November 2020 Photograph courtesy of The Nature Conservancy

Final Report
Phase 1: Aquatic and Riparian Invasive Species Inventory and Habitat Assessment
Aquatic Restoration Initiative

This plan was prepared for The Nature Conservancy, as the host organization for the Saint Lawrence Eastern Lake Ontario Partnership for Regional Invasive Species Management.

Final Report
Phase 1: Aquatic and Riparian Invasive Species Inventory and Habitat Assessment

Aquatic Restoration Initiative

Prepared for
The Nature Conservancy
SLELO PRISM
Northern New York Office
269 Ouderkirk Road
Pulaski, NY 13142

Prepared by
Rootz, LLC
PO Box 452
Chaumont, NY 13622

TABLE OF CONTENTS

Abbreviations

Executive Summary

1 Introduction 7

1.1 Project Need and Objective 7

1.2 Study Area and Highly Probable Areas 8

1.3 Project Team 10

1.4 Project Scope 10

2 Methods 12

2.1 Literature Review 12

2.1.1 Characteristic Soils 13

2.1.2 Characteristic Ecological Communities 13

2.1.3 Invasive Species Management 15

2.2 Aquatic Invasive Species Inventory and Habitat Assessment 17

2.2.1 Aquatic Plants 17

2.2.2 Aquatic Animals 19

2.3 Sample Identification and Field Documentation 20

2.4 Equipment Decontamination 21

3 Results 22

3.1 Sandy Creek 22

3.1.1 Aquatic Plants 22

3.1.2 Aquatic Animals 23

3.1.3 Habitat Conditions 24

3.2 South Sandy Creek 26

3.2.1 Aquatic Plants 26

3.2.2 Aquatic Animals 27

3.2.3 Habitat Conditions 27

3.3 Deer Creek 29

3.3.1 Aquatic Plants 29

3.3.2 Aquatic Animals 30

3.3.3 Habitat Conditions 30

4 Conclusion 32

4.1 Summary of Findings 32

4.2 Recommendations of Invasive Species Management 33
4.2.1 Proposed Management Strategies 33
4.2.2 Most Deserving Areas 36
4.2.3 Resilient and Connected Landscapes 39
4.3 Next Step 41
5 References 42

TABLES

Table 2-1: Summary of Key Literature Sources

Table 3-1: Aquatic Plants Presence per Reach in Sandy Creek

Table 3-2: Dominant Terrestrial Plants Observed in Riparian Zone

Table 3-3: Aquatic Plants Presence per Reach in South Sandy Creek

Table 3-4: Aquatic Plants Presence per Reach in Deer Creek

ILLUSTRATIONS

Illustration 1-1: Ecozones and Ecoregions of New York State

Illustration 2-1: Small, Shallow Draft Watercraft

Illustration 2-2: Rake Toss Sampling Equipment (Weed Anchor)

Illustration 2-3: Rootz Staff Holding a Whole Rake Plant Abundance- Dense

Illustration 2-4: Zooplankton Sampling Net

Illustration 2-5: Live Traps for Targeted Small Fish (A) and Crayfish (B)

Illustration 2-6: Small Vessels and Field Gear Following Equipment Decontamination

Illustration 3-1: Emergent Marsh Vegetation

Illustration 3-2: Japanese Knotweed Along Riparian Zone

TABLE

Table 1: Rake Toss Sampling Data

Table 2: Live Trap Sampling Data

Table 3: Proposed Invasive Species Management Strategy

FIGURES

Figure 1: Rake Toss Sampling Locations in Sandy Creek

Figure 2: Plankton Tow and Live Trap Sampling Locations in Sandy Creek

Figure 3: Rake Toss Sampling Locations in South Sandy Creek
Figure 4: Plankton Tow and Live Trap Sampling Locations in South Sandy Creek
Figure 5: Rake Toss Sampling Locations in Deer Creek
Figure 6: Plankton Tow and Live Trap Sampling Locations in Deer Creek
Figure 7: Invasive Species Patch Observed Along Sandy Creek
Figure 8: Invasive Species Patch Observed Along South Sandy Creek

APPENDICES

Appendix A Annotated Bibliography
Appendix B Regulatory Permits
Appendix C Standard Operating Procedures for the Collection of Zooplankton Samples Using a Horizontal Tow Net
Appendix D Plankton Tow Sample Data
Appendix E Photographs

ABBREVIATIONS

Abbreviation	Definition
AIS	aquatic invasive species
BCA	Bird Conservation Area
DC	Deer Creek
DEC	Department of Environmental Conservation
DFW	Division of Fish and Wildlife
eDNA	Environmental deoxyribonucleic acid
GLONASS	global navigation satellite system
GLRI	Great Lakes Restoration Initiative
GPS	global positioning system
HMP	habitat management plan
HPA	highly probable area
IBA	important bird area
LTS	live trap sampling
NYSDEC	New York State Department of Environmental Conservation
NYSFOLA	New York State Federation of Lake Association
NYNHP	New York Natural Heritage Program
NSC	Sandy Creek
PTS	plankton tow sampling
RTS	rake toss sampling
RFQ	request for quote
SAS	Simple Aquatic Survey
SLELO PRISM	Saint Lawrence Eastern Lake Ontario Partnership for Regional Invasive Species Management
SSC	South Sandy Creek
TNC	The Nature Conservancy
UAV	unmanned aerial vehicle
WMA	wildlife management area

Executive Summary

Waterbodies harbor vast aquatic resources that're socially, ecologically, and economically important to communities and ecosystems. Plants and animals play an essential role in healthy aquatic ecosystems. Non-native, invasive plant and animal species are a leading threat to aquatic ecosystems. SLELO PRISM, whom delivers core functions of an invasive species management program in the Eastern Lake Ontario region, developed an Aquatic Restoration Initiative to identify the most deserving areas in need of eradication, suppression, restoration, or management of invasive species. SLELO PRISM developed this Phase 1: Aquatic and Riparian and Invasive Species Inventory and Habitat Assessment to establish baseline conditions. Invasive plant and animal species were assessed in the aquatic and riparian areas within the tailwater sections of three riparian corridors, including Sandy Creek, South Sandy Creek, and Deer Creek near their confluences with Lake Ontario.

These ecosystems are part of the largest natural freshwater barrier beach system in New York State. Four key ecological communities that exist within the study areas of the three tributaries include, but are not limited to: unconfined river, deep emergent marsh, shallow emergent marsh, and Great Lakes dunes. These ecological communities host an assemblage of interacting plant and animal populations that share a common environment. As a result, these ecosystems are characterized as wildlife management areas and priority conservation areas.

A variety of fish and bird species were observed inhabiting and using the channel and riparian habitats at each tributary site. Fish species surveyed included largemouth bass (*Micropterus salmoides*), black crappie, yellow perch (*Perca flavescens*), bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), and pirate perch (*Aphredoderus gibbosus*). Bird species observed included Canada geese (*Branta canadensis*), Great blue heron (*Ardea Herodias*), wood duck (*Aix sponsa)*, mallard (*Anas platyrhynchos*), belted kingfisher (*Megaceryle alcyon*), to name a few. All of the fish and bird species surveyed are native to the eastern Great Lakes basin.

Non-native, invasive aquatic plants and animals were assessed within the study area. Various inventory methods were employed, including rake toss sampling, live trap sampling, horizontal plankton tow sampling, and visual observation. Invasive plant species were detected within the aquatic and riparian zones at each tributary site. Collectively, curly-leaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) are the most abundant and widespread aquatic invasive species. Other aquatic invasive species identified include brittle/slender naiad (*Najas spp.*), European frogbit (*Hydrcharis morsusranae*), variable watermilfoil (*Myriophyllum heterophyllum*), and water chestnut (*Trapa natans*). Terrestrial invasive species were observed along the channel margins; including, common reed grass (*Phragmites australis*), Japanese knotweed (*Reynoutria japonica*), purple loosestrife (*Lythrum salicaria*), and common buckthorn (*Rhamnus cathartica*). Populations of targeted invasive aquatic animals, consisting of round goby (*Neogobius melanostomus*), rusty crayfish (*Faxonius rusticus*), bloody red shrimp (*Hemimysis anomala*), and spiny water flea (*Bythotrephes longimanus*) were not detected in the study area.

Based on the findings of this Phase 1 study, recommendations for the most deserving areas to implement invasive species management are presented for each tributary. Invasive species management strategies are recommended for Japanese knotweed, common reed grass, purple loosestrife, European frogbit, and water chestnut. In addition, a monitoring program is recommended to prevent and detect new invasive plant and animal species from entering and establishing within the Priority Conservation Areas. Invasive species management will adhere to SLELO PRISM's integrated approach with emphasis on: prevention, early detection/rapid response, and education and outreach, as well as a tiered system to guide invasive species management, as follows:

- Tier 1 - Prevention/Early Detection Species
- Tier 2 - Eradication Species
- Tier 3 - Suppression Species
- Tier 4 - Local Control Species
- Tier 5 - Monitor Species

In addition, it's recognized that large-scale control of invasive species along waterways may require multiple management strategies centered around an ecosystem-based management approach, such as reducing turbidity and nutrient levels that enter waterways to lessen nutrient enrichment whereby aquatic invasive species flourish.

1 Introduction

The Nature Conservancy (TNC), under an agreement with the New York State Department of Environmental Conservation (NYSDEC), hosts the Saint Lawrence Eastern Lake Ontario Partnership for Regional Invasive Species Management (SLELO PRISM). SLELO PRISM delivers core functions of an invasive species management program in the Eastern Lake Ontario region. As part of the program, SLELO PRISM developed an Aquatic Restoration Initiative designed to identify the most deserving areas in need of eradication, suppression, restoration, or management of invasive species. The Aquatic Restoration Initiative is organized into three phases each with specific aspirations, as follows:

- Phase 1: conduct an initial baseline assessment of aquatic and riparian areas in target priority conservation areas within the Eastern Lake Ontario region and provide recommendations of most deserving areas for invasive species management;
- Phase 2: plan and implement an invasive species management and habitat restoration strategy; and
- Phase 3: perform monitoring of management of restored habitats.

The Phase 1: Aquatic and Riparian Invasive Species Inventory and Habitat Assessment was initiated in 2020. The methods and findings of the aquatic and riparian invasive species inventory and habitat assessment are presented in this Final Report, which is organized into the following sections:

- Section 1, Introduction, provides an overview of the project need and objective, study area and highly probable areas; as well as the project team and scope.
- Section 2, Methods, describes the methods to perform a literature review as well as aquatic invasive species and habitat assessment.
- Section 3, Results, describes the results of the aquatic and riparian invasive species and habitat assessment.
- Section 4, References, presents the literature cited in this Progress Report.

Based on the findings of Phase 1, it’s anticipated that Phases 2 and 3 activities will be implemented in subsequent years.

1.1 Project Need and Objective

Aquatic invasive species (AIS) and riparian invasive plants are non-native organisms whose introduction causes or is likely to cause harm to the environment, economy and/or human health. They are a form of biological pollution that originates from all around the world. A wide variety of species negatively impact many sectors of our global community including our food supplies, economies, human health, and ecosystems.

Invasive species are a leading threat to aquatic ecosystems, with ecological impacts ranging from behavioral shifts by native species to the complete restructuring of food webs (e.g., Simon and

Townsend 2003, Cucherouset and Olden 2011). For example, Eurasian watermilfoil *(Myriophyllum spicatum)* is an invasive aquatic plant native to Europe, Asia and North Africa. It was brought to North America and has since spread to almost every continental state and throughout Canada. Eurasian watermilfoil spreads easily and grows quickly. It crowds out native plants reducing biodiversity, diminishes fish habitat and negatively impacts wetland habitats. Additionally, dense mats of Eurasian milfoil can impact recreational activities on affected waterbodies by entangling boat propellers and interfering with swimming and fishing.

Continued shifts in commerce and climate will likely further accelerate the arrival and spread of invasive species (Rahel and Olden 2008). Current efforts to prevent and suppress invasive species populations are important, but without innovative and restorative plans being implemented, unintended negative anthropogenic impacts will continue to destabilize this system. With aquatic invasive species impacting the future of the Great Lakes, there's an opportunity to enhance a more diverse and resilient native ecosystem in the Eastern Lake Ontario region.

The objective(s) of Phase 1 are to inventory aquatic and riparian invasive species as well as assess habitat conditions within three priority conservation areas, which generally includes three tributaries that drain into the Eastern Lake Ontario basin. The Study Area is further described in Section 1.2 of this report. The results of the Phase 1 assessment serve as the foundation of this initiative by identifying the most deserving areas in need of suppression, restoration, and management of invasive species.

1.2 Study Area and Highly Probable Areas

The study area consists of the tailwaters of three tributaries: Sandy Creek (2.9 miles long), South Sandy Creek (2.0 miles long), and Deer Creek (2.8 miles long), which drain into Eastern Lake Ontario in Jefferson and Oswego Counties. Each tributary channel and its intermediate riparian zone were assessed from 50 meters beyond NYS Route 3 bridge(s) and extending to its confluence at Lake Ontario. According to the New York Natural Heritage Program, the study area is situated in the Great Lakes (Eastern Ontario) Plain Ecozone and Saint Lawrence-Champlain Valley Ecoregion (Edinger et al, 2016). Illustration 1-1 shows the ecozones and ecoregions throughout New York State as well as indicates the proximity of the study area.

SLELO PRISM has identified these tributaries as priority conservation areas. The tailwaters of Sandy Creek and South Sandy Creek are part of the Lakeview Wildlife Management Area (WMA). Similarly, Deer Creek is part of the Deer Creek Marsh WMA. These WMAs are part of the largest natural freshwater barrier beach system in New York State. NYSDEC has developed Habitat Management Plans (HMPs) for each respective WMA. Further details related to the habitat characteristics and management actions at Lakeview and Deer Creek Marsh WMAs are provided in Appendix A, Annotated Bibliography.

.

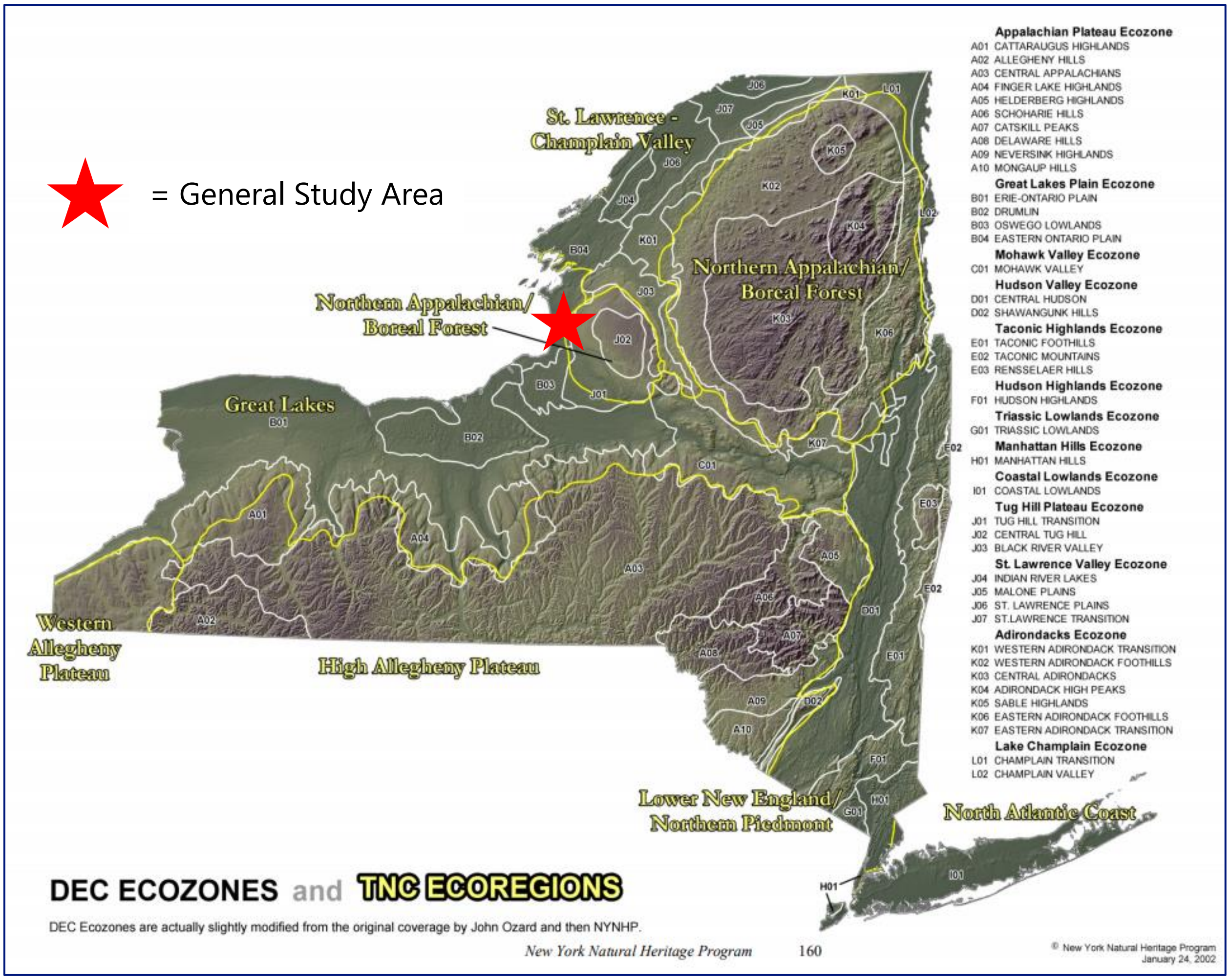


Illustration 1-1: New York State Ecozones and Ecoregions

For purposes of performing the fieldwork, each tributary was divided approximately into thirds along its length, and were designated as the upper reach, middle reach, and lower reach. Within each tributary, the presence of invasive species was assessed at highly probable areas (HPAs), which include those areas where human activities or site conditions that increase the probability of an invasive species becoming established. HPAs include several broad categories of aquatic environs according to SLELO PRISM as follows:

- Public boat launch sites, including car-top launches, unimproved ramps and improved concrete ramps;
- Public fishing access locations; and
- Quiet coves and shallow slow waters where plants may easily become established.

Probable HPAs were ascertained prior to the fieldwork based on reviewing aerial images and, ultimately, selected in the field based on observed field conditions.

1.3 Project Team

To support execution of Phase 1, TNC solicited the scope of services of a qualified consultant by means of a request for quote (RFQ). TNC selected Rootz, LLC as their Consultant. Matthew Biondolillo, Rootz' Owner and Principal Ecological Engineer, brought specialized expertise with understanding complexities associated with the natural environment, including experience of restoring aquatic and riparian ecosystems across the United States. Key project team members and contributing partners are as follows:

TNC

- Robert Williams, SLELO PRISM Program Manager
- Brittney Rogers, SLELO PRISM Aquatic Restoration and Resiliency Coordinator

Rootz, LLC

- Matthew Biondolillo, Principal Owner and Ecological Engineer

Contributing Partner Members

- NYSDEC - Regions 6 and 7 Wildlife Staff

1.4 Project Scope

The project scope was organized into four primary tasks, as follows:

- Task 01: Work Plan Preparation- included designing an approach (i.e., methods and schedule) to facilitate an invasive species inventory and habitat assessment.
- Task 02: Literature Review- included researching and reviewing available literature related to invasive species in the Eastern Lake Ontario tributaries.
- Task 03: Fieldwork– included inventorying invasive and native species observed in aquatic and intermediate riparian zones along three Eastern Lake Ontario tributaries.
- Task 04: Reporting- includes preparing a mid-season Progress Report and Final Report including an inventory of invasive species and recommendations for invasive species suppression and ecological site restoration.

In addition, TNC, with technical assistance from Rootz, applied for and received authorization for regulatory permits in support of performing the fieldwork at the Lakeview WMA and Deer

Creek Marsh WMA. NYSDEC issued the two permits for implementing the Phase 1 fieldwork, as follows: Temporary Revocable Permit and License to Collect or Possess (Scientific #2737). Regulatory permits are appended as Appendix B to this Final Report.

