa, connected to Blue Chip Casino, offering rooms with riverfront views	6
Trail Creek Marina	IN	La Porte	Michigan City	Private business	Public Marina located on Trail Creek offering access to Trail Creek and Lake Michigan	6

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Burns International Harbor	IN	Porter	Town of Burns Harbor, Portage Township	Public facility	International Harbor located along Lake Michigan coastline. Harbor includes a variety of manufacturers and shipping facilities (Federal Marine Terminals, Inc., Global Stone Portage, Lakes and River Transfers, Conrail, Metro International, etc.), as well as harbor water features (West and East Harbor Arms, seawalls, etc.)	7
John Merle Coulter Nature Preserve	IN	Lake	Portage Township	Conservation area	Nature preserve consisting of Oak Savanna, sand prairie, and interdunal wetlands, hiking and walking trails available for leisure	8
Woodlake Village Apartments	IN	Lake	City of Gary	Community	Apartment building complex within lake/dune ecosystem near Lake Michigan coastline	8
Indiana Dunes National Lakeshore	IN	Lake	Portage Township, City of Gary	Conservation area	Large lakefront federal park offering unique ecosystems, hiking trails, wildlife viewing, lake swimming and beaches,	8, 9
Grand Calumet River	IN	Lake	City of Gary	Natural feature	Tributary to Lake Michigan	9
Marquette Park	IN	Lake	City of Gary	Public Park	Park and events center offering rentable private event space, riverfront views, walking trails, etc.	9
Gary Harbor	IN	Lake	City of Gary	Natural/Built feature	Built harbor near shipping port mouth within Lake Michigan	10
Buffington Harbor	IN	Lake	City of East Chicago	Natural/Built feature	Built harbor near shipping port mouth within Lake Michigan	11

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Majestic Star Casino and Hotel	IN	Lake	City of East Chicago	Private business	Casino and Hotel in two cruise ships on Lake Michigan shoreline offering lakefront rooms and lounges	11
Jeorse Park	IN	Lake	City of East Chicago	Public Park	Beachfront park offering sand beach, walkable pier, fishing, etc.	12
Ameristar Casino Hotel	IN	Lake	City of East Chicago	Private business	Lakefront casino and hotel offering lake-view rooms and lounges, etc.	12
East Chicago Water Filtration	IN	Lake	City of East Chicago	Industrial facility	Water treatment facility located along Lake Michigan shoreline	12
East Chicago Marina	IN	Lake	City of East Chicago	Private business	Marina offering docking and access to Lake Michigan	12
Indiana Harbor Yacht Club	IN	Lake	City of East Chicago	Organization	Marina and boat club offering memberships, docking, clubhouse, “tiki deck”, etc.	12
Indiana Harbor	IN	Lake	City of East Chicago	Natural/Built feature	Built harbor near shipping port mouth within Lake Michigan	12
Arcelor Mittal	IN	Lake	City of East Chicago	Industrial facility	Steel and mining company/fabricator with multiple locations along Indiana Harbor, utilizing canals and Lake Michigan for transport and distribution	12
American Terminals, Inc.	IN	Lake	City of East Chicago	Industrial facility	Shipping/Distribution services located along Indiana Harbor	12
Indiana Harbor Canal	IN	Lake	City of East Chicago	Built resource	Built canal at the end of Indiana Harbor, servicing multiple facilities	12
Wolf Lake	IN, IL	Lake, Cook	City of Hammond, City of Chicago	Natural feature	Inland lake near the Lake Michigan shoreline	13
Lake George	IN	Lake	City of Hammond	Natural feature	Inland lake near the Lake Michigan shoreline	13

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Forsythe Park	IN	Lake	City of Hammond	Public Park	Lakefront park offering walking trails, fishing, ball fields/courts, etc.	13
Lakeshore Cal Ripken/Babe Ruth	IN	Lake	City of Hammond	Public Park	Lakefront baseball facility, offering multiple baseball diamonds and concessions	13
Wolf Lake Memorial Park	IN	Lake	City of Hammond	Public Park	Lakefront park offering walking paths, lake access, and a music venue pavilion, boardwalk across lake	13
Wolf Lake Aquatic Play Center	IN	Lake	City of Hammond	Public Park	Water/aquatics park offering large splash pad and walking trails beside Wolf Lake	13
The Pavilion at Wolf Lake Memorial Park	IN	Lake	City of Hammond	Built resource	Waterside musical venue within Wolf Lake Memorial Park	13
Environmental Education Center	IN	Lake	City of Hammond	Institution	Environmental education center within Wolf Lake Park offering lessons in recycling, etc., and crafts	13
Lost Marsh Golf Course	IN	Lake	City of Hammond	Golf Course	Golf course bordering Lake George offering club house, lake views, and restaurant	13
William W. Powers State Recreation Area	IL	Cook	City of Chicago	Public Park	Lakefront park and recreation area offering bike/walking trails, boating, fishing, hiking, shelter reservations, etc.	13
Illiana Yacht Club	IN	Lake	City of Hammond	Organization	Yacht club and Marina located on Wolf Lake offering access to lake, memberships, social events, etc.	13
Calumet Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and marina offering memberships, access to Lake Michigan, boat launch, etc.	14
Calumet Harbor	IL	Cook	City of Chicago	Natural/Built feature	Built harbor near shipping port mouth within Lake Michigan	15

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Illinois International Port District	IL	Cook	City of Chicago	Built resource	International port, home to multiple port facilities and terminals utilized by multiple businesses/corporations for distribution and transport	15
Calumet River	IL	Cook	City of Chicago	Natural feature	Tributary to Lake Michigan	15
Crowley's Yacht Yard	IL	Cook	City of Chicago	Private business	Boat storage and maintenance facilities located along Calumet River	15
Karma Yacht Sales	IL	Cook	City of Chicago	Private business	Boat and yacht sales room located along Calumet River	15
Skyway Yacht Works	IL	Cook	City of Chicago	Private business	Boat repair and storage service located along Calumet River	15
Morton Salt	IL	Cook	City of Chicago	Industrial facility	Salt distributor utilizing Calumet River for transport and distribution	15
Carmeuse Lime Inc.	IL	Cook	City of Chicago	Industrial facility	Lime distributor utilizing Calumet River for transport and distribution	15
TPG Chicago Dry Docks	IL	Cook	City of Chicago	Built resource	Dry docks along Calumet River offering repair and maintenance services for marine vessels	15
Steelworkers Park	IL	Cook	City of Chicago	Public Park	Lakefront park offering walking paths, views of Lake Michigan and Calumet Harbor, fishing, etc.	15
Jackson Park Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and marina offering memberships, docking, rentals (bike/boat), clubhouse and restaurant, social events, etc.	16
Southern Shore Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and marina offering memberships, docking, access to Lake Michigan, etc.	16

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Jackson Park Outer Harbor	IL	Cook	City of Chicago	Natural feature	Harbor within Jackson Park, connected to Lake Michigan	16
Jackson Park Historic Landscape District and Midway Plaisance	IL	Cook	City of Chicago	Public park	NRHP Listed lakefront park and district; NPS # 72001565	16, 17
63rd St Beach Park	IL	Cook	City of Chicago	Public Park	Historic beachfront offering sand beach area, swimming, bathhouse, walkable pier, etc.	17
Museum Shores Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and marina offering memberships, docking, access to Lake Michigan, etc.	17
Museum of Science and Industry	IL	Cook	City of Chicago	Organization	Waterfront museum offering hands on learning environment, waterside walking paths, park, etc.	17
Garden of the Phoenix	IL	Cook	City of Chicago	Public Park	Japanese garden on Jackson Park's Wooded Island featuring a waterfall & foot bridges.	17
Wooded Island	IL	Cook	City of Chicago	Natural feature	Island within East/West Lagoon near Lake Michigan shoreline	17
East Lagoon	IL	Cook	City of Chicago	Natural feature	Water basin fed by Lake Michigan	17
West Lagoon	IL	Cook	City of Chicago	Natural feature	Water basin fed by Lake Michigan	17
Bobolink Meadow	IL	Cook	City of Chicago	Public Park	Nature area dominated by woodland and tall grass prairie	17
31st St Harbor	IL	Cook	City of Chicago	Marina	Public marina offering 1000 slips, protected harbor, access to Lake Michigan	18
Chicago Watersports Rentals	IL	Cook	City of Chicago	Private business	Watercraft rental service offering jet skis, kayak and stand-up paddleboard rentals as well as lessons and tours	18

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Carefree Boat Club	IL	Cook	City of Chicago	Organization	Boat club offering memberships, dockside playground, picnic areas, social events, etc.	18
Northerly Island	IL	Cook	City of Chicago	Public Park	Large peninsula park area adjacent to Lake Michigan offering many walking paths, community events, concerts, etc.	19
Burnham Harbor	IL	Cook	City of Chicago	Natural/built feature	Lake harbor protected by Northerly Island	19
Dive Chicago	IL	Cook	City of Chicago	Private business	Scuba diving rental and tour service offering lessons, certification, sightseeing tours, etc.	19
Free Spirit Yacht Cruises	IL	Cook	City of Chicago	Private business	Luxury private yacht charters offering social events, private event charters, all on Lake Michigan	19
Burnham Harbor	IL	Cook	City of Chicago	Public facility	Public marina offering 1,126 boat slips, access to Lake Michigan, etc.	19
Burnham Park Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and marina within Burnham harbor, offering memberships, clubhouse, sailing lessons, social events, etc.	19
Huntington Bank Pavilion at Northerly Island	IL	Cook	City of Chicago	Built resource	Music venue and pavilion on Northerly Island offering multiple concerts per season, adjacent to Burnham Harbor and Lake Michigan	19
City of Chicago	IL	Cook	City of Chicago	Community	Large lakefront city along Lake Michigan shoreline. Third most populous city in the United States with a population of over 2.7 million	13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Shedd Aquarium	IL	Cook	City of Chicago	Organization	Indoor aquarium located along Lake Michigan shoreline	20
Shoreline Water Taxi		Cook	City of Chicago	Private business	Water taxi and sightseeing service offering tours and ferries on Lake Michigan	20
Southerly Breakwater	IL	Cook	City of Chicago	Built resource	Breakwater wall protecting Chicago Harbor	20
Chicago Harbor	IL	Cook	City of Chicago	Natural/built feature	Harbor adjacent to downtown Chicago and Lake Michigan, protected by breakwater walls	20
Chicago Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and marina offering memberships, nautical education, sailing lessons, community events, etc.	20
Columbia Yacht Club	IL	Cook	City of Chicago	Organization	Yacht club and cruise ship located in Chicago harbor, offering memberships, sailing lessons/races, community events, etc.	20
DuSable Harbor	IL	Cook	City of Chicago	Private business	Marina located adjacent to downtown Chicago offering 420 slips, access to Lake Michigan and downtown Chicago, etc.	20
Knockout Charters	IL	Cook	City of Chicago	Private business	Yacht charter offering a variety of charter services including sightseeing, concerts, fireworks special, tours, etc.	20
Anita Dee Yacht Charters	IL	Cook	City of Chicago	Private business	Private luxury yacht charter available for private and social events, tours, weddings, etc.	20
Navy Pier	IL	Cook	City of Chicago	Built resource	Community pier offering many private businesses, carnival rides, venues, restaurants, and catering halls	20

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
USS SILVERSIDES (SS 236) National Historic Landmark	IL	Cook	City of Chicago	Built resource	NRHP Listed ship offering tours; NPS # 72001566	20
SS Clipper	IL	Cook	City of Chicago	Built resource	NRHP Listed ship offering tours; NPS # 83003570	20
Municipal Pier	IL	Cook	City of Chicago	Built resource	NRHP Listed district/built resource; NPS # 79000825	20
Chicago Line Cruises	IL	Cook	City of Chicago	Private business	Water cruise tours and charter services, offering sightseeing tours, private event charters, etc.	20
River Esplanade Park	IL	Cook	City of Chicago	Public Park	Riverside public park offering riverside walking paths and views	20
Urban Kayaks	IL	Cook	City of Chicago	Private business	Kayak rental and tour guide services offering tours of downtown Chicago by water	20
Island Party Hut	IL	Cook	City of Chicago	Private business	Riverside bar offering outdoor seating, island themed, etc.	20
Chicago River	IL	Cook	City of Chicago	Natural feature	Tributary to Lake Michigan, running through downtown Chicago	20
Chicago Riverwalk	IL	Cook	City of Chicago	Public Park	Riverside walking path through downtown Chicago along Chicago River	20
Chicago First Lady Cruises	IL	Cook	City of Chicago	Private business	Cruise touring agency on Chicago river offering tours of Chicago and Lake Michigan by boat	20
Michigan-Wacker Historic District	IL	Cook	City of Chicago	Built resource	NRHP Listed district along Chicago River and downtown Chicago; NP # 7801124	20
McCormick Bridgehouse & Chicago River Museum	IL	Cook	City of Chicago	Organization	Riverfront museum focusing on the Chicago River and its movable bridges	20

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Obrien's Riverwalk Café	IL	Cook	City of Chicago	Private business	Restaurant and café along Chicago Riverwalk and Chicago River, offering outdoor seating and river views	20
Lincoln Park	IL	Cook	City of Chicago	Public park	NRHP Listed park and cultural complex offering multiple museums, nature sanctuaries, zoo, gardens, walking paths, etc.; NPS # 94001029	21
South Lagoon	IL	Cook	City of Chicago	Natural/built feature	Water feature/basin fed by Lake Michigan, protected by barrier beach and road	21
Lincoln Park Boat Club	IL	Cook	City of Chicago	Organization	Rowing and paddling club located in Lincoln Park complex on South Lagoon, offering lessons and rowing clubs	21
Fullerton and Lake Front Trail	IL	Cook	City of Chicago	Public Park	Bike and walking path along Lake Michigan offering expansive paths and lakefront views	21
North Pond	IL	Cook	City of Chicago	Natural/built feature	Inland pond near Lake Michigan shoreline	21
Diversey Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and marina offering access to Lake Michigan, docking, social events, etc.	21
Boat Launch	IL	Cook	City of Chicago	Public facility	Public boat launch offering access to Lake Michigan	21
Belmont Harbor	IL	Cook	City of Chicago	Public facility	Public marina offering docking, access to Lake Michigan, etc.	22
Chicago Sailboat Charters	IL	Cook	City of Chicago	Private business	Sailboat and powerboat rental service on Lake Michigan, offering rentals and tours	22
Kingfisher Charters	IL	Cook	City of Chicago	Private business	Fishing charter service offering fishing trip tours on Lake Michigan	22
Belmont Harbor Dog Beach	IL	Cook	City of Chicago	Public Park	Public dog park in Belmont Harbor offering a beach area for dogs	22

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Montrose Harbor	IL	Cook	City of Chicago	Public facility	Public marina offering 711 slips, docking, access to Lake Michigan, etc.	23
Chicago Corinthian Yacht Club	IL	Cook	City of Chicago	Organization	Boat club and private marina offering memberships, clubhouse, docking, sailing lessons and clubs, social events, etc.	23
Church Street Power Boat Ramp	IL	Cook	City of Evanston	Public facility	Public boat launch offering access to Lake Michigan	24
Arrington Lagoon at Dawes Park	IL	Cook	City of Evanston	Public Park	Lakefront park and ice-skating rink offering Lake Michigan views and lakeside walking paths, etc.	24
Northwestern University	IL	Cook	City of Evanston	Institution	Lakefront university campus offering views of Lake Michigan, open harbor-front space, walking paths, educational programs, etc.	25
The Lakefill	IL	Cook	City of Evanston	Public Park	Park on Northwestern college campus offering lakeside walking paths and views of Lake Michigan	25
Wilmette Harbor	IL	Cook	Village of Wilmette	Natural/built feature	Boat harbor protected from Lake Michigan	26
Gilson Park Dog Beach	IL	Cook	Village of Wilmette	Public Park	Lakefront dog park with dog friendly beach area	26
US Coast Guard	IL	Cook	Village of Wilmette	Government facility	Coast guard station in Wilmette Harbor	26
Sheridan Shore Yacht Club	IL	Cook	Village of Wilmette	Organization	Boat club and marina in Wilmette Harbor, offering membership, private event space, clubhouse, docking, sailing lessons and clubs, etc.	26

Attachment F-6 Natural and Socio-Cultural Features Within Focus Areas Along the Lake Michigan Shoreline in the Southern Lake Michigan Watershed

Feature or resource name	State	County	City/Town	Type of feature or resource	Description	Focus Area Number
Free at Last Charters	IL	Cook	Village of Wilmette	Private business	Sailboat charter offering reservations for special water events in Chicago, regular tours, parties, etc.	26

G Tribal Impacts

This appendix presents the results of the desktop analysis to identify tribes within the Great Lakes Basin, and plant and animal species of interest or concern to these tribes. This information was developed in order to consider the potential impacts of Hydrilla occurrence at selected, representive locations in the Great Lakes Basin, as described in Section 3.3.4 of this report.

G.1 Introduction

The spread of Hydrilla in the Great Lakes basin may result in indirect socio-cultural impacts on communities by altering the natural resources that certain communities use for subsistence or for economic purposes. Considering the continued use of Great Lakes ecosystems by Native Americans for subsistence hunting/gathering, cultural and spiritual practices, and economic purposes, and their spiritual/religious connections to the earth and its resources, this assessment focuses on the potential impacts of Hydrilla on those resources identified as being of economic or cultural importance to various federally recognized Indian tribes surrounding the Great Lakes.

G.2 Methodology

As part of the Great Lakes Hydrilla Risk Assessment, publicly available information for federally recognized Indian tribes was examined to identify species of interest or concern to tribes for economic and/or cultural reasons that may be affected by the potential environmental and/or economic impacts resulting from the establishment of Hydrilla in the Great Lakes.

For the purposes of this portion of the risk assessment, the study area was identified as those counties within the eight states that are located along the shoreline within the Great Lakes basin. The Great Lakes basin extends from Minnesota, south through eastern Wisconsin, sections of Illinois, Indiana, and Ohio, includes all of Michigan, and follows the lakes east to include portions of Pennsylvania and New York (see Figure G-1). The U.S. Army Corps of Engineers (USACE) has previously defined this area in its study entitled "Treaty Rights and Subsistence Fishing in the U.S. Waters of the Great Lakes, Upper Mississippi River, and Ohio River Basins" (USACE 2012).

Source: USACE 2012

Figure G-1 Federally Recognized Indian Tribes within the Great Lakes Basin

All federally recognized Indian tribes physically located within the eight states included in the study area were identified (USACE 2012). Additional federally recognized Indian tribes located outside the United States portion of the Great Lakes basin but with a historic or cultural interest in counties located along the U.S. shoreline of the Great Lakes were also identified (NPS 2015). The purpose of this effort was to identify all federally recognized Indian tribes within the study area that may use, manage, or otherwise be interested in or concerned with species or water resources that could be directly or indirectly impacted by the establishment of Hydrilla along the U.S. shoreline of the Great Lakes.

Following identification of federally recognized Indian tribes either in the Great Lakes basin or with an interest in counties along the U.S. shoreline of the Great Lakes, additional research was conducted for each tribe, using publicly available information from official tribal websites, in order to identify any aquatic and terrestrial animal or plant species of significance to the tribe. Various species may be of importance because of economic practices, subsistence hunting, fishing and gathering, cultural practices, ceremonial usage, or spiritual meaning. In some cases, this interest is directly related to treaty rights retained by federally recognized Indian tribes in the United States for traditional hunting, fishing, and wild rice gathering practices (USACE 2012). The purpose of this effort was to identify all aquatic and terrestrial animal and plant species of potential interest or concern to federally recognized Indian tribes within the study area. The results of the risk assessment would be used to help understand whether the establishment of Hydrilla in the Great Lakes would potentially impact any species of interest or concern to the tribes, and result in direct or indirect impacts on socio-economic or socio-cultural practices of the tribes.

