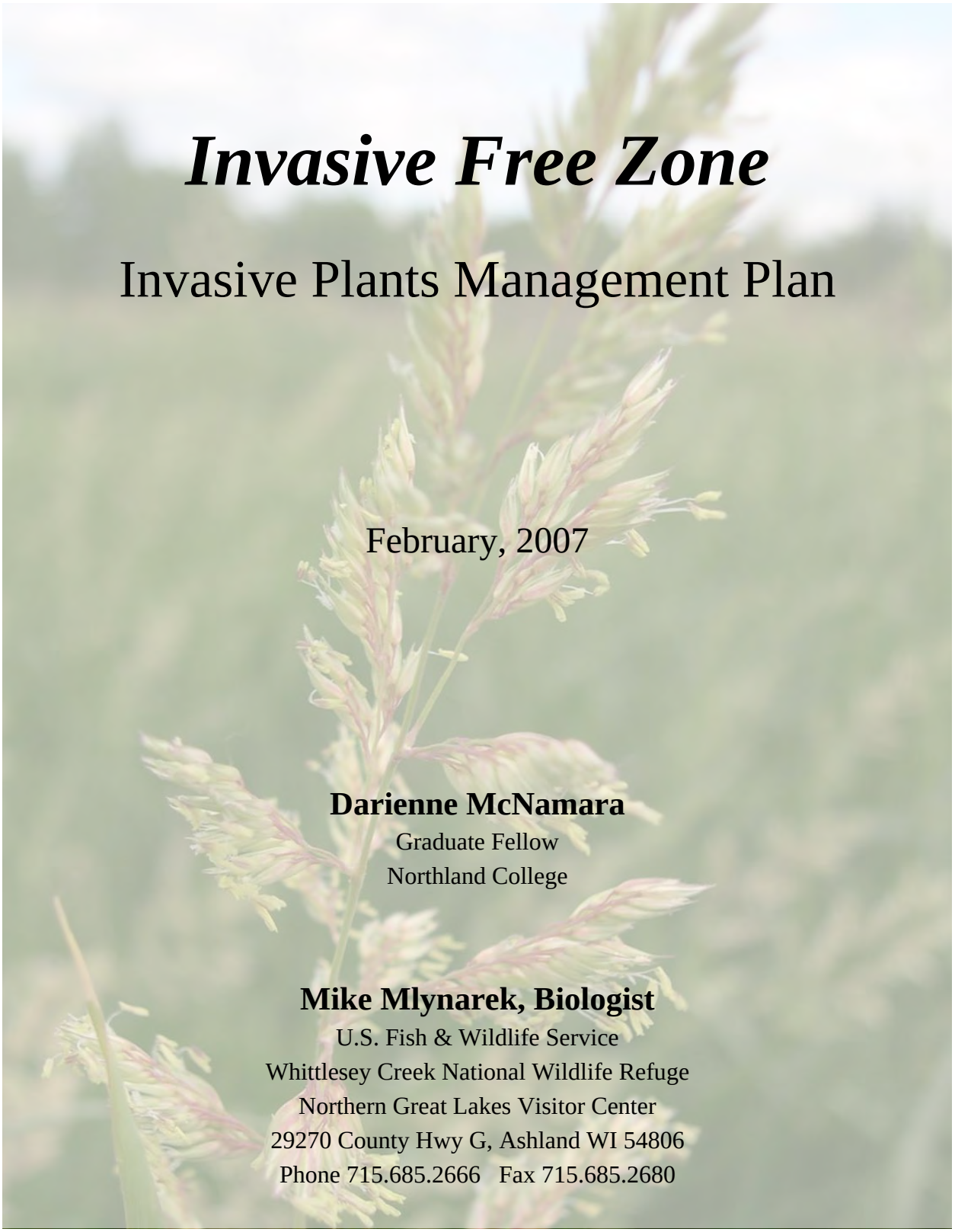

Invasive Free Zone

Invasive Plants Management Plan

February, 2007

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INTRODUCTION

Invasive Free Zone

In a recent article published in Natural Areas Journal, researchers Sebastien Lavernge and Jane Molofsky (2006) wrote:

> *"…management of invasive species must switch from isolated efforts of stand eradication to a landscape approach, emphasizing infestation prevention and accounting for surrounding human activities and the socio-economic context."*

Invasive species do not recognize arbitrary boundaries, therefore an effective management strategy must overcome these boundaries to the greatest extent possible. To this end, the Whittlesey Creek National Wildlife Refuge, U.S. Forest Service and partners of the Northern Great Lakes Visitor Center (NGLVC) are working to establish a model Invasive Free Zone (IFZ). The IFZ will encompass 720 acres and include multiple landowners, multiple habitat types, and multiple invasive species. Of the total area, 214 acres are US Fish & Wildlife Service (Refuge) lands, 180 acres are U.S. Forest Service (NGLVC) lands, and 326 acres within the Refuge acquisition boundary remain in private ownership. Fortunately, many of the private landowners have granted access to their property for the purpose of invasive species management (see Table 1). By working across ownership boundaries, we are able to take a more eco-*logical* approach to invasive species control.

Table 1. Land Ownership Within the Invasive Free Zone (as of October 2006).

	Total acres		**Percent of Invasive Free Zone**	
Refuge lands	214	600	30%	83%
US Forest Service lands	180		25%	
Private lands – access granted	206		29%	
Private lands without access (*as of May 2006*)	120		17%	
Total	720		100%	

The IFZ project will inventory, map, control and monitor terrestrial and emergent aquatic plants that are known to exhibit invasive characteristics. In the early stages of the project, we have chosen to focus on terrestrial and emergent aquatic plants for several reasons. First, there is very little aquatic habitat within the IFZ capable of supporting aquatic invasive species such as Eurasian water milfoil (*Myriophyllum spicatum*) and curly-leaved pondweed (*Potamogeton crispus*). Secondly, in order to keep the scale of the project at a workable level, control of other invasive organisms has not been included at this time.

The project goal is to eliminate invasive terrestrial and emergent aquatic plants and restore native plant communities. It is important to acknowledge that becoming and remaining entirely "invasive-free" is unlikely. New infestations, re-infestations and newly occurring species will pose a continuing challenge. The goal is similar to managing for "Zero Discharge" of persistent toxins into the Great Lakes or attaining 100% compliance with certain environmental regulations. The project strives to drastically reduce invasive populations and achieve a "monitoring and maintenance mode" in which ongoing monitoring will identify isolated infestations, and minimal maintenance will be required to control them before they expand into a long-term problem. This approach follows the "Early Detection, Rapid Response" strategy.

Document Intent & Scope

This document is the product of a partnership among numerous agencies and individuals. It is based upon a review of recently published literature regarding invasive species biology and control, consultation with local and regional natural resource professionals, and the experiences of the staff at the Whittlesey Creek National Wildlife Refuge (Whittlesey Creek NWR). The report is intended to summarize relevant information and establish a management plan for controlling invasive species within the Invasive Free Zone.

It is anticipated that the findings and recommendations in this report will be applicable to areas beyond the boundaries of the IFZ. It is our hope that these efforts will assist others in identifying the most effective means to control invasive species on their property – be it a National Park, a National Wildlife Refuge, or a private home site. This management plan should serve as a template for others. Project specifics such as site conditions, access to labor and equipment as well as control and restoration goals and objectives will dictate the approach taken.

BACKGROUND

❖ Physical or Geographic Setting

(Excerpts from the *Whittlesey Creek NWR Habitat Management Plan 2006*)

The Invasive Free Zone is located in the Lake Superior basin on Wisconsin's Bayfield Peninsula in (see Figure 1). It is situated at the lower end of both the Whittlesey Creek watershed and the Terwilliger Creek watershed. Total surface acres of all watersheds contributing water to Lake Superior are less than the lake's surface area, resulting in very short drainage systems. Coastal wetland function and composition are affected directly and indirectly by lake level fluctuations.

The Whittlesey Creek watershed covers approximately 24,000 acres when both surface water and groundwater recharge contributing areas are included. The surface water contributing area is approximately 4,700 acres, which includes Whittlesey Creek, the North Fork and numerous small tributaries. The elevation of the surface water contributing area changes from 1,100 feet mean sea level (msl) at the upper end, to approximately 600 feet msl at Lake Superior. The Terwilliger Creek watershed is only approximately 1,400 acres.

❖ Climate

(Excerpts from the *Whittlesey Creek NWR – Habitat Management Plan 2006*)

The climate of northern Wisconsin along Lake Superior is moderated by the lake, producing longer springs and falls, cooler summers and increased precipitation when compared to inland areas. Over the last 30 years, the average annual temperature was 40.5°F. The average temperature for January was 9.8°F and for July it was 67.2°F. The area averaged 40.4 days where the temperature was below 0°F and only 6.3 days above 90°F. The average annual precipitation over the past 30 years was 30.02 inches. The greatest precipitation falls from June to September. Average annual snowfall is 58.0 inches, which typically falls from November through March. The average growing season, using median of 28°F, is from May 18 to October 1 (135 days).

❖ Hydrology

(Excerpts from the *Whittlesey Creek NWR – Habitat Management Plan 2006*)

Early surveyors made notes about streams, lakes, marshes or swamps and vegetation. Over time, roads, railroads and bridges affected the flow of streams within the IFZ and altered overland flood flows, either channeling them or slowing them by creating artificial dikes. Timber harvest and land use changes have affected overland flow and stream conditions significantly. Conversion from forests to cropland and pastures has increased peak flows on the creeks. Clay soils in the watersheds exacerbate peak flows. While erosion, sediment transport and deposition are normal stream processes, excess sedimentation will contribute to stream destabilization and aggradation downstream.

❖ Pre-Settlement Vegetation

(Excerpts from the *Whittlesey Creek NWR – Habitat Management Plan 2006*)

Pre-settlement vegetation was documented by the Public Land Survey (PLS) conducted from 1833-1866. Public Land Survey records were written in the 1850's and 1860's (in northern Wisconsin) by the first surveyors who mapped the region. While establishing section lines, they documented tree species, understory species, soil conditions, and notable features such as streams or villages. This information is available from the University of Wisconsin Library website: http://digicoll.library.wisc.edu/SurveyNotes/SurveyInfo.html. The notes are not a comprehensive list of pre-settlement plant species. PLS records, along with the work of Robert W. Finley and John T. Curtis, were used to determine the pre-settlement vegetation of the region (see Figures 2 & 3).