2 Methods

This section presents the methods used to perform the literature review (Task 02) and fieldwork (Task 03) as part of the Phase 1: Aquatic and Riparian Invasive Species Inventory and Habitat Assessment.

2.1 Literature Review

Rootz compiled and reviewed available literature related to the plant community in the Eastern Lake Ontario basin, focusing on the geographical area of this study. Available literature was requested from a variety of organizations, including but not limited to, the following: NYSDEC, New York Sea Grant and Tug Hill Commission. Assembled literature was reviewed to glean information regarding the presence of native and invasive plant and animal species resulting from previous studies and restoration efforts. Table 2-1 provides a summary of the key literature sources compiled and reviewed; however, it's not intended to be an exclusive list of literature.

Table 2-1: Summary of Key Literature Sources

Literature Title	Year	Literature Type
Habitat Management Plan for Lakeview Wildlife Management Area (2018-2027)	2018	Management Plan
Habitat Management Plan for Deer Creek Marsh Wildlife Management Area (2018-2027)	2018	Management Plan
Restoration of Eastern Lake Ontario Coastal Wetlands and Invasive Species Control.	2015	Technical Report
Ecological Communities of New York State	2014	Technical Report
Sandy Creeks Watershed Inventory and Landscape Analysis	2011	Technical Report
Sandy Creeks Watersheds: Baseline Conditions Report	2008	Technical Report
Vegetation of a Freshwater Dune Barrier under High and Low Recreational Uses	1998	Journal Article
Vegetative Analysis of Deer Creek Barrier Beach	1981	Technical Report
iMapInvasives	---	Worldwide Web

Complete literature citations are provided in Section 4, References. An overview the above literature sources are attached as Appendix A, Annotated Bibliography. In addition, a summary of characteristic ecological communities according to the New York Natural Heritage Program is captured below.

2.1.1 Characteristic Soils

Lakeview and Deer Creek WMAs are natural wetland complexes including a barrier beach, dunes, marshes, swamps and cold-water streams. The soil across much of these WMAs are seasonally inundated or poorly drained, with few exceptions of moderately well drained. Lakeview WMA includes soils from the Saprists and Aquents series (United States Department of Agriculture, Natural Resources Conservation Service Soils). Deer Creek Marsh WMA includes soils from the Wayland-Saprists-Flovaquents-Aquents series, Sodus-Scriba-Ira series, and Williamson-Wellington-Raynham-Niagara-Canaseraga series (Ibid.). The western boundary of each WMA is the dune system with sand beaches. The non-wetland soils, primarily around the edges of each WMA, are sand or silt loams. These soil types include, but are not limited to: Galway, Wayland, Massena, Windsor, and Deerfield. Vegetation is equally representative of the soil variability and has wide-ranging emergent marsh communities and limited forest growth and regeneration to only a percentage of each WMA.

2.1.2 Characteristic Ecological Communities

Lakeview and Deer Creek WMAs are natural wetland complexes consisting of productive ecological communities. An ecological community is defined as a variable assemblage of interacting plant and animal populations that share a common environment. The plants and animals in a community occupy a habitat, often shaping the habitat. Based on local knowledge of the geographic area, four key ecological communities that exist within the study area of the three tributaries include, but are not limited to: unconfined river, deep emergent marsh, shallow emergent marsh, and Great Lakes dunes (Edinger et al, 2016). These aforementioned ecological communities are described below.

<u>Unconfined River</u>

Although the middle of an unconfined river is usually too deep for aquatic macrophytes to occur, the shallow channel margins and backwaters typically have rooted macrophytes. Edinger (2016) identified that "characteristic submergent vascular plants may include naiad (*Najas flexilis*), pondweeds (*Potamogeton epihydrus, P. perfoliatus, P. spirillus*), bur-reed (*Sparganium fluctuans*), tapegrass or wild celery (*Vallisneria americana*), and Robbins spikerush (*Eleocharis robbinsii*). Floating aquatic macrophytes such as white water-lily (*Nymphaea spp*.) may be common in pools along shallow shores and in backwaters. Two non-native weeds, Eurasian milfoil (*Myriophyllum spicatum*) and water chestnut (*Trapa natans*) may also occur along shores and backwaters."

Fish characteristic of unconfined rivers in the St. Lawrence River and Eastern Lake Ontario region may include muskellunge (*Esox masquinongy*), yellow perch (*Perca flavescens*), white perch (*Morone americana*), walleye (*Stizostedion vitreum*), mooneye (*Hiodon tergisus*), longnose sucker (*Catostomus catostomus*), Iowa darter (*Etheostoma exile*), johnny darter

(*Etheostoma nigrum*), banded killifish (*Fundulus diaphanus*), spottail shiner (*N. hudsonius*), and blackchin shiner (*N. heterodon*).

Deep Emergent Marsh

Deep emergent marsh occurs on mineral or fine-grained organic soils that're flooded by waters and not subject to violent wave action. Water depths can range from 15 cm to 2 meter (0.5 to 6.6 ft) and water levels may fluctuate seasonally. The composition and structure of aquatic plant communities are quite variable in deep emergent marsh habitat. They may have a single dominant species, or be co-dominated by a mixture of species.

Edinger (2016) stated "in shallower areas, the most abundant emergent aquatic plants are cattails (*Typha angustifolia, T. latifolia, T. x glauca*), wild rice (*Zizania aquatica*), bur-reeds (*Sparganium eurycarpum, S. androcladum*), pickerel weed (*Pontederia cordata*), bulrushes (*Schoenoplectus tabernaemontani, S. heterochaetus, S. acutus, S. pungens, S. americanus Bolboschoenus fluviatilis*), arrowhead (*Sagittaria latifolia*), arrowleaf (*Peltandra virginica*), rice cutgrass (*Leersia oryzoides*), bayonet rush (*Juncus militaris*), water horsetail (*Equisetum fluviatile*) and bluejoint grass (*Calamagrostis canadensis*).

The most abundant floating-leaved aquatic plants interspersed with emergents include fragrant water lily (*Nymphaea odorata*), duckweeds (*Lemna minor*, *L. trisulca*), pondweeds (*Potamogeton natans, P. epihydrus, P. friesii, P. oakesianus, P. crispus, P. pusillus, P. zosteriformis, P. strictifolius*), common yellow pond-lily (*Nuphar variegata*), frog's-bit (*Hydrocharis morsus-ranae*), watermeal (*Wolffia spp*.), and water-shield (*Brasenia schreberi*).

The most abundant submerged aquatic plants are pondweeds (*Potamogeton richardsonii, P. amplifolius, P. spirillus, P. crispus, P. zosteriformis*), coontail (*Ceratophyllum demersum*), stonewort (*Chara globularis*), water milfoils (*Myriophyllum spicatum, M. sibericum*), pipewort (*Eriocaulon aquaticum*), tapegrass or wild celery (*Vallisneria americana*), a thallose liverwort (*Riccia fluitans*), naiad (*Najas flexilis*), water lobelia (*Lobelia dortmanna*), waterweed (*Elodea canadensis*), water stargrass (*Heteranthera dubia*), and bladderworts (*Utricularia macrorhiza, U. intermedia*).

Characteristic birds with varying abundance include swamp sparrow (*Melospiza georgiana*), red-winged blackbird (*Agelaius phoeniceus*), marsh wren (*Cistothorus palustris*), American bittern (*Botaurus lentiginosus*), Virginia rail (*Rallus limicola*), and pied-billed grebe (*Podilymbus podiceps*)."

Shallow Emergent Marsh

A shallow emergent marsh is a marsh meadow community that occurs on mineral soil or deep muck soils, that are permanently saturated and seasonally flooded. Water depths may range from

0.5 to 3.3 ft. during flood stages, but the water level usually lower by middle to late summer and the substrate is exposed during an average year. Shallow emergent marshes are very common and quite variable. They may be co-dominated by a mixture of species, or have a single dominant species.

Great Lakes Dunes

Great Lakes dunes are a community dominated by grasses, shrubs and trees that occur on sand dunes along the shores of the Great Lakes. The composition and structure of the community is variable depending on stability of the dunes; the amount of sand deposition and erosion; and distance from the lake. Great Lake dunes can be divided into six physiographic zones: 1) beach, 2) foredune front, 3) foredune back and swale, 4) secondary dunes, 5) last lee face of high dune, and 6) last lee face of low dune.

Each of these zones may develop any one to several vegetative community types (Bonanno 1998). Characteristic plant species in the beach and foredune zones include beachgrass (*Ammophila breviligulata, A. champlainensis*), tall wormwood (*Artemisia campestris ssp. caudata*), sand dune willow (*Salix cordata*), sand dropseed (*Sporobolus cryptandrus*), beach pea (*Lathyrus japonicus var. maritimus*), riverbank grape (*Vitis riparia*), poison ivy (*Toxicodendron radicans*), and cottonwood (*Populus deltoides*). Other characteristic shrubs and vines with low percent cover include red osier dogwood (*Cornus serice*a), silky dogwood (*C. amomum*), sand cherry (*Prunus pumila var. pumila*), and bittersweet (*Celastrus scandens*).

An open forest canopy commonly include red oak (*Quercus rubra*), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), striped maple (*Acer pensylvanicum*), serviceberries (*Amelanchier spp*.), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), chokecherry (*Prunus virginiana*), blackberry (*Rubus allegheniensis*), red raspberry (*Rubus idaeus*), nannyberry (*Viburnum lentago*), arrowwood (*V. dentatum var. lucidum*), wild sarsaparilla (*Aralia nudicaulis*), and wreath goldenrod (*Solidago caesia*).

More information regarding the characteristic ecological communities in New York State is provided in Appendix A, Annotated Bibliography. In addition, the Natural Heritage Program (2011) has documented several rare plants, animals, and significant natural communities that exist within the Sandy Creeks watershed. The western pirate perch (*Aphredoderus sayanus gibbosus*), piping plover (*Charadrius melodus)*, black tern (*Chlidonias niger*), Least Bittern (*Ixobrychus exilis*) and northern harrier (*Circus cyaneus*) are examples of rare animals that're part of the biodiversity of this area.

2.1.3 Invasive Species Management

Consistent with SLELO PRISM's mission, invasive species management involves a collaborative and integrated approach with emphasis on: prevention, early detection, rapid response, and education and outreach (Williams 2019). Preventing the introduction of new invasive terrestrial and aquatic plant and animal species not currently found in the SLELO region is the number one priority. Early detection and rapid response for new species help to eradicate new infestations and to contain and/or suppress species populations upon initial detection. Educating the general public on various issues related to invasive species is at the forefront of any long-term management effort.

SLELO PRISM has developed a tiered system to guide invasive species management, as follows:

- **Tier 1** – Prevention/Early Detection Species. Not in PRISM, but within a 100-mile buffer or introduction pathway exists. Highest level of early detection survey efforts.
- **Tier 2** – Eradication Species. Present in PRISM, but at low abundance making eradication feasible within Priority Conservation Areas.
- **Tier 3 -**Suppression Species. Too widespread for eradication from PRISM. Targeted management to suppress the population within Priority Conservation Areas.
- **Tier 4** – Local Control Species. Present/widespread throughout PRISM with no chance of eradication. Localized, landowner management applied to protect high priority resources like rare plant or recreation assets.
- **Tier 5** – Monitor Species. These are species that may or may not be in PRISM but are difficult to respond to or that require more knowledge of (Ibid.)

SLELO's tiered system supports prioritizing species and communicating appropriate management actions between other NY PRISMs and partners.

NYSFOLA (2009) identified a core group of aquatic plant management strategies that have been used in New York State, as follows:

- "physical control strategies that impact the physical growth patterns of the weeds by disturbing the sediment, altering light transmission through the water or to the plants, or water-level manipulation;
- mechanical control strategies that remove the plants and root systems, such as cutting, harvesting, and rotovating;
- chemical control strategies, such as herbicides that are toxic to all or selected aquatic plants; and
- biological control strategies, such as herbivorous fish and insects that are predators consuming enough plant matter to reduce growth below nuisance levels."

An important understanding is that there is no 'magic bullet', no single strategy that will work on all invasive species problems. AIS management, similar to the larger goal of watershed management, involves the delicate process of evaluating and selecting the most feasible management strategy, building consensus toward the use of a selected strategy, implementing the strategy using conventional and/or innovative methods, monitoring the resulting changes to the target plant population(s), and adapting the strategy based on observed conditions in order to achieve a desired outcome. In many cases, multiple strategies are implemented jointly as an integrated plant management approach.

2.2 Aquatic Invasive Species Inventory and Habitat Assessment

Invasive and native aquatic plants and animals were assessed within the study area. Field personnel used a small, shallow-draft watercraft (i.e., flat-bottom boat and canoe, see Illustration 2-1), which enabled navigating the tributary channels and maneuvering into shallow water areas. Inventory and assessment methods included:

- rake toss sampling,
- live trap sampling,
- horizontal plankton tow sampling, and
- visual observation.

Sampling methods were comparable amongst each tributary. Information collected in the field were recorded on electronic data forms using a Samsung® tablet. The methods are further described in this section.

Illustration 2-1: Small, shallow-draft watercraft

2.2.1 Aquatic Plants

2.2.1.1 Rake Toss Sampling

Aquatic plants were examined and inventoried using rake toss plant survey techniques developed by Madsen (United States Army Corps of Engineers, 1999) and Lord (Cornell University, 2006), and adopted by the NYSDEC and New York State Federation of Lake Association (NYSFOLA). This survey technique is based on a point intercept method; whereby, aquatic plants are assessed linearly between two points. Rake toss sampling sites were selected based on HPAs identified within the upper, middle and lower reaches for each tributary. At each sampling location, rake tosses were performed on both sides of the boat (port and starboard) and designated as 'A' and 'B' as part of the sample identification, accordingly.

Aquatic plants were collected by tossing a rake apparatus (commonly referred to as the weed anchor, see Illustration 2-2) into the waterbody, letting the rake settle to the bottom, and slowly retrieving the weed anchor to the boat. The weed anchor consists of two standard 13" long garden rake heads secured back to back and fastened to a rope. Aquatic plant density or whole rake abundance was estimated in accordance with established abundance scale developed by Madsen (Ibid) and Lord (Ibid), as follows:

Illustration 2-2: Rake toss sampling equipment (weed anchor)

- Zero = no plants on rake
- Trace = fingerful (1-2 stems) on rake
- Sparse = handful (3-6 stems) on rake
- Medium = most to all rake tines covered with plants
- Dense = difficult to bring into boat

Illustration 2-3 demonstrates a *dense* whole rake plant abundance, as described above. Subsequently, plant mass was separated into different species and each species was assigned a relative abundance.

Illustration 2-3: Rootz staff holding a whole rake plant abundance - dense

Data collected using rake toss sampling methods were recorded electronically on a Samsung® tablet, as further described in Section 2.3 below. Data gathered by rake toss sampling included sample identification, date/time, sample coordinates (i.e., northing and easting), water depth, whole rake abundance, as well as the presence and relative abundance of native (e.g., floating-leaf pondweed, eel grass, and common waterweed) and invasive aquatic plant species (e.g., Eurasian watermilfoil, curly-leaf pondweed, and water chestnut). Rake toss sampling results are presented in Section 3 of this report.

2.2.1.2 Visual Observations

Visual surveys were conducted at select sampling locations and, generally, while navigating throughout the tributary in a watercraft. The presence of dominate native and invasive plant species that form the aquatic and riparian habitat conditions were recorded manually in a field logbook and/or electronically on the tablet. In addition, at certain sampling locations, the presence of floating native and invasive plant materials was recorded on electronic forms.

2.2.2 Aquatic Animals

2.2.2.1 Plankton Tow Sampling

Plankton tow sampling was performed within each tributary. Three plankton samples were collected from each tributary, consisting of one sample each from the upper, middle and lower reaches. Bloody red shrimp (*Hemimysis anomala*) and spiny water flea (*Bythotrephes longimanus*) were the targeted AIS.

Plankton tow sampling was conducted consistent with the standard operating procedure for Collection of Zooplankton Samples Using a Horizontal Net Tow, which is appended as Appendix C to this report. Generally, plankton samples were collected using a 30 cm x 90 cm x 250 microns-mesh net towed horizontally through the water column over a distance of approximately 50 meters at the back of a small watercraft. Each plankton sample was rinsed from the end cup assembly into a glass container, labeled with a unique sample identification, filled with 80% ethanol preservative, and stored in a cooler with wet ice.

Illustration 2-4: Zooplankton Sampling Net (Photograph courtesy of Aquatic Research Instruments)

Plankton samples were provided to SLELO PRISM for examination under a microscope. Plankton samples were assessed for zooplankton taxa present and community composition, with a focus on percent native versus invasive species. Data collected using plankton toss sampling methods were recorded into the Survey 123™ and SAS Pro™ software programs. Plankton tow sampling results are presented in Section 3.

2.2.2.2 Live Trap Sampling

Live trap sampling was performed within each tributary. Live trap sets, which consisted of one oval metal trap (‘A’), which targeted small fishes, and one rectangular metal trap (‘B’), which targeted crayfish, were deployed within the upper, middle and lower reaches of each tributary.

As a result, three live trap sampling locations were established in each tributary. The target AIS included the round goby (*Neogobius melanostomus*) and rusty crayfish (*Faxonius rusticus*).

Illustration 2-5: Live traps for targeted small fish (A) and crayfish (B)

Live trap sets were typically deployed in shallow water along the channel margin and secured to large woody debris, which provides suitable habitat for many aquatic anaimals. Each trap was baited using rib meat from filleted fish. After approximately 24 - 48 hours following deployment, the live traps were gathered and examined for aquatic species. Aquatic species present in the live traps were recorded in the integrated Survey 123™ and SAS Pro™ software programs on an electronic tablet. In general, data collected included sample ID, type and size of trap, type of bait, water depth, sampling duration, species collected (type/quantity), presence of fish species (native and invasive), and comments/notes. Live trap sampling results are presented in Section 3 of this Report.

2.2.2.3 Visual Observations

A variety of wildlife were observed visually while navigating through the waterbody. Properly identified fish and bird species were recorded in the field logbook.

2.3 Sample Identification and Field Documentation

Samples were identified with a unique designation system to facilitate sample tracking. The sample designation system employed during the sampling activities was consistent, yet flexible enough to accommodate unforeseen sampling events and conditions. An alpha-numeric system was used by field personnel to assign each sample with a unique sample identification number, as follows: *Tributary Site-Reach-Sample Type/Number- Date*

- Tributary Site: a two or three-digit identifier including South Sandy Creek (SSC), Sandy Creek (NSC) and Deer Creek (DC)
- Reach: a two-digit identifier including Upper (UP), Middle (MI), Lower (LO)
- Sample Type: a three-digit identifier including Rake Toss Sample (RTS), Live Trap Sample (LTS), Plankton Tow Sample (PTS)

- Sample Number: a two-digit sample number was assigned to the sample type and incremented by one as samples were collected from one to the next (i.e., 01, 02, 03, etc.).
    - In addition, an 'A' and 'B' suffix were added to collocated grab samples associated with rake toss sampling and live trap sampling
- Date: a six-digit date including two digits each for the month/day/year

Information collected in the field were recorded on electronic data forms using a Samsung® tablet. Data were recorded using ESRI's Survey 123™ software program integrated with Simple Aquatic Survey (SAS) Pro, which was developed by New York Natural Heritage Program (NYNHP). One notable feature is that invasive species data entered into Survey 123 software is automatically uploaded into iMapInvasives, which is also maintained by NYNHP. The tablet was paired to a Garmin GLO™ 2 Portable global navigation satellite system (GLONASS) and global positioning system (GPS) sensor to enhance the accuracy of geolocation survey information. Upon availability of online connectivity at the end of each field day, data were uploaded into TNC's server for purposes of data management and security.

2.4 Equipment Decontamination

Field equipment was decontaminated prior to and between sampling sites to remove foreign particles (i.e., invasive species); thereby, preventing the spread of invasive species between tributary sites. Decontamination methods included physically removing foreign matter (i.e., leaves and stems); washing field equipment using high-pressured water; and drying in the sun.