Relevant information for any species of interest or concern to the federally recognized Indian tribes, primarily because of conservation, economic, and/or subsistence practices, as well as contact information and governmental organization, was gleaned from various intertribal departments, mainly natural resources and conservation departments, and recorded in individual documents (see Attachment A).

G.3 Results

A total of 61 federally recognized Indian tribes are located in the study area or have an interest in counties along the U.S. shoreline of the Great Lakes. Thirty of these are federally recognized tribes that physically reside within the basin (see Table G-1). An additional 31 federally recognized tribes do not physically reside within the basin, but may have a historical or cultural interest in at least one county along the U.S. shoreline of the Great Lakes (see Table G-2)[1].

Table G-1 Federally Recognized Indian Tribes located within the Great Lakes Basin (Study Area)

Name of Tribe[a]	Residing State
Bad River Band of the Lake Superior Tribe of Chippewa Indians of the Bad River Reservation, Wisconsin	Wisconsin
Bay Mills Indian Community, Michigan	Michigan
Cayuga Nation	New York
Fond du Lac Band, component reservation of the Minnesota Chippewa Tribe, Minnesota[b]	Minnesota
Forest County Potawatomi Community, Wisconsin	Wisconsin
Grand Portage Band, component reservation of the Minnesota Chippewa Tribe, Minnesota[b]	Minnesota
Grand Traverse Band of Ottawa and Chippewa Indians, Michigan	Michigan
Hannahville Indian Community, Michigan	Michigan
Keweenaw Bay Indian Community, Michigan	Michigan
Lac Courte Oreilles Band of Lake Superior Chippewa Indians of Wisconsin[c]	Wisconsin
Lac du Flambeau Band of Lake Superior Chippewa Indians of the Lac du Flambeau Reservation of Wisconsin[c]	Wisconsin

[1] While Table 4-2 contains 42 tribes that have a potential interest in counties along the U.S. shoreline of the Great Lakes, 11 of these tribes also physically reside within the basin and are also listed in Table 4-1: the Lac Courte Oreilles Band of Lake Superior Chippewa Indians of Wisconsin; the Lac du Flambeau Band of Lake Superior Chippewa Indians of the Lac du Flambeau Reservation of Wisconsin; the Match-e-be-nash-she-wish Band of Pottawatomi Indians of Michigan; the Onondaga Nation; the Pokagon Band of Potawatomi Indians, Michigan and Indiana; the Saint Regis Mohawk Tribe; the Seneca Nation of Indians; the Sokaogon Chippewa Community, Wisconsin; the Tonawanda Band of Seneca; and the Tuscarora Nation. Therefore, the total number of tribes has been adjusted to avoid duplication.

Table G-1 Federally Recognized Indian Tribes located within the Great Lakes Basin (Study Area)

Name of Tribe[a]	Residing State
Lac Vieux Desert Band of Lake Superior Chippewa Indians of Michigan	Michigan
Little River Band of Ottawa Indians, Michigan	Michigan
Little Traverse Bay Bands of Odawa Indians, Michigan	Michigan
Match-e-be-nash-she-wish Band of Pottawatomi Indians of Michigan[c]	Michigan
Menominee Indian Tribe of Wisconsin	Wisconsin
Nottawaseppi Huron Band of the Potawatomi, Michigan[c]	Michigan
Oneida Nation of New York	New York
Oneida Nation	Wisconsin
Onondaga Nation[3]	New York
Pokagon Band of Potawatomi Indians, Michigan and Indiana[c]	Michigan
Red Cliff Band of Lake Superior Chippewa Indians of Wisconsin	Wisconsin
Saginaw Chippewa Indian Tribe of Michigan	Michigan
Saint Regis Mohawk Tribe[c]	New York
Sault Ste. Marie Tribe of Chippewa Indians, Michigan	Michigan
Seneca Nation of Indians[c]	New York
Sokaogon Chippewa Community, Wisconsin[3]	Wisconsin
Stockbridge Munsee Community, Wisconsin	Wisconsin
Tonawanda Band of Seneca[c]	New York
Tuscarora Nation[3]	New York

Source: USACE 2012

Notes:

a Tribal names used in this table are based on the list of federally recognized Indian tribes published in the Federal Register on Tuesday, January 17, 2017. Some Indian nations may have alternatively preferred names.

b One of six component reservations of the Minnesota Chippewa Tribe, Minnesota.

c Also listed in Table 4-2.

Table G-2 Federally Recognized Indian Tribes with a Potential Interest in Counties along the U.S. Shoreline of the Great Lakes

Name of Tribe[a]	State(s) of Interest	Counties of Interest
Absentee-Shawnee Tribe of Indians of Oklahoma;	Ohio	Lucas, Ottawa
Bois Forte Band (Nett Lake), component reservation of the Minnesota Chippewa Tribe, Minnesota[b]	Michigan	Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon
	Minnesota	Cook, Lake, St. Louis
	Ohio	Cuyahoga, Erie, Lorain, Lucas
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Marinette, Oconto

Table G-2 Federally Recognized Indian Tribes with a Potential Interest in Counties along the U.S. Shoreline of the Great Lakes

Name of Tribe[a]	State(s) of Interest	Counties of Interest
Chippewa-Cree Tribe of the Rocky Boy's Reservation, Montana	Ohio	Lucas, Ottawa
Citizen Potawatomi Nation, Oklahoma	Illinois	Cook, Lake
	Indiana	Lake, La Porte, Porter
	Michigan	Allegan, Berrien, Delta, Kewaunee, Van Buren
	Ohio	Cuyahoga, Erie, Lorain, Lucas
	Wisconsin	Brown, Door, Kenosha, Manitowoc, Milwaukee, Ozaukee, Racine, Sheboygan
Delaware Nation, Oklahoma	New York	Cayuga, Chautauqua, Erie, Jefferson, Monroe, Niagara, Orleans, Oswego, St. Lawrence, Wayne
	Ohio	Cuyahoga, Lake, Lorain, Lucas, Ottawa, Sandusky
	Pennsylvania	Erie
Delaware Tribe of Indians	Ohio	Cuyahoga, Lake
	Pennsylvania	Erie
Eastern Shawnee Tribe of Oklahoma	Ohio	Lucas, Ottawa
Flandreau Santee Sioux Tribe of South Dakota	Wisconsin	Brown, Douglas
Lac Courte Oreilles Band of Lake Superior Chippewa Indians of Wisconsin[c]	Michigan	Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon
	Minnesota	Cook, Lake, St. Louis
	Ohio	Cuyahoga, Erie, Lorain, Lucas
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Marinette, Oconto
Lac du Flambeau Band of Lake Superior Chippewa Indians of the Lac du Flambeau Reservation of Wisconsin[c]	Minnesota	Cook, Lake, St. Louis
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Marinette, Oconto

Table G-2 Federally Recognized Indian Tribes with a Potential Interest in Counties along the U.S. Shoreline of the Great Lakes

Name of Tribe[a]	State(s) of Interest	Counties of Interest
Leech Lake Band, component reservation of the Minnesota Chippewa Tribe, Minnesota[b]	Michigan	Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto
Lower Sioux Indian Community in the State of Minnesota	Wisconsin	Brown, Douglas
Match-e-be-nash-she-wish Band of Pottawatomi Indians of Michigan[c]	Michigan	Allegan
	Ohio	Cuyahoga, Erie, Lorain, Lucas
Miami Tribe of Oklahoma	Ohio	Ashtabula; Lake; Lucas
Mille Lacs Band, component reservation of the Minnesota Chippewa Tribe, Minnesota[b]	Michigan	Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon
	Minnesota	St. Louis
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto
Minnesota Chippewa Tribe, Minnesota	Michigan	Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon
	Minnesota	St. Louis
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto
Nottawaseppi Huron Band of the Potawatomi Indians, Michigan[c]	Michigan	Alcona, Allegan, Alpena, Arenac, Bay, Berrien, Huron, Iosco, Macomb, Ottawa, Sanilac, St. Clair, Tuscola, Van Buren
	Ohio	Cuyahoga, Erie, Lorain, Lucas
Onondaga Nation[c]	New York	Jefferson, St. Lawrence

Table G-2 Federally Recognized Indian Tribes with a Potential Interest in Counties along the U.S. Shoreline of the Great Lakes

Name of Tribe[a]	State(s) of Interest	Counties of Interest
Ottawa Tribe of Oklahoma	Michigan	Allegan, Huron, Monroe, Wayne
	Ohio	Cuyahoga, Erie, Lorain, Lucas, Ottawa, Sandusky
Peoria Tribe of Indians of Oklahoma	Ohio	Ottawa
Pokagon Band of Potawatomi Indians, Michigan and Indiana[c]	Ohio	Cuyahoga, Erie, Lorain, Lucas
Prairie Band Potawatomi Nation	Illinois	Cook, Lake
	Indiana	Lake, La Porte, Porter
	Michigan	Allegan, Berrien, Delta, Kewaunee, Van Buren
	Ohio	Cuyahoga, Erie, Lake, Lorain, Lucas
	Wisconsin	Brown, Door, Kenosha, Manitowoc, Milwaukee, Ozaukee, Racine, Sheboygan
Prairie Island Indian Community in the State of Minnesota	Wisconsin	Brown, Douglas
Red Lake Band of Chippewa Indians, Minnesota	Michigan	Alger, Antrim, Benzie, Charlevoix, Sheboygan, Chippewa, Delta, Emmet, Grand Traverse, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Muskegon, Oceana, Ottawa, Schoolcraft
	Minnesota	Lake
	Ohio	Cuyahoga; Erie; Lorain; Lucas
Sac & Fox Nation of Missouri in Kansas and Nebraska	Wisconsin	Brown, Douglas
Sac & Fox Nation, Oklahoma	Wisconsin	Douglas
Sac & Fox Tribe of the Mississippi in Iowa	Wisconsin	Douglas
Saint Regis Mohawk Tribe[c]	New York	Jefferson, Oswego, St. Lawrence
Santee Sioux Nation, Nebraska	Wisconsin	Brown, Douglas

Table G-2 Federally Recognized Indian Tribes with a Potential Interest in Counties along the U.S. Shoreline of the Great Lakes

Name of Tribe[a]	State(s) of Interest	Counties of Interest
Seneca-Cayuga Nation	New York	Cayuga, Chautauqua, Erie, Monroe, Niagara, Wayne
	Ohio	Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa
	Pennsylvania	Erie
Seneca Nation of Indians[c]	New York	Cayuga, Chautauqua, Erie, Monroe, Niagara, Wayne
	Ohio	Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa
	Pennsylvania	Erie
Shawnee Tribe	Ohio	Lucas, Sandusky
Sisseton-Wahpeton Oyate of the Lake Traverse Reservation, South Dakota	Wisconsin	Brown, Douglas
Sokaogon Chippewa Community, Wisconsin[c]	Ohio	Cuyahoga, Erie, Lorain
Spirit Lake Tribe, North Dakota	Wisconsin	Brown, Douglas
St. Croix Chippewa Indians of Wisconsin	Michigan	Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto
	Ohio	Cuyahoga, Erie, Lorain
Tonawanda Band of Seneca[c]	New York	Cayuga, Chautauqua, Erie, Monroe, Niagara, Wayne
	Ohio	Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa
	Pennsylvania	Erie
Turtle Mountain Band of Chippewa Indians of North Dakota	Ohio	Cuyahoga, Erie, Lorain
Tuscarora Nation[c]	New York	Niagara
Upper Sioux Community, Minnesota	Wisconsin	Brown, Douglas

Table G-2 Federally Recognized Indian Tribes with a Potential Interest in Counties along the U.S. Shoreline of the Great Lakes

Name of Tribe[a]	State(s) of Interest	Counties of Interest
White Earth Band, component reservation of the Minnesota Chippewa Tribe, Minnesota[b]	Michigan	Baraga, Chippewa, Delta Gogebic, Houghton, Marquette, Menominee, Ontonagon
	Minnesota	St. Louis
	Wisconsin	Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto
Wyandotte Nation	Ohio	Cuyahoga, Erie, Lorain, Ottawa, Sandusky
	Pennsylvania	Erie

Sources: NPS 2015, 2017; and information obtained from individual nations through consultation by the USACE.

Notes:
a Tribal names used in this table are based on the list of federally recognized Indian tribes published in the Federal Register on Tuesday, January 17, 2017. Some Indian nations may have alternatively preferred names.
b One of six component reservations of the Minnesota Chippewa Tribe, Minnesota.
c Also listed in Table 4-1.

Information on official tribal websites resulted in the identification of a number of aquatic and terrestrial animal and plant species of interest or concern. Most tribal websites identify specific species of interest or concern, and often reasons for their significance (e.g., for economic purposes or for conservation or wildlife management purposes; see Attachment A). A total of 146 different species or families of species were identified from tribal websites, including: 37 aquatic/fish species; 87 wildlife species, including mammals, birds, waterfowl, furbearers, and game species; and 22 plant species. These species are identified in Tables G-3, G-4, and G-5, respectively.

Table G-3 Fish Species of Interest or Concern to Federally Recognized Indian Tribes in the Study Area

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
Bluegill	*Lepomis macrochirus*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Bullhead	*Ameiurus nebulosus*
Burbot	*Lota lota*
Catfish	*Ictalurus punctatus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chub	*Couesius plumbeus*

Table G-3 Fish Species of Interest or Concern to Federally Recognized Indian Tribes in the Study Area

Common Name	Scientific Name
Cisco	*Coregonus artedi*
Coho salmon	*Oncorhynchus kisutch*
Crappie	*Pomoxis annularis/nigromaculatus* (white/black)
Grayling	*Thymallus thymallus*
Hellbender	*Cryptobranchus alleganiensis*
Herring	*Clupea harengus*
Lake trout	*Salvelinus namaycush*
Largemouth bass	*Micropterus salmoides*
Menominee	*Prosopium cylindraceum*
Muskellunge	*Esox masquinongy*
Northern pike	*Esox lucius*
Paddlefish	*Polyodon spathula*
Pink salmon	*Oncorhynchus gorbuscha*
Pumpkinseed	*Lepomis gibbosus*
Rainbow trout	*Ambloplites rupestris*
Rock bass	*Ambloplites rupestris*
Sauger	*Sander canadensis*
Sheepshead	*Archosargus probatocephalus*
Smallmouth bass	*Micropterus dolomieu*
Smelt	*Osmeridae* (family)
Sturgeon	*Acipenser fulvescens*
Sucker	*Catostomidae* (family)
Sunfish[a]	*Centrarchidae* (family)
Tiger muskellunge	*Esox masquinongy* X *Esox lucius*
Walleye	*Sander vitreus*
White bass	*Morone chrysops*
White perch	*Morone americana*
Yellow perch	*Perca flavescens*

Sources: See Appendix A.

Notes:
[a] This is a broad range of fish including some already mentioned in this table.

Table G-4 Wildlife Species of Interest or Concern to Federally Recognized Indian Tribes in the Study Area

Common Name	Scientific Name
Antelope	*Antilocapra americana*
Badger	*Taxidea taxus*
Bald eagle	*Haliaeetus leucocephalus*
Beaver	*Castor canadensis*
Bison	*Bison bison*
Bittern	*Botaurus lentiginosus*

Table G-4 Wildlife Species of Interest or Concern to Federally Recognized Indian Tribes in the Study Area

Common Name	Scientific Name
Black bear	*Ursus americanus*
Black duck	*Anas rubripes*
Black squirrel	*Sciurus carolinensis*
Blue-winged teal	*Anas discors*
Bluebird	*Sialia* (genus)
Bobcat	*Lynx rufus rufus, Lynx rufus superiorensis*
Brant	*Branta bernicla*
Mud hens (American coot)	*Fulica americana*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Caribou	*Rangifer tarandus caribou*
Coots	*Fulica* (genus)
Cougar	*Puma concolor*
Coyote	*Canis latrans*
Crow	*Corvus*
Diver ducks	*Aythyinae* (family)
Doves	*Columbidae* (family)
Elk	*Cervus canadensis*
Falcons	*Falco* (genus)
Feral swine	*Sus scrofa*
Fisher	*Martes pennanti*
Fox squirrel	*Sciurus niger*
Gadwall	*Anas strepera*
Gallinule	*Gallinula galeata*
Golden eagle	*Aquila chrysaetos*
Gray fox	*Urocyon cinereoargenteus*
Gray squirrel	*Sciurus carolinensis*
Green-winged teal	*Anas carolinensis*
Hawks	*Accipitrinae* (subfamily)
Heron	*Ardeidae* (family)
Lesser scaup	*Aythya affinis*
Loon	*Gavia* (genus)
Lynx	*Lynx Canadensis*
Mallard	*Anas platyrhynchos*
Mergansers	*Mergus merganser*
Mink	*Neovison vison*
Moose	*Alces alces*
Mourning dove	*Zenaida macroura*
Mule deer	*Odocoileus hemionus*
Muskrat	*Ondatra zibethicus*
Opossum	*Didelphis virginiana*

Table G-4 Wildlife Species of Interest or Concern to Federally Recognized Indian Tribes in the Study Area

Common Name	Scientific Name
Otter	*Lontra canadensis*
Owls	*Strigiformes* (order)
Partridge (Hungarian)	*Perdix perdix*
Pheasant (ring-necked)	*Phasianus colchicus*
Pine marten	*Martes americana*
Pintail	*Anas acuta*
Porcupine	*Erethizon dorsatum*
Prairie chicken	*Tympanuchus cupido*
Puddle/dabbler ducks[1]	*Anatidae* (family)
Quail (bobwhite)	*Colinus virginianus*
Rabbit (cottontail)	*Sylvilagus floridanus*
Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes*
Red squirrel	*Tamiasciurus hudsonicus*
Redhead duck	*Aythya americana*
Ruffed grouse	*Bonasa umbellus*
Sandhill crane	*Grus canadensis*
Sea ducks	*Merginae* (subfamily)
Sharp-tailed grouse	*Tympanuchus phasianellus*
Striped skunk	*Mephitis mephitis*
Wilson's snipe	*Gallinago delicata*
Snow goose	*Chen caerulescens*
Snowshoe hare	*Lepus americanus*
Sora rail	*Porzana carolina*
Spotted skunk	*Spilogale putorius*
Spruce grouse	*Falcipennis canadensis*
Swan	*Cygnus* (genus)
Tree ducks	*Dendrocygnidae* (family)
Turkey	*Meleagris gallopavo*
Turtle	*Testudines* (order)
Virginia rail	*Rallus limicola*
Weasel (short-tailed, long-tailed, least)	*Mustela ermine, Mustela frenata, Mustela nivalis*
White-fronted goose	*Anser albifrons*
White-tailed deer	*Odocoileus virginianus*
Wolf	*Canis lupus*
Wood duck	*Aix sponsa*
Woodchuck	*Marmota monax*
Woodcock	*Scolopax minor*

Sources: See Attachment A.

Notes:
[a] This is a broad range of duck including some already mentioned in this table.

Table G-5 Vegetative Species of Interest or Concern to Federally Recognized Indian Tribes in the Study Area

Common Name	Scientific Name
Basswood	*Tilia* (genus)
Beans	*Phaseolus acutifolius, Phaseolus vulgaris*
Black ash	*Fraxinus nigra*
Cedar	*Thuja, juniperus* (genus)
Christmas trees[a]	Multiple species
Ginseng	*Panax quinquefolius*
Green corn	*Zea mays*
Ironwood[b]	*Carpinus caroliniana*
Jack pine	*Pinus banksiana*
Princess pine	*Lycopodium obscurum*
Red pine	*Pinus resinosa*
Sheet moss	*Hypnum curvifolium*
Squash	*Cucurbita* (genus)
Strawberry	*Fragaria vesca*
Sugar maple	*Acer saccharum*
Sweetgrass	*Hierochloe odorata*
Tamarack	*Larix laricina*
White birch	*Betula papyrifera*
White pine	*Pinus strobus*
White spruce	*Picea glauca*
Wild rice	*Zizania palustris*

Sources: See Appendix A.