The historic vegetation of the Invasive Free Zone, according to the map created by Finley in 1976, shows a large conifer swamp at the mouth of Fish Creek, extending into the property owned by the Northern Great Lakes Visitor Center and up to Whittlesey Creek. The vegetation would likely have been northern white cedar (*Thuja occidentalis*), black spruce (*Picea mariana*), tamarack (*Larix laricina*) and balsam fir (*Abies balsamea*). Remnants of this vegetation type exist at the southern edge of the Whittlesey Creek NWR and northern edge of the NGLVC land. The northern edge of the IFZ, which is at a higher elevation, is described as mixed conifer-deciduous forest, which would include white pine (*Pinus strobus*), red pine (*Pinus resinosa*), yellow birch (*Betula alleghaniensis*), and hemlock (*Tsuga canadensis*). The area south of the conifer swamp is noted as boreal forest, with species such as aspen (*Populus spp.*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), balsam fir, red pine and white pine.

The Public Land Survey notes from 1852 to 1855 listed black ash (*Fraxinus nigra*), spruce, tamarack, white pine, red pine, balsam, cedar, and elm (*Ulmus Americana*) as timber or post tree species. Understory species listed include alder (*Alnus spp.*), cedar, willow (*Salix spp.*), hazel (*Corylus spp.*), and dwarf maple (*Acer spp*.).

Most of the timber noted by surveyors was harvested by the early 1900's. Land nearest to Lake Superior was the first to be cleared by European settlers and was primarily used for farming. The 1938 aerial photo shows the extent of farming (see Figure 4). Most likely, land within the IFZ was often too wet, either from floods or from high groundwater, to produce consistent crops. Ditch networks were established to hasten land drainage for agricultural purposes. When the Whittlesey Creek NWR was established in 1999, only about 90 acres were hayed or pastured within the Refuge boundary. No annually tilled cropland remained.

❖ Current Vegetation

(Excerpts from the *Whittlesey Creek NWR – Habitat Management Plan 2006*)

There are a few sites within the Invasive Free Zone that still exhibit many of the characteristics described by the original surveyors in the 1850's. These "relict" plant communities serve as ecological reference sites and provide direction for restoration efforts. These sites include a cedar/tamarack swamp, black ash swamp, sedge meadow and mixed coniferous forest.

Currently, less than 60 acres of the historic farmland is hayed or pastured. Some of the former agricultural land has transitioned to water-tolerant trees and shrubs such as willows, white cedar, black ash and speckled alder (*Alnus incana*). Other old fields are largely comprised of invasive reed canarygrass (*Phalaris arundinacea*), with varying amounts of both native and/or invasive grasses and forbs.

According to the National Hierarchical Framework of Ecological Units (NHFEU), the IFZ is located within Province 212, the Laurentian Mixed Forest. Province 212 is located across the northern portion of the Lake States eastward through Pennsylvania, New York, and Maine. The vegetation of Province 212 is described as transitional, between the boreal forest and broadleaf deciduous forest. Based on the U.S. Forest Service description, "part of it consists of mixed stands of a few coniferous species (mainly pine) and a few deciduous species (mainly yellow birch, sugar maple, and American beech - *Fagus grandifolia*); the rest is a macromosaic of pure deciduous forest in favorable habitats with good soils and pure coniferous forest in less favorable habitats with poor soils."

A portion of the Whittlesey Creek NWR was slated for development into an 18-hole golf course in the late 1980s. Construction started in 1990, with large quantities of fill spread to shape fairways. This project was discontinued around 1997, prior to Refuge establishment. Presently, this site is dominated by non-native grasses and forbs such as reed canarygrass, Canada thistle, tansy and other cool-season forage grasses. Traces of native sedges remain in small patches scattered throughout the site.

Figure 6 provides an example of invasive species infestations throughout the Invasive Free Zone. These data were collected in 2005 and 2006.

❖ Current Land Use

The majority of the land within the IFZ is public land. The Whittlesey Creek National Wildlife Refuge (U.S. Fish & Wildlife Service) is located in the northern portion of the IFZ, with the Northern Great Lakes Visitor Center (U.S. Forest Service) to the south. The remaining private property within the Invasive Free Zone is undeveloped or rural residential. Several roads transect the IFZ, including a heavily traveled state highway, a county highway and town roads. In addition, an old railroad right-of-way and utility rights-of way transect the site. The railroad right-of-way is used as a snowmobile trail that is periodically maintained using heavy equipment to cut back vegetation and groom trails. A natural gas pipeline that transects the IFZ also receives infrequent maintenance with heavy equipment to clear shrubs and trees.

Northern Great Lakes Visitor Center near Ashland, WI.

Southeast of the IFZ is the Fish Creek Sloughs, an extensive wetland system which is owned and protected by the Wisconsin Department of Natural Resources and city of Ashland. Combined, these sites account for nearly 2,000 acres of publicly owned land.

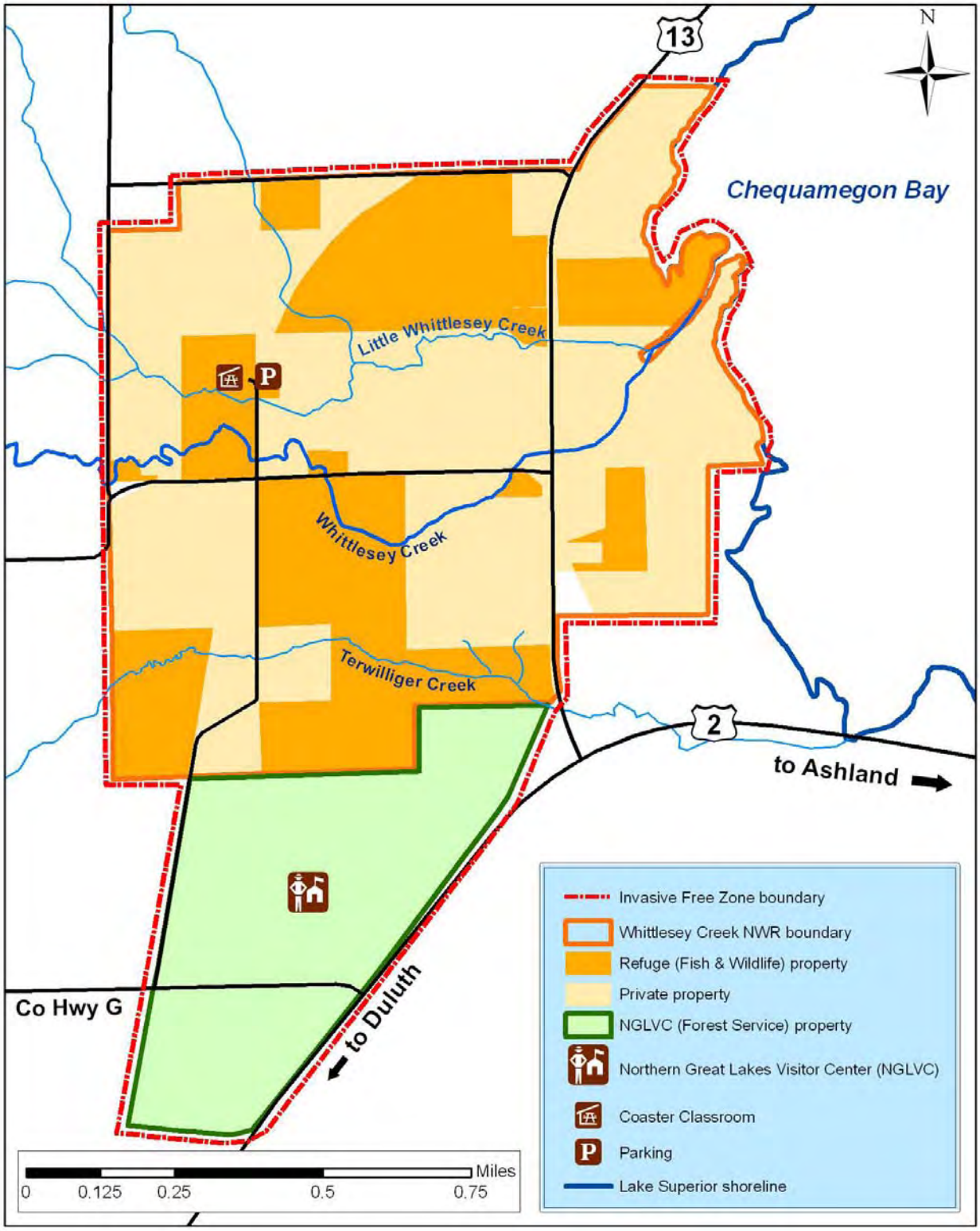

Figure 1. Map showing the Invasive Free Zone, comprised of the Whittlesey Creek National Wildlife Refuge (including private in-holdings) and the Northern Great Lakes Visitor Center.