Illustration 2-6: Small vessels and field gear following equipment decontamination

3 Results

This section presents the results of the Phase 1: Aquatic and Riparian Invasive Species Inventory and Habitat Assessment. The aquatic plant and animal species assessed and inventoried by sampling methods and visual observation are described for Sandy Creek, South Sandy Creek, and Deer Creek.

3.1 Sandy Creek

3.1.1 Aquatic Plants

A total of 18 rake toss sampling events were performed in Sandy Creek, consisting of seven rake tosses in the upstream reach, five rake tosses in the middle reach, and six rake tosses in the lower reach. Rake toss sampling locations are illustrated in Figure 1. At each sampling location, congruent rake tosses, which were labeled 'A' and 'B', were performed on the port and starboard sides of the boat. Native and invasive aquatic plants detected in each reach is summarized in Table 3-1 below. Data collected (i.e., rake toss ID, date/time, coordinates, water depth, and whole rake plant mass abundance) for each rake toss sampling location are summarized in Table 1: Rake Toss Sampling Results.

Table 3-1: Aquatic Plants Presence per Reach in Sandy Creek

Aquatic Plant Species (Common/Scientific Name)	Upper Reach	Middle Reach	Lower Reach
Submersed			
Common bladderwort (*Utricularia macrorhiza*)			X
Common waterweed (*Elodea canadensis*)	X		X
Coontail (*Ceratophyllum demersum*)		X	X
Curly-leaf pondweed (*Potamogeton crispus*)	X		X
Eurasian watermilfoil (*Myriophyllum spicatum*)	X		X
Floating-leaf pondweed (*Potamogeton natans*)	X		
Flat-stem pondweed (*Potamogeton zosterformis*)	X	X	X
Freshwater eelgrass (*Vallisneria american*)	X	X	X
Naiad species (brittle and/or slender, *Najas* spp.)		X	X
Narrow-leaf pondweed (*Potamogeton pusillus*)	X		
Variable watermilfoil (*Myriophyllum heterophyllum*)		X	
Water chestnut (*Trapa natans*)			X
White-stem pondweed (*Potamogeton praelongus*)			
Floating			
White water lily (*Nymphaea odorata*)		X	X

1. Aquatic plants colored red represent non-native, invasive species.

As documented above, a variety of native and invasive aquatic plants (submersed and floating) were detected in Sandy Creek. In line with Edinger et al. (2016), the middle of the unconfined river was usually too deep for aquatic macrophytes to occur, but the shallow shores and backwaters typically have rooted macrophytes. Based on rake toss sampling and visual observation, native and invasive species generally co-inhabit the shallow water depths (1.0 to 5.0 ft) along the channel margins. Pondweed species (i.e., floating-leaf and flat-stem) and coontail represent the most abundant native aquatic plants. White water lily was inventoried as the most abundant floating aquatic plant. Other native, aquatic species detected include common bladderwort, common waterweed, eel grass, and narrow-leaf pondweed. Invasive species detected include brittle/slender naiad, curly leaf pondweed, Eurasian watermilfoil, variable watermilfoil, and water chestnut. Target AIS, consisting of water thyme (*Hydrilla verticillata*), fanwort (*Cabomba caroliniana*), and water hyacinth (*Eichhornia crassipes*) were not detected within the tributary.

Edinger et al. (2016) acknowledged characteristic submergent vascular plants may include naiad (*Najas spp.*), pondweeds (*Potamogeton epihydrus, P. perfoliatus, P. spirillus*), bur-reed (*Sparganium fluctuans*), tapegrass or wild celery (*Vallisneria americana*), and Robbins spikerush (*Eleocharis robbinsii*). Floating aquatic macrophytes, such as white water-lily (*Nymphaea spp*.), may be common in shallow shores and backwaters. Two non-native weeds, Eurasian milfoil (*Myriophyllum spicatum*) and water chestnut (*Trapa natans*) may also occur along shores and backwaters.

3.1.2 Aquatic Animals

A total of three live trap sets, consisting one sample each from the upper, middle and lower reaches, were deployed in Sandy Creek. Live trap sampling locations are illustrated in Figure 2. Juvenile yellow perch (*Perca flavescens*) and bluegill (*Lepomis macrochirus*) species were captured in the live traps. These fish species are native to the eastern Lake Ontario basin and; therefore, released back to the waterbody. The target AIS, consisting of the round goby and rusty crayfish, were not captured in the live trap sets. Data collected (i.e., trap identification, trap retrieval date/time, coordinates, water depth, bed substrate, duration, target species, bait, presence of aquatic species, and present aquatic species) at each live trap sampling location are summarized in Table 2: Live Trap Sampling Data.

A total of three horizontal plankton tow samples were collected in Sandy Creek, consisting of one each from the upper, middle and lower reaches. Plankton tow sampling locations are illustrated in Figure 2. Plankton tow samples are being examined by SLELO PRISM staff. The final results of the plankton tow samples will be appended to this report as Appendix D.

3.1.3 Habitat Conditions

The presence of dominant native and invasive plant species that form the riparian habitat were assessed while navigating throughout the tributary in a small watercraft. Representative photographs of ecological communities inhabiting Sandy Creek are provided in Appendix E.

In the upper reach, a varying width riparian zone is nestled between agricultural lands and the tributary channel. The riparian habitat consists of a variety of native trees, shrubs, and grasses. Black willow (*Salix nigra*) is the dominate tree species, with some box elder (*Acer negundo*) intermixed. The entire tree (e.g., canopy, logs and roots) provide detritus, shade, shelter and food for fish and other aquatic animals. Sandy Creek branches at the northern end of Seamans Island. Seasonal houses with maintained turf lawns exist along the southern end of Seamans Island. In the downstream portion of the upper reach, one stand of Japanese knotweed was observed and recorded within the riparian zone adjacent to Seaman's Island Road near the private boat launch. The stand is approximately 100 ft long x 15 ft wide, which equates to a surface area of 1,500 sf (0.03 acres). Individual non-native purple loosestrife (*Lythrum salicaria*) plants were observed along the channel margins.

The middle reach of Sandy Creek winds through the Lakeview WMA. In upland areas, black willow stands and emergent marsh are the dominant ecological communities in the riparian zone. Characteristic emergent plants include cattail (Typha spp.), bullrushes (*Scirpus* or *Schoenoplectus* spp.), and arrowhead (*Sagittaria latifolia*). In addition, two apparent stands of native common reed grass were observed bordering the channel. Individual and groups of purple loosestrife plants were observed amongst the emergent marsh along the channel margins (see Illustration 3-1).

Illustration 3-1: Emergent Marsh Vegetation

In the lower reach, sand dunes arise at the channel confluence with Lake Ontario. The most dominant observed native terrestrial plants observed populating the sand dune are listed in Table 3-2.

A variety of fish and bird species were visually observed within the channel and intermediate riparian zone. Small schools of juvenile largemouth bass (*Micropterus salmoides*), yellow perch and bluegill were observed swimming in shallow water areas. Based on personal communication with a local fisherman, he successfully caught two gamefish species: largemouth bass and northern pike (*Esox lucius)*. These freshwater fish species are common in the Eastern Great Lakes basin as well as other waterbodies throughout North America. Bird species identified making use of the aquatic and surrounding riparian habitats are as follows: Canada geese (*Branta canadensis*), Great blue heron (*Ardea herodias*), wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), belted kingfisher (*Megaceryle alcyon*), osprey (*Pandion haliaetus*), and common tern (*Sterna hirundo*).

Table 3-2: Dominant Terrestrial Plants that Form the Riparian Habitat

Common Name	Scientific Name
Channel Bank (Mineral Soil)	
black willow	*Salix nigra*
speckled alder	*Alnus incana*
common burdock	*Arctium lappa*
common boneset	*Eupatorium perfoliatum*
common jewelweed	*Impatiens capensis*
eastern daisy fleabane	*Erigeron annuus*
giant foxtail	*Setaria faberi*
goldenrod	*Solidago* spp.
goutweed	*Aegopodium podagraria*
horsenettle	*Solanum carolinense*
Jerusalem artichoke	*Helianthus tuberosus*
joe-pye weed	*Aegopodium podagraria*
New England aster	*Symphyotrichum novae-angliae*
ostrich fern	*Matteuccia struthiopteris*
riverbank grape	*Vitis riparia*
rough cocklebur	*Xanthium strumarium*
Sand Dune (Sandy Soil)	
beach grass	*Ammophila* spp.
chokecherry	*Prunus virginiana*
common buckthorn	*Rhamnus cathartica*
common milkweed	*Asclepias syriaca*
cottonwood	*Populus deltoides*
dune willow	*Salix hookeriana*
eastern red cedar	*Juniperus Virginiana*
evening primrose	*Oenothera biennis*
grape	*Vitis* spp.
poison ivy	*Toxicodendron radicans*
seaside pea	*Lathyrus japonicus*
spotted knapweed	*Centaurea stoebe*
white sweet clover	*Melilotus alba*
wormwood	*Artemisia absinthium*

1. Terrestrial plants colored red represent non-native, invasive species.

3.2 South Sandy Creek

3.2.1 Aquatic Plants

The aquatic plant community in the study area of South Sandy Creek was inventoried and assessed using rake toss techniques. A total of 15 rake toss sampling events were performed in South Sandy Creek, consisting of five rake tosses in the upstream reach, five rake tosses in the middle reach, and five rake tosses in the lower reach. Rake toss sampling locations are illustrated in Figure 3. At each sampling location, corresponding rake tosses were performed on the port and starboard sides of the boat. An overview of native and invasive aquatic plants detected in each reach is presented in Table 3-3 below. Data collected (i.e., rake toss ID, date/time, coordinates, water depth, and whole rake plant mass abundance) for each rake toss sampling location are presented in Table 1.

Table 3-3: Aquatic Plants Presence per Reach in South Sandy Creek

Common/Scientific Name	Upper Reach	Middle Reach	Lower Reach
Submersed			
Common bladderwort (*Utricularia macrorhiza*)			X
Common waterweed (*Elodea canadensis*)	X	X	X
Coontail (*Ceratophyllum demersum*)		X	X
Curly-leaf pondweed (*Potamogeton crispus*)	X	X	X
Eurasian watermilfoil (*Myriophyllum spicatum*)	X		X
Floating-leaf pondweed (*Potamogeton natans*)	X	X	X
Flat-stem pondweed (*Potamogeton zosterformis*)			X
Freshwater eelgrass (*Vallisneria american*)	X	X	X
Naiad species (brittle and/or slender, *Najas* spp.)	X	X	X
Narrow-leaf pondweed (*Potamogeton pusillus*)	X	X	X
Richardson pondweed (*Potamogeton richardsonii*)	X	X	X
Variable watermilfoil (*Myriophyllum heterophyllum*)			
Water chestnut (*Trapa natans*)			
White-stem pondweed (*Potamogeton praelongus*)	X		
Floating			
White water lily (*Nymphaea odorata*)			X
Emergent			
Arrowhead (*Sagittaria latifolia*)		X	X

1. Aquatic plants colored red represent non-native, invasive species.

As shown above, a variety of native and invasive aquatic plants (submersed, floating and emergent) were detected within South Sandy Creek. Both native and invasive species generally co-inhabit the shallow water depths (1.0 to 5.0 ft) along the channel margins. Collectively, pondweed species (i.e., floating-leaf, narrow-leaf, Richardson, and flat-stem), common waterweed, and freshwater eelgrass represent the most abundant and widespread native, submersed aquatic plants. Other native, aquatic plant species detected include common bladderwort, slender naiad, and white-stem pondweed. AIS detected include brittle naiad, curly leaf pondweed, and Eurasian watermilfoil. It shall be noted that variable watermilfoil and water chestnut were not detected in South Sandy Creek, but were observed in Sandy Creek, this is likely due to the extensive management conducted by NYS DEC and partners. In addition, target AIS, consisting of water thyme, fanwort, and water hyacinth were not detected within the study area.

3.2.2 Aquatic Animals

A total of three live trap sets, including one sample each from the upper, middle and lower reaches, were deployed in South Sandy Creek. Live trap sampling locations are illustrated in Figure 4. Yellow perch (juvenile), bluegill (juvenile), and darter species were captured in the collective live traps. These fish species are native to the Eastern Lake Ontario basin and, thereby, were released back to the waterbody. The target aquatic invasive species, consisting of the round goby and rusty crayfish, were not present in the live traps. Data collected (i.e., trap identification, trap retrieval date/time, coordinates, water depth, bed substrate, duration, target species, bait, presence of aquatic species, and present aquatic species) at each live trap sampling location is summarized in Table 2: Live Trap Sampling Data.

A total of three plankton tow samples were collected in South Sandy Creek, consisting of one each from the upper, middle and lower reaches. Plankton tow sampling locations are illustrated in Figure 4. Plankton tow samples are being examined by SLELO PRISM staff and will be appended to this report as Appendix D.

3.2.3 Habitat Conditions

The presence of dominant native and invasive plant species that form the riparian habitat were assessed while navigating throughout the tributary in a small watercraft. Representative photographs of South Sandy Creek are appended as Appendix E.

In the upper reach, a variety of native trees, shrubs, and grasses comprise the riparian habitat. Black willow is the dominate tree species. Box elder (*Acer negundo*) and cottonwood (*Populus deltoides*) were also observed in lesser quantities. Large woody debris was observed regularly throughout the upper reach. Representative native grasses and vines dwelling in the upland areas presented in Table 3-2 above.

Japanese knotweed, an invasive terrestrial species, was observed along both creek banks within the upper reach, as illustrated on Figure 8. The areal coverage of Japanese knotweed along the northern and southern riparian zones is roughly estimated at 1.2 acres and 0.8 acre, respectively, over approximately 0.7-mile length of the tributary. The distribution of Japanese knotweed varied from single clumps/patches (trace) to large thick stands (dense). Similarly, the percent cover varied mostly from 25 – 75%, because in most cases it's intermixed with other terrestrial plant species (see Illustration 3-2). Japanese knotweed appeared to proliferate more abundantly in the absence of a tree canopy, where sunlight is more accessible. It shall also be noted that Japanese beetles (*Popillia japonica*) were observed feeding on the Japanese knotweed plants. This behavior represents a form of biological control. While present, individual plants and small patches of purple loosestrife were observed in lesser quantity.

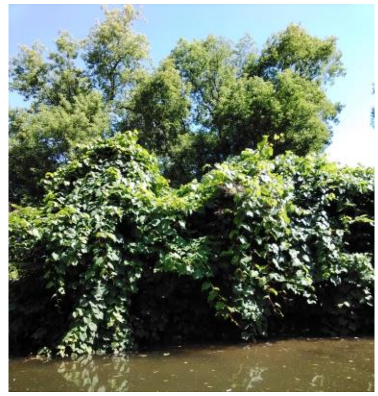


Illustration 3-2: Japanese Knotweed Along Riparian Zone

The middle reach of South Sandy Creek winds through the Lakeview WMA. Along the tributary banks, black willow stands and emergent marsh vegetation are the dominant riparian habitat structure. Characteristic emergent plants include cattail, bullrushes, and arrowhead. An isolated patch of invasive common reed grass was observed at the beginning of the middle reach. Purple loosestrife was observed as individual plants and small patches amongst the emergent marsh habitat along the channel margins.

In the lower reach, sand dunes arise along the southern bank near its confluence with Lake Ontario. The native terrestrial plants observed populating the sand dune are listed in Table 3-2. Common buckthorn, an invasive species, was detected occupying the sand dune.

A variety of fish and bird species were visually observed within the channel and intermediate riparian zone. Small schools of juvenile largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), yellow perch and bluegill were observed swimming in shallow water areas. A local fisherman at the public boat launch had caught several bluegill (based on personal communication). Bird species identified making use of the channel habitat and surrounding riparian habitat are as follows: Canada geese (*Branta canadensis*), Great blue heron (*Ardea Herodias*), wood duck (*Aix sponsa),* mallard (*Anas platyrhynchos*), belted kingfisher (*Megaceryle alcyon*), northern harrier (*Circus hudsonius*), red-tailed hawk (*Buteo jamaicensis*), and common tern (*Sterna hirundo*).

3.3 Deer Creek

3.3.1 Aquatic Plants

The aquatic plant community in the Deer Creek study area was assessed and inventoried using rake toss techniques. A total of 19 rake toss sampling events were performed in Deer Creek, consisting of five rake tosses in the upstream reach, seven rake tosses in the middle reach, and seven rake tosses in the lower reach. Rake toss sampling locations are illustrated in Figure 5. At each sampling location, corresponding rake tosses were performed on the port and starboard sides of the boat. Data collected for each rake toss sampling location are summarized in Table 1. Native and invasive aquatic plants detected in each reach are summarized in Table 3-4 below.

Table 3-4: Aquatic Plants Presence per Reach in Deer Creek

Aquatic Plant Species (Common/Scientific Name)	Upper Reach	Middle Reach	Lower Reach
Submersed			
Common bladderwort (*Utricularia macrorhiza*)			X
Common waterweed (*Elodea canadensis*)	X	X	X
Coontail (*Ceratophyllum demersum*)	X	X	X
Curly-leaf pondweed (*Potamogeton crispus*)	X	X	
Eurasian watermilfoil (*Myriophyllum spicatum*)	X	X	X
Floating-leaf pondweed (*Potamogeton natans*)	X	X	
Flat-stem pondweed (*Potamogeton zosterformis*)	X	X	X
Freshwater eelgrass (*Vallisneria americana*)			
Naiad species (brittle and/or slender, *Najas* spp.)		X	X
Narrow-leaf pondweed (*Potamogeton pusillus*)	X		
Richardson pondweed (*Potamogeton richardsonii*)	X		
Variable watermilfoil (*Myriophyllum heterophyllum*)			
Water chestnut (*Trapa natans*)			
Whorled watermilfoil (*Myriophyllum verticillatum)*			X
White-stem pondweed (*Potamogeton praelongus*)	X		
Floating			
European frogbit (*Hydrcharis morsusranae*)	X	X	X
White water lily (*Nymphaea odorata*)	X	X	X
Yellow water lily (*Nymphaea odorata*)		X	
Emergent			
Arrowhead (*Sagittaria latifolia*)	X	X	X

1. Aquatic plants colored red represent non-native, invasive species.

As shown above, a variety of native and invasive aquatic plants (submersed and floating) were detected within Deer Creek. Both native and invasive species generally coexist in the shallow water depths (1.0 to 5.0 ft) along the channel margins. Collectively, pondweed (i.e., floating-leaf and flat-stem subspecies), common waterweed, and coontail represent the most abundant and widespread native, submersed aquatic plants. Other native, submersed plant species detected include common bladderwort, pondweed subspecies (i.e., narrow-leaf, Richardson, and white-stem), and slender naiad. Aquatic invasive species detected include brittle naiad, curly-leaf pondweed, Eurasian watermilfoil, European frogbit, and whorled watermilfoil. Target AIS, consisting of water thyme, fanwort, and water hyacinth were not detected within the study area.

3.3.2 Aquatic Animals

A total of three live trap sets, including one set each from the upper, middle and lower reaches, were deployed in Deer Creek. Live trap sampling locations are illustrated in Figure 6. A northern crayfish (*Orconectes propinquus*) was captured in the upstream reach. A young-of-year brown bullhead (*Ameiurus nebulosus*) was captured in the live trap set in the lower reach. These species are native to the eastern Great Lakes region. Data collected (i.e., trap identification, trap retrieval date/time, coordinates, water depth, bed substrate, duration, target species, bait, presence of aquatic species, and present aquatic species) at live trap sampling locations are summarized in Table 2: Live Trap Sampling Data. The target aquatic invasive species, consisting of the round goby and rusty crayfish, were not present in the live traps.

A total of three plankton tow samples were collected in Deer Creek, consisting of one each from the upper, middle and lower reaches. Plankton tow sampling locations are illustrated in Figure 6. Plankton tow samples are being examined by SLELO PRISM staff and will be added to this report as an appendix.

3.3.3 Habitat Conditions

The presence of dominant native and invasive plant species that form the riparian habitat were assessed while navigating throughout the tributary in a small watercraft. Photographs of Deer Creek are provided in Appendix E.