Notes:
[a] Multiple species.
[b] Many different species referred to as ironwood.

Aquatic wildlife and plant species are of particular importance to tribes who have retained subsistence rights though various treaties with the U.S. government. These treaties ceded original territory to the United States, but upheld tribal rights to continue their traditional way-of-life practices, including subsistence hunting/fish, and gathering of culturally important plants and/or minerals (USACE 2012). Although not all tribes within the Great Lakes basin are included in these ceded territories, members of most other tribes still practice subsistence hunting/fishing on their territories or public land in accordance with respective tribal or state hunting laws (USACE 2012).

Fishing may be the most vital source of subsistence for many of the tribes in the study area. Especially for tribes residing along the shoreline and western lakes, abundant aquatic resources have been a sustainable and convenient source of sustenance since their settlement. Historically and presently, fishing was practiced year round, utilizing multiple fishing techniques, and targeting a large variety of fish, including muskellunge, sturgeon, trout, perch, pike, walleye, and many others. Fish caught were eaten immediately, smoked or dried to preserve for future use, or frozen during the winters (USACE 2012). Additionally, many elders among tribes today rely on the community and its resources to survive as they are no longer healthy or active enough to sustain themselves on their own. Elders are a respected and honored people, and are provided with fish from these tribal practices; without them, their survival and/or ability to pass on the cultural heritage and traditions of the tribes would be affected. This custom is a spiritual ritual as well, as the waters from which fish are gathered are believed to have a spirit. The Creator or "Great Spirit" established the Indian people and their resources in these areas because they were made to shepherd the land and waters (USACE 2012).

Wildlife species have also been important to the livelihood of all Native American tribes since they settled in the Great Lakes region. In the past, hunting and trapping of game species was a necessity to ensure the survival of tribes during various seasons when other food sources had become scarce (USACE 2012). Game species include deer, black bear, elk, bison, moose, turkey, caribou, and others, as well as trapping species, such as marten, fisher, beaver, otter, and bobcat. In the eastern Great Lakes basin, hunting functions as a more integral part of subsistence because that region does not have the same abundant fisheries resources or wild rice resources as the western region of the basin (USACE 2012). Waterfowl and migratory bird species have played an important role as a meat source to Native American tribes as well. Geese, ducks, pheasants, grouse, quail, turkey, and a large variety of other bird species have been hunted in the past and still continue to be hunted today. Not only is hunting a source of sustenance, it is also considered a spiritual connection to the earth and to the Creator. Animals were historically offered to the Great Spirit during many different religious ceremonies to thank the spirit and ensure ease of the hunt (USACE 2012).

Plant species are also utilized in an assortment of ways ranging from spiritual rituals, charms and decorations, to basketry, hunting equipment, medicine, and food sources (USACE 2012). Gathering and agricultural practices included such species as strawberries, corn, beans, squash, and wild rice. Wild rice was and still is an integral part of many tribes' culture, sustenance, and spiritual beliefs. The wild rice region extends from east of the Upper Mississippi River to the southwest shores of Lake Superior, and through the middle portion of Wisconsin expanding as far south as Green Bay (USACE 2012). There are many tribes within this vast extent and the majority of them have utilized wild rice as a main source of subsistence over the centuries, and continue to do so either by direct consumption or by selling wild rice for economic purposes (USACE 2012).

Wild rice is harvested during the fall after the seeds have had time to ripen during the summer. Seeds are collected the same way they have been for hundreds of years, by special "rice sticking" while navigating the waters by canoe. In only a few sessions of collection, a tribe may have enough rice to last them through the winter. Although wild rice is no longer an essential part of tribal diets, tribes do sell thousands of pounds of wild rice to consumers around the world for economic gain.

The process of collecting and preparing the rice is as much a sustenance practice, as it is a spiritual and bonding experience among tribe members. It has been done the same way since their ancestors began the tradition. Wild rice is so important in fact, that it is the reason these tribes settled there in the first place. Many tribes believe their people were instructed to move west to the lakes after a vision from one of the “seven prophets” predicted the arrival of the European settlers. The vision directed their people to “go to the place where there is food upon the waters” (USACE 2012).

Tribal restoration projects in progress acknowledge the potential negative effects of invasive plant species in the Great Lakes. For example, it is known that the growth of invasive species hinders the success of wild rice. The Bois Forte Band in Minnesota experienced this on Nett Lake, the largest known wild rice lake in the world. For six years there had been a consistent, substantial decline in kernel yield, from historic highs of over one million pounds per year, to less than 400,000 pounds in 2002. The reason for this major decline was the growth of invasive plants, impacting over 3,000 acres of Nett Lake. Invasive species crowd water inlets and outlets, causing increasingly stagnant waters that are detrimental to wild rice growth; they take up precious opportunity space for seeds to colonize and germinate as well. The invasive species causing these problems include: horsetail, white water lily, cattail, reed canary grass, sedges, and square-stem bulrush. Large weed uprooting/cutting rigs were used on the lake for removal of these invasive species. After months of weed removal, areas where there had been no wild rice growth showed dense stands of wild rice after multiple consecutive seasons without reseeding. From these types of projects, it is clear that growth and overgrowth of invasive species have the potential to negatively affect wild rice.

G.4 Summary and Conclusions

The establishment of Hydrilla in the Great Lakes Basin has the potential to disrupt traditional tribal ways of life and affect customary tribal nourishment practices, as well as spiritual beliefs. Such impacts would be likely if dense Hydrilla infestations were to develop in aquatic habitats traditionally used by one or more to the tribes identified in this section.

Information obtained from the websites of federally recognized Indian tribes in the study area confirms the importance of aquatic and terrestrial animal and plant species for tribal economic and cultural activities. Fishing continues to be essential to many tribes for both subsistence and economic reasons. Although not as essential to survival as in the past, subsistence hunting is also still an important aspect of tribal life. Present members of the majority of tribes in the Great Lakes basin hunt traditional game species as their ancestors did generations ago.

Various plant species also remain economically, culturally, and spiritually important to tribal life. In particular, wild rice remains an essential component of many tribes' economic and cultural practices. The potential for Hydrilla to affect aquatic habitats where harvesting of wild rice is conducted presently in the Great Lakes basin is possible if Hydrilla were to be introduced into those habitats.

References

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National Park Service. 2017. National NAGPRA: Indian Land Areas Judicially Established 1978. Available online at https://www.nps.gov/nagpra/DOCUMENTS/ClaimsMAP.htm. Website accessed December 28, 2017.

U.S. Army Corps of Engineers (USACE). 2012. *Treaty Rights and Subsistence Fishing in the U.S. Waters of the Great Lakes, Upper Mississippi River, and Ohio River Basins*. Great Lakes and Mississippi River Interbasin Study. June 2012. Available online at http://glmris.anl.gov/documents/docs/Subsistence_Fishing_Report.pdf. Website accessed December 28, 2017.

Attachment A

Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Absentee-Shawnee Tribe of Indians of Oklahoma

Counties of Interest along Great Lakes: Lucas, Ottawa (Ohio).

Contact Info:

Edwina Butler-Wolfe
Governor
Absentee Shawnee Tribe Executive Committee
2025 South Gordon Cooper Drive
Shawnee, OK 74801
(405) 275-4030, etc. 6308
Email: None provided
http://www.astribe.com/astribe/?reload

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Absentee Shawnee Tribe. 2014. Absentee Shawnee Tribe: Absentee Shawnee Tribe Executive Committee. Available online at http://www.astribe.com/astribe/?reload. Website accessed December 29, 2017.

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Bad River Band of the Lake Superior Tribe of Chippewa Indians of the Bad River Reservation, Wisconsin

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Cook, Lake, St. Louis (Minnesota); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin).

Contact Info:

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The Bad River Tribe
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http://www.badriver-nsn.gov/tribal-operations/natural-resources/nr-programs-a-personnel

Species of Interest or Concern or Managed Species:

- Primary Game Species:
  - deer
  - bear
  - rabbit
  - ruffed grouse
  - duck
  - geese
- Primary furbearers:
  - muskrat
  - beaver
  - mink
  - marten
  - raccoon
  - fox
  - fisher
- Primary Fish Species:
  - walleye

  - northern pike
  - sucker
  - trout/salmon
  - burbot
  - bass
  - sturgeon
- Plant Species of Interest
  - Sugar Maple
  - Wild Rice

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:
- Treaty of 1837
- Treaty of La Pointe 1842
- Treaty of 1854

References:

Bad River Band 2015a. Natural Resources Department Mission Statement. Website accessed on June 1, 2015: http://www.badriver-nsn.gov/tribal-operations/natural-resources.

Bad River Band 2015b. Natural Resources Department Wildlife Management Program. Website Accessed on June 1, 2015: http://www.badriver-nsn.gov/tribal-operations/natural-resources/wildlife-program.

Bad River. 2015c. Natural Resources Department Programs and Personnel. Website Accessed on June 1, 2015: http://www.badriver-nsn.gov/tribal-operations/natural-resources/nr-programs-a-personnel.

Bad River. 2015d. Treaty of 1837. Website Accessed on June 1, 2015: http://www.badriver-nsn.gov/legislative/treaty-of-1837.

Bad River. 2015e.Treaty of 1854.Website Accessed on June 1, 2015: http://www.badriver-nsn.gov/legislative/treaty-of-1854.

Bad River. 2015f. Treaty of La Pointe 1842. Website Accessed on June 1, 2015: http://www.badriver-nsn.gov/legislative/treaty-of-la-pointe-1842.

Bad River. 2015g. History. Website Accessed on June 1, 2015: http://www.badriver-nsn.gov/legislative/treaty-of-la-pointe-1842.

Bad River. 2015f. Official Tribal Website Homepage. Website Accessed on June 1, 2015: http://www.badriver-nsn.gov/history.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Bay Mills Indian Community, Michigan

Counties of Interest along Great Lakes: Alger, Antrim, Benzie, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Grand Traverse, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Muskegon, Oceana, Ottawa, Schoolcraft (Michigan).

Contact Info:

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906-248-8100
906-248-3283 fax
lcarricksr@baymills.org

Captain Don Carrick Jr.
Department of Conservation
(906) 248-8640

Species of Interest or Concern or Managed Species:

- Primary Big Game Species:
  - deer
  - bear
  - elk
  - moose
- Primary furbearers:
  - muskrat
  - beaver
  - mink
  - marten
  - raccoon
  - red/gray fox
  - fisher
  - otter
  - bobcat
  - coyote
  - badger
  - snowshoe hare
  - cottontail rabbit
- Small Game Species:
  - beaver
  - bobcat
  - coyote

  - raccoon
  - red/gray fox
  - bobwhite quail
  - cottontail rabbit
  - Hungarian partridge
  - ring-necked pheasant
  - red/gray/fox squirrel
  - ruffed grouse
  - sharp-tailed grouse
  - snowshoe hare
  - wild turkey
- Fish Species:
  - walleye
  - northern pike
  - sucker
  - trout/salmon
  - bass
  - sturgeon
  - Menominee whitefish
  - whitefish
  - grayling
  - muskellunge
  - herring
  - cisco
  - chub
  - alewife
  - smelt
- Plant Species of Interest
  - sugar Maple
  - wild Rice
  - birch
  - ginseng
  - conifer
  - princess pine
  - sheet moss
  - sugarbush

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:
- None identified.

References:

Bay Mills. 2004. Fishing Regulations. Website Accessed June 1, 2015: http://www.baymills.org/resources/bmic_fishing_regulations.pdf. Regulations adopted 1989-2004.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Bay Mills. 2010. Conservation Code. Website Accessed June 1, 2015: http://www.baymills.org/resources/Revised%20conservation%20code%20July%2014.pdf. Revised 2010, 2010, 2014.

Bay Mills. 2015a. Tribal Phone Directory. Website Accessed on June 1, 2015: http://www.baymills.org/phone-directory.php.

Bay Mills. 2015b. Conservation Department. Website Accessed on June 1, 2015: http://www.baymills.org/conservation.php.

Bay Mills. 2015c. Official Tribal Website Homepage. Website Accessed on June 1, 2015: http://www.baymills.org/.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Bois Forte Band (Nett Lake), component reservation of the Minnesota Chippewa Tribe, Minnesota

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Cook, Lake, St. Louis (Minnesota); Cuyahoga, Erie, Lorain, Lucas (Ohio); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin).

Contact Info:

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Tara Geshick
Commissioner of Natural Resources
Bois Forte Department of Natural Resources
Bois Forte RTC
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Nett Lake, MN 55772
Phone: 218-757-3261, ext. 309
tgeshick@boisforte-nsn.gov

Species of Interest or Concern or Managed Species:

- Primary Game Species:
    - Waterfowl (lots in the siting list link below)
- Plant Species of Interest
    - Wild Rice
- Invasive Species
    - Horsetail

- White water lily
- Cattail
- Reed canary grass
- Sedges
- Square-stem bulrush

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1854.

References:

Bois Forte. 1998. Department of Natural Resources. Website Accessed June 1, 2015: http://www.boisfortednr.com/index.html.

Bois Forte. 2007a. Nett Lake Bird Count. Website Accessed June 12, 2015: http://www.boisfortednr.com/restoringwildrice/BirdSpecies2Fall2007.pdf/

Bois Forte. 2007b. Restoring Wild Rice to Nett Lake. Website Accessed June 12, 2015: http://www.boisfortednr.com/restoringwildrice/index.html.

Bois Forte. 2015a. Official Tribal Website Homepage. Website Accessed June 1, 2015: http://www.boisforte.com/links.htm.

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Cayuga Nation

Counties of Interest along Great Lakes: Cattaraugus (New York)

Contact Info:
Clint Halftown, Heron Clan
Cayuga Nation Federal Representative
2540 SR-89
Seneca Falls, NY 13148
Phone: (315) 568-0750
Fax: (315) 568-0752

Species of Interest or Concern or Managed Species:

- Clan animals
  - Heron
  - Turtle
  - Bear
  - Snipe
  - wolf
- Plant Species of Interest
  - Strawberry
  - Green corn
  - Beans
  - squash

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Jay Treaty
- Treaty of Fort Stanwix (1784)
- Treaty of Canandaigua

References:

Cayuga.2009a. Ceremonies. Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/Culture/Ceremonies.

Cayuga 2009b. Jay Treaty. Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/LandRights/Treaties/JayTreaty.

Cayuga. 2009c. Treaty of Fort Stanwix (1784). Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/LandRights/Treaties/TreatyofFortStanwix

Cayuga. 2009d. Treaty of Canandaigua. Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/LandRights/Treaties/TreatyofCanandaigua.

Cayuga. 2009e. Government. Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/Government.

Cayuga. 2009f. Food. Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/Culture/Food.

Cayuga. 2009g. Clans. Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/Culture/Clans.

Cayuga. 2009f. Contact Us. Website Accessed June 1, 2015: http://www.cayuganation-nsn.gov/About/ContactUs.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Tribe Name: Chippewa-Cree Tribe of the Rocky Boy's Reservation, Montana

Counties of Interest along Great Lakes: Lucas, Ottawa (Ohio)

Contact Info:

Harlan Baker
Chairman
Chippewa Cree Business Committee
Chippewa Cree Tribe
P.O. Box 544
Box Elder, MT 59521
Phone: (406) 395-5705
Email: none provided
www.chippewacree.org

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Montana.gov. 2017. Montana Governor's Office of Indian Affairs: Chippewa Cree Tribe, Annishinabe Ne-I-Yah-Wahk Rocky Boys. Available online at http://tribalnations.mt.gov/chippewacree. Website accessed December 29, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Citizen Potawatomi Nation, Oklahoma

Counties of Interest along Great Lakes: Cook, Lake (Illinois); La Porte, Lake, Porter (Indiana); Allegan, Berrien, Delta, Kewaunee, Van Buren (Michigan); Cuyahoga, Erie, Lorain, Lucas (Ohio); Brown, Door, Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan (Wisconsin).

Contact Info:

John “Rocky” Barrett
Chairman
Tribal Council
Citizen Potawatomi Nation, Oklahoma
1601 S. Gordon Cooper Dr.
Shawnee, OK 74801
Phone: (405) 275-3121 or (800) 880-9880
rbarrett@potawatomi.org

Species of Interest or Concern or Managed Species:

- Eagles

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Citizen Potawatomi Nation. 2015a. Government: Executive. Website accessed December 2, 2015: http://www.potawatomi.org/government/executive

Citizen Potawatomi Nation. 2015. Culture: Eagle Aviary. Website accessed December 2, 2015: http://www.potawatomi.org/culture

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Delaware Nation, Oklahoma

Counties of Interest along Great Lakes: Cayuga, Chautauqua, Eire, Jefferson, Monroe, Niagara, Orleans, Oswego, St. Lawrence, Wayne (New York); Cuyahoga, Lake, Lorain, Lucas, Ottawa, Sandusky (Ohio); Erie (Pennsylvania)

Contact Info:

Kerry Holton
President
Delaware Nation, Oklahoma
P.O. Box 825
Anadarko, OK 73005
Phone: 405-247-2448, ext. 1101
Fax: 405-247-9393

Ivy Smith
DNEP Director/GAP Coordinator
Delaware Nation, Oklahoma
P.O. Box 825
Anadarko, OK 73005
Phone: (405) 247-2448 x1172
Fax: 405-247-9393
ismith@delawarenation.com

Species of Interest or Concern or Managed Species:

- None identified

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

The Delaware Nation. 2015a. Staff Directory. Website accessed December 2, 2015: http://delawarenation.com/Administration/tabid/68/Default.aspx

The Delaware Nation. 2015b. Environmental Programs. Website accessed December 2, 2015: http://delawarenation.com/Departments/EnvironmentalPrograms/tabid/58/Default.aspx

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Delaware Tribe of Indians

Counties of Interest along Great Lakes: Cuyahoga, Lake (Ohio); Erie (Pennsylvania).

Contact Info:

Chester "Chet" Brooks
Chief
Delaware Tribal Council
Delaware Tribe of Indians
Oklahoma Headquarters
5100 Tuxedo Blvd
Bartlesville, OK 74006
Phone: (918) 337-6590
Email: cbrooks@delawaretribe.org
www.delawaretfs.com

Tim Houseberg
Delaware Tribe of Indians
Kansas Headquarters
601 High Street
Caney, KS 67333
Phone: (620) 879-2189

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty signed September 17, 1778

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Delaware Tribe of Indians. 2017b. Official Web Site of the Delaware Tribe of Indians: Delaware Tribal Council. Available online at http://delawaretribe.org/tribal-government/tribal-council/. Website accessed December 29, 2017.