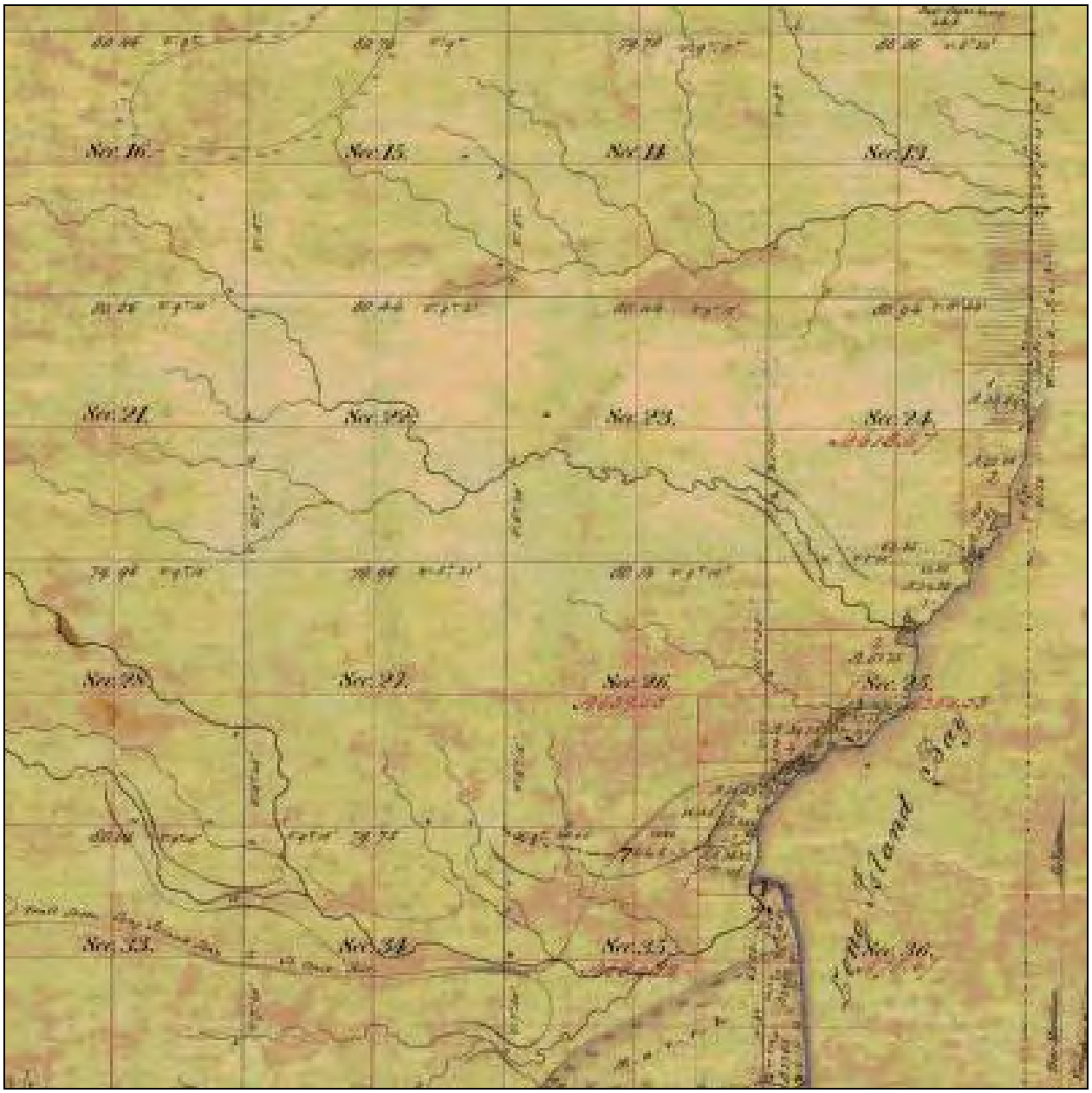

Figure 2. Map of the Chequamegon Bay area created in 1852 for the Public Land Survey of Wisconsin (*image courtesy of the Wisconsin Board of Commissioners of Public Lands website at* [*http://digicoll.library.wisc.edu/SurveyNotes/*](http://digicoll.library.wisc.edu/SurveyNotes/)).

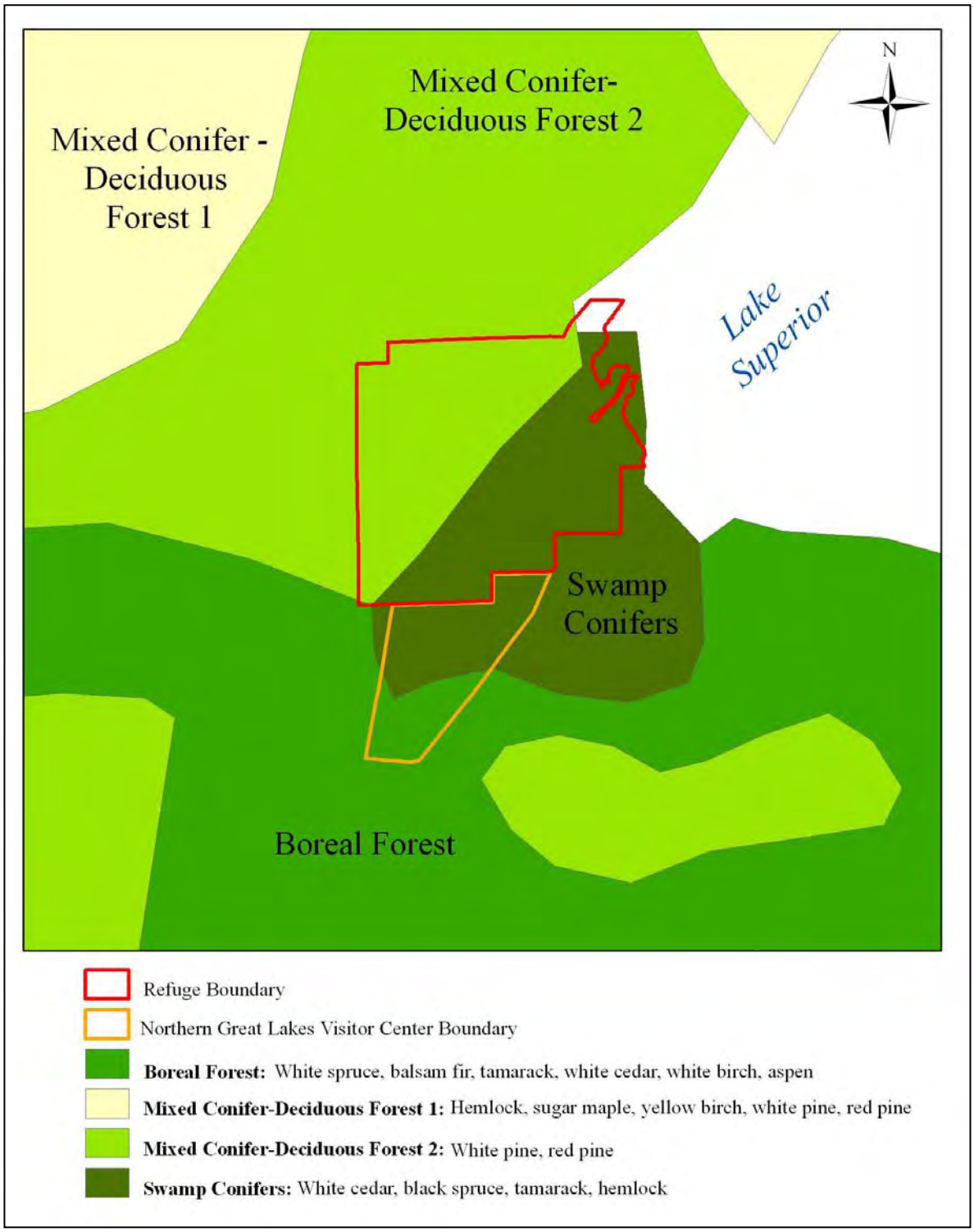

Figure 3. Map of pre-settlement vegetation in the Chequamegon Bay area *(data created by Robert J. Finley – 1976, provided courtesy of the Wisconsin Department of Natural Resources GIS Services Section).*

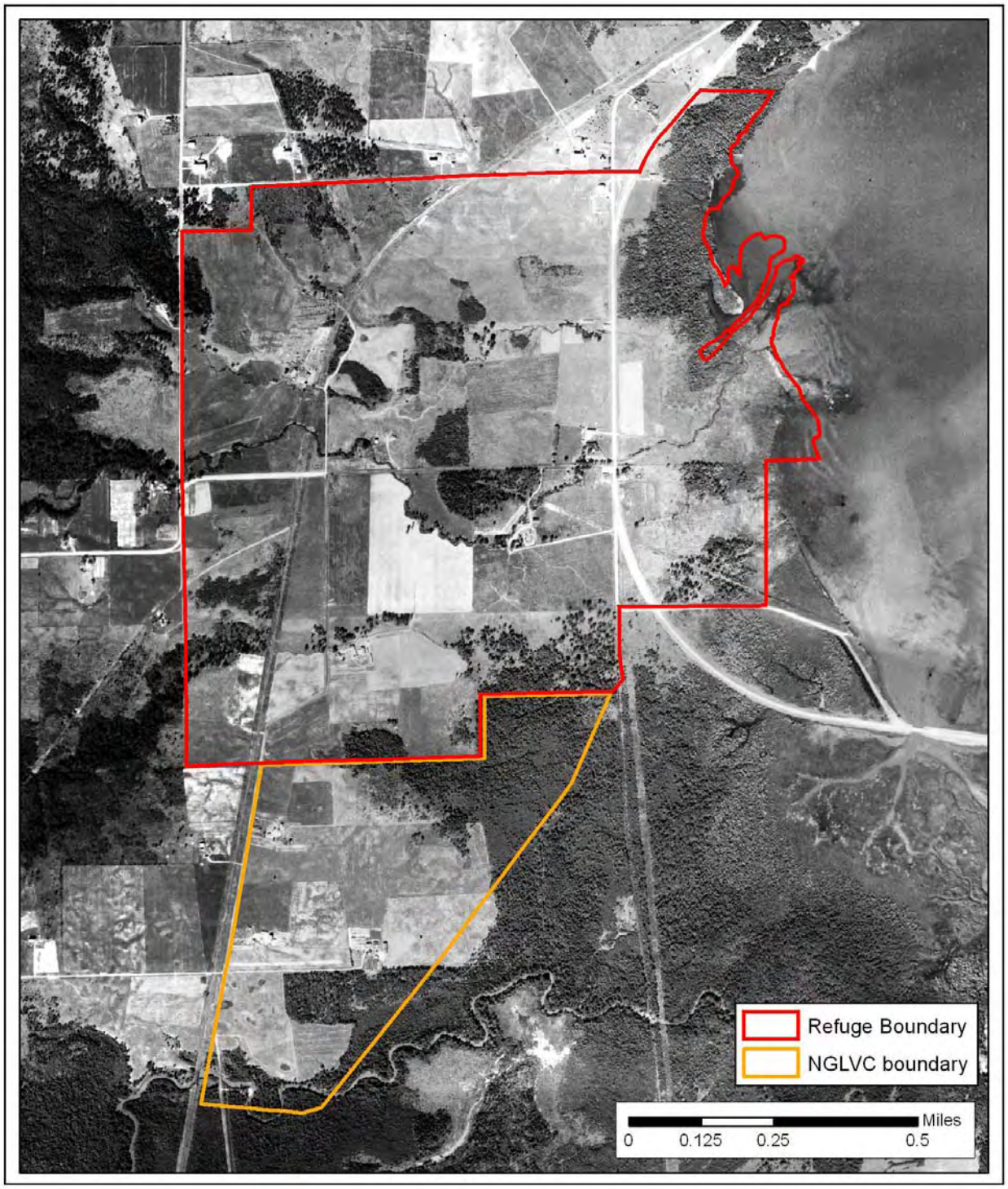

Figure 4. Aerial photograph of the Invasive Free Zone taken in 1938. Note the extensive farmland as compared to the 2005 aerial photo (Figure 5).