In the upper reach, a variety of native trees, shrubs, and grasses comprise the riparian habitat. Black willow, box elder and oak (*Quercus spp*.) were observed within the terrestrial riparian zone. Speckled alder (*Alnus incana*) is the dominant wetland shrub observed within the emergent marsh habitat of the riparian zone. Non-native purple loosestrife was present along both creek banks within the upper reach. Native grasses and vines included ostrich fern, horsenettle, common boneset, joe-pye weed, and riverbank grape. Large woody debris was observed regularly throughout the upper reach.

Illustration 3-2: Purple Loosestrife Intermixed with Other Emergent Plants within the Riparian Zone

The middle reach of Deer Creek winds through Deer WMA. Native species consisting of common cattail and arrowhead form the base of the emergent marsh habitat. Other native species, including speckled alder, buttonbush, swamp rose mallow, and swamp loosestrife, are also present amongst the emergent marsh habitat. Individual and clusters of non-native purple loosestrife were observed amongst the emergent marsh habitat along both channel margins.

In the lower reach, sand dunes arise along the both tributary banks near its confluence with Lake Ontario. The native terrestrial plants observed inhabiting the sand dune include, but are not limited to: cottonwood, chokecherry, eastern red cedar, dune willow, beach grass, evening primrose, grape, wormwood, seaside pea, common milkweed, and white sweet clover, as listed in Table 3-2. Individual and clusters of non-native purple loosestrife were observed amongst the emergent marsh habitat along both channel margins.

Bird species observed making use of the aquatic and riparian habitats include Canada geese, Great blue heron, wood duck, mallard, belted kingfisher, and common tern.

4 Conclusion

4.1 Summary of Findings

Waterbodies within the SLELO region hold vast aquatic resources that have ecological, economic and social importance to communities and ecosystems. Plants play an essential role in healthy aquatic ecosystems. Non-native, invasive plant and animal species are a leading threat to aquatic ecosystems. As part of this Phase 1 study, invasive plant and animal species were assessed in the aquatic and riparian areas within the lowermost sections of three riparian corridors, including Sandy Creek, South Sandy Creek, and Deer Creek near their confluences with Lake Ontario. The tailwaters of these tributaries are part of the largest natural freshwater barrier beach system in New York State. They abound with a diverse array of ecological communities and, as a result, are characterized as priority conservation areas. The objective of this study was to identify and inventory the native and invasive plant species that form the ecological communities in the aquatic and intermediate riparian zones within the study area of each tributary.

Invasive plant species were detected within the aquatic and riparian zones at each tributary site. The presence (type and diversity), relative abundance (density), and general distribution of aquatic invasive species differed at each site. Collectively, curly-leaf pondweed and Eurasian watermilfoil are the most abundant and widespread aquatic invasive species. Other aquatic invasive species identified include brittle/slender naiad, European frogbit, variable watermilfoil, and water chestnut. It shall be noted that variable watermilfoil, and water chestnut were observed in Sandy Creek, but were not detected in South Sandy Creek. Water Chestnut was likely to be absent due to the extensive removal efforts by NYS DEC and partners. European frogbit, a floating-leaf plant, and whorled watermilfoil were detected in Deer Creek, but not detected in Sandy Creek and South Sandy Creek. In addition, the target AIS for this study, consisting of water thyme, fanwort, and water hyacinth, were not detected within the study area.

Non-native purple loosestrife, common reed grass, Japanese knotweed, and common buckthorn are invasive plant species observed in the riparian zones. Non-native purple loosestrife is considered the most widespread, as it was observed in the riparian zones at all three tributaries. In contrast, the presence and distribution of non-native common reed grass were limited within the study area. Specifically, an isolated patch of non-native common reed grass was observed in the middle reach of South Sandy Creek only. The density of this particular common reed grass patch is high, because this invasive plant tends to outcompete native plants and proliferate in a monolithic culture. It shall be noted that other patches of common reed grass may exist farther away than the intermediate riparian zones within the study area. For example, a monolithic patch of common reed grass was observed adjacent to the parking lot at the public boat launch for South Sandy Creek. The presence of Japanese knotweed was most prevalent in the upstream reach of South Sandy Creek. The distribution of Japanese knotweed varied from single clumps/patches to large dense stands along both intermediate riparian zones. Also noted, an isolated patch was observed in the upstream reach of Sandy Creek. Common buckthorn was observed occupying the sand dunes at the mouth of South Sandy Creek.

Diverse assemblages of animals were observed inhabiting and using the aquatic and riparian habitats at each tributary site. Fish species surveyed included largemouth bass, black crappie, yellow perch, bluegill, brown bullhead, and pirate perch.

Illustration 3-3: Pirate Perch (Image Courtesy of NYSDEC Website)

Pirate perch reside in low-gradient streams with large woody debris. It's characterized by a single dorsal fin with both spines and rays. Pirate perch most distinctive feature is its anus located below its opercula, a plate-like bone that covers the gills. The eastern subspecies (*sayanus*) lives in streams and ponds of Long Island, but has declined to levels below detection. The western subspecies (*gibbosus*) is native in two watersheds in western and central NY. It has declined to levels below detection in the Erie watershed but has increased in tributaries in the Ontario watershed. Pirate perch are classified as Species of Greatest Conservation Need (NYSDEC https://www.dec.ny.gov/animals/85737.html). The captured fish specimen was sent to the NYS Museum in Albany, New York for preservation and custody, because this species had not been detected in the area over the past 50 years.

Bird species observed included Canada geese, Great blue heron, wood duck, mallard, and belted kingfisher, to name a few. All of the fish and bird species noted are native to the eastern Great Lakes basin. Based on visual observations, populations of targeted invasive aquatic animals, consisting of round goby, rusty crayfish, bloody red shrimp, and spiny water flea were not detected in the study area. However, the results from the plankton tow and eDNA samples were not analyzed at the completion of this project. Once completed, a summary of the results will be added to this report as Appendix D.

4.2 Recommendations of Invasive Species Management

This section identifies proposed control strategies for invasive species management within the most deserving areas based on the results of this study.

4.2.1 Proposed Management Strategies

Invasive species management will follow SLELO PRISM's integrated approach and tiered system as previously described and summarized below.

- Tier 1 - Prevention/Early Detection Species
- Tier 2 - Eradication Species
- Tier 3 - Suppression Species
- Tier 4 - Local Control Species
- Tier 5 - Monitor Species

Comprehensive, large scale control of invasive species along waterways commonly require multiple management strategies within a context of an ecosystem-based management approach. The following conventional and novel invasive species management strategies will be used to effectively manage invasive species within the most deserving areas.

- Prevention- continuation and/or implementation of preventative measures, such as the watercraft inspection steward program and educational outreach along the Eastern Lake Ontario basin, to support reducing the spread of AIS.

- Early Detection & Rapid Response- continuation and/or initiation of monitoring program(s) to help detect and eradicate new infestations as well as contain and/or suppress species populations upon initial detection. Early detection of and rapid response to invasive species can prevent significant impacts to natural communities. The use of local public volunteers as well as innovative techniques, such as environmental DNA described below, would support early detection that supports efficient and cost-effective rapid response.

- Control- use of in-situ treatments, such as manual or mechanical harvesting, chemical application, and biological agents, to manage populations of invasive species to achieve a desired outcome.

    - Mechanical techniques generally include mowing, cutting, and digging (excavating). Mechanical techniques commonly involve using conventional or specialized equipment (e.g., excavator or weed harvester) to physically remove the invasive species. Manual harvesting, such as hand pulling, has shown to be an effective way to control spread and reduce the size of AIS infestations. However, it's typically labor intensive. Targeting floating AIS, such as water chestnut, and using public volunteers has shown to be a cost-effective approach.

    - Chemical application includes applying an herbicide to actively growing plants by one or more methods (e.g., foliar spray, cut-stump, stem injection) to interfere with plant growth and foster mortality. While a variety of synthetic chemical herbicides have been used to effectively control invasive species, they can have unintended consequences on the environment, including negative impacts on other organisms. Therefore, it's recommended that natural, non-toxic treatment methods (e.g., concentrated vinegar and salt) should be considered in lieu of synthetic, chemical herbicides, such as glyphosate. It is important to note that non-toxic treatment methods would need to be thoroughly reviewed and assessed before use.

  - Biological control agents have been used with a goal of establishing a long-term control of selective invasive species. For example, Beetles (*Galerucella* spp.) have been extensively tested in the United States to assess their safety and efficacy as biocontrol agents for purple loosestrife, leading to an approval by the USDA of their use for biocontrol purposes. Milfoil weevil (*Euhrychiopsis lecontei*), which is native to North America, has shown the most effective as a potential biocontrol agent for Eurasian watermilfoil.

- Ecological Restoration- implementing strategies that serve to reestablish the integrity and resilience of our lands and waters by restoring the ecological structure (e.g., biodiversity) and functions in areas infested by invasive species.

- Innovative Technologies and Techniques-

  - Environmental deoxyribonucleic acid (eDNA)- is an innovative early detection tool for aquatic invasive species. Using highly specialized processes known as quantitative polymerase chain reaction, this novel technology detects the presence of genetic material release by both invasive and native aquatic animals. In 2020, SLELO PRISM staff collected three samples for eDNA analysis from each tributary.

  - Unmanned aerial vehicle, or drone technology, coupled with professional judgment, would help assess the presence and distribution of invasive species within the intermediate riparian zone. SLELO PRISM staff are planning to perform aerial surveys within the study areas of all three tributaries.

  - Soil solarization and/or occultation are environmentally-friendly methods used to enhance or block the sun's power, respectively. These practices are commonly used in horticulture and agricultural systems. These processes involve covering the ground with a tarp, usually a transparent polyethylene or black cover, to accelerate, trap and/or block solar energy (light and heat).

4.2.2 Most Deserving Areas

The most deserving areas to implement invasive species management are presented in Table 3 and summarized below for each tributary.

Sandy Creek

The isolated patch of Japanese knotweed (estimated 1,500 sf or 0.03 acres), which exits near the private boat launch on Seaman's Island, could spread and infest the riparian habitat overtime. If further established, it would reduce terrestrial species diversity and displace native plant species (Bi´i´mova´et al. 2004). This isolated patch represents the furthest upstream infestation within the study area, and on waterways, begin control on the furthest upstream infestation because knotweed spreads downstream. Therefore, it's recommended that this isolated patch of Japanese knotweed is managed to advocate eradication or containment of the invasive species.

A variety of techniques for the management of Japanese knotweed exist, but generally fall into two categories: mechanical techniques and chemical application. Mechanical techniques include mowing, cutting, digging and covering. Chemical application includes applying an herbicide to actively growing plants by one or more methods (e.g., foliar spray, cut-stump, stem injection) to interfere with plant growth and promote mortality. SLELO PRISM previously performed a Japanese knotweed management project at the Salmon River, and the information and lessons developed through this project, will be helpful in scoping a similar ecological restoration effort.

The proposed recommended strategy for this patch of Japanese knotweed is mechanical removal and subsequent ecological restoration. Mechanical removal would involve using conventional construction equipment and practices, such as excavation, loading, hauling, and disposal. Extreme care must be taken to avoid spreading plant fragments, which could lead to further infestation. This control technique is recommended because the Japanese knotweed patch is located adjacent to a private roadway and; therefore, is easily accessible with heavy equipment. Chemical application of an environmentally-friendly, non-toxic herbicide represents an alternative control method. The disturbed area would be restored by backfilling with imported topsoil, sowing a riparian seed mix with native species (e.g., goldenrod, common boneset, common jewelweed, and joe-pye weed), and planting with native shrubs and/or trees (e.g., black willow). While restoring the land would eradicate or contain Japanese knotweed within this Priority Conservation Area, it shall be noted that Japanese knotweed is too widespread to completely eradicate the species from the Lakeview WMA and SLELO PRISM. Nevertheless, a targeted management action would limit the spread of Japanese knotweed so it does not impact habitat value throughout the remainder of the riparian zone within this Priority Conservation Area.

A variety of submersed AIS were detected in Sandy Creek; including brittle naiad, curly leaf pondweed, Eurasian watermilfoil, variable watermilfoil, and water chestnut. Purple loosestrife, a terrestrial invasive, was observed intermixed with the emergent marsh habitat along the tributary margins. Based on the occurrence data, we believe that these invasive species are widely distributed and comingled with native aquatic species, as such are not candidates for any aggressive management actions, such as mechanical harvesting. Nevertheless, the use of a biological control(s) to suppress Eurasian watermilfoil and purple loosestrife could be used as an effective control measure. The milfoil weevil (*Euhrychiopsis lecontei*), which is native to North America, has shown the most effective as a potential biocontrol agent for Eurasian watermilfoil and has been the subject of much research. Similarly, beetles (*Galerucella* spp.) have been extensively tested to assess their safety and efficacy as a biocontrol agent for purple loosestrife, leading to an approval by the United States Department of Agriculture (USDA). It shall also be noted that, at the watershed-scale, reducing turbidity and nutrient loading that enter the upstream reaches of the tributary would lessen nutrient enrichment within the lower reaches; thereby, addressing a primary catalyst that create favorable conditions for AIS to flourish.

Water chestnut, however, was detected in low abundance in Sandy Creek only. Based on the localized and low abundance of water chestnut, management strategies, such as manual harvesting, should be continued and/or implemented to suppress the population. It's recommended that water chestnut monitoring and control strategies are continued in this waterbody. Sargis (2015) noted that seasonal crews had removed over 7,000 pounds of water chestnut by hand pulling methods from Lakeview WMA. This effort has been annually coordinated by the SLELO-PRISM and NYSDEC and is planned to continue. The good news is that water chestnut can be controlled and perhaps even extirpated from this waterbody. The bad news is that if there is a collection of nutlets skulking in the lake sediments, these seeds can remain viable for up to twelve years.

<u>South Sandy Creek</u>

Japanese knotweed is abundant along the riparian zone in the upper reach of South Sandy Creek. This invasive terrestrial plant species was observed in single patches to large dense stands at the water-land interface. The areal coverages of Japanese knotweed along the northern and southern riparian zones are roughly estimated at 1.2 acres and 0.8 acre, respectively. A recent study showed distinct phytotoxic impacts from Japanese knotweed leaf litter decomposition, causing ecological effects that differed from that of native species (Cybill et al. 2020). For this reason, coupled with other known ecological impairments, it's recommended that invasive species management strategy centered on ecological restoration is initiated to contain or suppress Japanese knotweed within the Priority Conservation Area.

The proposed management strategy for the Japanese knotweed patches along the upstream reach of South Sandy Creek is the same as listed above and includes chemical application and/or solarization/occultation followed by ecological restoration. The objective of this control strategy is to destroy the invasive plant species, including the rhizosphere (root zone), followed by restoring the area with native vegetation (trees, shrubs, and grasses). The disturbed area would be restored by scarifying the existing topsoil, sowing a riparian seed mix with native species (e.g., goldenrod, common boneset, common jewelweed, and joe-pye weed), and planting with native shrubs and/or trees (e.g., black willow). While restoring the land would suppress Japanese knotweed within this Priority Conservation Area, it shall be noted that Japanese knotweed is too widespread to completely eradicate the species from the Lakeview WMA and SLELO PRISM. Nevertheless, a targeted management action would contain or suppress the Japanese knotweed impairment on the aquatic and riparian zones as well as restore the ecological integrity and resiliency within this Priority Conservation Area. It is important to note that this population of Japanese knotweed is considered the highest priority to the land manager.

A single, isolated patch of common reed grass (estimated 12,000 sf or 0.3 acres) was surveyed along the intermediate riparian zone in the middle reach of South Sandy Creek. It's recommended that this patch is controlled using non-toxic treatment and restored with native species (riparian and/or emergent seed mix) using ecological restoration principles. Proper management of this isolated patch of non-native common reed grass would suppress this invasive species within the Priority Conservation Area. However, it shall be noted that invasive common reed grass is too widespread to completely eradicate the species from the Lakeview WMA and SLELO PRISM. As previously noted, a monolithic stand of common reed grass was observed adjacent to the parking lot at the public boat launch though this is not included in the map, it should also be noted this site is a priority for control by the land manager.

Purple loosestrife was observed intermixed with other emergent marsh plants along channel margins within the middle and lower reaches of South Sandy Creek. The population of purple loosestrife is less dense, but more widespread than Japanese knotweed. It's recommended that management strategies are considered to continue suppression of purple loosestrife. As part of a previous project, over 7,000 biological control agents (i.e., *Galerucella beetles*) were released across three wetlands within the Lakeview WMA, with a goal of establishing a long-term control for purple loosestrife (Sargis 2015). This invasive species work is furthered described in Appendix A, Annotated Bibliography. The feasibility and long-term effectiveness of a biological control strategy should be reassessed and considered for implementation.

AISs detected include brittle naiad, curly leaf pondweed, and Eurasian watermilfoil. Based on the occurrence data, we believe that these AISs are widely distributed and comingled with native aquatic species, as such are not candidates for control or suppression actions. It shall be noted that water chestnut and European frogbit were not detected in South Sandy Creek. As a result, prevention and early detection is recommended associated with these species.

<u>Deer Creek</u>

Purple loosestrife is widely distributed along the channel margins throughout Deer Creek, mainly in the middle and lower reaches. Individual and clumps of purple loosestrife plants are intermixed with other emergent marsh plants along the channel margins. It's recommended that invasive species management strategies are evaluated to suppress the population of purple loosestrife. As noted above, biological controls of purple loosestrife were previously implemented and monitored at the Lakeview WMA.

Based on these occurrence data, brittle naiad, curly-leaf pondweed, Eurasian watermilfoil and European frogbit are well established, at least relative to the sampling points, and as such are not candidates for any in-situ actions. As a result, it's recommended that localized AIS management is applied to protect any high priority resources like rare plant or recreation assets. One example would be to implement localized AIS management at the New York State public recreational platform situated at the dune crossover on Deer Creek. In addition, an 'early detection and rapid response' program could be instituted at Deer Creek to prevent water chestnut from becoming established in this waterbody.

<u>All</u>

The introduction or entry of AIS, which may or may not be in PRISM but are difficult to respond to, into each Priority Conservation Area is a concern. Examples invasive plant and animal species include water thyme, fanwort, water hyacinth, tench (*Tinca tinca*), Asian carp (*Hypophthalmichthys* spp.), Asian swamp eel (*Monopterus albu),* and northern snakehead (*Channa argus*). Therefore, it's recommended that an invasive species monitoring program using conventional (e.g., field sampling and observation) and/or innovative techniques (e.g., eDNA), is designed and implemented to detect the presence of AIS of concern. If target AIS is detected, then the detected species would be upgraded to a higher tiered species and corresponding response action.

4.2.3 Resilient and Connected Landscapes

The tailwaters of three tributaries are part of the largest natural freshwater barrier beach system in New York State. The ecosystem is comprised of diverse ecological communities, including sand dunes, barrier beach, tributaries, wetlands, and floodplains that provide essential services and benefits to society, such as flood resilience, water purification, and carbon storage, as well as wildlife habitat. A key understanding is that these individual ecological communities are connected by natural processes as part of a larger ecosystem.

It's often asserted that everything we do in a watershed affects the conditions downstream. Land use practices (both past and present) in the watersheds have dramatic effects on the health of streams, lakes and other waterbodies. Shore and riparian corridors are subject to stressors stemming from watershed land-use practices (e.g., nutrient and sediment inputs, shoreline hardening, hydrologic alteration, recreational pressure, and the proliferation of nuisance species) that affect their physical and biological structures. For example, Trebitz & Taylor (2007) observed that several aquatic and terrestrial invasive species are associated with an increase of agriculture in a watershed, which in turn is correlated with increased turbidity and nutrient levels within the waterbodies. Specifically, the study concluded that Eurasian milfoil and curly pondweed were positively associated with agricultural intensity in the watershed, which is a surrogate for nutrient loading. Common reed grass, purple loosestrife and cattails were also more likely to be present and dominant as agricultural intensity increased, and were associated with elevated emergent cover and decreased emergent richness (Ibid).