Delaware Tribe of Indians. 2017b. Official Web Site of the Delaware Tribe of Indians: About the Delaware Tribe of Indians. Available online at http://delawaretribe.org/home-page/about-the-tribe/. Website accessed December 29, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Eastern Shawnee Tribe of Oklahoma

Counties of Interest along Great Lakes: Lucas, Ottawa (Ohio)

Contact Info:

Glenna J. Wallace
Chief
Eastern Shawnee Tribe of Oklahoma
P.O. Box 39
Odanah, WI 54861
Email: brtchair@badriver-nsn.gov

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty with the Wyandot, Etc., Aug. 3, 1795, Greenville, 7 Stat. 49; 2 Kappler, 39.
- Treaty with the Delawares, Etc., June 7, 1803, Fort Wayne, 7 Stat. 74; 2 Kappler, 64.
- Treaty with the Wyandot, Etc., July 4, 1805, Ft. Industry, 7 Stat. 87; 2 Kappler, 77.
- Treaty with the Chippewa, Etc., Nov. 25, 1808, Brownstown, Michigan Territory, 7 Stat. 112; 2 Kappler, 99.
- Treaty with the Wyandot, Etc., July 22, 1814, Greenville, 7 Stat. 118; 2 Kappler, 105.
- Treaty with the Wyandot, Etc., Sept. 8, 1815, Spring Wells, 7 Stat. 131; 2 Kappler, 117.
- Treaty with the Wyandot, Etc., Sept. 29, 1817, Rapids of the Miami of Lake Erie, 7 Stat. 160; 2 Kappler, 145.
- Treaty with the Wyandot, Etc., Sept. 17, 1818, St. Mary's, 7 Stat. 178; 2 Kappler, 162.
- Treaty with the Seneca, Etc., July 20, 1831, Lewistown, 7 Stat. 351; 2 Kappler, 327.
- Treaty with the Seneca and Shawnee, Dec. 29, 1832, Seneca Agency, Head waters of the Cowskin River, 7 Stat. 411; 2 Kappler, 383.
- Agreement with the Seneca and Shawnee, Aug. 23, 1854, Neosho Agency, Deloria says this agreement was rejected by Congress., 2 Deloria & DeMallie, 850-53.
- Treaty with the Seneca and Shawnee with the Confederate States of America, Oct. 4, 1861, Park Hill, Cherokee Nation Ratified by CSA Congress Dec. 21, 1861; 1 Deloria & DeMallie, 650-59.
- Agreement with the Cherokee and Other Tribes in the Indian Territory, Sept. 13, 1865, Ft. Smith, Arkansas, Not ratified (perhaps not meant to be a treaty), 2 Kappler, 1050 (Appendix); 2 Deloria & DeMallie, 1355.
- Treaty with the Seneca, Mixed Seneca and Shawnee, Quapaw, Etc., Feb. 23, 1867, Washington, D.C., 15 Stat. 513; 2 Kappler, 960.
- Agreement with the Eastern Shawnee, June 23, 1874, Quapaw Agency (H.W. Jones US Indian Agent), 1 Deloria & DeMallie, 260-61 (Deloria says Congress approved the agreement March, 3, 1875, citing 18 Stat. 447 and 1 Kappler, 158)

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Eastern Shawnee Tribe of Oklahoma. 2015a. Eastern Shawnee Tribe of Oklahoma: Government. Available online at https://www.estoo-nsn.gov/government/. Website accessed December 29, 2017.

Eastern Shawnee Tribe of Oklahoma. 2015a. Eastern Shawnee Tribe of Oklahoma: Eastern Shawnee Treaties Chart. Available online at http://history.estoo-nsn.gov/wp-content/uploads/2015/05/Eastern-Shawnee-Treaties-Chart1.xls. Website accessed December 29, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Flandreau Santee Sioux Tribe of South Dakota

Counties of Interest along Great Lakes: Brown, Douglas (Wisconsin).

Contact Info:

Anthony Reider
President
Executive Committee
Flandreau Santee Sioux Tribe of South Dakota
P.O. Box 283, 603 W. Broad Avenue
Flandreau, South Dakota 57028
Phone: 605/997-3891
Fax: 605/997-3878
c/o amber.alllen@fsst.org

Mark Allen
GAP/GIS Coordinator
Natural Resources Office/Department of Natural Resources/Natural Resources Program
Flandreau Santee Sioux Tribe of South Dakota
403 W. Broad Ave.
Flandreau, SD 57028
Phone: 605-997-5123 ext. 1012
Fax: 605-997-5230
E-mail: mallen@fsst.org

Species of Interest or Concern or Managed Species:

- Buffalo

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Flandreau Santee Sioux Tribe. 2015a. Contact Us: Flandreau Santee Sioux Tribal Office Staff Directory. Website accessed December 2, 2015: http://www.santeesioux.com/fsst_contactUs.html

Flandreau Santee Sioux Tribe. 2015b. Programs: Natural Resources. Website accessed December 2, 2015: http://www.santeesioux.com/fsst_dept_natural_resources.htm

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Fond du Lac Band, component reservation of the Minnesota Chippewa Tribe, Minnesota

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Cook, Lake, St. Louis (Minnesota); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin)

Contact Info:

Wally Dupuis
Chairman
Fond du Lac Tribal Council
Fond du Lac Reservation
1720 Big Lake Road
Cloquet, MN 55720
(218) 879-4593

Reginald DeFoe
Director
Fond Du Lac Resource Management
(218) 878-7100
Email: reggiedefoe@fdlrez.com
http://www.fdlrez.com/newnr/staff.htm

Species of Interest or Concern or Managed Species:

- Primary Game Species:
  - deer
  - bear
  - turkey
- Primary small game and furbearers:
  - badger
  - beaver
  - bobcat
  - cottontail rabbit
  - cougar
  - coyote
  - fisher
  - gray fox
  - lynx
  - marten
  - mink
  - muskrat
  - opossum
  - otter
  - pheasant
  - raccoon
  - red fox

  - ruffed grouse
  - sharp-tailed grouse
  - snowshoe hare
  - spruce grouse
  - spotted skunk
  - red/gray/fox squirrel
  - striped skunk
  - weasel
  - wolf
- Primary Fish Species:
  - northern pike
  - muskellunge & hybrids
  - walleye & sauger
  - yellow perch
  - largemouth bass
  - smallmouth bass
  - black crappie
  - bluegills & sunfish
  - rock bass
  - white bass
  - catfish
  - bull heads
  - lake sturgeon
  - whitefish
  - trout & salmon
  - lake trout
  - smelt
- Plant Species of Interest (N/A)

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of La Pointe 1842

References:

Fond du Lac 2013a. Tribal Government. Website Accessed June 2, 2015: http://www.fdlrez.com/government.htm.

Fond du Lac 2013b. Department of Resource Management. Website Accessed June 2, 2015: http://www.fdlrez.com/newnr/main.htm.

Fond du Lac 2013c. Wildlife Department. Website Accessed June 2, 2015: http://www.fdlrez.com/newnr/wildlife.htm

Fond du Lac 2013d. Fisheries Department. Website Accessed June 2, 2015: http://www.fdlrez.com/newnr/fisheries.htm

Fond du Lac 2013e. Forestry Department. Website Accessed June 2, 2015: http://www.fdlrez.com/newnr/forestry.htm.

Fond du Lac 2013f. Treaty of 1837. Website Accessed June 2, 2015: http://www.badriver-nsn.gov/legislative/treaty-of-1837.

Fond du Lac 2013g. Treaty of 1854. Website Accessed June 2, 2015: http://www.badriver-nsn.gov/legislative/treaty-of-1854.

Fond du Lac 2013h. Treaty of La Pointe 1842. Website Accessed June 2, 2015: http://www.badriver-nsn.gov/legislative/treaty-of-la-pointe-1842.

Fond du Lac 2013i. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.fdlrez.com/Default.htm.

Fond du Lac 2013j. Staff Directory. Website Accessed June 2, 2015: http://www.fdlrez.com/newnr/staff.htm.

Fond du Lac 2014. 2014-15 Seasons and Limits. Website Accessed June 2, 2015: http://www.fdlrez.com/newnr/2014-2015%20Hunting%20and%20Trapping%20Seasons%20and%20Limits.pdf

Fond du Lac 2015. 2015 Fishing Season. Website Accessed June 2, 2015: http://www.fdlrez.com/newnr/2015%20Fishing%20Seasons%20and%20Limits.pdf.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Forest County Potawatomi Community, Wisconsin

Counties of Interest along Great Lakes: Cook, Lake (Illinois); La Porte, Lake, Porter (Indiana); Allegan, Berrien, Delta, Huron, Macomb, Monroe, Ottawa, Van Buren, Wayne (Michigan); Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, Sandusky (Ohio); Ashland, Brown, Door, Kenosha, Kewaunee, Manitowoc, Marinette, Milwaukee, Oconto, Ozaukee, Racine, Sheboygan (Wisconsin)

Contact Info:

Executive Council
5416 Everybody's Road
P.O. Box 340
Crandon, WI 54520
(715) 478-7275 • Fax: (715) 478-4714

Forestry
5320 Wensaut Lane
P.O. Box 340
Crandon, WI 54520
(715) 473-6034 • Fax: (715) 473-6054

Natural Resources
5320 Wensaut Lane
P.O. Box 340
Crandon, WI 54520
(715) 478-7222
Fax: (715) 478-7225

Heather Stricker
Wildlife Program Manager
(715) 478-4196

Matt Steinbach
Water Resources Program Director
Phone: 715-478-7361
Email: Matt.Steinbach@fcpotawatomi-nsn.gov

Species of Interest or Concern or Managed Species:

- Animal Species
    - Deer
    - Elk
    - Moose
    - Back Bear
    - Loon
    - Bluebird
    - Bald eagle

- Fish Species:
  - Rainbow trout
  - Brook trout
  - Black crappie
- Plant Species:
  - Wild rice
  - Eurasian Watermilfoil
  - Snow-on-the-Mountain (goutweed, bishop's weed, ground elder)

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

Forest County. 2015a. Department Directory. Website Accessed June 2, 2015: https://www.fcpotawatomi.com/government/departments/.

Forest County. 2015b. Wildlife Resources. Website Accessed June 2, 2015: https://www.fcpotawatomi.com/natural-resources/wildlife-resources/.

Forest County. 2015c. Website Accessed June 2, 2015: Land and Natural Resources: https://www.fcpotawatomi.com/natural-resources/.

Forest County. 2015d. Water Resources Program. Website Accessed June 2, 2015: https://www.fcpotawatomi.com/natural-resources/water-resource-program/.

Forest County. 2015e. Watch out for Eurasian Watermilfoil. Website accessed December 2, 2015: https://www.fcpotawatomi.com/wp-content/uploads/2015/06/EurasianWatermilfoil.pdf

Forest County. 2015f. Wanted Dead ~~or Alive~~ for Fraud (Snow-on-the-Mountain). Website accessed December 2, 2015: https://www.fcpotawatomi.com/wp-content/uploads/2014/10/Snow-on-the-Mountain.pdf

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Grand Portage Band, component reservation of the Minnesota Chippewa Tribe, Minnesota

Counties of Interest along Great Lakes: Cook, Lake, St. Louis (Minnesota); Baraga, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Ashland, Bayfield, Douglas, Iron, Oconto (Wisconsin);

Contact Info:

Norman W. Deschampe
Chairman
Grand Portage Band of the Minnesota Chippewa Tribe, Minnesota Tribal Council
Grand Portage Band of the Minnesota Chippewa Tribe, Minnesota
PO Box 428
Grand Portage, MN 55605
Phone (218) 475-2277
Fax (218) 475-2284

Species of Interest or Concern or Managed Species:

- Primary Fish Species:
    - walleye
    - trout
    - sturgeon
- Plant Species of Interest
    - Wild Rice
    - Cedar

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1854

References:

Grand Portage. 2006. Natural Resources Plan. Website Accessed June 2, 2015: http://www.epa.gov/osp/tribes/NatForum06/4_18.pdf.

Grand Portage. 2012. Indian Affairs Council. Website Accessed June 2, 2015: http://mn.gov/indianaffairs/tribes_grandportage.html.

Grand Portage. 2015a. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.grandportage.com/heritage.php.

Grand Portage. 2015b. Programs and Services. Website Accessed June 2, 2015: http://www.grandportage.com/program.php.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Grand Traverse Band of Ottawa and Chippewa Indians, Michigan

Counties of Interest along Great Lakes: Alger, Antrim, Benzie, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Grand Traverse, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Muskegon, Oceana, Ottawa, Schoolcraft (Michigan)

Contact Info:

Al Pedwaydon
Tribal Chairman
Grand Traverse Band of Ottawa and Chippewa Indians Tribal Council
Grand Traverse Band of Ottawa and Chippewa Indians
2605 N. West Bay Shore Drive
Peshawbestown, MI 49682
(231) 534-7129
Email: Al.Pedwaydon@gtbindians.com

Desmond L. Berry
Natural Resources Department Manager
Department of Natural Resources
3010 N. West Bay Shore Dr.
Peshawbestown, MI 49682
(231) 534-7363
Email: Desmond.Berry@gtbindians.com

Species of Interest or Concern or Managed Species:

- Primary Game Species:
  - deer
  - wild turkey
  - black bear
  - elk
- Primary furbearers:
  - bobcat
  - badger
  - mink
  - gray/red fox
  - raccoon
  - coyote
  - pine marten
  - otter
  - fisher
  - beaver
  - muskrat
- Waterfowl Species:
  - ducks
  - white front, brant snow and blue geese

  - Canada geese
  - woodcock
  - snipe
  - sora rail
  - mourning dove
  - coots
  - gallinules
- Primary Fish Species:
  - walleye
  - large/small mouth bass
  - muskellunge
  - tiger muskellunge
  - northern pike
  - trout/salmon
  - sturgeon

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:
- None identified.

References:

Grand Traverse. 2009a. Inland Hunting, Trapping, Gathering Regulations. Website Accessed June 2, 2015: http://www.gtbindians.org/downloads/hunttgather_sept_2010.pdf.

Grand Traverse. 2009b. Fishing Regulations. Website Accessed June 2, 2015: http://www.gtbindians.org/downloads/fishing_regulations.pdf.

Grand Traverse. 2015a. Tribal Council Members. Website Accessed June 2, 2015: http://www.gtbindians.org/council_members.asp.

Grand Traverse. 2015b. Chairman. Website Accessed June 2, 2015: http://www.gtbindians.org/chair.asp.

Grand Traverse. 2015c. Natural Resources. Website Accessed June 2, 2015: http://www.gtbindians.org/naturalresources.asp.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Hannahville Indian Community, Michigan

Counties of Interest along Great Lakes: Cook, Lake (Illinois); La Porte, Lake, Porter (Indiana); Allegan, Berrien, Delta, Huron, Macomb, Menominee, Monroe, Ottawa. Van Buren, Wayne (Michigan); Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, Sandusky (Ohio); Ashland, Brown, Door, Kenosha, Kewaunee, Manitowoc, Milwaukee, Ozaukee, Racine, Sheboygan (Wisconsin)

Contact Info:

Kenneth Meshigaud
Tribal Chairman
Hannahville Tribal Council
Hannahville B-1 Road
Wilson, MI 49896
(906) 466-2932 ext. 101

Scott Wieting
Environmental Programs Coordinator
(906) 723-2295

Species of Interest or Concern or Managed Species:

- None identified.

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

Hannahville. 2009. Phone Directory. Website Accessed June 2, 2015: http://hannahville.net/wp-content/uploads/2013/07/PhoneListing.pdf.

Hannahville. 2013a. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.hannahville.net/.

Hannahville. 2013b. Environmental Programs. Website Accessed June 2, 2015: http://www.hannahville.net/services/environmental-programs/.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Keweenaw Bay Indian Community, Michigan

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Cook, Lake, St. Louis (Minnesota); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin)

Contact Info:

Warren C. Swartz
President
Keweenaw Bay Indian Community Tribal Council
Keweenaw Bay Indian Community, Michigan
16429 Beartown Road
Baraga, MI 49908
906-353-6623
906-353-7540 fax
tcchris@kbic-nsn.gov

CEO: Larry J. Denomie III
16429 Bear Town Road
Baraga, MI 49908
(906) 353-6623 ext. 4104

Gary Loonsfoot, Jr.
Director/Officer
Tribal Historic Preservation Office
(906) 353-6623 ext. 4178
gloonsfoot@kbic-nsn.gov

Keweenaw Bay Indian Community Department of Natural Resources
14359 Pequaming Road
L'Anse, MI 49946
(906) 524-5757
http://nrd.kbic-nsn.gov/

Species of Interest or Concern or Managed Species:

- Primary Big Game Species:
  - deer
  - bear
- Small Game Species:
  - rabbit
  - squirrel
  - raccoon
- Primary furbearers:
  - muskrat

  - coyote
  - beaver
  - badger
  - bobcat
  - mink
  - marten
  - raccoon
  - fox
  - fisher
  - otter
  - opossum
  - skunk
  - weasel
- Primary Fish Species:
  - large/smallmouth bass
  - sauger
  - muskellunge
  - tiger muskellunge
  - northern pike
  - trout
  - salmon
  - walleye
  - sturgeon
- Amphibians and Reptiles
  - Bullfrog
  - green frog
  - mink frog
  - spring peeper
  - gray tree frog
  - American toad
  - fowler's toad
- Migratory Game Bird
  - duck
  - geese
  - merganssters
  - coots
  - sora
  - rail
  - woodcock
  - snipe
  - doves
  - cranes
- Upland Game Bird
  - wild turkey
  - ruffed grouse
  - pheasant
  - quail
- Plant Species of Interest

- Conifer
- Ginseng
- Maple
- birch
- Sugar-bush
- Christmas trees
- Wild Rice

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1854
- Treaty of La Pointe 1842

References:

Keweenaw Bay. 1904. Treaty with the Chippewa 1854. Website Accessed June 2, 2015: http://digital.library.okstate.edu/kappler/Vol2/treaties/chi0648.htm.

Keweenaw Bay. 2003. Hunting, Fishing, Trapping, and Gathering Code of Law. Website Accessed June 2, 2015: http://nrd.kbic-nsn.gov/sites/default/files/Hunt-Fish-Regulations-5-1-08.pdf.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Lac Courte Oreilles Band of Lake Superior Chippewa Indians of Wisconsin

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Cook, Lake, St. Louis (Minnesota); Cuyahoga, Erie, Lorain, Lucas (Ohio); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin).

Contact Info:

Mic Ishman
Chairman
Lac Courte Oreilles Tribal Government
13394 W Trepania Road
Hayward, WI 54843
Phone: (715) 634-8934

Species of Interest or Concern or Managed Species:

- Primary Game Species:
    - deer
    - moose
    - elk
    - bear
- Primary bird/waterfowl species:
    - swan
    - geese
    - prairie chicken
    - sand hill crane
    - sharptail grouse
    - ruffed grouse
    - spruce grouse
    - wild duck
    - coot
    - wild goose
    - brant
    - pheasant
    - Hungarian partridge
    - bobwhite
    - quail
    - rail
    - Wilson's snipe
    - woodcock
    - shorebird
    - protected songbird
    - harmless bird
    - wild turkey
- Primary furbearers:

    - bobcat
    - cougar
    - fox
    - raccoon
    - mink
    - coyote
    - fox
    - fisher
    - muskrat
    - rabbit
    - squirrel
    - pine martens
    - wolves
- Primary Fish Species:
    - muskellunge
    - rock sturgeon
    - lake sturgeon
    - largemouth bass
    - smallmouth bass
    - brook trout
    - rainbow trout
    - brown trout
    - steelhead trout
    - walleye
    - northern pike
- Animal Species of Interest
    - Raptors
    - Golden eagles
    - Bald eagles
    - owls
    - falcons
- Plant Species of Interest
    - Wild Rice
    - white spruce
    - cedars
    - jack pine
    - balsam
    - white pine
    - red pine
    - white birch
    - speckled alder
    - red willow
    - hazelnut
    - pin cherry
    - choke cherry
    - juniper
    - sumac
    - princess pine

- sheet moss
- ginseng
- sugar maple

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1837
- Treaty of 1842
- Treaty of 1854

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Lac Courte Oreilles Tribal Government. 2015. Lac Courte Oreilles Mission. Available online at http://www.lco-nsn.gov/lac-courte-oreilles-mission.php. Website accessed December 29, 2017.