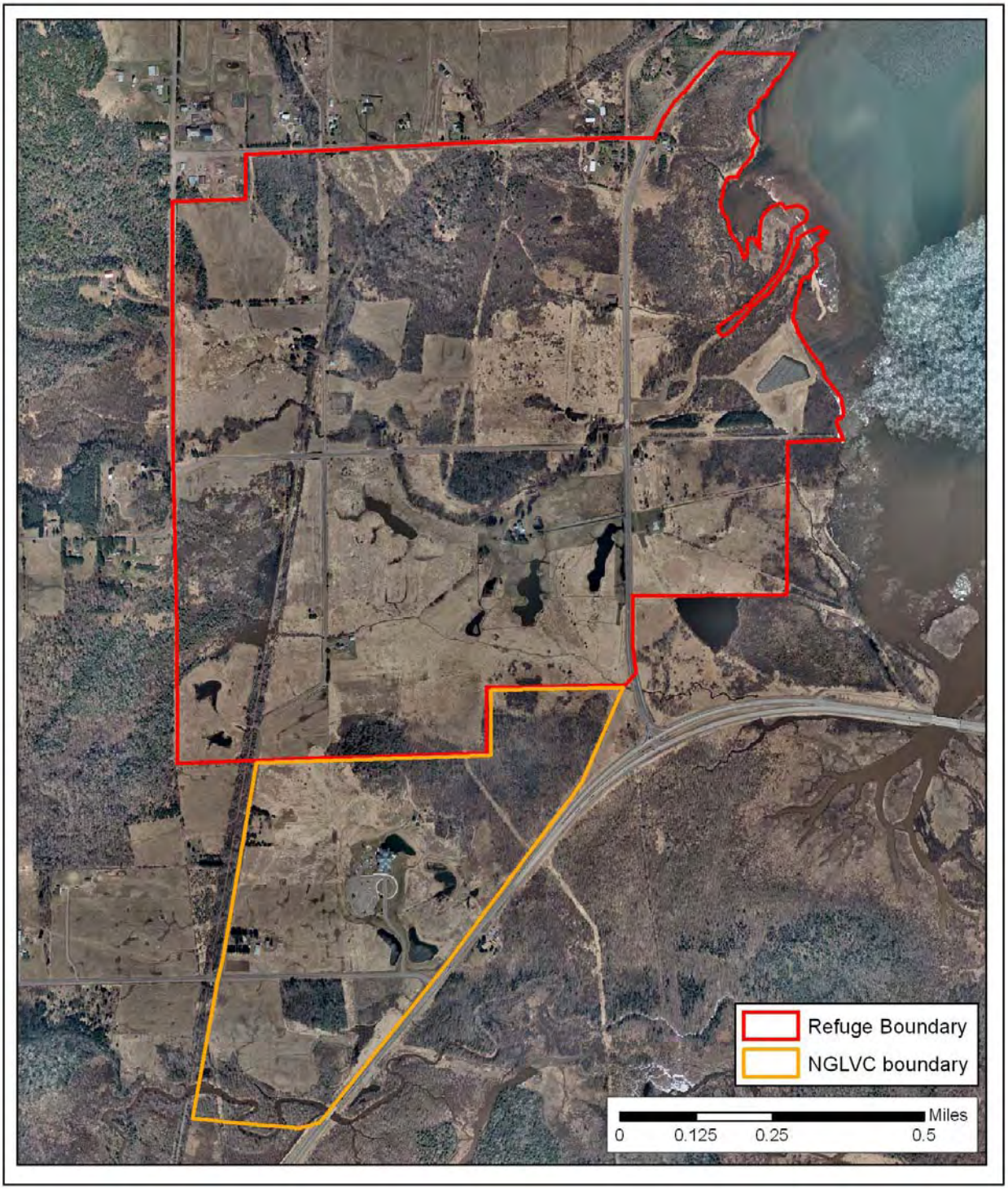

Figure 5. Aerial photograph of the Invasive Free Zone taken in 2005.

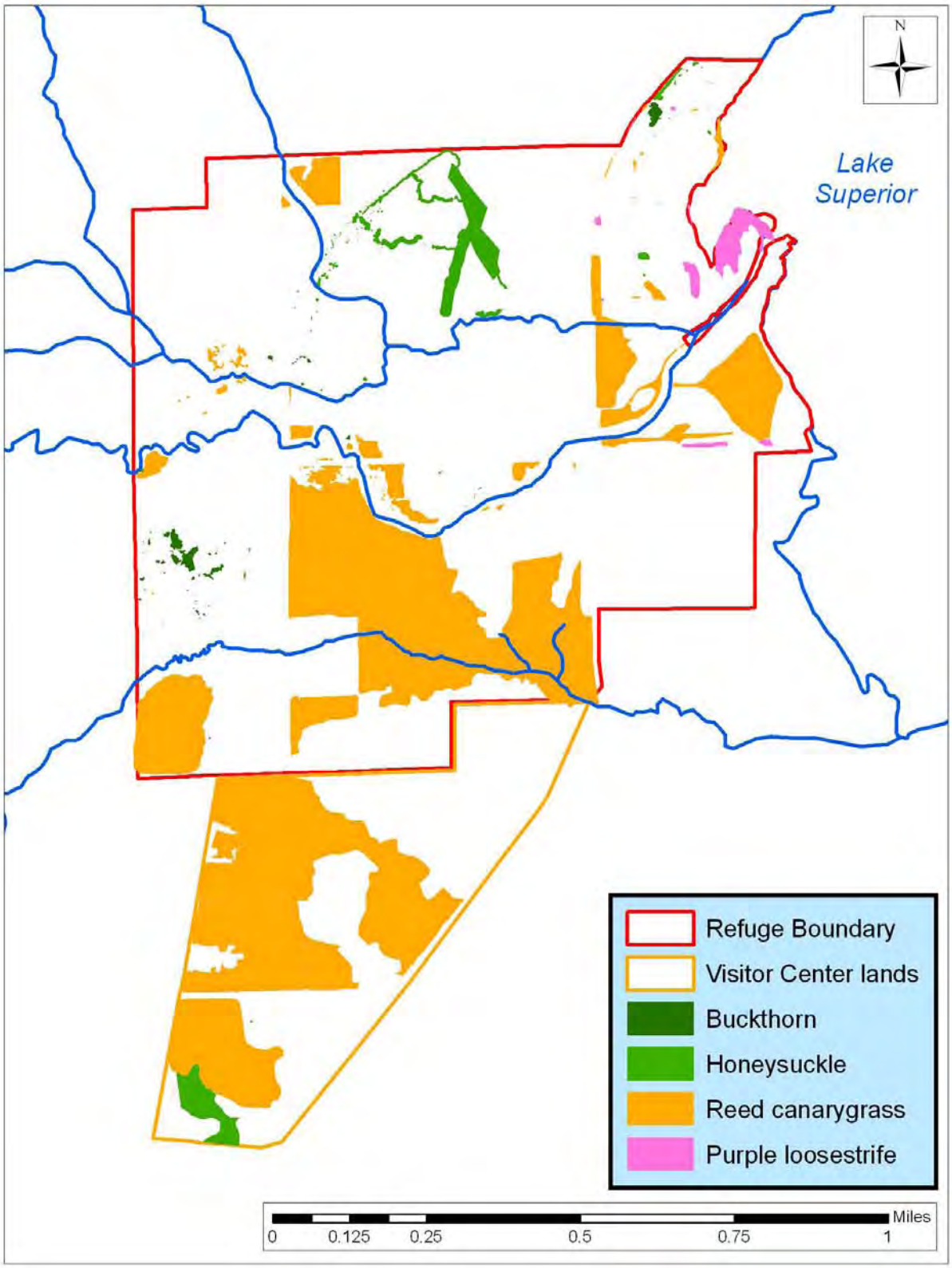

Figure 6. Map of buckthorn, honeysuckle, purple loosestrife and reed canarygrass IFZ infestations *(depicts data collected as of Oct 2006)*.

PROJECT COMPONENTS

❖ Mapping

Invasive species within the IFZ are inventoried and mapped on a landscape-scale using a mapping GIS/GPS unit (Thales® MobileMapper®) setup with a data dictionary to record information required by the mapping standards of the North American Weed Management Association (NAWMA). The information includes date, species, percent cover, landowner, and observer's name (see http://www.nawma.org/). Although other mapping standards exist, such as the Weed Information Management System (WIMS) used by The Nature Conservancy (see http://tncweeds.ucdavis.edu/wims.html), NAWMA standards were selected because they are somewhat more comprehensive than WIMS. Additionally, NAWMA standards have been endorsed by the U.S. Fish & Wildlife Service, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds, and are used by one of our major partners – the Great Lakes Exotic Plant Management Team (National Park Service).

Data are post-processed (spatially corrected) in the office and are managed and analyzed using ArcGIS 9.1®. Future mapping will aid in assessing treatment efficacy and document changes in infestation size and density. Ongoing mapping will guide treatment strategies and is critical for early detection and rapid response as new infestations occur.

Mapping in the IFZ occurred in 2005 and 2006 and will be completed during 2007. As of 2006, mapping is 65% completed. Sites remaining to be mapped include certain forested areas on both private and public land, and utility rights-of-way.

For some species, mapping in the field can be aided by evaluating high-resolution aerial photography. Analyzing color imagery from early spring (leaf-off) 2005 has reduced time spent transecting the IFZ. With experience, for instance, reed canarygrass infestations can be identified by color and textural patterns. Infested areas are then delineated (digitized) with ArcGIS 9.1® and in-field time is reduced to verification and recording percent cover. Also, purple loosestrife infestations have been located by looking at the photos for clearings in dense brush within coastal wetlands.

❖ Photographic Chronology

Control success often depends on treating individual species during the proper phenological stage. Also, appropriate control options for a particular species can change as plant development progresses. To document plant phenology within the Invasive Free Zone, invasive species were photographed every 7-10 days throughout the 2006 growing season. This photographic record of plant development will serve as a predictive calendar for timing control efforts when individual species are at their most vulnerable stage or stages, thus assisting with scheduling and prioritizing treatments (see Appendix A). A predictive calendar will also identify suites of invasive species that can be treated at similar times.