Comprehensive, large-scale control of invasive species along waterways commonly require multiple management strategies centered around an ecosystem-based management approach. As such, in addition to the localized control strategies described above, a long-term invasive species management strategy may include response actions at the broader scale, such as ecosystem- or watershed-level. Several examples are as follows:

- protecting and conserving connected landscapes within the natural ecosystem to promote habitat connectivity, biological diversity, and shore resiliency;
- implementing best management practices (e.g., vegetated buffers) adjoining agricultural fields and improving stormwater systems in urban areas using green infrastructure (e.g., rain gardens and bioswales) to reduce nutrient dynamics (runoff and loading) that drive the propagation and proliferation of aquatic invasive species;
- Shifting from hardened shoreline structures (e.g., revetments and bulkheads) to living shorelines that incorporate living materials (e.g., trees, shrubs, and grasses) that're more adaptable and resilient features;
- Controlling or suppressing invasive species and re-establishing native communities and functional ecosystems.

Relatedly, nutrient and sediment control from agricultural watersheds and stormwater runoff, invasive species management, and habitat protection and restoration are all part of the suite of restoration initiatives currently proposed in the Great Lakes coastal areas (Interagency Task Force and Regional Working Group Agencies 2019). An invasive species management strategy shall integrate local and regional response actions that support developing or maintaining a connected landscape, a contiguous network of ecological communities within a natural ecosystem that function together, in an effort to reduce environmental and ecological stressors; enhance coastal/shore resilience; promote biodiversity; and adapt to the earth's changing climate conditions.

4.3 Next Step

An Invasive Plant Management Decision Analysis Tool (IPMDAT), which was developed by TNC, will be applied to aid in selecting an appropriate management technique(s) for each identified invasive species (Zimmerman et al. 2011, https://www.ipmdat.org/). The IPMDAT is comprised of a strategy-selection decision tree used to determine if the harm caused by an invasive plant species is significant enough to warrant control. Eight feasibility criteria are used, as follows:

1. ecological impact,
2. distribution and abundance,
3. social-political environment,
4. control (kill) effectiveness,
5. ability to prevent reinvasion,
6. ease of detection,
7. resource availability, and
8. return on investment.

The decision tree is used to identify the appropriate control strategy based on the abundance and distribution of the invasive plant. The IPMDAT contains three potential control strategies: eradication, containment/exclusion and suppression.

- The goal of eradication is to eliminate all individuals and the seed bank from an area with the low likelihood of needing to address the species again in the future.
- A containment/exclusion project aims to prevent infestations of invasive species from spreading to uninfected areas.
- The goal of a suppression project is to reduce an invasive plant population in size, abundance, and/or reproductive output below the threshold needed to maintain a species or ecological process. Suppression is only feasible at the local scale due to resource constraints.

The IPMDAT has four possible outcomes:

1. Proceed with control strategy implementation – project has a high probability of success and has conservation value,
2. Stop – secure sustainable funding source,
3. Stop – control not feasible and/or not warranted, or
4. Peer-review required – feasibility and/or conservation value is uncertain.

5 References

This section describes the literature sources cited in this report.

Bı´mova´ et al. 2004. "How Does Reynoutria Invasion Fit the Various Theories of Invasibility?" *Journal of Vegetation Science*. Volume 15. pp. 495–504.

Biohabitats, Inc. and Camion Associates. 2008. *Sandy Creeks Watersheds: Baseline Conditions Report*. Prepared for The Nature Conservancy. February 2008.

Bonanno, Sandra; Leopold, Donald; and Hilaire, Lisa. 1998. "Vegetation of a Freshwater Dune Barrier under High and Low Recreational Uses." *Journal of the Torrey Botanical Society* 125(1): pp. 40-50.

Cucherouset and Olden. 2011. "Ecological Impacts of Non-native Freshwater Fishes." *Fisheries*. Volume 36, No. 5. Pp. 215-230. May 2011.

Cybill et al. 2020. "Ecological Implications of the Replacement of Native Plant Species in Riparian systems: Unexpected Effects of Reynoutria Japonica Houtt. Leaf Litter.″ *Biological Invasions*. Volume 22. pp. 1917–1930.

Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero (editors). 2014. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

Interagency Task Force and Regional Working Group Agencies. 2019. Great Lakes Restoration Initiative Action Plan III. Fiscal year 2020 – 2024.

iMapInvasives, https://www.imapinvasives.org/ and https://www.nyimapinvasives.org/. New York Natural Heritage Program.

Lord and Johnson, 2006. *Aquatic Plant Monitoring Guidelines.*

Madsen. 1999. *Point and Line Intercept Methods for Aquatic Plant Management.* APCRP Technical Notes Collection (TN APCRP-Ml-02), U.S. Army Engineer Research and Development Center, Vicksburg, MS, USA.

Mazzocchi and Latremore. 2018. *Habitat Management Plan for Lakeview Wildlife Management Area (2018 – 2027).* New York State Depart of Environmental Conservation, Division of Fish and Wildlife Bureau of Wildlife.

NYSFOLA. 2009. *Diet for a Small Lake: The Expanded Guide to New York State Lake and Watershed Management*. 2nd edition. New York State Federation of Lake Associations, Inc.

Rahel and Olden. 2008. “Assessing the Effects of Climate Change on Aquatic Invasive Species.” *Conservation Biology*. Volume 22, No. 3, pp. 521–533. July 2008.

Reschke, C. 1990. Ecological communities of New York State. New York Natural Heritage Program. New York State Department of Environmental Conservation, Latham, NY.

Saint Lawrence-Eastern Ontario Commission. 1981. *Vegetative Analysis of Deer Creek Barrier Beach*. January 1981.

Sargis. 2015. *Restoration of Eastern Lake Ontario Coastal Wetlands and Invasive Species Control*. The Nature Conservancy. March 31, 2015.

Simon and Townsend. 2003. “Impacts of Freshwater Invaders at Different Levels of Ecological Organisation, with Emphasis on Salmonids and Ecosystem Consequences.” *Freshwater Biology*. Volume 48. pp. 982-994.

Smith, T. 1985. Natural communities of Pennsylvania. Unpublished report, Pennsylvania Natural Diversity Inventory, Harrisburg, PA.

Trebitz, A. S. & D. L. Taylor, 2007. *Exotic and Invasive Aquatic Plants in Great Lakes Coastal Wetlands: Distribution and Relation to Watershed Land Use and Plant Richness and Cover*. Journal of Great Lakes Research 33: 705–721.

United States Department of Agriculture, Natural Resources Conservation Service. Soil classification information available online at: http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=NY.

Williams, 2019. SLELO Strategic Plan. July 24, 2019.

Zimmerman, C., M. Jordan, G. Sargis, H. Smith, K. Schwager. 2011. An Invasive Plant Management Decision Tool. Version 1.0. The Nature Conservancy, Arlington, Virginia.

Tables

Table 1: Rake Toss Sampling Data
Table 2: Live Trap Sampling Data
Table 3: Invasive Species Management Strategy

Table 1
Proposed Invasive Species Management Strategy

Study Area / Priority Conservation Area	Aquatic Invasive Species	Invasive Species Management			General Approach
		Type	Method	Objective	
Sandy Creek	Japanese Knotweed	Suppression Species	Ecological Restoration	Strategic, localized management to contain infestation and slow spread in a Priority Conservation Area	Mechanically remove invasive species using heavy equipment and conventional construction practices, such as excavation, loading, hauling, and disposal. Care must be taken to avoid spreading plant fragments, which could lead to further infestation. Restore disturbed area by backfilling with topsoil, sowing a riparian seed mix with native grass species, and planting native trees.
	Eurasion Watermilfoil	Local Control Species	Biological Control	Strategic management to protect priority resources like rare plant or recreational assets	Release a biological control agent with a goal of establishing a long-term control for Eurasion watermilfoil. Milfoil weevil (*Euhrychiopsis lecontei*), which is native to North America, has shown the most effective as a potential biocontrol agent for Eurasian watermilfoil and why it has been the subject of much research.
	Purple Loosestrife	Local Control Species	Biological Control	Strategic management to protect priority resources like rare plant or recreational assets	Release a biological control agent with a goal of establishing a long-term control for purple loosestrife. Beetles (*Galerucella* spp.) have been extensively tested in the United States to assess their safety and efficacy as biocontrol agents, leading to an approval by the USDA of their use for biocontrol purposes. Published literature indicates that no significant long-term impacts on native plant species have been observed.
	Water Chestnut	Suppression Species	Manual Harvest	Strategic, localized management to contain infestation and slow spread in a Priority Conservation Area	Continue or implement a manual harvesting (hand pulling) program on an annual basis. Hand-pulling when rosettes first appear (mid-June to early July) is an effective way to control spread and reduce the size of infestations.
	European Frogbit	Prevention/ Early Detection Species	Early Detection and Rapid Response	Continuation and/or initiation of monitoring program to help detect and eradicate new infestation(s) as well as contain and/or suppress species populations upon initial detection	Develop an invasive species monitoring program using conventional practices (e.g., visual observation) and/or innovative technologies (e.g., eDNA and/or UAV), where appropriate. If target AIS is detected, contain and/or suppress AIS using hand pulling technigue or alternative methods based on site conditions.

Table 1 Continued
Proposed Invasive Species Management Strategy

Study Area / Priority Conservation Area	Aquatic Invasive Species	Invasive Species Management			General Approach
		Type	Method	Objective	

South Sandy Creek	Japanese Knotweed	Suppression Species	Ecological Restoration	Strategic, localized management to contain infestation and slow spread in a Priority Conservation Area	Raze the invasive plant species using conventional (e.g., controlled fire, non-toxic chemical control) and/or innovative techniques (e.g., solarization, occulation). Restore disturbed area by scarifying the topsoil (as needed), sowing a riparian seed mix with native grass species, and planting native shrubs and/or trees.
	Common Reed Grass	Suppression Species	Ecological Restoration	Strategic, localized management to contain infestation and slow spread in a Priority Conservation Area	Raze the invasive plant species using conventional (e.g., controlled fire, chemical control) and/or innovative techniques (e.g., solarization, occulation) in an effort to destroy the plant and its root zone. Restore disturbed area by backfilling with topsoil (as needed), scarifying the topsoil, sowing a riparian seed mix with native grass species, and planting native shrubs and/or trees.
	Purple Loosestrife	Local Control Species	Biological Control	Strategic management to protect priority resources like rare plant or recreational assets	Release a biological control agent with a goal of establishing a long-term control for purple loosestrife. Beetles (*Galerucella* spp.) have been extensively tested in the United States to assess their safety and efficacy as biocontrol agents, leading to an approval by the USDA of their use for biocontrol purposes. Published literature indicates that no significant long-term impacts on native plant species have been observed.
	Water Chestnut & European Frogbit	Prevention/Early Detection Species	Early Detection and Rapid Response	Continuation and/or initiation of monitoring program(s) to help detect and eradicate new infestations as well as contain and/or suppress species populations upon initial detection	Develop an invasive species monitoring program using conventional practices (e.g., visual observation) and/or innovative technologies (e.g., eDNA and/or UAV), where appropriate. If target AIS is detected, contain and/or suppress AIS using hand pulling technigue or alternative methods based on site conditions.

Table 1 Continued
Proposed Invasive Species Management Strategy

Study Area / Priority Conservation Area	Aquatic Invasive Species	Invasive Species Management			General Approach
		Type	Method	Objective	
Deer Creek	Purple Loosestrife	Local Control Species	Biological Control	Strategic management to protect priority resources like rare plant or recreational assets	Release a biological control agent with a goal of establishing a long-term control for purple loosestrife. Beetles (*Galerucella* spp.) have been extensively tested in the United States to assess their safety and efficacy as biocontrol agents, leading to an approval by the USDA of their use for biocontrol purposes in 1992. Published literature indicates that no significant long-term impacts on native plant species have been observed.
	Water Chestnut	Prevention/Early Detection Species	Early Detection and Rapid Response	Continuation and/or initiation of monitoring program to help detect and eradicate new infestation(s) as well as contain and/or suppress species populations upon initial detection	Develop invasive species monitoring program using conventional practices (e.g., visual observation) and/or innovative technologies (e.g., eDNA and/or UAV), where appropriate. If target AIS is detected, contain and/or suppress AIS using hand pulling technigue or alternative methods based on site conditions.
All	Water Thyme, Fanwort, Water Hyacinth, Tench, Asian carp, Asian Swamp Eel, Northern Snakehead	Monitor Species	Monitoring Program	Initiation of monitoring program using coventional and/or innovative technigues to detect the presence of an invasive species	Develop invasive species monitoring program using conventional practices (e.g., plankton tow sampling) and/or innovative technologies (e.g., eDNA), where appropriate. If target AIS is detected, then upgrade priority to a higher tiered response action.

Figures

Figure 1: Rake Toss Sampling Locations in Sandy Creek
Figure 2: Plankton Tow and Live Trap Sampling Locations in Sandy Creek
Figure 3: Rake Toss Sampling Locations in South Sandy Creek
Figure 4: Plankton Tow and Live Trap Sampling Locations in South Sandy Creek
Figure 5: Rake Toss Sampling Locations in Deer Creek
Figure 6: Plankton Tow and Live Trap Sampling Locations in Deer Creek
Figure 7: Invasive Species Patch Observed Along Sandy Creek
Figure 8: Invasive Species Patch Observed Along South Sandy Creek

Rootz

Figure 1: Rake Toss Sampling Locations in Sandy Creek

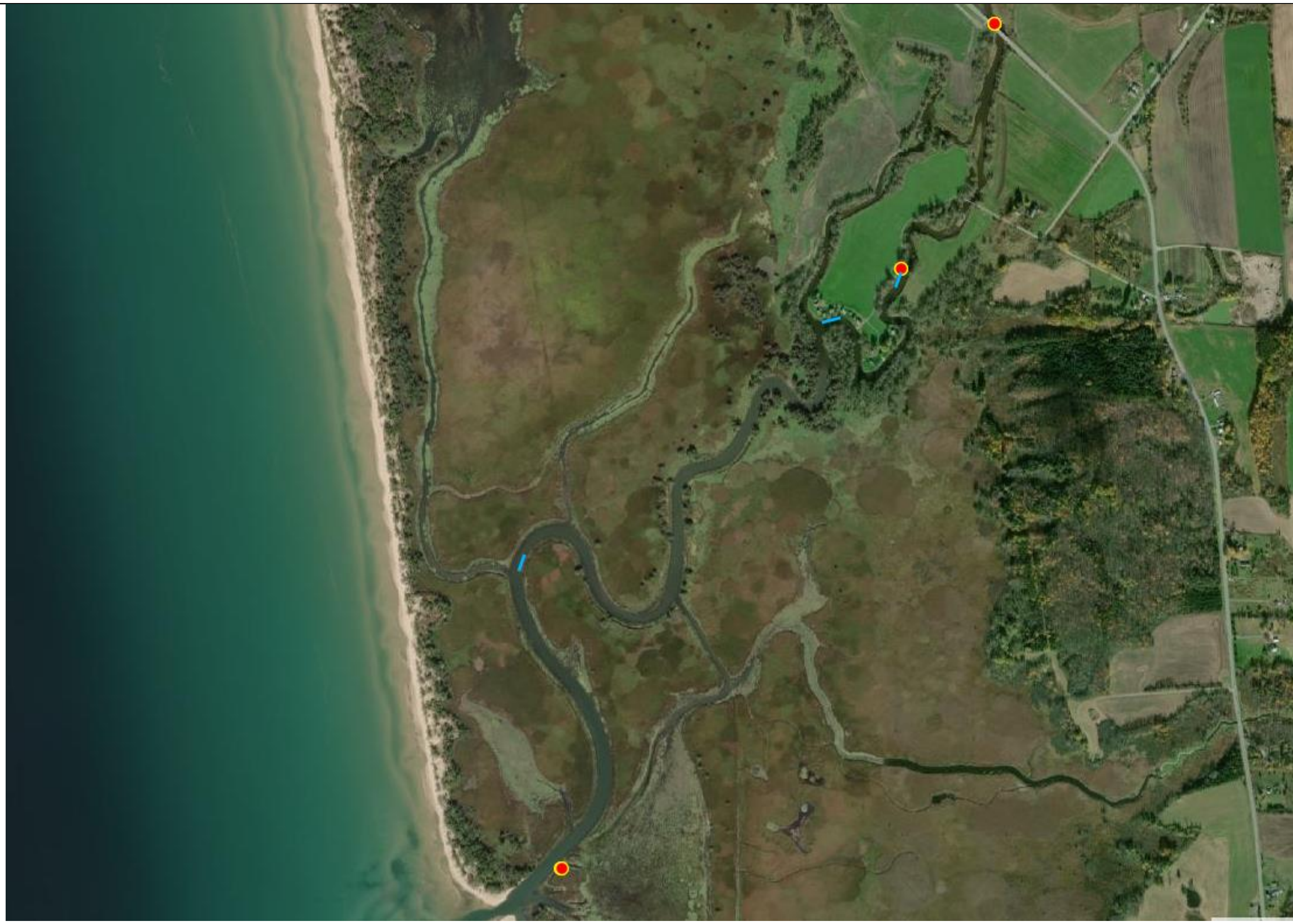
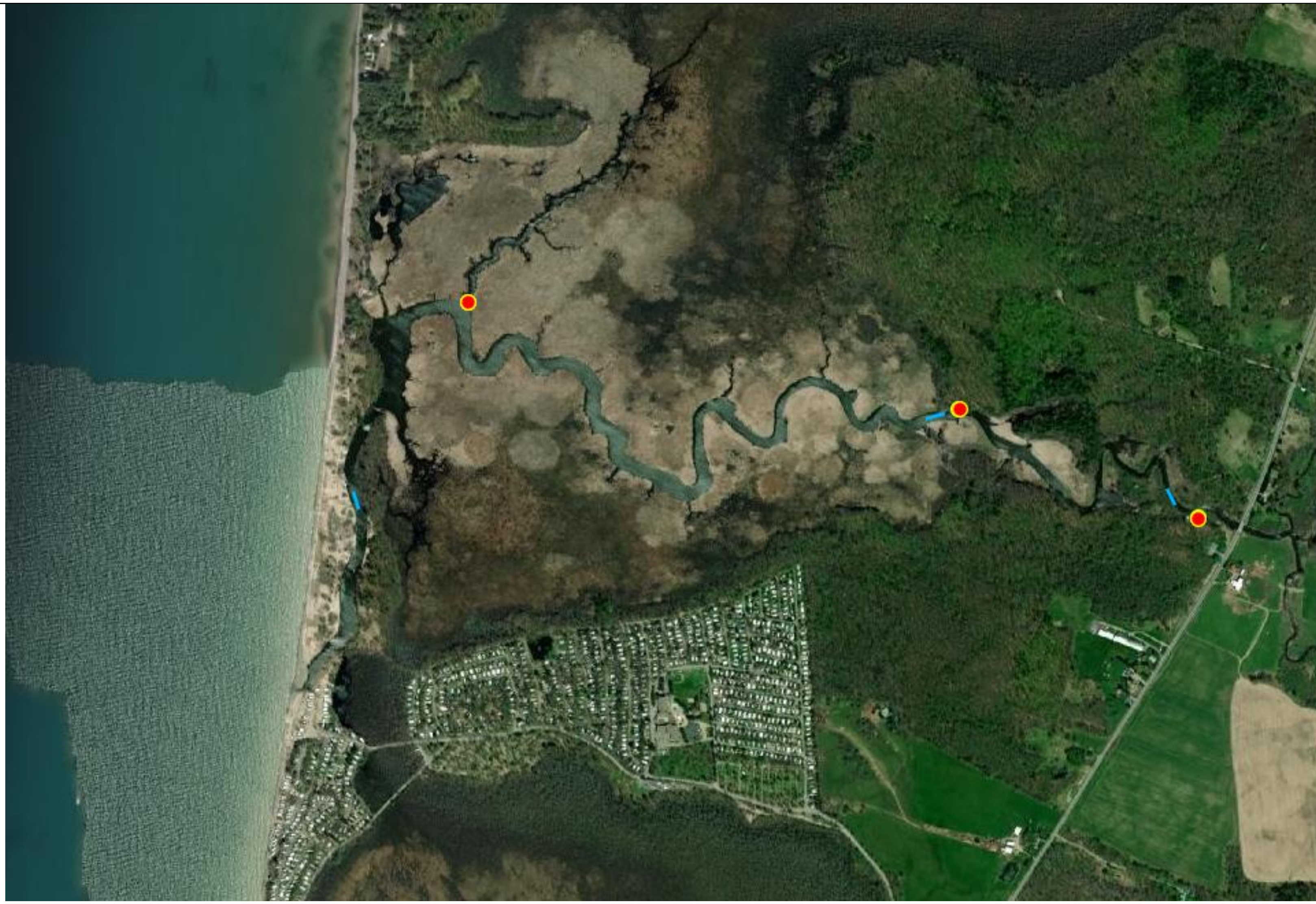