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Lac Courte Oreilles Band of Lake Superior Chippewa Indians. 2015b. *Lac Courte Oreilles Band of Lake Superior Chippewa Indians Tribal Code of Law: Title VI – Conservation, Chapter 1 WI 1837/1842 Treaty Off-Reservation Conservation Code of the Lac Courte Oreilles Band of Lake Superior Chippewa Indians*. Enacted October 19, 2015. Available online at http://www.lco-nsn.gov/docs/Title%20VI%20Conservation.%20Chapter%202.%20WI%2037-42%20Off-Reservation%20Conservation%20Code.pdf. Website accessed December 29, 2017.

Lac Courte Oreilles Band of Lake Superior Chippewa Indians. 2016. *Lac Courte Oreilles Band of Lake Superior Chippewa Indians Tribal Code of Law: Title VI – Conservation, Chapter 7 Shoreland Protection Code of the Lac Courte Oreilles Band of Lake Superior Chippewa Indians*. Enacted April 11, 2016. Available online at http://www.lco-nsn.gov/docs/Title%20VI%20Conservation.%20Chapter%207.%20Shoreland%20Protection%20Code.%20Enacted%20041116.pdf. Website accessed December 29, 2017.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Lac du Flambeau Band of Lake Superior Chippewa Indians of the Lac du Flambeau Reservation of Wisconsin

Counties of Interest along Great Lakes: Cook, Lake, St. Louis (Minnesota); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin).

Contact Info:

Joseph Wildcat, Sr.
President
Lac du Flambeau Tribe
418 Little Pines
Lac du Flambeau WI. 54538
Phone: (715) 588-4264

Lac du Flambeau Tribe
P.O. Box 67
Lac du Flambeau, WI 54538
Phone: (715) 588-3303

Eric Chapman
Chief Conservation Officer/Emergency management Director
Tribal Conservation Law Enforcement Department
Lac du Flambeau Tribe
Conservation Law Enforcement Department
P.O. Box 67
Lac du Flambeau, WI 54538
Phone: (715) 588-4175
Email: elliot@ldftribe.com

Henry St. Germaine
Hatchery Manager
Fisheries and Fish Culture Program
Lac du Flambeau Tribe
P.O. Box 67
2500 Highway 47 N
Lac du Flambeau, WI 54538
Phone: (715) 588-4203 (office) or (715) 588-4223 (Hatchery Manager)

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Gretchen Watkins
Water Resource Specialist/Hydrologist
Water Resources
P.O. Box 67
2500 Highway 47 N
Lac du Flambeau, WI 54538
Phone: (715) 588-3303, ext. 5316 and ext. 5258 (office) and (715) 588-4238 (Watkins)
Email: gwsurfacewater@gmail.com

Species of Interest or Concern or Managed Species:

- Primary Game Species:
    - deer
    - bear
- Primary furbearers:
    - 'various'
- Primary Fish Species:
    - walleye
    - sturgeon
    - muskellunge
- Other animal species of interest
    - Eagles
    - waterfowl
    - hare
    - osprey
    - grouse
- Plant Species of Interest
    - Sugar Maple
    - Wild Rice

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1854

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Lac du Flambeau Band of Lake Superior Chippewa Indians. 2017a. Lac du Flambeau Tribe: Tribal Operations. Available online at https://www.ldftribe.com/departments/82/Tribal_Operations/Tribal_Administration.html. Website accessed December 29, 2017.

Lac du Flambeau Band of Lake Superior Chippewa Indians. 2017b. Lac du Flambeau Tribe: Conservation Law Enforcement. Available online at https://www.ldftribe.com/departments/17/Natural_Resources/Conservation_Law_Enforcement.html. Website accessed December 29, 2017.

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Lac du Flambeau Band of Lake Superior Chippewa Indians. 2017d. Lac du Flambeau Tribe: Water Resources. Available online at https://www.ldftribe.com/departments/23/Natural_Resources/Water_Resources.html. Website accessed December 29, 2017.

Lac du Flambeau Band of Lake Superior Chippewa Indians. 2017e. Lac du Flambeau Tribe: Wildlife Management. Available online at https://www.ldftribe.com/departments/24/Natural_Resources/Wildlife_Management.html. Website accessed December 29, 2017.

Lac du Flambeau Band of Lake Superior Chippewa Indians. 2017f. Lac du Flambeau Tribe: About Us. Available online at https://www.ldftribe.com/pages/2/About-Us/. Website accessed December 29, 2017.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Lac Vieux Desert Band of Lake Superior Chippewa Indians of Michigan

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Cook, Lake, St. Louis (Minnesota); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin)

Contact Info:

James Williams Jr
Tribal Chairman
Lac Vieux Desert Band of Lake Superior Chippewa Indians
(906) 358-4577

George Beck
Director
Planning and Environmental
(no further contact information)

Species of Interest or Concern or Managed Species:

- None identified.

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1854

References:

Lac Vieux Desert. 2015a. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.lvdtribal.com/default.html.

Lac Vieux Desert. 2015b. Administration and Offices. Website Accessed June 2, 2015: http://www.lvdtribal.com/offices.html.

Lac Vieux Desert. 2015c. Tribal Council. Website Accessed June 2, 2015: http://www.lvdtribal.com/council.html.

Lac Vieux Desert. 2015d. A Brief History of the Lac Vieux Desert Tribe. Website Accessed June 2, 2015d: http://www.lvdtribal.com/history.html.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Leech Lake Band, component reservation of the Minnesota Chippewa Tribe, Minnesota

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon (Michigan); Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto (Wisconsin).

Contact Info:

Faron Jackson Sr.
Chairman
Leech Lake Band of Ojibwe
190 Sailstar Drive NW
Cass Lake, MN 56633
Phone: (218) 335-8200
Email: brtchair@badriver-nsn.gov

Steve Mortenson
Director
Fish, Wildlife & Plant Resources Program
Division of Resource Management
Leech lake Band of Ojibwe
15756 State 371 NW
Cass Lake, MN 56633
Phone: (218) 335-7400

Species of Interest or Concern or Managed Species:

- Primary Hunting Species:
  - Bobcat
  - Fisher
  - Pine Marten
  - River Otter
  - White-tailed deer
  - Black Bear
  - rabbits
  - squirrel
  - ruffed grouse
  - woodcock
  - common snipe
  - sora rail
  - beaver
  - coyote
  - fox
  - mink
  - muskrat
  - raccoon

  - ducks
  - coots
  - mergansers
  - geese
- Primary Animal Species:
  - fisher
  - pine martin
  - red fox
  - coyote
  - gray wolf
  - voles
  - mice
  - shrews
  - white-tailed deer
  - Eastern Timber wolf
- Primary Bird Species:
  - ruffed grouse
  - trumpeter swan
  - woodducks
  - common goldeneyes
  - hooded mergansers
  - common terns
  - double-crested cormorant
- Primary Fish Species:
  - walleye
  - northern pike
  - largemouth bass
  - panfish
  - lake whitefish
  - black crappie
  - musky
  - tullibee
  - white sucker
  - yellow perch
- Plant Species of Interest
  - Sugar Maple
  - Wild Rice
  - Northern Red Oak
  - Bur Oak
  - Black Ash
  - Green Ash
  - American Elm
  - Aspen
  - Aspen Quaking (Popple)
  - Aspen Big Tooth (Popple)
  - Aspen Balm of Gilead (Popple)
  - Northern White Cedar
  - Tamarack

  - White Spruce
  - Black Spruce
  - Balsam Fir
  - Red Maple
  - Basswood
  - Red Pine (Norway Pine)
  - Eastern White Pine
  - Jack Pine
  - Wild Plum
  - Crabapple
  - Red Osier Dogwood
  - Highbush Cranberry
  - Chokecherry
  - Pin Cherry
  - White Pine
  - A list of 820 plant species within the reservation, including many that have traditional uses, or are non-native, or are toxic, or have a nuisance or noxious weed status (may include those plants listed above)
- Non-native Invasive Species
  - Aquatic Invasive Species
    - purple loosestrife
    - Eurasian watermilfoil
    - zebra mussel
    - faucet snail
  - Aquatic Invasive Species Potential Threats
    - Asian carp – common carp
    - grass carp
    - silver carp
    - bighead carp
  - Terrestrial Invasive Species
    - garlic mustard
    - common buckthorn
    - wild parsnip
    - common tansy
    - spotted knapweed
    - earthworms
  - Terrestrial Invasive Species Potential Threats
    - glossy buckthorn
    - Japanese barberry
    - Oriental bittersweet
    - Japanese knotweed
    - Japanese hops
    - giant hogweed
    - Dalmatian toadflax
    - Grecian foxglove
    - black swallow-wort
    - common teasel
    - cut-leaved teasel

- yellow starthistle
- burnet saxifrage
- emerald ash borer
- gypsy moth

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Leech Lake Band of Ojibwe. 2016a. Leech Lake Government. Available online at http://www.llojibwe.org/government/government.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017a. Fisheries. Available online at http://www.llojibwe.org/drm/fpw/fish.html. Website accessed December 29, 2017.

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Leech Lake Division of Resource Management. 2017h. Aquatic Invasive Species. Available online at http://www.llojibwe.org/drm/fpw/aquaticinvasive.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017i. Aquatic Invasive Species Potential Threats. Available online at http://www.llojibwe.org/drm/fpw/aquaticthreats.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017j. Terrestrial Invasive Species. Available online at http://www.llojibwe.org/drm/fpw/terrestrialinvasive.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017k. Terrestrial Invasive Species Potential Threats. Available online at http://www.llojibwe.org/drm/fpw/terrestrialthreats.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017l. Tree Identification. Available online at http://www.llojibwe.org/drm/forestry/treeid.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017m. Annual Tree/Shrub Giveaway. Available online at http://www.llojibwe.org/drm/forestry/treegiveaway.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017n. 2017-2018 Big Game/Small Game/Trapping. Available online at http://www.llojibwe.org/drm/license/hunttrap.html. Website accessed December 29, 2017.

Leech Lake Division of Resource Management. 2017n. Migratory Waterfowl Season Dates & Limits. Available online at http://www.llojibwe.org/drm/license/waterfowl.html. Website accessed December 29, 2017.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Little River Band of Ottawa Indians, Michigan

Counties of Interest along Great Lakes: Manistee (Michigan)

Contact Info:

Jimmie Mitchell
Natural Resources Department Director
Department of Natural Resources
159 Brick Yard Rd.
Manistee, MI 49660
(231) 723-1594
Email: jmitchell@lrboi-nsn.gov

Species of Interest or Concern or Managed Species:

- Primary Big Game Species:
  - deer
  - wild turkey
  - black bear
  - elk
  - moose
- Small Game Species:
  - Ruffed grouse (partridge)
  - ring-neck pheasant
  - cottontail rabbit
  - snowshoe hare
  - gray squirrel
  - black squirrel
  - fox squirrel
  - red squirrel
  - quail
  - woodchuck
  - porcupine
  - sharp-tailed grouse
  - crow
- Primary furbearers:
  - bobcat
  - badger
  - mink
  - gray/red fox
  - raccoon
  - coyote
  - pine marten
  - otter
  - fisher

- beaver
- muskrat
- weasel
- skunk
- wolf
- cougar
- opossum

- Migratory Bird Species:
  - ducks
  - geese
  - swans
  - doves
  - rails
  - coots
  - gallinules
  - woodcock
  - snipe
- Primary Fish Species:
  - walleye
  - large/small mouth bass
  - muskellunge
  - tiger muskellunge
  - northern pike
  - trout/salmon
  - sturgeon

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

Little River. 2008. Hunting Regulation Book. Website Accessed June 2, 2015: https://www.lrboi-nsn.gov/images/docs/nrd/docs/LRBOI%20Wildlife%20Regulation%20Book%202008.pdfFishing.

Little River. 2015. Natural Resources Department. Website Accessed June 2, 2015: https://www.lrboi-nsn.gov/index.php/government/departments/natural-resources.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Little Traverse Bay Bands of Odawa Indians, Michigan

Counties of Interest along Great Lakes: Alger, Antrim, Benzie, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Grand Traverse, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Muskegon, Oceana, Ottawa, Schoolcraft (Michigan)

Contact Info:
Regina Gasco Bentley
Tribal Chairman
Little Traverse Bay Bands of Odawa Indians, Michigan Tribal Council
7500 Odawa Circle
Harbor Springs, MI 49740
(231) 242-1418
Email: chairman@ltbbodawa-nsn.gov

Department of Natural Resources
7845 Odawa Circle
Harbor Springs, MI 49740
Office phone: (231) 242-1670
Conservation Duty Officer: (231) 242-1673
Email: DBrowne@ltbbodawa-nsn.gov

Species of Interest or Concern or Managed Species:

- Primary Game Species:
    - deer
    - wild turkey
    - bear
    - rabbit
    - ruffed grouse
    - duck
    - geese
- Primary furbearers:
    - bobcat
    - badger
    - mink
    - gray/red fox
    - raccoon
    - coyote
    - elk
    - feral swine
- Migratory Bird Species:
    - duck
    - mergansers
    - geese
    - woodcock

  - common snipe
  - Virginia and Sora rails
  - mourning dove
  - coots & gallinules
  - sandhill cranes
  - swans (unlawful)
  - eagles (unlawful)
- Primary Fish Species:
  - walleye
  - large/small mouth bass
  - sauger
  - muskellunge
  - tiger muskellunge
  - bluegill
  - sunfish
  - crappie
  - rock bass
  - perch
  - lake whitefish
  - menominee
  - catfish
  - northern pike
  - sucker
  - trout/salmon
  - burbot
  - bass
  - sturgeon
- Plant Species of Interest
  - Sugar Maple
  - Wild Rice
  - Sweetgrass
  - Black ash
  - Bass/ironwood
  - White birch
  - conifer

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

Little Traverse Bay. n.d. (a).Phone Directory. Website Accessed June 2, 2015: http://www.ltbbodawa-nsn.gov/PhoneDirectory.pdf.

Little Traverse Bay. n.d. (b). Gathering Regulations for National Forest Lands: http://www.ltbbodawa-nsn.gov/NRD/MOU%20Gathering.pdf

Little Traverse Bay. 2014. Natural Resources Department. Website Accessed June 2, 2015: http://www.ltbbodawa-nsn.gov/NRD/NRD.html.

Little Traverse Bay. 2015. 2015 Reservation Natural Resources Rules and Regulations. Website Accessed June 2, 2015: http://www.ltbbodawa-nsn.gov/NRD/2015/LTBB%202015%20Reservation.pdf.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Lower Sioux Indian Community in the State of Minnesota

Counties of Interest along Great Lakes: Brown, Douglas (Wisconsin).

Contact Info:

Brian Pendleton
President
Lower Sioux Indian Community Tribal Council
Lower Sioux Indian Community
P.O. Box 308
39527 Reservation Highway 1
Morton, MN 56270
Phone: (507)697-6185 Ext. 2512
Email: brian.pendleton@lowersioux.com

Deb Dirlam
Director
Office of the Environment
Lower Sioux Indian Community
P.O. Box 308, 39527 Res Hwy 1
Morton, MN 56270
Phone: (507) 697-8643
Cell: (507) 430-1729
Email: deb.dirlam@lowersioux.com

Species of Interest or Concern or Managed Species:

- Invasive Species:
    - emerald ash borer
    - forest tent caterpillar
    - gypsy moth
- Plant Species of Interest
    - Wild Rice

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Lower Sioux Indian Community. 2017a. Tribal Government. Available online at http://lowersioux.com/departments/tribal-government/. Website accessed December 29, 2017.

Lower Sioux Indian Community. 2017b. Tribal Directory. Available online at http://lowersioux.com/tribal-directory/. Website accessed December 29, 2017.

Lower Sioux Indian Community. 2017b. Office of the Environment. Available online at http://lowersioux.com/departments/office-of-the-environment/. Website accessed December 29, 2017.

Lower Sioux Indian Community. 2017d.
Wild Rice has been seeded around Lower Sioux. Available online at http://lowersioux.com/wp-content/uploads/2015/11/Wild-Rice.pdf. Website accessed December 29, 2017.

Lower Sioux Indian Community. 2017e. Resources. Available online at http://lowersioux.com/departments/office-of-the-environment/resources/. Website accessed December 29, 2017.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Match-e-be-nash-she-wish Band of Pottawatomi Indians of Michigan

Counties of Interest along Great Lakes: Allegan (Michigan); Cook, Lake, St. Louis (Minnesota); Cuyahoga, Erie, Lorain, Lucas (Ohio)

Contact Info:

Scott Sprague
Tribal Chairman
Gun Lake Tribal Council
Match-e-be-nash-she-wish Band of Pottawatomi Indians of Michigan
Tribal Administration
2872 Mission Dr.
Shelbyville, MI 49344
Phone: (269) 397-1780

Liz Binoniemi-Smith
Environmental Director
Gun Lake Tribe Environmental Department
2872 Mission Dr.
Shelbyville, MI 49344
Phone: (269) 397-1780

Species of Interest or Concern or Managed Species:

- Primary animal Species:
  - turtle
- Primary Fish Species:
  - lake sturgeon
- Plant Species of Interest
  - Wild Rice

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of Greenville 1795
- Treaty of Chicago 1821
- Treaty of St. Joseph 1827

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Gun Lake Tribal Council. 2017a. Tribal Council. Available online at https://gunlaketribe-nsn.gov/about/tribal-council/. Website accessed December 29, 2017.

Gun Lake Tribal Council. 2017b. Environmental. Available online at https://gunlaketribe-nsn.gov/departments/administration/environmental/. Website accessed December 29, 2017.

Gun Lake Tribal Council. 2017c. Environmental Projects. Available online at https://gunlaketribe-nsn.gov/departments/administration/environmental/environmental-projects/. Website accessed December 29, 2017.

Gun Lake Tribal Council. 2017d. Gun Lake Tribe History. Available online at https://gunlaketribe-nsn.gov/about/our-heritage/. Website accessed December 29, 2017.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Menominee Indian Tribe of Wisconsin

Counties of Interest along Great Lakes: Oconto (Wisconsin)

Contact Info:

Gary Besaw
Chairman
Menominee Indian Tribe of Wisconsin Tribal Council
Menominee Indian Tribe of Wisconsin
W2908 Tribal Office Loop Road
Keshena, WI 54135
Email: gbesaw@mitw.org

Douglas Cox
Environmental Program Coordinator
Environmental Services
(715) 799-4937
Email: dgcox@mitw.org

Jeremy Pyatskowit
Environmental Services Director
Environmental Services
(715) 799-6150
Email: jpyatskowit@mitw.org

Species of Interest or Concern or Managed Species:

- Wildlife/game Species
    - Black bear
    - Deer
    - Small game
        - Rabbit
        - (no other specified)
- Game Bird Species:
    - Ruffed grouse
    - Hungarian partridge
    - Bobwhite quail
    - Pheasant
    - Woodcock
    - Wild turkey
- Waterfowl (none specified)
- Fur bearing species
    - Fisher
    - Bobcat
    - (none others specified)

- Fish species:
    - Trout
    - Lake sturgeon
    - Bass
    - Walleye
    - Northern pike
    - Muskellunge
    - Salmon
    - Yellow perch
    - Pumpkinseed
    - Bluegill
    - Crappie
    - Rock bass
    - bullhead

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1836
- Treaty of 1848
- Treaty of 1854
- Treaty of 1856

References:

Menominee. 2015a. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/Default.aspx.

Menominee. 2015b. 2012-2015 Hunting &Trapping Rules and Regulations. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/formDetails.aspx?formID=91.

Menominee. 2015c. 2013-2015 Fishing Regulations. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/formDetails.aspx?formID=135.

Menominee. 2015d. Government. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/Govt.aspx.

Menominee. 2015e. Treaty of 1836. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/treaty1836.aspx.

Menominee. 2015f. Treaty of 1848. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/treaty1848.aspx.