It may not always be possible to apply treatments at the "ideal" phenological stage due to issues like weather, labor shortages or equipment breakdowns. Quite likely, treatments will be applied to some species over a range of developmental stages. By evaluating

control effects of treatments applied across a range of phenological stages, experience will be gained regarding the "window of opportunity." This information will assist with IFZ adaptive management decisions. Chronologic photos should be collected annually.

This visual record can also assist with scheduling mapping. Accuracy will increase and labor requirements will decrease by mapping individual species during periods when they can be quickly and easily identified.

❖ Monitoring

Several monitoring techniques will be used due to individual species' growth habits and favored site conditions. Quadrats, transects, stem counts, photo-points and chronological mapping will be utilized as described in later sections. Monitoring will facilitate adaptive management, ensure effective long-term control and enable early detection and rapid response as new infestations or new invasive species occur. For species-specific protocol, refer to the High Priority and Low Priority Species sections.

❖ Education & Outreach

Education and outreach are fundamental components of the Invasive Free Zone project. This includes informing the public, natural resource professionals and others involved with invasive species control.

IFZ staff hosted a workshop for homeowners on June 24, 2006 along with the Northwoods Cooperative Weed Management Association (NCWMA), which fosters collaborative invasive species efforts among its agency, non-governmental organization and private citizen members. Residents from the city of Ashland learned about invasive species biology, control options, and landscaping with native plants.

An Invasive Species Field Day was held August 22, 2006 at the Whittlesey Creek NWR. The event was co-sponsored by the NCWMA. Regional natural resource professionals discussed invasive species biology, treatment methods, and "watch list" species that occur nearby. This event provided an opportunity for the 35 attendees to discuss their respective experiences and form partnerships. A similar workshop has been scheduled for the summer of 2007.

A young visitor examines the beetle rearing process at the Northern Great Lakes Visitor

The Northern Great Lakes Visitor Center provides a unique setting that allows the IFZ project to reach thousands of visitors annually. In early summer, visitors can learn about raising beetles for purple loosestrife control. Beetles are collected locally, brought to the NGLVC and raised on loosestrife plants harvested from the IFZ. Once they have laid their eggs, the beetles and their larvae are released at sites infested with purple loosestrife. Posters and signs explain the rearing process and inform visitors about the damage loosestrife inflicts on native wetland ecosystems.

The NGLVC trail system also exposes visitors to habitats that range from marginally- to highly-impacted by invasive species. One of the trails goes past the reed canarygrass research plot described in the *Reed Canarygrass Monitoring* section (page 39). Signs have been posted explaining the IFZ project and the reed canarygrass research being conducted.

IFZ presentations have been made in the U.S. and Canada to the Lake Superior Binational Program, the Lake Superior Task Force, the U.S. Fish & Wildlife Service Region 3 Headquarters, the U.S. EPA – Great Lakes National Program Office, and the U.S. Forest Service Regional Office Leadership. All of the above have generously provided IFZ support and funding.

The IFZ project strives to do more than simply educate people about invasive species. The intention is to inspire others to take action and ultimately manage their own "invasive free" area, however large or small. An IFZ project case study will provide additional guidance for such efforts. The case study will detail successes, challenges and experiences. Topics will range from the complexities of securing funding, working with multiple agencies and private landowners, to experiences using various control techniques and herbicide application tools. The case study is expected to be finalized prior to the 2007 field season.

INVASIVE SPECIES MANAGEMENT

Prevention is an integral part of invasive species management. Viable plant propagules (i.e., seeds, rhizome fragments) can be moved to a site by wind, water and wildlife, on equipment, in seed, mulch, gravel or fill, on clothing, etc. A successful invasive plants control program must account for and address these methods of plant dispersal. For instance, when seeding, always use seed that is inspected and certified as not containing other plant species. Whenever possible, conduct work beyond the borders of the Invasive Free Zone.

There has been a substantial amount of research conducted on invasive species, and a wealth of literature has been produced in recent years. Much of the current research on the subject has originated from southern Wisconsin, Minnesota, and the Pacific Northwest, as well as many western states. When applying this research, it is important to consider differences in habitats, climatic conditions and plant phenology in these areas. Variations will inevitably occur in the effectiveness and timing of treatment and restoration. Further experimentation will need to take place in this region to determine the most effective control and restoration techniques for the Invasive Free Zone. Also, it will be critical to stay current with new research so that informed adaptive management decisions can be made as the science of invasive species control evolves.

Invasive species control began in 2005 in the IFZ and is ongoing. Small infestations were targeted first with the goal of eradication during the early stages of invasion. In the future, these control efforts will continue while larger infestations are addressed. Additionally, "controlling the invasion front" will become a focus. Encroaching reed canarygrass, for example, should be kept out of intact sedge meadows. Monitoring will be carried out annually to facilitate adaptive management and ensure that effective control is achieved. Adaptive management cannot be stressed enough. Treatment techniques must be critically evaluated continuously. Most options will require multiple years of treatment since one application rarely eradicates an invasive species. Invasive species management must be on-going since new infestations will arise as seedlings emerge from the seed bank, dormant plants re-emerge, and propagules are moved on-site.

Table 2 lists the invasive species found within the IFZ. The **Gross Infested Acres** column lists the total number of acres which are infested with individual invasive species. If a 10-acre parcel is infested with Canada thistle, **Gross Infested Acres** equals 10 acres, even if Canada thistle only covers 20% of the parcel. **Net Infested Acres** is calculated by proportionally reducing **Gross Infested Acres** based on percent coverage. For the Canada thistle example, **Net Infested Acres** equals 2 acres (20% of 10 acres). Species and acreages will change as new infestations are located, and treated infestations are eradicated. Note that some areas of the IFZ have not been mapped, including areas on both public and private lands. Mapping completion is a high priority during 2007. Also, efforts to gain access to all property will continue, with a project goal of working across the entire 720-acre target area.

Table 2. Invasive species mapped and treated in 2005 and 2006. Note that treated acres will likely need to be treated multiple times before target species are eradicated.

Common Name	Scientific Name	Gross Infested Acres*	Net Infested Acres**	Gross Acres Treated	Gross Acres NOT Treated
cool season grasses	various species	193.6	60.4	0.0	193.6
reed canarygrass	***Phalaris arundinacea***	**181.7**	**69.4**	**9.8**	**171.9**
bird's foot trefoil	*Lotus corniculatus*	83.2	5.2	0.0	83.2
red clover	*Trifolium pratense*	37.8	0.8	0.0	37.8
common tansy	*Tanacetum vulgare*	18.3	0.8	0.0	18.3
white clover	*Trifolium repens*	18.0	0.3	0.0	18.0
oxeye daisy	*Chrysanthemum leucanthemum*	11.0	0.3	0.0	11.0
buckthorn	***Rhamnus cathartica*** and ***R. frangula***	**10.7**	**1.0**	**8.7**	**2.0**
Canada thistle	***Cirsium arvense***	**5.7**	**0.8**	**5.7**	**0**
honeysuckle	***Lonicera spp.***	**4.9**	**0.7**	**4.9**	**0**
purple loosestrife	***Lythrum salicaria***	**4.7**	**1.5**	**4.6**	**0.1**
bull thistle	*Cirsium vulgare*	2.3	<0.1	2.3	0
common burdock	*Arctium minus*	2.1	0.4	2.1	0
knapweed	***Centaurea jacea*** and ***C. biebersteinii***	**1.1**	**0.4**	**1.1**	**0**
sweet clover	*Melilotus alba* and *M. officinalis*	0.2	<0.1	0.0	0.2
common reed	***Phragmites australis***	**0.2**	**0.1**	**0.0**	**0.2**
bishop's goutweed	*Aegopodium podagraria*	<0.1	<0.1	<0.1	0
crown vetch	*Coronilla varia*	<0.1	<0.1	<0.1	0
garden lupine	*Lupinus polyphyllus*	<0.1	<0.1	<0.1	0
orange daylily	*Hemerocallis fulva*	<0.1	<0.1	<0.1	0
hawkweed	*Heiracium spp.*	not mapped	-	-	-
crack willow	*Salix fragilis*	not mapped	-	-	-
common mullein	*Verbascum thapsus*	not mapped	-	-	-
Totals		**575.6**	**142.2**	**39.3**	**536.3**

Bold = high priority species (refer to page 20-42 for more information).

*Gross infested acres = the total number of acres which are infested with an individual invasive species.

**Net infested acres is calculated by proportionally reducing Gross Infested Acres based on percent coverage.

In addition to the species identified within the Invasive Free Zone, several other invasive species occur in the region, but have not been found in the project area. These include, but are not limited to, Japanese knotweed (*Polygonum cuspidatum*), leafy spurge (*Euphorbia esula*), garlic mustard (*Alliaria petiolata*), and giant hogweed (*Heracleum montegazzianum*). Each of these poses a significant threat to native plants. IFZ staff should become familiar with these and other "Early Detection, Rapid Response" species and take immediate action if they are found.

❖ Control Techniques

Manual methods such as pulling, digging or cutting; mechanical techniques such as mowing, tilling and clipping; cultural methods such as planting cover, smother or nurse crops after tillage; and biological control agents can all effectively control certain species. Burning and torching (i.e. spot treatment with a propane torch) can be successful, especially when combined with a well-timed herbicide application. The Nature Conservancy has written extensively on these methods in the "Weed Control Methods Handbook: Tools & Techniques for Use in Natural Areas" (Tu, et. al., 2001). Some invasive species are not adapted to natural fire cycles, whereas many native species have evolved to survive these events and even flourish after a fire. Flaming or torching with a small propane torch can be used as an alternative when prescribed burns are impractical due to weather conditions, site conditions, limited resources, or other complicating factors. Burning within the IFZ currently is not a control option. Once a burn plan has been developed and approved by federal and state agencies, prescribed fire or torching may become a viable alternative. Mixed federal, private and residential ownership and proximity to county, state and U.S. highways may complicate prescribed burning.

More passive, long-term approaches are sometimes used as well. For instance, tree and shrub seedlings can be planted to restore forest or shrub habitat in an open field. In highly infested sites, spot treatments may be required around the trees and shrubs to keep invasive species from choking out seedlings. However, once trees and shrubs are established, shading can be an excellent control mechanism as the canopy develops. Active control may only target the most aggressive invasive species which will initially crowd out seedlings.