Figure 2: Plankton Tow and Live Trap Sampling Locations in Sandy Creek

Figure 3: Rake Toss Sampling Locations in South Sandy Creek

Figure 4: Plankton Tow and Live Trap Sampling Locations in South Sandy Creek

Figure 5: Rake Toss Sampling Locations in Deer Creek

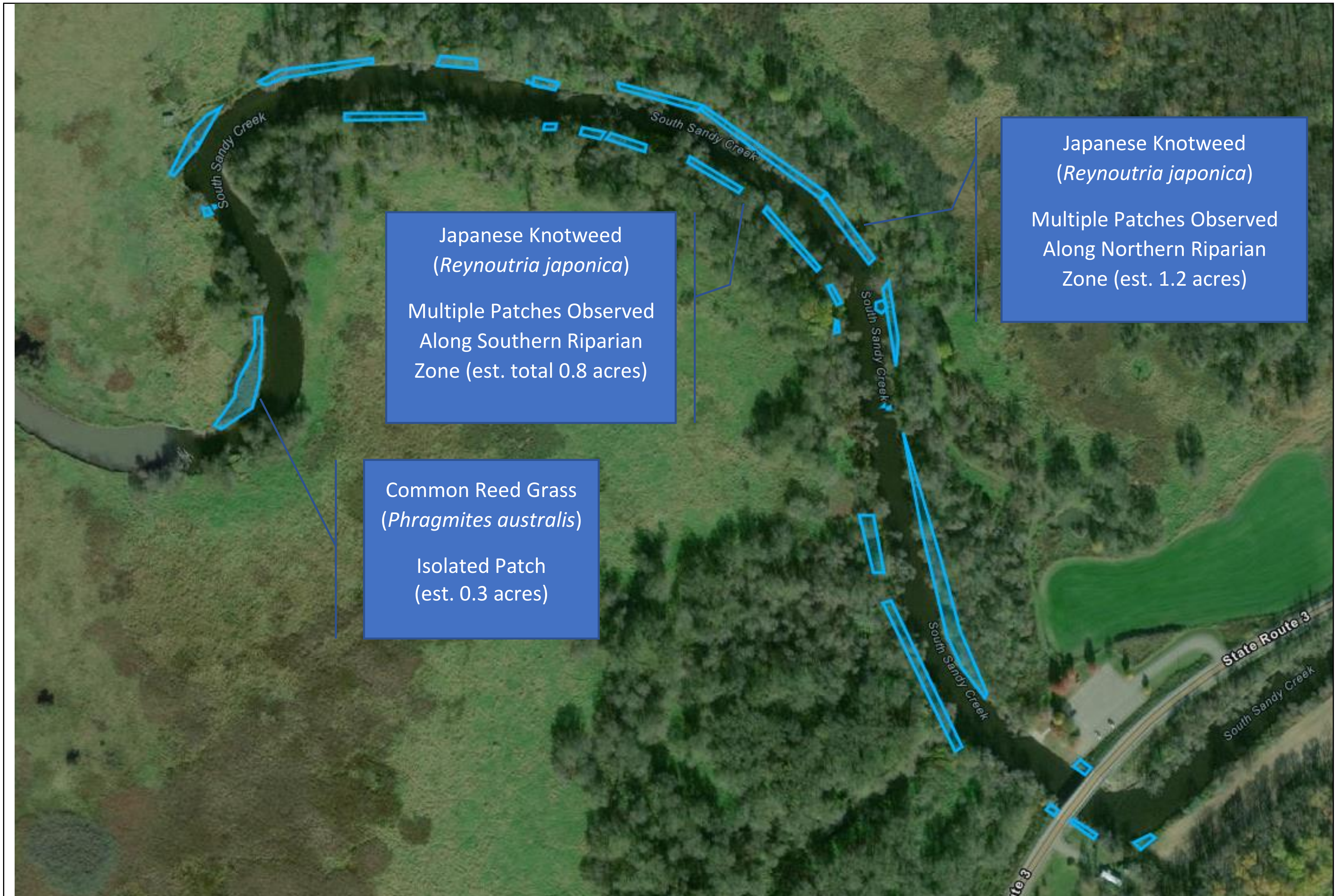


Rootz

Figure 6: Plankton Tow and Live Trap Sampling Locations in Deer Creek

Rootz

Figure 7: Invasive Species Patch Observed Along Riparian Zone on Sandy Creek



Rootz

Figure 8: Invasive Species Patches Observed Along Riparian Zone on South Sandy Creek

Appendix A:
Annotated Bibliography

Appendix A

Annotated Bibliography

Phase 1: Aquatic and Riparian Invasive Species Inventory and Habitat Assessment

1. Mazzocchi and Latremore. 2018. *Habitat Management Plan for Lakeview Wildlife Management Area (2018 – 2027).* New York State Depart of Environmental Conservation, Division of Fish and Wildlife Bureau of Wildlife.

   NYS Department of Environmental Conservation (DEC) Division of Fish and Wildlife (DFW) developed a Habitat Management Plan (HMP) for Lakeview Wildlife Management Area (WMA) administered by DFW Bureau of Wildlife. Lakeview WMA is a natural wetland complex consisting of a long barrier beach, dunes, marshes, and swamps with cold-water streams. The WMA is part of the largest natural fresh water barrier beach system in New York State. It has been designated as a National Natural Landmark, a significant coastal fish and wildlife habitat by the New York Department of State, a Bird Conservation Area (BCA). In addition, as part of the Eastern Lake Ontario Barrier Beach and Wetland Complex, it was also designated as a Natural Heritage Area.

   The HMP serves as the overarching guidance for habitat management, and incorporates management recommendations from Unit Management Plans, existing WMA habitat management guidelines, NY Natural Heritage Program's WMA Biodiversity Inventory Reports, Bird Conservation Area guidelines, and other documents available for individual WMAs. Lakeview WMA is managed for open water, shoreline, and wetland habitats and preservation of unique ecological resources within the WMA. Key habitat management goals include:

   - Maintaining 65% of the WMA as open water and wetland habitat to provide high-quality migratory waterfowl nesting, resting, and foraging habitat; prime waterfowl hunting, furbearer trapping, and fishing opportunities; and breeding habitat for endangered, threatened, or Species of Greatest Conservation Need (SGCN) bird species;
   - Managing approximately 2% of the WMA (10% of the forested acres) as young forest (0- 10 years) to promote habitat for American Woodcock, Ruffed Grouse, Wild Turkey, white-tailed deer, migratory songbirds, and other SGCN; Maintaining approximately 17% as intermediate and mature forest;
   - Maintaining approximately 3% as agricultural lands to provide forage for many wildlife game and non-game species;
   - Managing approximately 2% as early successional shrublands and grasslands; and
   - Protecting approximately 9% as Lake Ontario beaches and dunes.

2. Putnam et al. 2018. *Habitat Management Plan for Deer Creek Marsh Wildlife Management Area (2018 – 2027)*. New York State Depart of Environmental Conservation, Division of Fish and Wildlife Bureau of Wildlife.

   NYS DEC Division of Fish and Wildlife developed a Habitat Management Plan (HMP) for Deer Creek Marsh WMA, which is is located along the eastern edge of Lake Ontario. Deer Creek Marsh WMA covers 1,771 acres of marshland, mixed shrubland and grassland, mature forest, and, most importantly, a section of natural barrier beach and sand dune. The WMA includes several rare and significant ecological zones created over centuries of hydrologic influence from the adjacent Lake Ontario. These unique habitats are home to multiple rare and species of special concern that are attracted to those shoreline habitats and large, shallow marshes that occur within close proximity to the lake. This WMA is an important resting area for thousands of migrating birds, including waterfowl and shorebirds, with many of these species utilizing the property for breeding and wintering habitat as well. Surrounding the wetland complex are mixed upland forests typical of upstate New York that are utilized by common wildlife of all types. As a result of these various habitat types and the species that utilize them, this WMA has been identified as a Bird Conservation Area (BCA) and is included in the larger Ontario Barrier Beaches Important Bird Area (IBA).

   The HMP serves as the overarching guidance for habitat management, and incorporates management recommendations from Unit Management Plans, existing WMA habitat management guidelines, NY Natural Heritage Program's WMA Biodiversity Inventory Reports, Bird Conservation Area guidelines, and other documents available for individual WMAs. Habitat management goals for Deer Creek Marsh WMA include:

   - Maintain the WMA's intermediate and mature forested acreage at approximately 35% (622 acres) to continue to provide habitat diversity for forest species.

   - Manage approximately 7% of the WMA as young forest (116 acres, 16% of the total forested area) within the next 10 years to improve habitat for young forest-dependent species.

   - Manage 2% of the WMA (37 acres) as shrubland habitat to provide habitat for shrubland obligate species.

   - Maintain the WMA's grassland at approximately 4% (63 acres) to continue to provide habitat diversity for grassland species.

   - Maintain the remaining 52% of the WMA as wetlands, open water and roads.

   - Protect the natural barrier beach and sand dunes from disturbance (46 acres).

- Protect critical habitat for the endangered bog buckmoth.

3. Sargis. 2015. *Restoration of Eastern Lake Ontario Coastal Wetlands and Invasive Species Control*. The Nature Conservancy. March 31, 2015.

   The Eastern Lake Ontario barrier beach and coastal wetland complex includes a core of nearly 16,000 acres along 17 miles of Lake Ontario shoreline in Oswego and Jefferson Counties, New York. The 4,973-acre Lakeview WMA includes a series of streams, ponds, drowned river mouths, and embayments, as well as bur-reed-cattail emergent marshes, forested and shrubby swamps, several types of globally rare coastal fens, and extensive submerged aquatic beds. Due to the continued spread and establishment of invasive species and large-scale vegetation shifts stemming from altered Lake Ontario water levels, the function and health of these key wetland complexes were considered at risk. Species such as the black tern (an indicator species for hemi-marsh conditions) and the muskrat (an ecosystem engineer) had markedly declined. Due to the dense cattail and the lack of open water channels and potholes that exists in these altered wetlands, access by fish species such as the northern pike may also had been reduced.

   The goals of this project were to:

   - Detect invasive species through surveillance monitoring, and lessen the impact aquatic and riparian invasive species pose on the ecologically significant communities of the Eastern Lake Ontario barrier beach and costal wetland complex;

   - Restore coastal wetland habitat through the creation of new wetland features, such as channels and potholes, to improve access to nesting, breeding and spawning habitat; and

   - Return hydrologic connectivity to a wetland impacted by a local road through the installation of new culverts.

   As part of the restoration project, channels and potholes were excavated within a large, portion of Lakeview Marsh WMA in an effort to increase pike access to the marsh interior for spawning and rearing, increase suitable nesting habitat for black tern, and increase habitat and water depth in channels for muskrat. The excavated material was used to construct "habitat mounds", creating microtopography within the marsh, to facilitate more rapid and thorough establishment of species other than cattail and to be used as potential housing sites for muskrats.

   Throughout the four years of this project, the presence of aquatic invasive species was monitored and documented. Control strategies were implemented on three species (i.e., purple loosestrife, glossy buckthorn and water chestnut). Over 7,000 biological control agents (i.e., *Galerucella beetles*) were released at three wetlands across the project area, with a goal of establishing a long-term control for purple loosestrife. In addition, glossy buckthorn was managed within a 55-acres portion of wetland and over 7,000 pounds of water chestnut were physically removed by hand.

Management actions were applied to over 800 acres of wetland habitat. Pre and post restoration monitoring were conducted to assess the response of fish, vegetation, muskrat and black tern. Overall, responses in the indicator species (i.e., black tern, muskrat and pike) were not detected, because the results showed but high variability of the data that made detecting potential changes difficult. In addition to the original indicators, the response of vegetation to the wetland restoration was assessed. Initially, cattail densities were lower along the excavated channels perimeter but after two years they were slightly greater than reference areas. The response of vegetation to the small piles of excavated material places along the outside of the constructed channels were also assessed. In these "habitat mounds", plant species richness was greater and cattail density was lower compared with densities closer to the channel. It's expected that over time the benefits of this project will continue to develop as wildlife species and vegetation communities respond to the restored wetland structure and function.

4. Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero (editors). 2014. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

   The primary objective of this report is to classify and describe ecological communities representing the full array of biological diversity of New York State. An ecological community is a variable assemblage of interacting plant and animal populations that share a common environment. As part of the New York Natural Heritage Program inventory, a classification has been developed to help assess and protect the biological diversity of the state. The Natural Heritage Program inventory work maintains a regularly updated database of information on rare animals, rare plants, and significant natural communities of New York State. This inventory also provides a ranking system for determining priorities for conservation and management of New York State's significant natural areas.

   The three principal ecological communities observed in the study area include: unconfined river, deep emergent marsh, and Great Lakes dunes. Each ecological community according to Ecological Communities of New York State (Second Edition) is described below.

“**Unconfined river**: the aquatic community of large, quiet, base level sections of streams with a very low gradient. This community was formerly called “main channel stream” in Reschke (1990). These rivers are typically dominated by runs with interspersed pool sections and a few short or no distinct riffles. Unconfined rivers usually have clearly distinguished meanders (i.e., high sinuosity) and well developed natural levees, are in unconfined valleys and are most typical of the lowest reaches of stream systems. These rivers are typically deep, wide, have a high low flow discharge, and usually represent a network of 5th to 6th and up to 7th order stream segments. They are characterized by considerable deposition, predominated by fine substrates such as silt, with a relatively minor amount of erosion. Waterfalls may be present; these are treated here as features of the more broadly defined community. The predominant source of food energy to the river biota is generated in the river (these are autochthonous rivers). These rivers are usually warm water, may have high turbidity and be somewhat poorly oxygenated. They are typically surrounded by floodplain forest or eroded sand or clay banks or fine sediment bars.

Species assemblage’s characteristic of pools and soft bottoms dominate the community. Characteristic fishes are deep-bodied fishes, such as sturgeon (*Acipenser spp*.), shad (*Alosa spp*.), and suckers (*Catostomids*) – especially redhorses (*Moxostoma spp*.). Many of the fishes are anadromous. Other characteristic fishes include warmwater fishes such as rock bass (*Ambloplites rupestris*), northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), pumpkinseed (*Lepomis gibbosus*), brown bullhead (*Ameiurus nebulosus*), and white sucker (*Catostomus commersoni*). Pools may also contain pickerel (*Esox americanus*). Characteristic macroinvertebrates may include numerous species of mollusks such as pea clams (*Pisidium spp.)*, suspected to differ substantially among regional variants, as well as stoneflies (*Plecoptera*), beetles (*Stenelmis spp.)*, midges (*Polypedilum spp*.), mayflies (*Baetidae, Heptageniidae, Ephemeridae*), clams, odonates (*Aeshnidae, Calopterygidae, Coenagrionidae, Gomphidae*), caddisflies (*Cheumatopsyche spp*.), and leeches (*Hirudinea*).

Although the middle of an unconfined river is usually too deep for aquatic macrophytes to occur, the shallow shores and backwaters typically have rooted macrophytes. Characteristic submergent vascular plants may include naiad (*Najas flexilis*), pondweeds (*Potamogeton epihydrus, P. perfoliatus, P. spirillus*), bur-reed (*Sparganium fluctuans*), tapegrass or wild celery (*Vallisneria americana*), and Robbins spikerush (*Eleocharis robbinsii*). Floating aquatic macrophytes such as white water-lily (Nymphaea spp.) may be common in pools along shallow shores and in backwaters. Two non-native weeds, Eurasian milfoil (*Myriophyllum spicatum*) and water chestnut (*Trapa natans*) may also occur along shores and backwaters. Mosses in the genus Fontinalis may be characteristic of shallow areas. Plankton assemblages may be abundant.

Four to six variants associated with a combination of ecoregions (including Northern Appalachian, Great Lakes, Lower New England and Allegheny Plateau types) or major watersheds distinguished by Smith (1985) (the St. Lawrence River basin, Hudson River, Delaware River, Susquehanna River, and Allegheny River) are suspected to differ substantially in dominant and characteristic vascular plants, fishes, mollusks, and insects as well as water chemistry, water temperature, underlying substrate type, and surrounding forest type. For example, the species of fish genera present in any one river varies between major watersheds. In addition, the biota is suspected to differ among rivers of medium size (roughly 3rd to 4th order streams) and large size (roughly 5th to 6th order streams). Aquatic connectivity factors are thought to strongly influence the fish and mollusk composition.

Fishes characteristic of the St. Lawrence River and Lake Champlain Valley may include muskellunge (*Esox masquinongy*), yellow perch (*Perca flavescens*), white perch (*Morone americana*), walleye (*Stizostedion vitreum*), mooneye (*Hiodon tergisus*), longnose sucker (*Catostomus catostomus*), Iowa darter (*Etheostoma exile*), johnny darter (*Etheostoma nigrum*), banded killifish (*Fundulus diaphanus*), spottail shiner (*N. hudsonius*), and blackchin shiner (*N. heterodon*). Pugnose shiner (*Notropis anogenus*) is a rare fish of some unconfined rivers in this region.

The Northern Appalachian variant of this river type has relatively cool water. Characteristic fishes of this variant may include brook trout (Salvelinus fontinalis), slimy sculpin (*Cottus cognatus*), creek chub (*Semotilus atromaculatus*), longnose dace (*Rhinichthys cataractae*), tessellated darter (*Etheostoma olmstedi*), fathead minnow (*Pimephales promelas*) and bluntnose minnow (*Pimephales notatus*). Characteristic macroinvertebrates of the Northern Appalachian river variant may include caddisflies (*Helicopsyche spp., Brachycentrus spp., Psilotreta spp.).*

More data on flora (macrophytes and algae) and invertebrate fauna, as well as regional variants, are needed (Edinger et al, 2016)."

"Deep emergent marsh: that occurs on mineral soils or fine-grained organic soils (muck or well- decomposed peat); the substrate is flooded by waters that are not subject to violent wave action. Water depths can range from 15 cm to 2 m (6 in to 6.6 ft); water levels may fluctuate seasonally, but the substrate is rarely dry, and there is usually standing water in the fall. This is a somewhat broadly defined type that includes several variants based on the dominant plants. Deep emergent marshes are quite variable. They may be codominated by a mixture of species, or have a single dominant species. It is likely that an individual occurrence of deep emergent marsh will not include all of the species listed below.

In shallower areas the most abundant emergent aquatic plants are cattails (*Typha angustifolia, T. latifolia, T. x glauca*), wild rice (*Zizania aquatica*), bur-reeds (*Sparganium eurycarpum, S. androcladum*), pickerel weed (*Pontederia cordata*), bulrushes (*Schoenoplectus tabernaemontani, S. heterochaetus, S. acutus, S. pungens, S. americanus Bolboschoenus fluviatilis*), arrowhead (*Sagittaria latifolia*), arrowleaf (*Peltandra virginica*), rice cutgrass (*Leersia oryzoides*), bayonet rush (*Juncus militaris*), water horsetail (*Equisetum fluviatile*) and bluejoint grass (*Calamagrostis canadensis*).

The most abundant floating-leaved aquatic plants interspersed with emergents include fragrant water lily (*Nymphaea odorata*), duckweeds (*Lemna minor, L. trisulca*), pondweeds (*Potamogeton natans, P. epihydrus, P. friesii, P. oakesianus, P. crispus, P. pusillus, P. zosteriformis, P. strictifolius*), common yellow pond-lily (*Nuphar variegata*), frog's-bit (*Hydrocharis morsus-ranae*), watermeal (*Wolffia spp*.), and water-shield (*Brasenia schreberi*).