Menominee. 2015g. Treaty of 1854. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/treaty1854.aspx.

Menominee. 2015h. Treaty of 1856. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/treaty1856.aspx.

Menominee. 2015i. Environmental Services. Website Accessed June 2, 2015: http://www.menominee-nsn.gov/MITW/DepartmentDetails.aspx?departmentID=2100.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

<u>Tribe Name:</u> Miami Tribe of Oklahoma

<u>Counties of Interest along Great Lakes:</u> Ashtabula, Lake, Lucas (Ohio).

<u>Contact Info:</u>

Douglas G. Lankford
Chief
Miami Tribe of Oklahoma
Miami Nation Headquarters
3410 P. Street
Miami, OK 74354
Mailing Address:
P.O. Box 1326, Miami, OK 74355
Phone: 918-541-1300

Dustin Olds, Second Chief
Natural Resources Officer
Natural Resources Office
Miami Tribe of Oklahoma
3410 P. Street
Miami, OK 74354
Mailing Address:
P.O. Box 1326, Miami, OK 74355
Phone: 918-541-1300

<u>Species of Interest or Concern or Managed Species:</u>

- Animal Species of Interest
  - white-tailed deer
  - bison
  - Eastern elk
- Plant Species of Interest
  - Corn
  - Sugar maple

<u>Treaties</u> which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of Greenville 1795
- Treaty of 1840
- Treaty of 1867

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Miami Tribe of Oklahoma. 2017a. Elected Leaders. Available online at http://miamination.com/node/17. Website accessed December 29, 2017.

Miami Tribe of Oklahoma. 2017b. Natural Resources Office. Available online at http://miamination.com/node/14. Website accessed December 29, 2017.

Miami Tribe of Oklahoma. 2017c. History. Available online at http://miamination.com/node/11. Website accessed December 29, 2017.

Miami Tribe of Oklahoma. 2017d. About Us. Available online at http://miamination.com/about. Website accessed December 29, 2017.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Mille Lacs Band, component reservation of the Minnesota Chippewa Tribe, Minnesota

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); St. Louis (Minnesota); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin).

Contact Info:

Melanie Benjamin
Chief Executive
Mille Lacs Band of Ojibwe
43408 Oodena Drive
Onamia, MN 56359
Phone: (320) 532-7505

Bradley Harrington
Commissioner of Natural Resources
Mille Lacs Band of Ojibwe
43408 Oodena Drive
Onamia, MN 56359
Phone: (320) 532-7439

Species of Interest or Concern or Managed Species:

- Primary Fish Species:
  - walleye
  - perch
  - tullibee
- Plant Species of Interest
  - wild rice
  - sugar maple

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1837
- Treaty of 1855

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Mille Lacs Band of Ojibwe. 2017a. Chief Executive. Available online at https://millelacsband.com/government/chief-executive. Website accessed December 31, 2017.

Mille Lacs Band of Ojibwe. 2017b. Chief Executive. Available online at https://millelacsband.com/contact. Website accessed December 31, 2017.

Mille Lacs Band of Ojibwe. 2017c. Department of Natural Resources. Available online at https://millelacsband.com/government/department-of-natural-resources. Website accessed December 31, 2017.

Mille Lacs Band of Ojibwe. 2017d. Our History. Available online at https://millelacsband.com/about/our-history. Website accessed December 31, 2017.

Mille Lacs Band of Ojibwe. 2017e. Our Community. Available online at https://millelacsband.com/about/our-communities. Website accessed December 31, 2017.

Mille Lacs Band of Ojibwe. 2017f. Our Economy. Available online at https://millelacsband.com/about/our-economy. Website accessed December 31, 2017.

Mille Lacs Band of Ojibwe. 2017g. Treaty of 1837. Available online at https://millelacsband.com/about/treaty-of-1837. Website accessed December 31, 2017.

Mille Lacs Band of Ojibwe. 2017g. Treaty of 1855. Available online at https://millelacsband.com/about/treaty-of-1855. Website accessed December 31, 2017.

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Minnesota Chippewa Tribe, Minnesota

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon (Michigan); St. Louis (Minnesota); Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto (Wisconsin).

Contact Info:

Gary Frazer
Executive Director
Minnesota Chippewa Tribe, Minnesota
P.O. Box 39
Odanah, WI 54861
Email: gfrazer@mnchippewatribe.org

Species of Interest or Concern or Managed Species:

- Primary Animal Species:
    - None identified
- Primary Bird Species:
    - None identified
- Primary Fish Species:
    - None identified
- Plant Species of Interest
    - Wild Rice

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Minnesota Chippewa Tribe. 2107a. Division of Administration. Available online at http://www.mnchippewatribe.org/administration.html. Website accessed December 31, 2017.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Nottawaseppi Huron Band of the Potawatomi, Michigan

Counties of Interest along Great Lakes: Alcona, Allegan, Alpena, Arenac, Bay, Berrien, Huron, Iosco, Macomb, Ottawa, Sanilac, St. Clair, Tuscola, Van Buren (Michigan); Cuyahoga, Erie, Lorain, Lucas (Ohio).

Contact Info:

Homer A. Mandoka
Chairman
Nottawaseppi Huron Band of the Potawatomi Tribal Council
Nottawaseppi Huron Band of the Potawatomi
1485 Mno-Bmadzewn Way
Fulton, MI 49052
269-729-5151
269-729-5920 fax
Email: hmandoka@nhbpi.com

John Rodwan
Environment Director
(269) 282-7028
Email: jrodwan@nhbpi.com

Mon-ee Zapata
Cultural Associate
(269) 704-8353
Email: mzapata@nhbpi.com

Species of Interest or Concern or Managed Species:

- Primary Game Species:
  - Whitetail deer
  - Black bear
  - Wild turkey
  - Moose
- Furbearers (including but not limited to)
  - Coyote
  - Red/gray fox
  - Bobcat
  - Beaver
  - Otter
  - Muskrat
  - Mink
  - Weasel
  - Skunk
  - Raccoon
  - Badger

    - Opossum
- Migratory Birds:
    - Ducks
    - Geese
    - Swans
    - Doves
    - Pigeons
    - Rails
    - Coots
    - Gallinules
    - Woodcocks
    - Snipes
- Small Game:
    - Ruffed grouse (partridge)
    - Ring-necked pheasant
    - Cottontail rabbit
    - Gray, black, fox, red squirrels
    - Quail
    - Woodchuck
    - Crow

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Nottawaseppi. 2015a. Tribal Council. Website Accessed June 2, 2015: http://nhbpi.com/sovereignty/tribal-council/.

Nottawaseppi. 2015b. Environmental Department. Website Accessed June 2, 2015: http://nhbpi.com/members/environment/.

Nottawaseppi. 2015c. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://nhbpi.com/.

Tribe Name: Oneida Nation

Counties of Interest along Great Lakes: Brown (Wisconsin)

Contact Info:

Christina S. Danforth
Chairperson
Oneida Tribe of Indians of Wisconsin
P.O. Box 365
Oneida, WI 54155
800-236-2214 4364
920-869-4040 FAX
Email: tdanfort@oneidanation.org

Marlene Garvey
Vice Chairperson
Environmental Resources Board

Conservation Department
(920) 869-6500

Species of Interest or Concern or Managed Species:
http://www.oneidanation.org/uploadedFiles/Game%20Species.pdf

- Primary Game Species:
  - wild turkey
  - deer
  - ruffed grouse
  - ring-necked pheasant
  - gray/fox squirrel
  - woodcock
  - cottontail rabbit
  - mourning dove
- Furbearers (includes but not limited to)
  - Mink
  - Muskrat
  - Beaver
  - Weasel
  - Fox
  - Coyote
  - Bobcat
  - Badger
  - Raccoon
- Small game (includes but not limited to)
  - Geese

- Brants
- Dabbling ducks
- Diving ducks
- Tree ducks
- Sea ducks
- Mergansers
- Rails
- Coots
- Mud hens
- Gallinule
- Snipe
- Woodcock
- Grouse
- Pheasant
- Partridge
- Quail
- Cottontail rabbit
- Gray/fox squirrel

- Game fish
  - Trout
  - Pike
  - Catfish
  - Bullhead
  - Sunfish (bluegill, crappie)
  - Perch
- Raptors
  - Hawks
  - Owls
  - Eagles
  - Falcons

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Oneida. 2013. Hunting, Fishing, and Trapping Law. Website Accessed June 2, 2015: https://oneida-nsn.gov/uploadedFiles/wwwroot/Government/Laws,_Policies,_Resolutions/Oneida_Register/Code_of_Laws/HFT%20Both%205%2022%2013%20a.pdf. Adopted 1994, 1996, 1998; amended 2000-2013.

Oneida. 2015a. Tribe Directory. Website Accessed June 2, 2015: https://oneida-nsn.gov/templates/clean.aspx?id=1058.

Oneida. 2015b. Department of Conservation. Website Accessed June 2, 2015: http://www.oneidanation.org/Environment/page.aspx?id=2746.

Oneida. 2015c. General Tribal Council. Website Accessed June 2, 2015: https://oneida-nsn.gov/Templates/OneColumn.aspx?id=85&libID=106.

Oneida. 2015d. Official Tribal Website Homepage. Website Accessed June 2, 2015: https://oneida-nsn.gov/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Onondaga Nation

Counties of Interest along Great Lakes: Jefferson, St. Lawrence (New York)

Contact Info:

Irving Powless, Jr.
Chief
Onondaga Nation of New York
102 W. Conklin Ave.
P.O. Box 319-B
Nedrow, NY 13120
315-492-1922
315-469-4717 fax
admin@onondaganation.org

Species of Interest or Concern or Managed Species:

- None identified.

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of Fort Stanwix 1784
- Treaty of Fort Harmer 1789
- The Canandaigua Treaty of 1794

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Onondaga. 2014a. Symbolism of 2 Governments. Website Accessed June 2, 2015: http://www.onondaganation.org/government/symbolism/.

Onondaga. 2014b. Treaties. Website Accessed June 2, 2015: http://www.onondaganation.org/government/treaties/.

Onondaga. 2014c. Stewards of the Land (Environmental Stewardship). Website Accessed June 2, 2015: http://www.onondaganation.org/land-rights/stewards-of-the-land/.

Onondaga. 2014d. Contact Us. Website Accessed June 2, 2015: http://www.onondaganation.org/aboutus/contactus/.

Onondaga. 2014e. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.onondaganation.org/.

Tribe Name: Ottawa Tribe of Oklahoma

Counties of Interest along Great Lakes: Allegan, Huron, Monroe, Wayne (Michigan); Cuyahoga, Erie, Lorain, Lucas, Ottawa, Sandusky (Ohio)

Contact Info:

Ethel E. Cook
Chief
Ottawa Tribe of Oklahoma
Street Address:
13 S. 69 A
Miami, OK 74354
Mailing Address:
P.O. Box 110
Miami, OK 74355
Phone: 918-540-1536
Email: adawe.oto@gmail.com

Cheryl Stafford
Environmental Director
Ottawa Tribe of Oklahoma
Department of Environmental Protection
811 3rd St.
Miami, OK 74354
Phone: 918-541-1902

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Ottawa Tribe of Oklahoma. 2017a. Welcome to the Ottawa Tribe of Oklahoma Website. Available online at http://www.ottawatribe.org/. Website accessed December 31, 2017.

Ottawa Tribe of Oklahoma. 2017b. Contact Us. Available online at http://www.ottawatribe.org/contact-us/. Website accessed December 31, 2017.

Ottawa Tribe of Oklahoma. 2017c. EPA. Available online at http://www.ottawatribe.org/epa/. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Peoria Tribe of Indians of Oklahoma

Counties of Interest along Great Lakes: Ottawa (Ohio)

Contact Info:

John P. Froman
Chief & Tribal Adminstrator
Peoria Tribe of Indians of Oklahoma
Street Address:
118 S. Eight Tribes Trail
Miami, Oklahoma 74354
Mailing Address:
PO Box 1527
Miami, OK 74355
Phone: 918-540-2535

Species of Interest or Concern or Managed Species:

- Primary aquatic species:
  - Neosho Mucket Mussel
  - Rabbitsfoot

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of May 30, 1854, 10 Stat. 1082
- Omnibus Treaty of February 23, 1867, 15 Stat. 513

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Peoria Tribe of Indians of Oklahoma. 2017a. Peoria Tribe of Indians of Oklahoma. Available online at http://peoriatribe.com/. Website accessed December 31, 2017.

Peoria Tribe of Indians of Oklahoma. 2017b. Contact. Available online at http://peoriatribe.com/contact/. Website accessed December 31, 2017.

Peoria Tribe of Indians of Oklahoma. 2017c. Environmental. Available online at http://peoriatribe.com/programs/environmental/. Website accessed December 31, 2017.

Peoria Tribe of Indians of Oklahoma. 2017d. History. Available online at http://peoriatribe.com/history/. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Pokagon Band of Potawatomi Indians, Michigan and Indiana

Counties of Interest along Great Lakes: Allegan, Berrien, Van Buren (Michigan); Cuyahoga, Erie, Lorain, Lucas (Ohio)

Contact Info:

Tribal Chairman John Warren
Pokagon Tribal Council
58620 Sink Road
Box 180
Dowagiac, MI 49047
(800) 517-0777

Jennifer Kanine
Director
Department of Natural Resources
32142 Edwards Street
Dowagiac, MI 49047
(269) 782-9602
Email: jennifer.kanine@pokagonband-nsn.gov

Species of Interest or Concern or Managed Species:

- deer
- fur bearers
- wild turkey
- waterfowl
- sugar bush
- bough
- black ash, bass/ironwood
- white birch

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Pokagon. 2015a. Executive Committee. Website Accessed June 2, 2015: http://www.pokagon.com/government/tribal-council/executive-committee.

Pokagon. 2015b. Department of Natural Resources. Website Accessed June 2, 2015: http://www.pokagon.com/government/departments/natural-resources.

Pokagon. 2015c. Hunting, Fishing, and Gathering. Website Accessed June 2, 2015: http://www.pokagon.com/government/departments/natural-resources/natural-resources-and-conservation-division/%EF%BB%BFhunting.

Pokagon. 2015d. Wildlife Management. Website Accessed June 2, 2015: http://www.pokagon.com/government/departments/natural-resources/natural-resources-and-conservation-division/wildlife.

Pokagon. 2015e. Natural Resources Staff. Website Accessed June 2, 2015: http://www.pokagon.com/government/departments/natural-resources/natural-resources-staff.

Pokagon. 2015f. Invasive Species Regulations. PDF Accessed June 2, 2015.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Prairie Band Potawatomi Nation

Counties of Interest along Great Lakes: Cook, Lake (Illinois), Lake, La Porte, Porter (Indiana); Allegan, Berrien, Delta, Kewaunee, Van Buren (Michigan); Cuyahoga, Erie, Lake, Lorain, Lucas (Ohio); Brown, Door, Kenosha, Manitowoc, Milwaukee, Ozaukee, Racine, Sheboygan (Wisconsin).

Contact Info:

Liana Onnen
Office of Tribal Chairman
The Bad River Tribe
Prairie Band Potawatomi Nation
16281 Q Road
Mayetta, KS 66509
Phone: (785) 966-4008
Email: LianaOnnen@pbpnation.org

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Prairie Band Potawatomi Nation. 2017a. Prairie Band Potawatomi Nation. Available online at http://www.pbpindiantribe.com/. Website accessed December 31, 2017.

Prairie Band Potawatomi Nation. 2017a. Contact Us. Available online at http://www.pbpindiantribe.com/contact/. Website accessed December 31, 2017.

Tribe Name: Prairie Island Indian Community in the State of Minnesota

Counties of Interest along Great Lakes: Brown, Douglas (Wisconsin).

Contact Info:

Shelley Buck
President
Prairie Island Indian Community
5636 Sturgeon Lake Road
Welch, MN 55089
Phone: 651-385-4124

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of Oct. 15, 1851
- Treaty of June 19, 1858

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Prairie Island Indian Community. 2017a. Contact Us. Available online at http://prairieisland.org/contact-us/. Website accessed December 31, 2017.

Prairie Island Indian Community. 2017b. Community: Prairie Island Indian Community History. Available online at http://prairieisland.org/community/. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Red Cliff Band of Lake Superior Chippewa Indians of Wisconsin

Counties of Interest along Great Lakes: Baraga, Delta, Gogebic, Houghton, Keweenaw, Marquette, Menominee, Ontonagon (Michigan); Ashland, Bayfield, Douglas, Iron, Marinette, Oconto (Wisconsin)

Contact Info:

Tribal Chair Rose Gurnoe-Soulier
Red Cliff Tribal Council

Red Cliff Tribal Administrative Office
88455 Pike Road
Bayfield, WI 54814
(715) 779-3700

Red Cliff Forestry and Wildlife Program
88455 Pike Rd State Highway 13
Bayfield, WI 54814
Phone: 715-779-3795
E-mail: Jeremy.st.arnold@redcliff-nsn.gov

Red Cliff Fisheries Department
88455 Pike Rd State Highway 13
Bayfield, WI 54814
Phone: 715-779-3750
E-mail: mike.defoe@redcliff-nsn.gov or chad.abel@redcliff-nsn.gov

Red Cliff Environmental Program Office
37295 Community Rd.
Bayfield, Wi 54814

Red Cliff Environmental Programs Manager
Melonee Montano
melonee.montano@redcliff-nsn.gov
Office Phone: (715) 779-3650

Tribal Conservation Wardens Office
(715) 779-3732
Mark Duffy: (715) 779-3932
Email: mjduffy@redcliff-nsn.gov

Red Cliff Fish Hatchery
88455 Pike Rd State Highway 13
Bayfield, WI 54814

Phone: 715-779-3728
Fax: 715-779-3763
E-mail: chase.meierotto@redcliff-nsn.gov

Species of Interest or Concern or Managed Species:

- Primary Fish Species:
    - lake sturgeon
    - lake trout
    - whitefish
    - walleye
- Plant Species of Interest
    - Wild Rice

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1854

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Red Cliff. 2004a. Environmental Resources. Website Accessed June 2, 2015: http://redcliff-nsn.gov/resources/environmental.htm.

Red Cliff. 2004b. Council Members. Website Accessed June 2, 2015: http://redcliff-nsn.gov/Government/council.htm.

Red Cliff. 2004c.Tribal Conservation Wardens. Website Accessed June 2, 2015: http://redcliff-nsn.gov/resources/popup/warden.htm.

Red Cliff. 2004d. Fisheries Department. Website Accessed June 2, 2015: http://redcliff-nsn.gov/divisions/TNRD/RCFD.htm.

Red Cliff. 2004e. Forestry and Wildlife. Website Accessed June 2, 2015: http://redcliff-nsn.gov/divisions/TNRD/FW.htm.

Red Cliff. 2004f. Treaty Natural Resources Division. Website Accessed June 2, 2015: http://redcliff-nsn.gov/divisions/TNRD/TNRD.htm.

Red Cliff. 2004g. Additional Resources ("Walleye Warriors"). Website Accessed June 2, 2015: http://redcliff-nsn.gov/Heritage&Culture/resources.htm.

Red Cliff. 2004h. Environmental Department. Website Accessed June 2, 2015: http://redcliff-nsn.gov/divisions/TNRD/RCED.htm.