Reference materials and experience will assist with determining the most appropriate control technique for each species in a particular situation. Effective and efficient non-chemical control will be used in the IFZ whenever practicable. Unfortunately, non-chemical control is not an effective option for some of the most aggressive invasive species.

❖ Herbicide Use

Based on reference materials and experience, herbicides may be the best option for long-term, large-scale control of certain invasive plants. There are numerous chemicals available, and it is imperative to consider all the ramifications involved with selecting and applying herbicides. Federal law requires that herbicides be used according to product label directions. By reading and understanding the label, decisions can be made about appropriate application rate, method, timing, etc. The label provides the information needed to minimize impacts on human health, wildlife, groundwater, surface water, soil

and non-target plants. Sample labels and Material Safety Data Sheets are available online at www.pesticideinfo.org or www.greenbook.net.

Although gallon prices vary considerably, the chemical cost per unit area of application may be similar for different herbicides since expensive compounds are typically applied at lower rates. Unfortunately, most chemicals can only be purchased in 1 gal., 2.5 gal. or larger containers. For the IFZ, large quantities of certain herbicides are far in excess of what will likely be used over time. Partnering with others working on invasive species management provides an opportunity to share herbicides, as well as labor and specialized equipment.

Glyphosate will primarily be used because: it is suitable for control of most invasive woody and herbaceous plants within the IFZ; it can be used effectively for spot spraying, cut stump application and weed wiping; it is strongly adsorbed to soil particles, minimizing potential leaching; it readily degrades, resulting in no residual activity; it exhibits low toxicity in tests required for federal authorization of sale and use; and it is inexpensive and readily available. Additionally, potential risks are reduced by storing fewer chemicals and smaller combined quantities. Triclopyr will be used during the winter for basal bark application with bark oil (Cide Kick II ®) to treat invasive shrubs. Although clopyralid is a commonly used herbicide, it is not recommended for sites with a shallow water table or where surface water is present, making it unsuitable for most locations within the IFZ. Also, sethoxydim and flauzifop have been researched for controlling reed canarygrass and other grasses. However, they are not approved for use in wet sites, which limits their applicability within the IFZ.

For the IFZ project, broadcast spray applications will be avoided in favor of techniques such as spot treatment, direct application and selective (weed wiper) treatment. All of these apply the herbicide to the target invasive plants with greater precision than a broadcast spray. A compatible short-lived marker dye should be added to the spray solution when spot-spraying patches or using directed application on isolated plants. Marker dye will reduce the number of missed plants while helping to avoid over-application.

Much of the target area is far too rough and soft for typical pull-type broadcast field sprayers such as those commonly used in agriculture. Also, IFZ partners don't own large volume broadcast spray equipment and rentals or custom application services are not locally available.

Weed wiper application of glyphosate diluted with water is effective and efficient in certain situations. Large weed wipers can be mounted on a tractor, ATV, boat, track-driven and amphibious equipment, making the tool extremely versatile. They come in many lengths (currently IFZ applicators can treat strips from 6¾ to 21 feet wide). Weed wiper booms are easily adjusted within a large range of heights. There must be a reasonable height difference between target and non-target plants so that damage to the latter is

Treating reed canarygrass with an ATV-mounted weed wiper, July, 2006.

minimized. Weed wipers are inexpensive, have no moving parts, are simple to operate and use less chemical per unit area than broadcast sprayers. They can effectively release existing native plants, new seedlings and transplants from taller competing invasive species. Refer to Appendix C for additional comments on various herbicide application tools.

Table 3 presents many of the herbicides recommended for invasive species management.

Table 3. General information for commonly used herbicides ("*Weed Control Methods Handbook: Tools & Techniques for Use in Natural Areas" by Tu et. al., 2001, available online at* http://tncweeds.ucdavis.edu/handbook.html). This list is not exhaustive and is not intended to serve as an endorsement for any of the products listed.

Chemical Name	Example Trade Names	Additional Information
2,4-D	Barrage, Lawn-Keep, Savage	Mimics growth hormone auxin, causes uncontrolled growth and death of plant; broadleaf specific; common and affordable; mod.-high soil mobility; generally degrades in soil and water within 10 days; highly volatile; low to moderate toxicity
Amino-pyralid	Milestone	Systemic, broad-leaf specific, non-persistent, relatively immobile in soil, slightly toxic to aquatic vascular plants, low toxicity to humans and wildlife
Clopyralid[1]	Transline, Confront, Stinger, Reclaim	Mimics growth hormone auxin, causes uncontrolled growth and death of plant; targets certain broadleaf families; potentially highly mobile; soil half-life from 1-2 months to a year; half-life in water from 8-40 days; relatively persistent; not highly volatile; practically non-toxic to fish and wildlife; can cause very severe eye damage; can indirectly affect plants by root uptake from soil in treated areas
Flauzifop	Fusilade, Fusion, Grass-b-gon	Prohibits fatty acid synthesis; grass-specific; soil half-life is 1-2 wks; low mobility; not water-soluble; low toxicity to birds and mammals, highly toxic to aquatic organisms
Glyphosate[1]	RoundUp, Cornerstone, Accord	Inhibits amino acid synthesis; nonselective; systemic; soil half-life avg. is 2 months; half-life in water is 2-10 wks; highly water-soluble, but low mobility due to strong adsorption to soil particles; low toxicity to birds, mammals, and fish
	Rodeo, AquaNeat	Similar to above; approved for use in wetlands and aquatic sites
Imazapyr	Arsenal, Topsite	Prevents synthesis of amino acids; nonselective; rapidly degrades in water (half-life of 2 days); soil half-life ranges from 1-5 months; potentially persistent in soil; low toxicity to birds, mammals, fish and insects, but may cause severe irreversible eye damage; field reports speculate that treated plants may exude Imazapyr and affect nearby non-target plants (especially when applied in high rates)
	Habitat	Similar to above; approved for use in wetlands and aquatic sites
Picloram	Tordon, Grazon, Pathway	Mimics growth hormone auxin, causes uncontrolled growth and death of plant; dicot specific; highly mobile; persists for months to years; slightly to practically nontoxic for birds and mammals, slightly to moderately toxic for aquatic species; can leach out of roots from treated plants to non-target plants; not for use in areas with shallow groundwater, Tordon is a **RESTRICTED USE HERBICIDE**
Sethoxydim	Vantage, Poast, Torpedo	Inhibits lipid synthesis; grass-specific; potentially highly mobile; soil half-life ranges from hours to 25 days; not highly volatile; water soluble; degrades readily in light (within 4 hrs in soil, within 1 hr in water); slightly toxic to birds and mammals (including humans), do not use if standing water is present
Triclopyr[1]	Garlon, Turflon, Redeem, Renovate	Mimics growth hormone auxin, causes uncontrolled growth and death of plant; broadleaf specific; average 30 day soil half-life; 2 formulations–ester and salt– which readily degrade to Triclopyr acid in soil; slightly toxic to birds, mammals, fish, and aquatic invertebrates; salt formulation can cause severe eye damage
	Garlon 3A	Similar to above, for dilution with water, for cut-stump & foliar application
	Garlon 4	Similar to above, designed for dilution with oil, used for cut-stump, foliar and basal bark application

[1]Approved for use on NGLVC (U.S. Forest Service) property according to the Chequamegon-Nicolet National Forest Nonnative Invasive Species Environmental Assessment (approved July 2005). The U.S. Fish & Wildlife Service has a more extensive list of approved herbicides for use on the Whittlesey Creek National Wildlife Refuge.

SPECIES PRIORITIZATION

High and low priority invasive species were chosen based on their relative abundance within the IFZ, as well as their relative *invasiveness*[1] (generally speaking, the degree to which they spread and exclude or replace native species). IFZ staff and local natural resource professionals assisted with prioritization. Ranking of individual species may change as continued mapping and monitoring indicate whether infestations are increasing, decreasing or remaining relatively stable. Over time, it may be determined through mapping and monitoring that some of the listed species are not exhibiting invasive characteristics within the IFZ. This can be due to site-specific conditions such as climate, soils, hydrology, competitive ability of native vegetation and land use history.

The following sections provide an overview of high priority species, including their biology, their effects on native ecosystems, and recommended control techniques. These data are based on a review of online resources, published literature, discussions with natural resources professionals and the experiences of the IFZ staff.

High Priority Species

[1] The measure of "invasiveness" was based largely on the observations of Whittlesey Creek NWR staff and discussions with local biologists. It is a subjective term and is not a documented or standardized indicator.
[2] Denotes a Noxious Weed in the state of Wisconsin.

Centaurea jacea and *C. biebersteinii* Brown knapweed and Spotted knapweed

Centaurea jacea (brown knapweed) and *C. biebersteinii* (spotted knapweed) are two distinct species with very similar characteristics. Consequently they will be addressed together in this section.

Knapweed was likely brought to the United States from Europe as a contaminant in agricultural seed during the 1890's. It was first identified as a problem in the western rangelands where it quickly began replacing forage crops. More recently, it has been invading natural areas with dry or sandy soils, such as sand barrens, dunes, and dry prairies and pastures in Wisconsin (WDNR website, see http://dnr.wi.gov/invasives/plants.htm).

To date, *Centaurea spp.* have only been recorded in three areas within the Invasive Free Zone. All three infestations are small (1.1 acre total), two of them are within 20 meters of Whittlesey Creek. Many sand and gravel pits in the area are infested with knapweed and not surprisingly, IFZ infestations are typically found along gravel roads, road shoulders and parking areas. Although it is not abundant, its allelopathic properties and rapid spread rate make it a high priority species.

- **Biology**

  Brown knapweed is a biennial or short-lived perennial forb that grows 8-32" tall depending on soil conditions. It is a sun-loving species typically found in dry upland sites with coarse soils. Leaves are small, pale green, and linear, giving the plant a distinctively sparse appearance. Flowers are very similar to those of Canada thistle (*Cirsium arvense*) – light pink or purple, approximately 1-1¾ inch in diameter, with a single flower at the end of each stem or axillary branch. Plants typically have multiple flowers. *C. jacea* flowers from June-August, and releases seeds in late summer. It reproduces solely by seed and can produce up to 1,000 seeds per plant. Seeds remain viable for up to 7 years (WDNR website). *Centaurea biebersteinii* (spotted knapweed) is similar except that it has deeply divided leaves, flowers are smaller, and bract tips are black rather than light brown.