The most abundant submerged aquatic plants are pondweeds (*Potamogeton richardsonii, P. amplifolius, P. spirillus, P. crispus, P. zosteriformis*), coontail (*Ceratophyllum demersum*), stonewort (*Chara globularis*), water milfoils (*Myriophyllum spicatum, M. sibericum*), pipewort (*Eriocaulon aquaticum*), tapegrass or wild celery (*Vallisneria americana*), a thallose liverwort (*Riccia fluitans*), naiad (*Najas flexilis*), water lobelia (*Lobelia dortmanna*), waterweed (*Elodea canadensis*), water stargrass (*Heteranthera dubia*), and bladderworts (*Utricularia macrorhiza, U. intermedia*).

Characteristic birds with varying abundance include swamp sparrow (*Melospiza georgiana*), red-winged blackbird (*Agelaius phoeniceus*), marsh wren (*Cistothorus palustris*), American bittern (*Botaurus lentiginosus*), Virginia rail (*Rallus limicola*), and pied-billed grebe (*Podilymbus podiceps*) (*P. Novak* pers. comm.).

Characteristic amphibians and reptiles include bullfrog (*Rana catesbeiana*), snapping turtle (*Chelydra serpentina*), and painted turtle (*Chrysemys picta*).

Deep emergent marshes typically occur in lake basins and along non-tidal rivers (or in semi-closed embayments) often intergrading with shallow emergent marshes, shrub swamps and sedge meadows, and they may occur together in a complex mosaic in a large wetland. Marshes that have been disturbed are frequently invaded by weedy species such as purple loosestrife (*Lythrum salicaria*), European common reed (*Phragmites australis*), and water chestnut (*Trapa natans*). These areas are better classified as purple loosestrife marsh, common reed marsh, and one of the water chestnut bed cultural communities respectively. Deep emergent marsh vegetation may develop in excavations that contain standing water (e.g., roadside ditches, gravel pits) and are also considered cultural communities (e.g., impounded marsh) (Ibid)."

“Great Lakes dunes: a community dominated by grasses and shrubs that occurs on active and stabilized sand dunes along the shores of the Great Lakes. The composition and structure of the community is variable depending on stability of the dunes, the amount of sand deposition and erosion, and distance from the lake. Unstable dunes are sparsely vegetated, whereas the vegetation of stable dunes is more dense, and can eventually become forested. Great Lake dunes can be divided into six physiographic zones: 1) beach (see sand beach), 2) foredune front, 3) foredune back and swale, 4) secondary dunes, 5) last lee face of high dune, and 6) last lee face of low dune. Each of these zones may develop any one to several vegetation associations or “community types” (Bonanno 1992). The species listed below are not necessarily restricted to a specific vegetation association. For example, beachgrass (*Ammophila breviligulata*, *A. champlainensis*) and riverbank grape (*Vitis riparia*) may occur in more than one of the listed associations, but their abundance will vary accordingly.

The first and largest vegetation association is dominated by beachgrass (*Ammophila breviligulata*, *A. champlainensis*) and tall wormwood (*Artemisia campestris ssp. caudata*). Other characteristic species with low percent cover include cottonwood (*Populus deltoides*), sand dune willow (*Salix cordata*), sand dropseed (*Sporobolus cryptandrus*), beach pea (*Lathyrus japonicus var. maritimus*), and riverbank grape (*Vitis riparia*). In more natural settings this association usually occurs on the more active parts of the beach, foredune, and swale zones.

The second association is dominated by poison ivy (*Toxicodendron radicans*), riverbank grape (*Vitis riparia*), and cottonwood (*Populus deltoides*). Other characteristic shrubs and vines with low percent cover include red osier dogwood (*Cornus sericea*), silky dogwood (*C. amomum*), sand cherry (*Prunus pumila var. pumila*), sand dune willow (*Salix cordata*), poison ivy (*Toxicodendron radicans*), and bittersweet (*Celastrus scandens*). Other characteristic herbs with low percent cover include beachgrass (*Ammophila breviligulata*, *A. champlainensis*), tall wormwood (*Artemisia campestris ssp. caudata*), Canada wild-rye (*Elymus canadensis*), spotted knapweed (*Centaurea stoebe ssp. micranthos*), starry Solomon's seal (*Maianthemum stellata*), jointweed (*Polygonella articulata*), seaside spurge (*Euphorbia polygonifolia*), and common hairgrass (*Avenella flexuosa*). In more natural settings this association occurs mostly on the moderately stabilized dune crests and occasionally in swales and on secondary dunes. This association may be split out as a new community (e.g., “Great Lakes dune shrubland”) in future versions of this classification.

The third association is an open forest canopy dominated by red oak (*Quercus rubra*) and red maple (*Acer rubrum*). Other characteristic species of the forested dunes include sugar maple (*Acer saccharum*), striped maple (*Acer pensylvanicum*), serviceberries (*Amelanchier spp*.), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), chokecherry (*Prunus virginiana*), blackberry (*Rubus allegheniensis*), red raspberry (*Rubus idaeus*), nannyberry (*Viburnum lentago*), arrowwood (*V. dentatum var. lucidum*), wild sarsaparilla (*Aralia nudicaulis*), and wreath goldenrod (*Solidago caesia*). In more natural settings this association occurs on very stabilized secondary dunes and the leeward side of the last high dune. This association may be split out as a new community (e.g., "Great Lakes dune woodland") in future versions of this classification.

A fourth association dominated by speckled alder (*Alnus incana ssp. rugosa*) that is often found in wet dune swales is tentatively included under shrub swamp. Palustrine "Great Lakes interdunal swales" have been reported in Oswego County in the vicinity of Lakeview Wildlife Management Area (J. Herter pers. comm.). More data are needed in order to describe and confirm this type in New York. More data on the physiognomic variants of this community are needed (Ibid)."

5. New York Natural Heritage Program. 2011. *Sandy Creeks Watershed Inventory and Landscape Analysis*. Prepared for the New York State Tug Hill Commission. January 2011.

   NYS Tug Hill Commission provided its communities with a clearer picture of the biodiversity and ecological patterns of the 284,000-acre Sandy Creeks Watershed. They identified natural areas in the watershed that are vital to protecting the landscape character and biodiversity of the region including the relative ecological quality of subwatersheds.

   The project comprised of four phases: i) Develop a list of rare species and natural communities known from or with the potential to be found in the Black River and Sandy Creeks watersheds and create their corresponding Element Distribution Models (EDMs); ii) Overlay the EDMs and note where multiple species overlapped, indicating a potential biodiversity "hotspot" in the Black River and Sandy Creeks Watershed; iii) Analyze the quality of the subwatersheds using a suite of GIS layers in the Sandy Creeks Watershed; and iv) Conduct field inventories and document locations of rare plants, rare animals, and significant natural communities in the Sandy Creeks Watershed.

   The analysis of the overall quality of the subwatersheds within the entire Sandy Creeks Watershed revealed a few high-quality areas. Field inventories had resulted in 170 new and updated locations for rare species and significant natural communities: 53 rare plant occurrences, 90 rare animal occurrences, and 27 significant natural community occurrences. High concentrations of these rare species and significant natural communities were identified in certain areas within the watershed.

This project identified two new areas that met the criteria as “Special Areas” under the Tug Hill Reserve Act of 1992, which included the Plum Tree Road-Pigeon Creek wetlands and the Adams wetland complex.

Overall, this project identified many areas of high biodiversity on private lands. The Natural Heritage Program was granted access to many of these areas which resulted in the documentation of new significant natural communities and rare species in the Sandy Creeks Watershed. However, many of these identified areas were not surveyed due to lack of access permission.

6. Biohabitats, Inc. and Camion Associates. 2008. *Sandy Creeks Watersheds: Baseline Conditions Report*. Prepared for The Nature Conservancy. February 2008.

   A Baseline Conditions Report was prepared as a supporting document for the Sandy Creeks Watersheds Ecosystem-based Management Strategy development project. Ecosystem-based Management (EBM) is a term used to describe an integrated approach to managing the natural resources and socio-economic components that comprise communities or other common boundaries such as watersheds. The goal of this project was to develop a baseline conditions report that characterizes the Sandy Creeks watersheds both ecologically and economically and, can be used by the current project partners (The Nature Conservancy, Tug Hill Commission and New York Departments of State and Environmental Conservation). The primary goal of EBM is to keep the economy of communities healthy by ensuring that the natural resources (arable lands, forests, lakes, rivers, scenic views, etc.), on which many economies directly and indirectly rely, can continue to support local communities. Examples in the Sandy Creeks Watershed that illustrate the important relationship between local economies and healthy natural resources include: working farms that provide both dairy and crops for consumption and open space; forests that provide recreational opportunities, valuable wood resources for paper, lumber and firewood as well as essential habitat to animals; and wetlands and streams that provide protection from floods and serve as habitat for fish and other wildlife.

7. Bonanno, Sandra; Leopold, Donald; and Hilaire, Lisa. 1998. “Vegetation of a Freshwater Dune Barrier under High and Low Recreational Uses.” *Journal of the Torrey Botanical Society* 125(1): pp. 40-50.

   The dune barrier on the eastern shore of Lake Ontario protects an extensive system of high- quality freshwater wetlands. Prior to this study, the vegetation community was largely undescribed, and development pressures required management decisions for which data were needed. The objective of the study was to inventory the vegetation composition as well as describe and compare the vegetation under high and low recreational use. A significant conclusion was that species richness and ground cover of vegetation, and density of colonizing species were lower on equivalent physiographic zones under high compared to low recreational uses.

8. Saint Lawrence-Eastern Ontario Commission. 1981. Vegetative Analysis of Deer Creek Barrier Beach, January 1981.

   In 1980, a vegetative assessment of Deer Creek barrier beach was conducted in Oswego County. The work was performed as part of a dune stabilization project that involved the introduction of Cape variety American Beachgrass (*Ammophila breviligulata*) to the Deer Creek barrier beach and dune complex. A vegetation survey of the barrier beach was executed using a quadrant sampling technique. The vegetative inventory identified 54 plant families. Species with the highest importance values were American beachgrass, wormwood (*Artemsia caudata*), and poison ivy (*Rhus radicans*).

Appendix B:
Regulatory Permits

Left blank intentionally.

Appendix C:
Standard Operating Procedure for the Collection of Zooplankton Samples Using a Horizontal Net Tow

STANDARD OPERATING PROCEDURE

FOR COLLECTION OF ZOOPLANKTON SAMPLES

USING A HORIZONTAL NET TOW

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the equipment, supplies, procedure, and laboratory analytical methods for collecting zooplankton samples using a horizontal net tow technigue.

2.0 EQUIPMENT AND SUPPLIES

____250 µm net with tube and clamp (Figure 1)

____7-8 m rope (marked off at every meter) with carabineer clip at one end

____80% ethanol

____Distilled rinse water in squirt bottles

____Pencils and sharpies

____Clear tape

____Sample labels

____Field notebook

____Electrical tape

Figure 1: Zooplankton Sampling Net (Photo courtesy of Aquatic Research Instruments)

3.0 PROCEDURE

3.1 Sample Collection

1) Prior to each use, carefully clean and thoroughly rinse the interior of the plankton net and mesh cup with distilled water. Collections will be made using a 250-µm mesh plankton net with a 30 cm opening.

2) Carefully inspect the net and mesh cup for holes or tears.

3) Attach the mesh cup (250-µm) to the end of the net and secure.

5) Attach the metal ring of the plankton net to a calibrated rope with markings every 1m, using the carabineer.

6) Lower the net until it is completely submerged (i.e. let the net settle into the water column but do not let it sink).

7) Let out a sufficient amount of line to allow the net to be towed beneath the surface.

8) Tow the net slowly over a distance of 50 meters (164 feet). [All samples in the study should be collected over the same distance.]

9) Once that distance is covered, pull the net slowly out of the water so that water flows out through the net mesh and not out the mouth of the net. If vegetation is present in the net when you retrieve it, pull it out gently and discard.

10) Rinse the plankton on the net surface down into the cup. Either: hold the net upright and dunk it several times into the water, up to the mouth, or splash water on the outside of the net and the plankton will be washed down to the bucket.

3.2 Sample Processing and Preservation

1) Carefully disconnect the 243 µm mesh cup from the net.

3) Hold the cup and over a sample container.

4) Using a rinse bottle filled with distilled water, rinse the sample from the mesh cup into the sample container, so that it’s three-fourths of the way full with sample + water.

5) Fill the sample container the rest of the way with 80% ethanol (leaving little to no headspace) and replace cap. Seal the jars with electrical tape around the lid to prevent leakage (as necessary).

6) Prepare the sample label, attach the sample label to the sample container, and cover the label with clear tape.

7) Place samples in a cooler with wet ice. [These samples do not need to be stored on ice but they cannot withstand high summer temperatures and should remain cool.]

8) Before using the zooplankton net at the next site, rinse the net thoroughly with distilled water to avoid any potential cross contamination of samples and wetland systems.

3.3 Labeling Sample Containers

Attach a label to the outside of the container making sure the container is dry and wrap with clear tape to ensure that the label stays on the container. Labels must contain the following information.

- station number and location description
- date and time of collection
- preservative used
- name of each collector
- sample type (grab, integrated, net, composite)
- number of hauls (e.g., composite of 2 horizontal tows)
- water depth (of hauls)
- container replicate number if needed (for example, 1 of 2 or 2 of 2)

Additional labeling is necessary depending on the method of collection. Samples will be delivered to SLELO's office for analyses.

3.0 LABORATORY ANALYTICAL METHODS

Zooplankton samples will be examined for taxa present and community composition, with a focus on percent native versus invasive species. Taxa will be identified to the lowest practical taxon. At least 100-200 individuals will be identified and enumerated from each sample.

Appendix D:
Plankton Tow Sampling Data

Left blank intentionally.

Appendix E:
Habitat Assessment Photographs

PHOTOGRAPHIC LOG

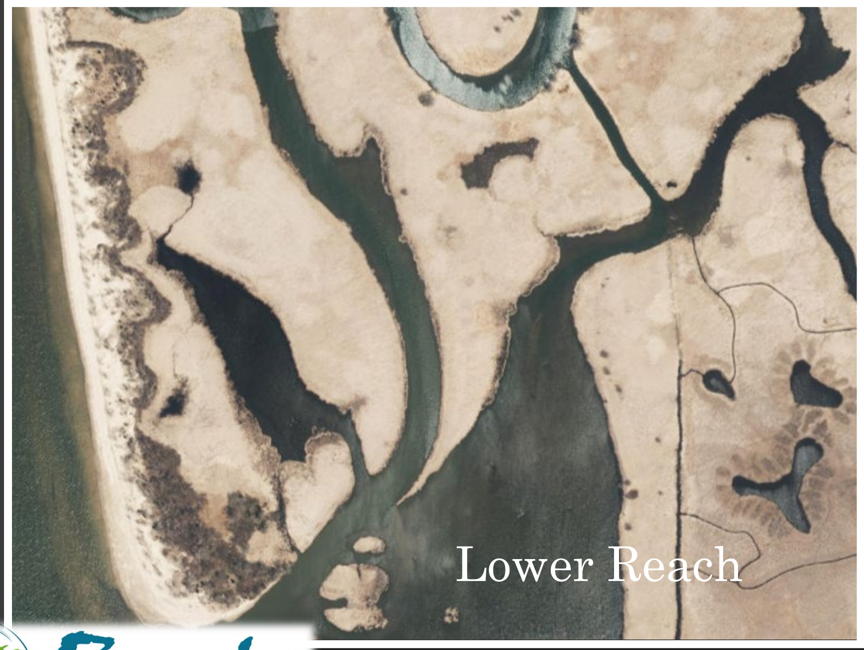
Phase 1: Aquatic and Riparian Invasive Species Inventory and Habitat Assessment

Rootz

SANDY CREEK

Study Area: 50 meters beyond NYS Route 3 bridge(s) and extending to its confluence at Lake Ontario

Photographs taken between 7/24 – 7/29



SANDY CREEK: UPPER REACH

Route 81 Bridge Abutment Upstream of Public Boat Launch

Bridge Crossing at Seamans Island Road

Channel Margin and Intermediate Riparian Zone

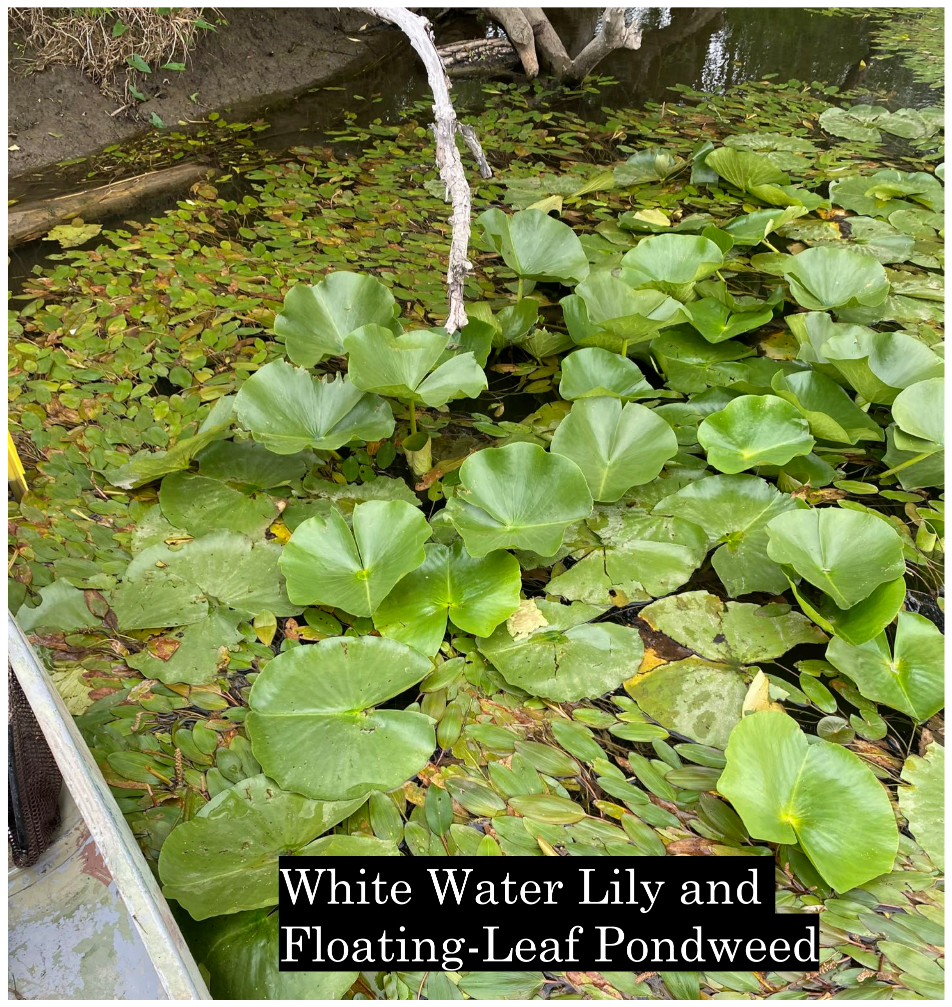
Rootz

SANDY CREEK:
MIDDLE REACH

Rootz

SANDY CREEK:
LOWER REACH

SANDY CREEK:
NATIVE AQUATIC SPECIES



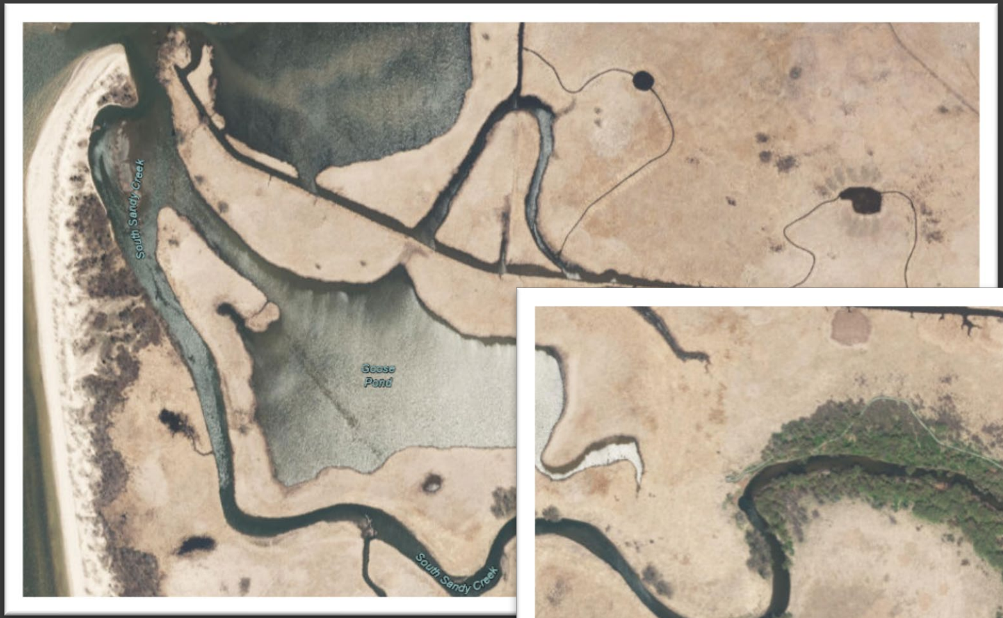
Rootz

SANDY CREEK: INVASIVE AQUATIC SPECIES

Rootz

SANDY CREEK:
NATIVE TERRESTRIAL SPECIES ON SAND DUNE

SOUTH SANDY CREEK



Study Area: 50 meters beyond NYS Route 3 bridge(s) and extending to its confluence at Lake Ontario