Red Cliff. 2004i. Tribal Fish Hatchery. Website Accessed June 2, 2015: http://redcliff-nsn.gov/divisions/TNRD/RCTFH.htm.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Red Lake Band of Chippewa Indians (Minnesota)

Counties of Interest along Great Lakes: Alger, Antrim, Benzie, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Grand Traverse, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Muskegon, Oceana, Ottawa, Schoolcraft (Michigan); Lake (Minnesota); Cuyahoga, Erie, Lorain, Lucas (Ohio)

Contact Information:

Tribal Chairman Darrell G. Seki, Sr.
Red Lake Tribal Council
24200 Council Street
Red Lake, MN 56671
(218) 679-3341
http://www.redlakenation.org/index.asp?SEC=6DC42211-BCA8-4C4D-81B1-57C09F8EF607&Type=B_BASIC

Al Pemberton
Director
Red Lake Department of Natural Resources
15761 High School Drive
PO Box 279
Red Lake, MN 56671
Phone: 218-679-3959
Fax: 218-679-2830
Email: rldnr@redlakenation.org
http://www.redlakenation.org/index.asp?SEC=BD9B4EF3-B1B9-4D2F-B62C-1C38CD04D3CE&Type=B_BASIC

Kade Ferris
Archaeologist
Archaeology and Historic Preservation Section
Red Lake Tribal Engineering Division
PO Box 247
Red Lake, MN 56671
Phone: (218) 679-1691
Email: kade.ferris@redlakenation.org
http://www.redlakenation.org/index.asp?SEC=63F794D5-100D-4317-9D52-6950B8BCA2BF&Type=B_BASIC

Species of Interest or Concern or Managed Species:

- Fish/Fisheries/Fishing Regulation/Fishing Production:
    - brook trout,
    - rainbow trout,
    - cold water lake trout
    - largemouth bass,

    - bluegill,
    - sunfish,
    - black crappie,
    - walleye (recreational fishing and economic production),
    - yellow perch,
    - northern pike,
    - lake sturgeon,
    - sheepshead,
    - sucker, and
    - bull head
- Wildlife Species/Management:
    - small game (minks),
    - big game (bear, white-tailed deer, moose and elk),
    - fur bearers (grey or timber wolves, striped skunk, red fox, raccoons, badgers, Franklin's ground squirrels),
    - beavers,
    - grouse,
    - American woodcocks,
    - local waterfowl (wood duck, Canada goose),
    - marsh birds (American bittern),
    - shore birds
    - migrating birds (Trumpeter swan, Canada goose)
- Plants/Production:
    - native strain wild rice,
    - cultivated wild rice (economic production)
- Forestry Species/Timber Production and Management Activities
    - red pine,
    - white pine,
    - jack pine,
    - white spruce,
    - tamarack and
    - northern white cedar
    - timber harvesting (economic production)
    - sale of stand timber (stumpage) (economic production)
    - fuels program using prescribed fire and mechanical methods

<u>Treaties</u>: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Old Crossing Treaty of 1863
- Treaty of 1864
- Treaty of 1889
- Land Agreement – 1902

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Red Lake. n.d.(a). Wolf Management Plan. Website Accessed June 2, 2015: http://www.redlakednr.org/PDF/RLDNR%20wolf%20press%20release.pdf.

Red Lake. n.d.(b). Gray Wolf Inventory, Monitoring, and Management Plan Development Project, Phase I. Website Accessed June 2, 2015: http://www.redlakednr.org/PDF/wolf.pdf.

Red Lake. n.d.(c). Butcher Knife Restoration Project. Website Accessed June 2, 2015: http://www.redlakednr.org/PDF/butcherknife.pdf.

Red Lake. n.d.(d). Farms and Kiwosay Wildlife Management Area. Website Accessed June 2, 2015: http://www.redlakednr.org/PDF/Kiwosay.pdf.

Red Lake. 2005. Good Lake Waterfowl Protection Area. Website Accessed June 2, 2015: http://www.redlakednr.org/PDF/GooDLake.pdf.

Red Lake. 2015a. Tribal Council. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=6DC42211-BCA8-4C4D-81B1-57C09F8EF607&Type=B_BASIC.

Red Lake. 2015b. Department of Natural Resources. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=BD9B4EF3-B1B9-4D2F-B62C-1C38CD04D3CE&Type=B_BASIC.

Red Lake. 2015c. Archaeology and Historic Preservation. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=63F794D5-100D-4317-9D52-6950B8BCA2BF&Type=B_BASIC.

Red Lake. 2015d. Tribally-Owned Businesses. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=34040A3B-DADB-496E-8683-F319EBFA740D&Type=B_BASIC

Red Lake. 2015e. Fishery. Website Accessed June 2, 2015: http://www.redlakewalleye.com/.

Red Lake. 2015f. Foods. Website Accessed June 2, 2015: http://redlakenationfoods.com/.

Red Lake Forest Products, Inc.: (no website)

Red Lake. 2015g. Fisheries Program. Website Accessed June 2, 2015: http://www.redlakednr.org/Fisheries.html.

Red Lake. 2015h. Lake Sturgeon Return to Red Lakes. Website Accessed June 2, 2015: http://www.redlakednr.org/sturgeon.html.

Red Lake. 2015i. Fishing Regulations. Website Accessed June 2, 2015: http://www.redlakednr.org/Fishing%20Regulations.html.

Red Lake. 2015j. Small Lakes Regulations. Website Accessed June 2, 2015: http://www.redlakednr.org/Small%20Lakes.htm.

Red Lake. 2015k. Forestry Program. Website Accessed June 2, 2015: http://www.redlakednr.org/Forestry.html.

Red Lake. 2015l. Forestry Development. Website Accessed June 2, 2015: http://www.redlakednr.org/Forest%20Development.html.

Red Lake. 2015m. Forest Inventory. Website Accessed June 2, 2015: http://www.redlakednr.org/Inventory_GIS.html.

Red Lake. 2015n. Timber Sales. Website Accessed June 2, 2015: http://www.redlakednr.org/TImber%20Sales.html.

Red Lake. 2015o. Fire Prevention. Website Accessed June 2, 2015: http://www.redlakednr.org/Fire%20Prevention%20Program.html

Red Lake. 2015p. Fuels Program. Website Accessed June 2, 2015: http://www.redlakednr.org/FireProgram.html.

Red Lake. 2015q. Wildlife Program. Website Accessed June 2, 2015: http://www.redlakednr.org/wildlife.html.

Red Lake. 2015r. Hunting Regulations. Website Accessed June 2, 2015: http://www.redlakednr.org/Hunting%20Seasons.html.

Red Lake. 2015s. Wildlife Projects. Website Accessed June 2, 2015: http://www.redlakednr.org/Wildlife%20Projects%20Butcher%20Knife.html.

Red Lake. 2015t. Treaties and Other Agreements. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=2A5CFE26-31D2-412F-85AB-7AFC1AB2FE91&Type=B_BASIC.

Red Lake. 2015u. Old Crossing Treaty of 1863. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=11389483-F50D-4ADF-B730-E91CCD1570B8&Type=B_BASIC .

Red Lake. 2015v. Treaty of 1864. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=6407DF72-1310-4F1B-BDD8-6C9049C85359&Type=B_BASIC.

Red Lake. 2015w. Treaty of 1889. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=C8AB09DD-7975-420D-B8A3-8C65721BC5BF&Type=B_BASIC.

Red Lake. 2015x. 1902 Minutes of the Council. Website Accessed June 2, 2015: http://www.redlakenation.org/index.asp?SEC=98ED3C84-B662-4E79-ABFA-91CB2144C4AB&Type=B_BASIC.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Sac & Fox Nation of Missouri in Kansas and Nebraska

Counties of Interest along Great Lakes: Brown, Douglas (Wisconsin).

Contact Info:

Tiauna Carnes
Chairperson
Tribal Council
Sac & Fox Nation of Missouri in Kansas and Nebraska
P.O. Box 39
305 N. Main Street
Reserve KS, 66434
Phone: (785) 742-0053
Email: tribalcouncil1@sacandfoxcasino.com

Department of Wildlife Management and Enforcement
401 North Arch St.
Reserve, KS 66434
Phone: 785) 742-7190

Species of Interest or Concern or Managed Species:

- Primary Animal Species:
    - coyotes
    - rabbits
    - hares
    - beavers
    - deer
    - elk
    - wild turkeys
    - small game
    - badger
    - red fox
    - opossum
    - weasel
    - migratory birds
    - mink
    - muskrat
    - big game
    - skunk
    - upland game
    - bobcat
    - beaver

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1804
- Treaty of 1837

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Sac & Fox Nation of Missouri in Kansas and Nebraska. 2017a. Governments. Available online at http://www.sacandfoxks.com/sacfox.nsf/ContentPage.xsp?action=openDocument&documentId=1BD47826B43740388625769A005B7AFB. Website accessed December 31, 2017.

Sac & Fox Nation of Missouri in Kansas and Nebraska. 2017b. Wildlife Management. Available online at http://www.sacandfoxks.com/sacfox.nsf/ContentPage.xsp?action=openDocument&documentId=841FA8008A4791BF862576F2004AAA04. Website accessed December 31, 2017.

Sac & Fox Nation of Missouri in Kansas and Nebraska. 2017c. Hunting, Fishing and Trapping Ordinance. Available online at http://www.sacandfoxks.com/sacfox.nsf/str/TPD/$file/HuntingFishingTrappingOrdinanceResolution.pdf Website accessed December 31, 2017.

Sac & Fox Nation of Missouri in Kansas and Nebraska. 2017d. History of the Tribe. Available online at http://www.sacandfoxks.com/sacfox.nsf/ContentPage.xsp?action=openDocument&documentId=EC854C1650666A8B862576950079CFE2. Website accessed December 31, 2017.

Tribe Name: Sac & Fox Nation, Oklahoma

Counties of Interest along Great Lakes: Douglas (Wisconsin).

Contact Info:

Kay Rhoads
Principal Chief
Sac and Fox Nation
Administration Building
920883 S. Hwy 99 Bldg A
Stroud, OK 74079
Phone: 918-968-3526
Email: chief@sacandfoxnation-nsn.gov

Sac and Fox Nation
Office Environmental Services
356263 E. 926 Rd.
Stroud, OK 74079
(918) 968-0046

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Sac and Fox Nation. 2009a. Leadership. Available online at http://sacandfoxnation-nsn.gov/government/leadership/. Website accessed December 31, 2017.

Sac and Fox Nation. 2009a. Office of Environmental Services. Available online at http://sacandfoxnation-nsn.gov/departments/office-of-environmental-services/. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Sac & Fox Tribe of the Mississippi in Iowa

Counties of Interest along Great Lakes: Douglas (Wisconsin).

Contact Info:

March Runner
Executive Director
Meskwaki Nation
Sac & Fox Tribe of the Mississippi in Iowa
Administration Building
349 Meskwaki Road
Tama, IA 52339
641-484-4678

Jarrett Pfimmer
Program Director
Natural Resources
Sac & Fox Tribe of the Mississippi in Iowa
1826 340th Street
Tama, IA 52339
641-484-3511

Species of Interest or Concern or Managed Species:

- Buffalo

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Sac & Fox Tribe of the Mississippi in Iowa. 2017a. Executive Offices. Available online at https://www.meskwaki.org/government/executive-offices/. Website accessed December 31, 2017.

Sac & Fox Tribe of the Mississippi in Iowa. 2017b. Contact Us. Available online at https://www.meskwaki.org/about-us/contact-us/. Website accessed December 31, 2017.

Sac & Fox Tribe of the Mississippi in Iowa. 2017a. Natural Resources. Available online at https://www.meskwaki.org/community-services/natural-resources/. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Saginaw Chippewa Indian Tribe of Michigan

Counties of Interest along Great Lakes: Manistee (Michigan)

Contact Info:

Steve Pego
Chief
Indian Tribe of Michigan
7070 E. Broadway
Mount Pleasant, MI 48858
(989) 775-4000

Sally Kniffen
Environmental Specialist (Manager)
Environmental Team
(989) 775-4015
Email: skniffen@sagchip.org

Species of Interest or Concern or Managed Species: (complete not data available)

- Deer
- Wild turkey

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Saginaw. 2015a. Environmental Team. Website Accessed June 2, 2015: http://www.sagchip.org/environment/staff.aspx#.VV3goflVikq.

Saginaw. 2015b. General Assistance Program. Website Accessed June 2, 2015: http://www.sagchip.org/environment/generalAssistProgram.htm#.VV3gyPlViko.

Saginaw. 2015c. Planning. Website Accessed June 2, 2015: http://www.sagchip.org/news.aspx?DepartmentName=Planning.

Saginaw. 2015d. Hunting Areas within the Saginaw Chippewa Tribal Lands. Website Accessed June 2, 2015: http://www.sagchip.org/news.aspx?newsid=387.

Saginaw. 2015e Fishing Areas within the Isabella Reservation:
http://www.sagchip.org/news.aspx?newsid=371.

Saginaw. 2015f. Turkey Hunting. Website Accessed June 2, 2015:
http://www.sagchip.org/news.aspx?newsid=366.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Saint Regis Mohawk Tribe

Counties of Interest along Great Lakes: Jefferson, Oswego, St. Lawrence (New York)

Contact Info:

Chief Paul O. Thompson
Chief Beverly Cook
Chief Ron LaFrance Jr.
Saint Regis Mohawk Tribal Council
412 Sate Route 37
Akwesasne, NY 13655
(518) 358-2272

Ken Jock
Director
Saint Regis Mohawk Environment Division
449 Frogtown Road
Akwesasne, NY 13655
(518) 358-5937
Email: ken.jock@srmt-nsn.gov

Species of Interest or Concern or Managed Species:

- Primary Large Game Species:
  - white-tailed deer
  - black bear
  - moose
  - caribou
- Small Game Species
  - rabbit
  - squirrel
  - beaver
  - muskrat
  - raccoon
- Upland Bird Species
  - pheasant
  - ruffed grouse
  - snipe
  - woodcock
  - turkey
- Waterfowl Species
  - puddle/dabbler ducks
  - diver ducks
  - geese
- Primary Fish Species:

  - walleye
  - northern pike
  - sucker
  - trout/salmon
  - burbot
  - bass
  - sturgeon
  - muskellunge
  - catfish
  - bullhead
  - crappie
  - bluegill
  - sunfish
  - perch
- Plant Species of Interest
  - Sugar Maple
  - Wild Rice

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:
- None identified.

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Saint Regis. n.d. Commonly Hunted Game. Website Accessed June 2, 2015: http://www.srmtenv.org/web_docs/WRP/2014/11/2014_game_commonly%20_hunted_poster.pdf.

Saint Regis. 2014a. Family Guide to Eating Locally-Caught Fish. Website Accessed June 2, 2015: http://www.srmtenv.org/web_docs/WRP/2014/11/201411_fish_advisory.pdf.

Saint Regis. 2014b. Game advisory. Website Accessed June 2, 2015: http://www.srmtenv.org/web_docs/WRP/2014/11/201411_game_advisory.pdf.

Saint Regis. 2015a. Environment Division. Website Accessed June 2, 2015: http://www.srmtenv.org/index.php.

Saint Regis. 2015b. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.srmt-nsn.gov/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Santee Sioux Nation, Nebraska

Counties of Interest along Great Lakes: Brown, Douglas (Wisconsin).

Contact Info:

Roger Trudell
Tribal Chairman
Santee Sioux Nation, Nebraska Tribal Council
Santee Sioux Nation Headquarters/Museum
108 Spirit Lake Ave. W
Niobrara, NE 68760
Phone: (402)857-2772
Email: rtrudell@santeedakota.org

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Santee Sioux Nation. 2015-2017a. Tribal Government. Available online at http://santeesiouxnation.net/tribal-government.html . Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Sault Ste. Marie Tribe of Chippewa Indians, Michigan

Counties of Interest along Great Lakes: Alger, Antrim, Benzie, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Grand Traverse, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Muskegon, Oceana, Ottawa, Schoolcraft (Michigan)

Contact Info:

Mr. Aaron Payment
Chairperson
Sault Ste. Marie Tribe of Chippewa Indians, Michigan
523 Ashmun Street
Sault Ste. Marie, MI 49783
906-635-6050
906-635-4969 FAX
aaronpayment@saulttribe.net

Kathie Brosemer
Environmental Program Manager
Department of Natural Resources
(906) 632-5575

Species of Interest or Concern or Managed Species:

- Primary Game Species:
    - white tailed deer
    - wild turkey
    - bear
    - waterfowl:
        - mallard, black duck, gadwall, blue winged teal, green winged teal, canvasback, redhead, wood duck, lesser scaup, bufflehead, pintail, Canada goose, snow goose
- Small Game Species:
    - ruffed grouse
    - sharptail grouse
    - pheasant
    - quail
    - squirrel
    - cottontail rabbit
    - snowshoe hare
- Primary Furbearers
    - beaver
    - muskrat
    - mink
    - red/gray fox
    - coyote

  - skunk
  - raccoon
- Mandatory Registration Species:
  - marten
  - fisher
  - bobcat
  - otter
- Fish Species
  - brook trout
  - brown trout
  - rainbow trout
  - chinook salmon
  - coho salmon
  - pink salmon
  - northern pike
  - muskellunge
  - walleye
  - perch
  - bluegill
  - sucker
  - smelt

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Sault Ste Marie. 2015a. Chairman's Office. Website Accessed June 2, 2015: http://www.saulttribe.com/government/chairmans-office.

Sault Ste Marie. 2015b. Department of Natural Resources. Website Accessed June 2, 2015: http://www.saulttribe.com/membership-services/natural-resources.

Sault Ste Marie. 2015c. 2014 Annual Inland Harvest Report. Form Accessed June, 2, 2015.

Sault Ste Marie. 2015d. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.saulttribe.com/.

Sault Ste Marie. 2015e. Environmental Department. Website Accessed June 2, 2015: http://www.saulttribe.com/membership-services/natural-resources/19-membership-services/natural-resources/1344-environmental-department.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Seneca-Cayuga Nation

Counties of Interest along Great Lakes: Cayuga, Chautauqua, Erie, Monroe, Niagara, Wayne (New York); Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa (Ohio); Erie (Pennsylvania)

Contact Info:

William L. Fisher
Chief
Seneca-Cayuga Nation
P.O. Box 453220
Grove, OK 74345-3022
Phone: (918) 787-5452
Email: brtchair@badriver-nsn.gov
www.scctribe.com

Rick Dubois
Program Director
Environmental Department
Seneca-Cayuga Nation
P.O. Box 453220
Grove, OK 74345-3022
Phone: 918-787-5452
Email: mailto:rdubois@sctribe.com?Subject=Hello

Species of Interest or Concern or Managed Species:

- Animal Species
  - None identified
- Plant Species
  - Corn

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Seneca-Cayuga Nation. 2017a. Home. Available online at http://sctribe.com/. Website accessed December 31, 2017.

Seneca-Cayuga Nation. 2017b. Staff. Available online at http://sctribe.com/contact/. Website accessed December 31, 2017.

Seneca-Cayuga Nation. 2017c. Seneca Cayuga Culture & Historic Preservation Program. Available online at http://sctribe.com/service/historicalcultural-preservation/. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Seneca Nation of Indians

Counties of Interest along Great Lakes: Cayuga, Chautauqua, Erie, Monroe, Niagara, Wayne (New York); Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa (Ohio); Erie (Pennsylvania)

Contact Info:

Maurice A. John, Sr.
President
Seneca Nation of Indians
90 Ohiyo Way
Salamanca, NY 14779
(716) 945-1790

Greg Lay
Fish and Wildlife Officer
Fish & Wildlife Dept.
3689 Center Rd
Salamanca, NY 14779
(716) 258-8869
Email: Greg.Lay@sni.org
Allegany Office: (716) 945-6421
Cattaraugus Office: (716) 532-4900

Species of Interest or Concern or Managed Species:

- Primary Fish Species:
    - Brown/brook trout
    - Rainbow trout
    - Lake trout
    - Northern pike
    - Walleye
    - Muskellunge
    - Tiger muskellunge
    - Largemouth bass
    - Smallmouth bass
    - Sunfish
    - Yellow perch
    - White perch
    - Crappies
    - Catfish
    - Rock bass
    - Suckers
    - Carp
    - White bass
    - Paddlefish

- Hellbender

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Seneca. 2015a. Elected Officials. Website Accessed June 18, 2015: https://sni.org/government/elected-officials/.