- **Impacts of Invasion**

  Centaurea jacea and *C. biebersteinii* are allelopathic, meaning they release toxins that harm surrounding plants, and therefore they pose a direct threat to native plants. Infestations are reducing populations of sensitive species such as the threatened *Cirsium pitcheri* (pitcher's thistle). Wildlife or livestock rarely eat knapweed.

- **Control Methods**

  Manual

  Hand-pulling is generally not recommended. Knapweed has a stout elongated taproot (WDNR website) which makes it difficult to pull. Additionally, chemicals contained within the plant can potentially irritate sensitive skin. For small populations in sensitive natural areas, manual removal may be an option. Wear leather gloves and use a shovel or spade to remove the long taproot.

Mechanical

Mowing is not effective on these species. Plants will respond by producing flowers at a lower height. Even plants that are mowed at the bud or early flower stage have enough carbohydrate storage to reseed in the same season (Mauer et al., 1987). However, repeated mowing close to the ground may reduce infestations if plants are not allowed to release seeds for several consecutive years.

Prescribed Fire

Prescribed burning has produced mixed results, ranging from 5-90% control. Intense burns that remove most of the duff layer appear to control knapweed most effectively. However, stands of knapweed are typically sparse and lack dead plant material, making it difficult to support an intense fire without the use of propane torches or similar tools. Repeated annual burns have been used with varying degrees of success, although annual summer burns reduced total production and fall seedling establishment in a Michigan study. Seeding with fire-tolerant native species is critical to re-establish native plants when utilizing annual burning.

Biological Control (Biocontrol)

Several insects have been evaluated as biological control agents for knapweed, including two fly species, *Urophora affinis* and *U. quadrifasciata*, which attack the seed heads, and a root weevil, *Cyphocleonus achates*. The latter has shown promise in recent studies which examined mortality and plant biomass in relation to the abundance of the weevil (Corn et. al., 2006). According to the WDNR, *Urofora spp.* are being released experimentally in Wisconsin but are not yet available for public use (WDNR website).

A University of Idaho researcher has identified a naturally occurring knapweed endophyte that may render knapweed sterile. Promising results occurred when plants were subjected to high endophyte concentrations in lab studies. Field test are planned for 2007 (Hagengruber, 2006). Approval for release of biocontrol agents can take many years, but research and approval progress may make this a future treatment option.

Chemical

Glyphosate – A nonselective systemic herbicide. This herbicide is not widely recommended for knapweed. However, the Wisconsin DNR suggests experimenting with relatively low-toxicity glyphosate to determine its effectiveness on knapweed. Apply glyphosate prior to stem elongation.
Triclopyr – A selective systemic herbicide used for woody and broadleaf species. A 3% active ingredient (a.i.) of Garlon 3A® should be sprayed on leaves 3-4 times per year for at least two years (Morisawa, 1999).
Additional broadleaf-specific herbicides, including **2,4-D** and **clopyralid**, control knapweed. However, clopyralid is not recommended for sites with a high water table or near surface water. Knapweed infestations within the IFZ are located at sites with a high water table in close proximity to surface water (within 50 feet). Therefore, clopyralid will not be used for controlling existing knapweed patches.

- **Treatment Plan**

  IFZ infestations are large enough that digging or hand-pulling is not a favored method. Flame torching using a propane torch may be an option if allowed by Federal agency and local regulations. The appropriate parties will be contacted regarding flame treatment. Until then, herbicides will continue to be used to control this species.

  Plants were spot sprayed in late June of 2006 using Rodeo® diluted 1:1 with water (applied at 26.9% active ingredient). Some plants survived and flowered. Future control will rely on hand-pulling young isolated plants and spot spraying larger patches with glyphosate. Triclopyr will be used if glyphosate is ineffective.

- **Monitoring**

  A 10m x 10m study plot was established in 2006 to monitor the efficacy of glyphosate. Stem counts were collected from 20 random ½ m^2 quadrats. Glyphosate diluted 1:1 with water was applied using a backpack sprayer. Unfortunately, the plot was mowed by the landowner shortly after treatment (he was unaware of the recent treatment). The study will be repeated in 2007.

Cirsium arvense
Canada thistle

Canada thistle is a **noxious weed** under Wisconsin law. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars. It is the responsibility of landowners to remove this species from their property.

Canada thistle is native to Europe, not Canada, as its name might suggest. It was introduced to the United States in the 17th century and declared a noxious weed in Vermont by 1795 (Nuzzo, 1997). Through its extensive rhizomes, prolific wind distribution, and incidental human dispersal, this species is now present in nearly every state and Canadian province. It is listed as a noxious weed in at least 35 states and 6 Canadian provinces.

Roughly 6 acres of Canada thistle have been located as scattered patches within the IFZ . Most of these infestations occur along roadways, at locations with recent soil disturbance and around piles of fill at the former golf course development site. This species will require diligent monitoring and control due to its abundance in the region.

- **Biology**

  Canada thistle is a perennial forb that grows 2-5 feet tall. Stems are hairy but not prickly. Thorns are present on leaf margins which are characteristically curly and light green. Small, light purple flowers are produced from July through September. Seed heads are light brown, with tufts of fine gray hairs loosely attached on the top. These fine hairs facilitate wind dispersal of seeds which can remain viable in the soil for up to 20 years (WDNR website). *C. arvense* also spreads through rhizomes, forming dense clones capable of resprouting from root segments underground. *C. arvense* is common along roadsides and utility rights-of-way. It readily invades disturbed upland sites with full or partial sun exposure. Canada thistle tolerates a wide range of soil types and moisture levels, except for permanently saturated soils (Nuzzo, 1997).

- **Impacts of Invasion**

  This species generally does not invade healthy native plant communities, but quickly colonizes disturbed areas and restoration sites nearby. By forming dense monotypic clones, *C. arvense* can replace native species. Canada thistle can compete with agricultural crops and reduce crop yields. It also serves as a host for several agricultural insect pests.

- **Control Methods**

  Manual

  For very limited infestations, cutting plants during the bud stage when carbohydrate storage is depleted can be effective if it is repeated throughout the season for 3-4 years. Cut flowers or seed heads should be bagged and removed from the site to prevent re-establishment (WDNR website). Also, flowers are produced over the course of several weeks, therefore multiple visits will be required in order to prevent flowering.

Mechanical

Tilling or mowing every 7 to 28 days can reduce or eliminate *C. arvense* if repeated for several years. Repeated treatment is necessary to suppress new shoots that emerge from root fragments. Deep tilling (10-20cm below the surface) is more effective than shallow tilling (surface only) as the majority of the root structure of *C. arvense* occurs 20-40 cm below ground (Nuzzo, 1997). These treatments can be damaging to native plants and require substantial time and effort.

Prescribed Fire

Early spring burns can *stimulate growth* of Canada thistle, while late spring burns can reduce infestations (WDNR website). In his review of multiple articles, Rice (2005) reports highly varied responses of Canada thistle to prescribed fire.

Biocontrol

A naturally occurring bacterium, *Pseudomonas syringae pv. Tagetis*, attacks *C. arvense* and is being considered for biological control. Infected plants are chlorotic (yellowish), stunted and rarely flower. Researchers at the University of Wisconsin-Madison have successfully inhibited stands of *C. arvense* with the bacterium. In test plots, they have not been able to eradicate the plant, but they continue to research new methods to increase efficacy (Doll and Tichich, 2006). Biocontrol progress will be monitored for possible future use of this technique within the IFZ.

Chemical

Late summer or early fall is the ideal time to treat *C. arvense* with herbicides (Nuzzo, p.14). Herbicides are most effective when applied in combination with other control measures such as cutting, mowing, or burning.

Glyphosate – It is most effective during the bud, flower, and rosette stage. It is best to apply glyphosate during summer through early fall before the first frost. Lower glyphosate concentrations (2.5% a.i.) have been more effective than higher concentrations (5-20% a.i.) for foliar applications. Higher concentrations kill leaf tissue and do not translocate to the roots as effectively. Severe drought reduces the effectiveness of glyphosate on *C. arvense* (Nuzzo, 1997).
Clopyralid – A selective herbicide that targets certain broadleaf species and woody plants, but has little or no impact on grasses or other monocots. It is most effective on young plants, with limited control of shoots over 80 cm (31 inches).

❖ Treatment Plan

This state-listed noxious weed requires an aggressive control strategy. Large patches of Canada thistle were treated in 2006 with glyphosate at concentrations of 10.25-41% active ingredient using hand-held sprayers, hand-held weed wipers, and an ATV-mounted weed wiper. All formulations appeared to be effective based on visual observations of dieback and lack of regrowth. These methods will continue to be used on large patches. Scattered plants will be spot treated with glyphosate using backpack or hand-held sprayers at a concentration of 10.25-13.5% active ingredient. Clopyralid will be used if glyphosate treatment proves ineffective.

Additionally, Canada thistle near buildings and landscaped areas has been and will continue to be mowed as part of general grounds and facility maintenance operations.

- **Monitoring**

  In 2006, a 10m x 10m study plot was established to evaluate the efficacy of weed wiper treatment using Cornerstone Plus® diluted 1:1 with water (applied at 20.5% a.i.). Stem counts were collected from 20 random ½ m^2 quadrats. Glyphosate was applied as described above at the early-bud growth stage. Control appeared to be excellent based on visual observations of dieback and lack of regrowth during 2006. Dieback developed slower than on adjacent plants which received a directed spray application on the same date. Stem counts and treatment will occur annually until Canada thistle within the patch is eradicated.

Lonicera morrowii, tatarica, and x. bella Honeysuckle

In addition to several native honeysuckle species, there are three invasive honeysuckle species in northern Wisconsin (*Lonicera morrowii, Lonicera tatarica, and the hybrid Lonicera x. bella*). Due to their similar growth characteristics, all three invasive non-native species have been addressed in one section with significant distinctions noted where appropriate.

Tartarian honeysuckle was brought to the United States in the 1750's, and other species were introduced in the late 1800's (WDNR website). The westward migration of honeysuckle has occurred due to its appeal as an ornamental or horticultural plant. Also, birds that feed on the berries disperse the seeds. Honeysuckle is generally more prevalent in urban areas, but it is quickly becoming established in natural areas.