Photographs taken between 7/20 – 7/22

Rootz

SOUTH SANDY CREEK: UPPER REACH

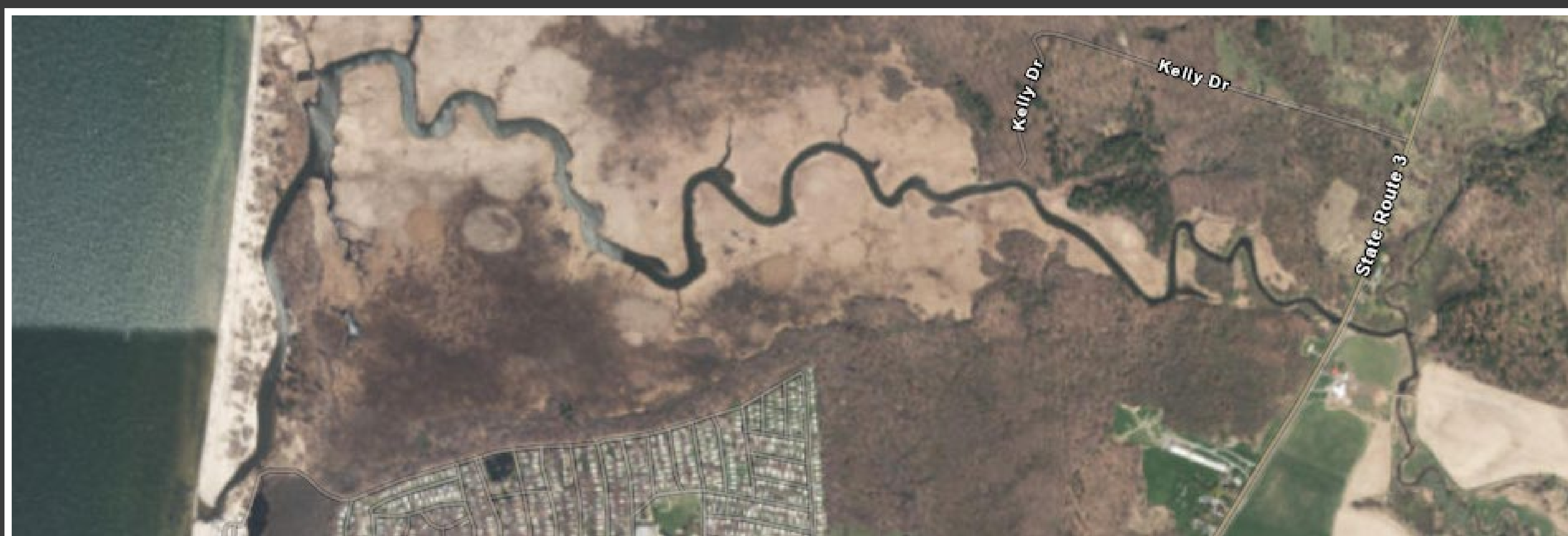
Rootz

SOUTH SANDY CREEK
MIDDLE REACH

SOUTH SANDY CREEK
LOWER REACH

DEER CREEK

Study Area: 50 meters beyond NYS Route 3 bridge(s) and extending to its confluence at Lake Ontario

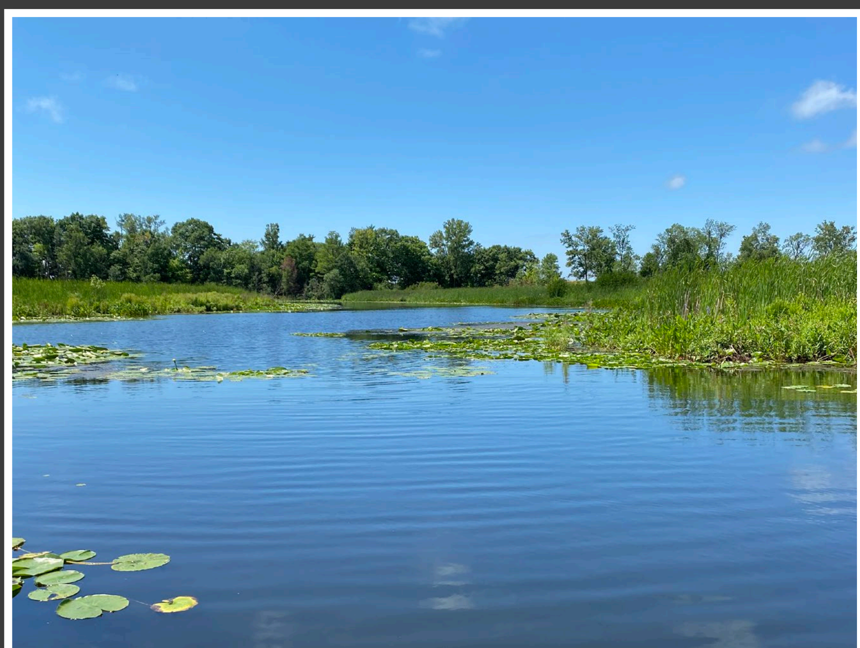


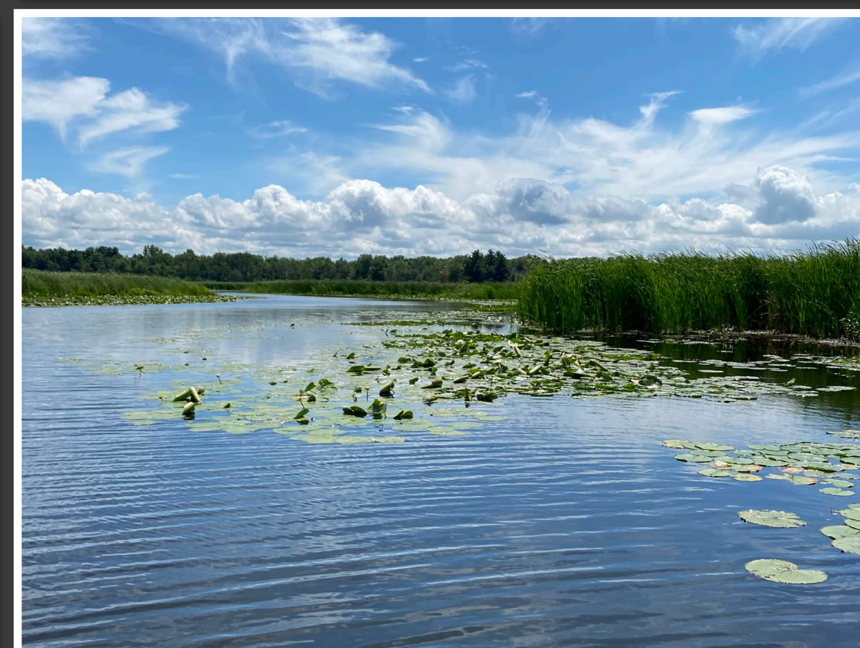
Rootz

DEER CREEK:
UPPER REACH

Photographs taken between 8/2 – 8/6

DEER CREEK: MIDDLE REACH

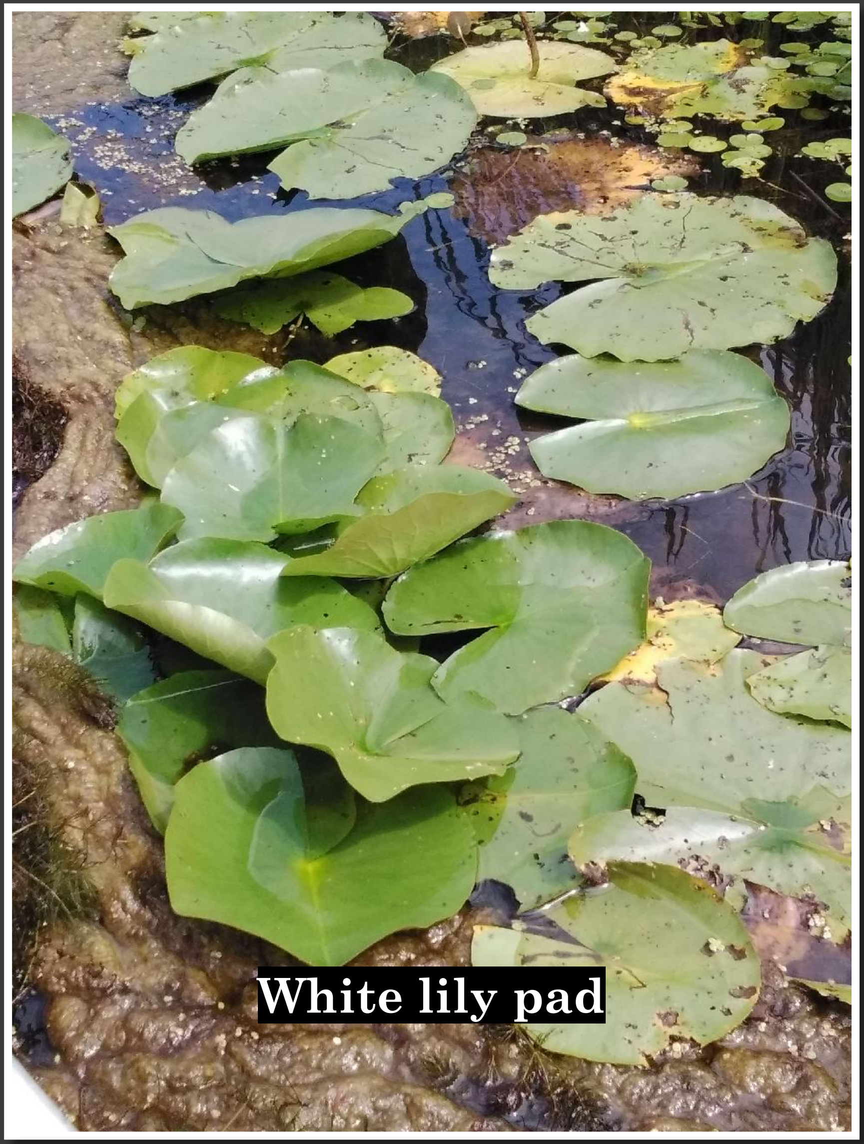


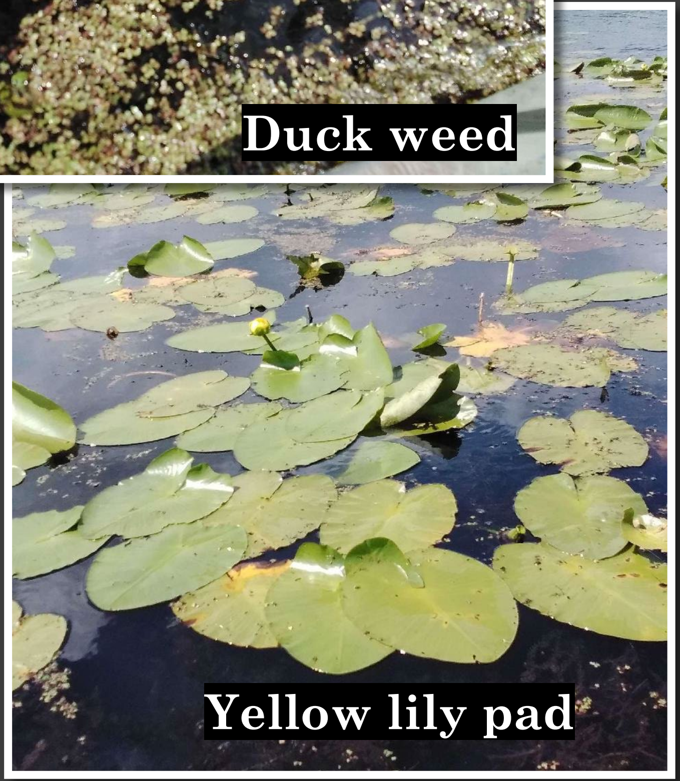


DEER CREEK: LOWER REACH

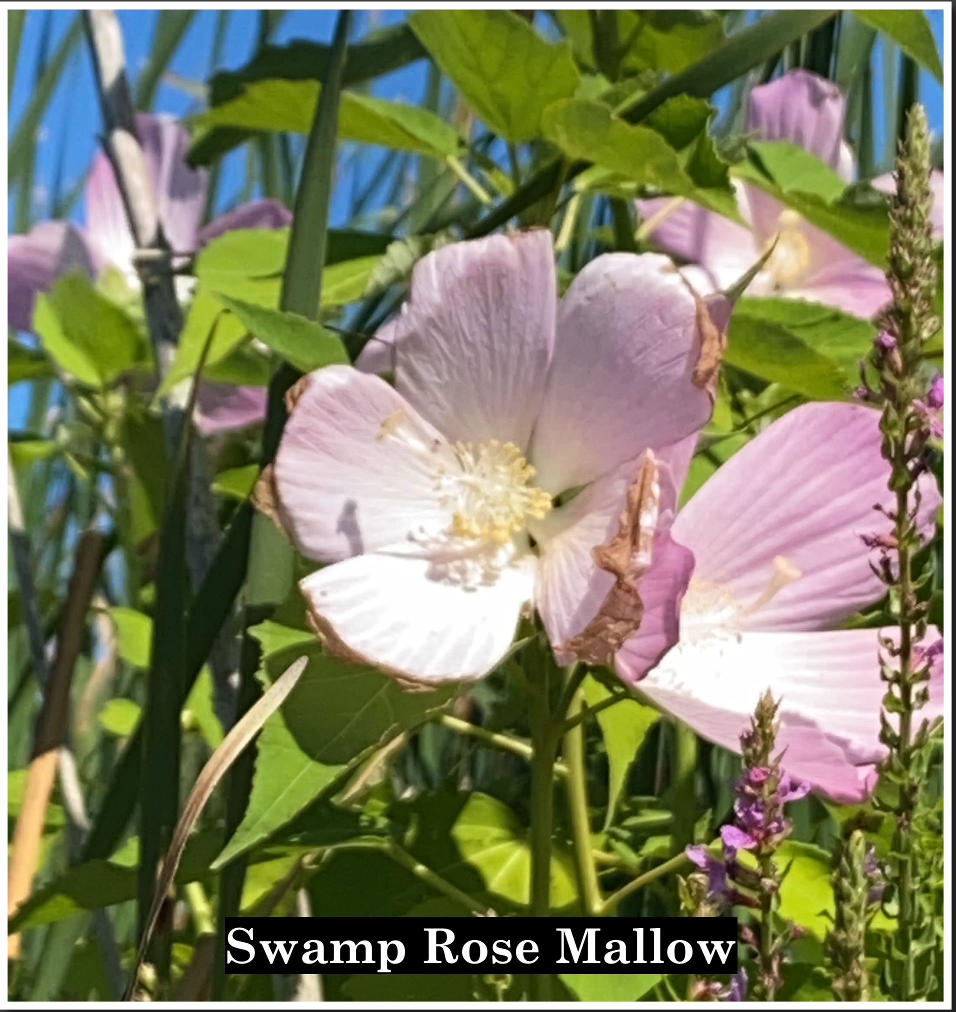
DEER CREEK:
NATIVE TERRESTRIAL SPECIES ON SAND DUNE

DEER CREEK: NATIVE, AQUATIC FLOATING-LEAF PLANT SPECIES

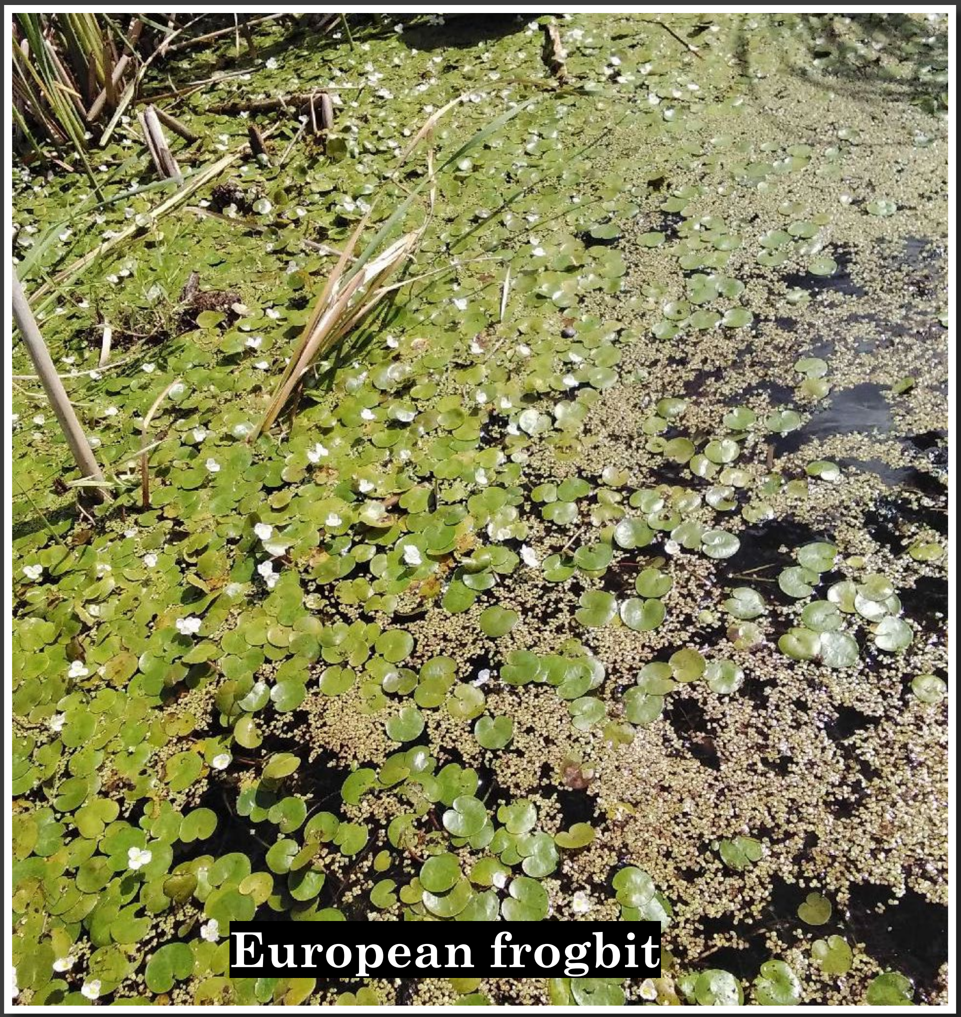




DEER CREEK: NATIVE, EMERGENT RIPARIAN PLANT SPECIES



DEER CREEK:
AQUATIC INVASIVE SPECIES


European frogbit


Purple loosestrife

Whorled water milfoil


Rootz