Seneca. 2015b. Fish and Wildlife Department. Website Accessed June 18, 2015: http://www.senecaconservation.com/senecaconservation.com/Home.html.

Seneca. 2015c. Fishing Regulations. Website Accessed June 18, 2015: http://www.senecaconservation.com/senecaconservation.com/Fishing_Regulations.html.

Seneca. 2015d. Fish and Wildlife Department Contacts. Website Accessed June 18, 2015: http://www.senecaconservation.com/senecaconservation.com/Contact_US.html.

Seneca. 2015e. Officers. Website Accessed June 18, 2015: http://www.senecaconservation.com/senecaconservation.com/Officers.html.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Shawnee Tribe

Counties of Interest along Great Lakes: Erie, Lucas, Ottawa, Sandusky (Ohio).

Contact Info:

Ron Sparkman
Chief
P.O. Box 189
29 S Hwy 69A
Miami OK 74355
Phone: 918-542-2441
Email: rondede1@gmail.com

Rosanna Sheppard
Director of Environment and Natural Resources Department
The Shawnee Tribe
P.O. Box 189
29 S Hwy 69A
Miami OK 74355
Phone: 918-542-2441
Email: rosanna@shawnee-tribe.com

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of Fort Meigs, 1817
- Treaty of 1825
- Treaty of 1831
- Treaty of 1854

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Shawnee Tribe. 2017a. Welcome to the Shawnee Tribe Website. Available online at http://www.shawnee-tribe.com/. Accessed December 31, 2017.

Shawnee Tribe. 2017a. Government: Business Council. Available online at http://www.shawnee-tribe.com/Government.html. Accessed December 31, 2017.

Shawnee Tribe. 2017a. Environmental Program. Available online at http://www.shawnee-tribe.com/Environmental.html. Accessed December 31, 2017.

Shawnee Tribe. 2017a. History. Available online at http://www.shawnee-tribe.com/History.html. Accessed December 31, 2017.

Tribe Name: Sisseton-Wahpeton Oyate of the Lake Traverse Reservation, South Dakota

Counties of Interest along Great Lakes: Brown, Douglas

Contact Info:

Fish and Wildlife Manager, Charlene Miller, (605) 698-3911

Species of Interest or Concern or Managed Species:

- Big Game Species:
  - deer
  - wild turkey
  - antelope
  - buffalo
  - elk
  - moose
  - mountain lion
  - wolf
- Small Game Species:
  - rabbits
  - squirrels
  - woodchucks
- Predators
  - coyote
  - fox
- Primary Furbearers
  - beaver
  - muskrat
  - mink
  - badger
  - weasel
  - bobcat
  - raccoon
- Upland Birds
  - Hungarian partridge
  - mourning dove
  - pheasants
  - grouse
- Fish Species

- waterfowl

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Sisseton. n.d.. Fish and Wildlife Code. Website Accessed on June 2, 2015: http://www.swo-nsn.gov/wp-content/uploads/2015/03/wildlife1.pdf

Sisseton. 2015. Official Tribal Website Homepage. Website Accessed June 18, 2015: http://www.swo-nsn.gov/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Sokaogon Chippewa Community, Wisconsin

Counties of Interest along Great Lakes: Cuyahoga, Erie, Lorain (Ohio)

Contact Info:

Chris McGeshick
Chairman
Sokaogon Chippewa Community, Wisconsin
3051 Sand Lake Road
Crandon, WI 54520
Phone: 715-478-7500
Fax: 715-478-5275
Website: http://www.sokaogonchippewa.com/

Species of Interest or Concern or Managed Species:

- Wildlife Species:
  - None identified
- Plant Species of Interest
  - Wild Rice

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Sokaogon. 2015a. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.sokaogonchippewa.com/.

Sokaogon. 2015b. About Us. Website Accessed June 2, 2015: http://www.sokaogonchippewa.com/index.php/sample-sites-2.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Spirit Lake Tribe, North Dakota

Counties of Interest along Great Lakes: Brown, Douglas (Wisconsin)

Contact Info:

- Fish and Wildlife Department, (701) 766-1243

Species of Interest or Concern or Managed Species:

- Big Game Species:
    - white tailed deer
    - mule deer
    - elk
    - moose
    - bison
- Primary Furbearers
    - beaver
    - muskrat
    - mink
    - badger
    - weasel
    - bobcat
    - raccoon
    - fisher
    - red fox
    - coyote
    - mountain lion
    - wolf
- Upland Birds
    - Hungarian/gray partridge
    - mourning dove
    - pheasants
    - sharp-tailed grouse
    - wild turkey
    - lesser prairie chicken

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Spirit Lake. 2013. Conservation Code. Website Accessed June 2, 2015: http://www.spiritlakenation.com/Documents/Conservation%20Code%20Markup.pdf.

Spirit Lake. 2014. Official Website Homepage. Website Accessed June 18, 2015: http://www.spiritlakenation.com/.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: St. Croix Chippewa Indians of Wisconsin

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon (Michigan); Cuyahoga, Erie Lorain (Ohio); Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto (Wisconsin).

Contact Info:

Lewis Taylor
Chairman
Tribal Council
St. Croix Chippewa Indians of Wisconsin
St. Croix Tribal Center
24663 Angeline Ave.
Webster, WI 54893
Phone: (715) 349-2195

Sarah Slayton
Environmental / Natural Resources Director
Environmental Services
St. Croix Chippewa Indians of Wisconsin
Email: sarahs@stcroixtribalcenter.com
Phone: (715) 349-2195 ext. 5240

Species of Interest or Concern or Managed Species:

- Fish Species:
  - walleye
- Plant Species:
  - Birch
  - Wild rice
  - Sugar maple
  - Corn
  - Squash

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- Treaty of 1837
- Treaty of 1842
- Treaty of 1854

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

St. Croix Chippewa Indians of Wisconsin. 2015a. Tribal Council. Available online at http://www.stcciw.com/depts/tribal-council. Website accessed December 31, 2017.

St. Croix Chippewa Indians of Wisconsin. 2015b. Environmental Services & Natural Resources. Available online at http://www.stcciw.com/epa-staff. Website accessed December 31, 2017.

St. Croix Chippewa Indians of Wisconsin. 2015c. About St. Croix. Available online at http://www.stcciw.com/home/about-stcroix. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Stockbridge Munsee Community, Wisconsin

Counties of Interest along Great Lakes: none

Contact Info:
Wally Miller
President
Stockbridge-Munsee Community, Wisconsin
N8476 Moh-He-Con-Nuck Road
Bowler, WI 54416
(715) 793-4387
Email: wally.miller@mohican-nsn.gov

Sherry White
Tribal Historic Preservation Manager
Department of Historic Preservation
Stockbridge-Munsee Community, Wisconsin W13447 Camp 14 Road
Bowler, WI 54416
(715) 793-3970
Email: sherry.white@mohican-nsn.gov

Greg Bunker
Environmentalist
Stockbridge-Munsee Environmental Department
(715) 793-4363
Email: greg.bunker@mohican-nsn.gov
http://www.mohican-nsn.gov/Departments/Enviromental/index.htm

Beau Miller
Conservation Warden/Forestry Committee Chairman
Stockbridge-Munsee Conservation Department
N7689 Koan Tuk Drive
PO Box 70
Bowler, WI 54416
(715) 793-4364
Email: beau.miller@mohican-nsn.gov
http://www.mohican-nsn.gov/Departments/Conservation/

Species of Interest or Concern or Managed Species:

- Primary Game Species:
    - wild turkey
    - deer
    - bear
- Primary furbearers:
    - beaver

    - mink
    - muskrat
    - otter
    - skunk
    - raccoon
    - fox
    - weasel
    - opossum
    - badger
    - coyote
    - fisher
    - bobcat
- Primary Fish Species:
    - perch
    - bluegill
    - crappie
    - sunfish
    - rock bass
    - bass
    - northern pike
    - walleye
- Protected Species:
    - elk
    - mountain lion
    - pine marten
    - moose
    - bald eagle
    - golden eagle
    - wolf

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Stockbridge. n.d. Employee Directory. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Directory/Employee%20Directory.pdf.

Stockbridge. 2009a. Department of Conservation. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Conservation/.

Stockbridge. 2009b. Forestry Department. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Forestry/index.htm.

Stockbridge. 2009c. Department of Historic Preservation. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Historic_Preservation/index.htm.

Stockbridge. 2009d. History 1784-1829 Part 1. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Library-Museum/Mohican_History/1784-1829-part1.htm.

Stockbridge. 2009e. History 1784-1829 Part 2. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Library-Museum/Mohican_History/1784-1829-part2.htm.

Stockbridge. 2009f. History 1784-1829 Part 3. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Library-Museum/Mohican_History/1784-1829-part3.htm.

Stockbridge. 2009g. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/index.htm.

Stockbridge. 2009h. Environmental Department. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Enviromental/index.htm.

Stockbridge. 2012. Fish and Wildlife Ordinance. Website Accessed June 2, 2015: http://www.mohican-nsn.gov/Departments/Legal/Ordinances/Ch%2021%20Fish%20and%20Wildlife.pdf. Adopted 1978; amended 2000-2012.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Tonawanda Band of Seneca

Counties of Interest along Great Lakes: Cayuga, Chautauqua, Erie, Monroe, Niagara, Wayne (New York); Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa (Ohio); Erie (Pennsylvania)

Contact Info:

Mr. Roger Hill
Chief
Tonawanda Band of Seneca Indians
P.O. Box 795
7027 Meadville Road
Basom, NY 14013
716-542-4244
716-542-4008 FAX
tonoseneca@aol.com

Species of Interest or Concern or Managed Species:

- None identified.

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Tonawanda. 2008. Address. Website Accessed June 2, 2015: http://www.waymarking.com/waymarks/WM3AP9_Tonawanda_Seneca_Nation_Genesee_County_NY.

Tonawanda. 2015. Address and Phone. Website Accessed June 2, 2015: http://www.naicja.org/node/1153.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Turtle Mountain Band of Chippewa Indians of North Dakota

Counties of Interest along Great Lakes: Cuyahoga, Erie, Lorain (Ohio).

Contact Info:

Wayne L. Keplin
Chairman
Bad River Tribal Council
Turtle Mountain Band of Chippewa Indians of North Dakota PO Box 900
Belcourt, North Dakota 58316
Phone: 701-477-2600
Email: info@tmbci.org

Species of Interest or Concern or Managed Species:

- Primary Animal Species:
  - chipmunk
  - muskrat
  - raccoon
  - caribou
  - deer
  - porcupine
- Plant Species of Interest
  - pumpkin
  - squash
  - wild rice
  - birch
  - cedar
  - pine
  - balsam
  - sugar maple

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

Butler, William. 2015. Agency Technical Review Comment Sheet for GLFER Hydrilla Risk Assessment (Cultural Impacts Draft (E&E, 10/7/15). 10 December 2015.

Turtle Mountain Band of Chippewa Indians. 2017a. Welcome. Available online at http://tmbci.org/. Website accessed December 31, 2017.

Turtle Mountain Band of Chippewa Indians. 2017b. Contemporary Tribal Leaders. Available online at http://tmbci.org/government/?page_id=616. Website accessed December 31, 2017.

Turtle Mountain Band of Chippewa Indians. 2017c. Annishnaabeg Culture: Introduction. Available online at http://tmbci.org/community/?page_id=485. Website accessed December 31, 2017.

Turtle Mountain Band of Chippewa Indians. 2017d. Annishnaabeg Culture: Woodland Ways of Culture. Available online at http://tmbci.org/community/?page_id=486. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: Tuscarora Nation

Counties of Interest along Great Lakes: Niagara (New York)

Contact Info:

Mr. Leo R. Henry
Chief
Tuscarora Nation, New York
2006 Mt. Hope Road
Lewiston, NY 14092
716-601-4737
716-297-7355 FAX
tennews@starband.net

Haudenosaunee Environmental Task Force
P.O. Box 992
Hogansburg, NY 13655
Phone: (518) 333-0228 | Fax: (315) 842-4515

Rene Rickard
Environmental Office Administrator
5226 E Walmore Road
Lewiston, NY 14092

Species of Interest or Concern or Managed Species:

- None identified.

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- 1784 Treaty with Six Nations
- 1789 Deed From The Six Nations of Indians to the State of Pennsylvania
- 1789 Articles of Agreement Between Six Nations and Pennsylvania
- 1789 Treaty with Six Nations
- 1792 Articles of Agreement (Five Nations)
- 1794 Treaty of Canandaigua
- 1794 Treaty With The Tuscarora, Oneida and Stockbridge Indians
- 1796 Jay Treaty of Amity Commerce and Navigation
- 1796 Treaty with the Seven Nations of Canada
- 1797 Treaty with the Mohawk
- 1797 Treaty with the Senecas
- 1797 Treaty Of Big Tree
- 1803 Treaty with the Tuscarora Nation
- 1838 Treaty at Buffalo Creek

References:

Haudenosaunee. 2015a. Environmental Task Force. Website Accessed June 2, 2015: http://www.hetf.org/.

Haudenosaunee. 2015b. Environmental. Website Accessed June 2, 2015: http://www.hetf.org/index.php/environmental-issues-impacts-on-our-communities.

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/

Tuscarora. n.d. 1797 Treaty of Big Tree. Website Accessed June 2, 2015: http://www.oswego.edu/library2/archives/digitized_collections/granger/bigtree.html.

Tuscarora. 2015a. Environmental Department. Website Accessed June 2, 2015: http://tuscaroraenvironment.com/.

Tuscarora. 2015b. Official Tribal Website Homepage. Website Accessed June 2, 2015: http://www.tuscaroras.com/.

Tuscarora. 2015c. 1784 Treaty with Six Nations of New York. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1784-treaty-with-six-nations.

Tuscarora. 2015d. 1789 Deed From The Six Nations of Indians to the State of Pennsylvania. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/deed-from-the-six-nations-of-indians-to-the-state-of-pennsylvania.

Tuscarora. 2015e. 1789 Articles of Agreement Between Six Nations and Pennsylvania. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1789-articles-of-agreement-between-six-nations-and-pennsylvania.

Tuscarora. 2015f. 1789 Treaty with Six Nations. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1789-treaty-with-six-nations.

Tuscarora. 2015g. 1792 Articles of Agreement with the Five Nations of Indians. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1792-articles-of-agreement-five-nations.

Tuscarora. 2015h. 1794 Treaty of Canandaigua. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1794-treaty-of-canandaigua.

Tuscarora. 2015i. 1794 Treaty with the Tuscarora, Oneida and Stockbridge Indians. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1794-treaty-with-the-tuscarora-oneida-and-stockbridge-indians.

Tuscarora. 2015j. 1796 Jay Treaty of Amity Commerce and Navigation. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1796-jay-treaty-of-amity-commerce-and-navigation.

Tuscarora. 2015k. 1796 Treaty with the Seven Nations of Canada. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1796-treaty-with-the-seven-nations-of-canada.

Tuscarora. 2015l. 1797 Treaty with the Mohawk. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1797-treaty-with-the-mohawk.

Tuscarora. 2015m. 1797 Treaty with the Senecas. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1797-treaty-with-the-senecas.

Tuscarora. 2015n. 1803 Treaty with the Tuscarora Nation. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1803-treaty-with-the-tuscarora-nation.

Tuscarora. 2015o. 1838 Treaty with the New York Indians. Website Accessed June 2, 2015: http://www.tuscaroras.com/index.php/1838-treaty-at-buffalo-creek.

Tribe Name: Upper Sioux Community, Minnesota

Counties of Interest along Great Lakes: Brown, Douglas (Wisconsin).

Contact Info:

Kevin Jensvold
Chairman
Upper Sioux Community
5722 Travers Lane
PO Box 147
Granite Falls, MN 56241

Barbara Long
Environmental Director
Upper Sioux Community
5722 Travers Lane
P.O. Box 147
Granite Fall, MN 56241

Species of Interest or Concern or Managed Species:

- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

Virtual Vision Computing, LLC. 2017a. Upper Sioux Community. Available online at http://www.uppersiouxcommunity-nsn.gov/. Website accessed December 31, 2017.

Virtual Vision Computing, LLC. 2017a. Board of Trustees. Available online at http://www.uppersiouxcommunity-nsn.gov/page/board-of-trustees. Website accessed December 31, 2017.

Virtual Vision Computing, LLC. 2017a. Environmental Department. Available online at http://www.uppersiouxcommunity-nsn.gov/page/usc-envrionmental. Website accessed December 31, 2017.

Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin

Tribe Name: White Earth Band, component reservation of the Minnesota Chippewa Tribe, Minnesota

Counties of Interest along Great Lakes: Baraga, Chippewa, Delta, Gogebic, Houghton, Marquette, Menominee, Ontonagon (Michigan); St. Louis (Wisconsin); Ashland, Bayfield, Douglas, Iron, Keweenaw, Marinette, Oconto (Wisconsin)

Contact Info:

Wildlife Manager, Doug MacArthur (218) 935-2524

Species of Interest or Concern or Managed Species:

- Big Game Species:
  - Bear
  - Moose (unlawful)
  - Gray wolf (unlawful)
  - deer
- Small Game Species
  - dove
  - woodcock
  - rail
  - snipe
  - coots
  - ruffed grouse
  - Hungarian partridge
  - ring-necked pheasant
  - prairie chicken (unlawful)
  - sharp-tailed grouse
  - wild turkey
  - rabbit
  - hare
  - squirrel
  - raccoon
  - fox
  - coyote
- Waterfowl
  - Goose
  - Duck
- Trapping Species
  - Raccoon
  - Badger

- Fox
- Coyote
- Beaver
- Muskrat
- Mink
- Otter
- Bobcat
- Fisher
- Pine marten
- Lynx (unlawful)
- Gray wolf (unlawful)

Treaties: which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:

- None identified.

References:

National Park Service. 2015. Native American Consultation Database (for all states and counties adjacent to the Great Lakes). Website accessed December 2, 2015: http://grantsdev.cr.nps.gov/Nagpra/NACD/.

White Earth. 2014. '14-'15 Hunting Trapping Season Limits. Website Accessed June 18, 2015: http://www.whiteearth.com/data/upfiles/files/2014_-2015_HUNTING_SEASONS_LIMITS.pdf.

White Earth. 2015. Natural Resources. Website Accessed June 18, 2015:http://www.whiteearth.com/programs/?page_id=267&program_id=8.

Tribe Name: Wyandotte Nation

Counties of Interest along Great Lakes: Cuyahoga, Erie, Lorain, Ottawa, Sandusky (Ohio); Erie (Pennsylvania)

Contact Info:

Billy Friend
Chief
Wyandotte Nation
Administrative Offices
64700 E. Highway 60
Wyandotte, OK 74370
Phone: 918-678-2297 ext. 6312

Species of Interest or Concern or Managed Species:
- None identified

Treaties which may specify treaty rights retained for hunting, fishing and gathering of plants on or off reservations or tribal-owned lands or in wetlands and waterbodies:
- Treaty of 1785
- Treaty of 1789
- Treaty of 1795
- Treaty of 1803
- Treaty of 1805
- Treaty of 1807
- Treaty of 1808
- Treaty of 1814
- Treaty of 1815
- Treaty of 1817
- Treaty of 1818
- Treaty of 1832
- Treaty of 1836
- Treaty of 1842
- Treaty of 1843
- Treaty of 1850
- Treaty of 1855
- Treaty of 1867

References:

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Appendix A: Federally Recognized Indian Tribes with an Interest in Lands included in the Great Lakes Basin