Approximately 5 acres of invasive honeysuckle have been identified in the IFZ, although mapping of forested areas and shrublands is not complete. The scattered plants and patches are more common in moist locations with some sunlight such as sparse shrub and forest sites, roadsides and fencerows.

❖ **Biology**

Exotic bush honeysuckles are shrubs with multiple woody trunks and long, extending branches. They have light-colored, shaggy bark and hollow stems, grow 3-15 feet high and are nearly as broad. They have showy flowers that bloom from May-June and bright-colored berries. Birds appear to provide the primary means of seed dispersal (WDNR website). In general, native honeysuckles grow as woody vines with the exception of *Diervilla lonicera*, which is a short bush species.

❖ **Distinguishing Characteristics**

	Lonicera morrowii Asian fly honeysuckle	*Lonicera tatarica* Tartarian honeysuckle	*Lonicera x. bella* Showy bush honeysuckle
Leaves	• elliptic to oblong • gray-green • 3-6 cm long • soft-pubescent beneath	• ovate to oblong • glabrous • 3-6 cm long	• slightly hairy beneath • oval
Flowers	• pubescent • white, fading to yellow • 1.5 to 2 cm long	• glabrous • white to pink to crimson • 1.5 to 2 cm long	• pink, fading to yellow
Berries	• red	• red, red-orange, rarely yellow	• red, rarely yellow

- **Impacts of Invasion**

  Wildlife

  Schmidt and Whelan (1999) conducted a study of the nesting success of robins and wood thrushes that utilize exotic buckthorn and honeysuckle shrubs. They found that birds nesting in the exotic shrubs experienced higher nest predation than those in two native shrubs, hawthorn (*Crataegus spp.*) and *Viburnum* species. They speculated that this was due to the structure of the exotic bushes, which generally create an open understory and a very dense canopy. Nests built in honeysuckle and buckthorn were constructed low to the ground where predators could easily travel in the absence of low limbs.

  Native Plants

  Exotic bush honeysuckles produce leaves very early in the spring and hold their leaves late into the fall. This extended annual growth period reduces the amount of sunlight reaching the understory. Ultimately, this shading results in a sparse understory and a dense canopy or honeysuckle thicket. Spring ephemerals are especially vulnerable since they typically grow prior to leaf-out of native trees and shrubs.

- **Control Methods**

  Manual

  Honeysuckle has shallow roots; small to medium-sized plants can be pulled by hand or by using tools. However, this can be time-consuming and inefficient for large infestations. Additionally, hand-pulling creates disturbed soil that can be readily invaded by other exotic species or recolonized by invasive honeysuckle. Pulling is only recommended for small infestations in areas with abundant native plants. Hand-cutting honeysuckle will kill the plant but *only when combined with herbicide* – cutting without applying herbicides will encourage aggressive resprouting and is not recommended.

  Mechanical

  Mowing is not recommended since honeysuckle tends to be found in habitat types where the technique is impractical (forests, shrublands, or wet areas). Also, as noted, honeysuckle will resprout aggressively if not treated with herbicides. The Nature Conservancy (TNC website, http://tncweeds.ucdavis.edu/esadocs.html) warns that honeysuckle wood is very tough and will quickly dull saw blades and power-tool blades.

  Prescribed Fire

  The Invasive Plants Association of Wisconsin (IPAW) and TNC both report success using fire to kill seedlings once larger plants have been successfully eradicated (IPAW website, see http://www.ipaw.org/). They also stress the importance of seeding with native species once large shrubs are removed and soil is exposed. Native fire-tolerant grasses and forbs will provide light fuels for future prescribed burns used to kill honeysuckle seedlings. Resprouting may occur, so annually or biennially prescribed burning for several years may be necessary (WDNR website). Such frequent burning will damage native shrubs and forbs that lack fire-tolerance and may be difficult in wet soils where honeysuckle is typically found.

Biocontrol

There are no known biological control agents for *Lonicera morrowii, L. tatarica,* or *Lonicera x. bella*.

Chemical

The cut-stump method is the most commonly recommended control method for honeysuckle. Although this can be effective any time of the year, spring and fall provide ideal times to distinguish honeysuckles from native shrubs because the former retain their leaves longer than native species. Applying herbicides in late fall and early spring, when native species are dormant, reduces the impact on non-target plants.

Glyphosate – A 20% a.i. glyphosate solution sprayed onto cut stumps will eradicate honeysuckle (Batcher and Stiles, 2000; WDNR website). Formulations labeled for aquatic sites must be used in moist soil locations.
Triclopyr – Triclopyr (Garlon 4®) formulated for dilution with petroleum-based oils or basal oil can be used for applications on cut stumps or as a basal bark treatment throughout the year. In some cases, winter application of triclopyr diluted in 3 to 4 parts oil has proven to be 100% effective. Spring treatment has shown 70-90% effectiveness. Also, a 1.5-2% a.i. triclopyr or glyphosate solution can be sprayed to cover the foliage (Batcher and Stiles, 2000; WDNR website).

❖ Treatment Plan

Approximately 3 acres of exotic honeysuckle were treated in 2005 and 2006 by the Great Lakes Exotic Plants Management Team (GL-EPMT) of the National Park Service as part of the crew's initial training. In late April prior to leaf-out, treatment consisted of cut-stump directed spray herbicide application using Cornerstone Plus® at an application rate of 20.5% active ingredient. Based on 2006 visual surveys of shrubs treated in 2005 and 2006, less than 5% had resprouted.

Great Lakes Exotic Plant Management Team cutting honeysuckle in the IFZ.

Early spring and late fall cut-stump glyphosate treatment will continue as described above. This direct application method uses a minimal amount of herbicide and is highly effective. Tree-marking paint applied to stumps provides a quick visual means for evaluating control in subsequent years. Glyphosate will be applied to small seedlings as a foliar spray during late fall and early spring when non-target species are less likely to be injured.

In order to spread out the seasonal workload, basal bark triclopyr (diluted with bark oil) will be used in the winter as conditions allow. Stems must be dry and the lower 12-15 inches must be free of snow, ice, or leaf litter. Direct basal bark application during the dormant season does not affect adjacent vegetation and does not require shrub cutting.

- **Monitoring**

  Bright blue tree marking paint is applied to the trunk at eye-level and ground-level. Marking paint remains visible for about 3 years, allowing easy monitoring of resprouting and thus, treatment efficacy. Eye-level marking helps to relocate the plants since treatment rarely occurs on the same day as mapping. This bright paint reduces the likelihood of missing plants while treating, minimizes time wasted in areas already mapped, and maximizes efficiency during treating. For the first 2 years after treatment, 100 random glyphosate treated cut stumps and 100 random triclopyr (basal bark) treated stems will be monitored for presence or absence of resprouts.

Lythrum salicaria
Purple loosestrife

Purple loosestrife is a **noxious weed** under Wisconsin law. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars. It is the responsibility of landowners to remove this species from their property. Many other states have similar regulations.

Purple loosestrife was first introduced to the United States from Europe and Asia in the early 1800's (WDNR and IPAW websites). Like several other invasive species, it likely came as a contaminant in the ballast water of ships entering the Great Lakes. It became a popular garden plant due to its showy purple flowers. The species was not recorded in Wisconsin until the 1930's, becoming widespread by the 1970's. Today it is found throughout the state, particularly along heavily used waterways such as the Fox and Wisconsin Rivers, and in the southeastern parts of the state (IPAW website).

There are several infestations of purple loosestrife throughout the Invasive Free Zone, totaling 4.7 acres. The largest occurs at the mouth of Whittlesey Creek, posing a threat to nearby coastal wetlands. Most of the remaining infestations are along Hwy 13 between Little Whittlesey Creek and the northern boundary of the Whittlesey Creek NWR. It is a high priority species in the IFZ due to its aggressiveness and rapid spread rate.

- **Biology**

  Lythrum salicaria is a perennial herb that grows in wet habitats such as wet prairies, shorelines, shallow marshes and riverbanks. Well-established populations can creep into drier areas. It has a distinctive square stem that grows 3-7 feet tall. Its leaves are light green, opposite, and sessile. Flowers are purple to magenta with 5-6 petals, and grow in a dense spike at the tip of the stem (IPAW website). Flowering takes place from mid-July through August. Reproduction is mainly by seed, with one plant producing 100,000 to 2 million seeds per year. Lower flowers produce seed before flowering is complete at the terminal portion of the spike. Germination can be up to 60-70%. *L. salicaria* also reproduces vegetatively via root or stem segments. Older plants form large crowns having dozens of shoots. Control will only occur after several consecutive seasons of treatment regardless of the method used.

- **Impacts of Invasion**

  This species exhibits many of the classic characteristics of an invasive plant. It grows in a wide range of conditions, forms dense monotypic stands, reproduces by seed and vegetatively, and often replaces native species. It poses a threat to rare wetland plants and reduces biotic diversity. It can grow so dense that it chokes waterways and inhibits recreational activities such as boating, fishing, and swimming.

- **Control Methods**

  Manual

  Hand-pulling can be effective for small infestations or young plants. It is important to remove all plant parts from the site to reduce vegetative reproduction. Pull plants at late bud stage to first flower to avoid self-seeding. Hand-pulling large stands is not

recommended since it disturbs soil that can be readily invaded by other exotic species or recolonized by purple loosestrife.

Mechanical

Cutting can be an effective management tool for purple loosestrife if timed correctly. Cutting too early can stimulate flowering. Cutting at late bud stage to first flower is recommended for reasons noted above.

Prescribed Fire

Burning is not recommended as a control method for *L. salicaria*.

Biocontrol

According to the Wisconsin Department of Natural Resources, biological control is the most effective option for *L. salicaria*. It can be utilized on populations of any size in many habitat types, and once established, requires few resources to maintain effective long-term control. Additionally, it is a low-impact alternative to hand-cutting, mechanical removal or chemical treatment.

The most commonly used biocontrol species are *Galerucella calmariensis* and *G. pusilla*, the "loosestrife beetles". A successful program to produce, distribute, and apply loosestrife beetles to infested areas has been developed. Local land managers and landowners can contact the WDNR if they are interested in raising and releasing beetles. Adult beetles can be collected from established populations and then transferred to other locations. Over several years, released beetle populations naturally increase and expand their range. Leaves will have holes from *Galerucella spp.* feeding. With adequate beetle populations, plants ultimately stop flowering, wither and die. The beetles rely on *L. salicaria* as their sole food source.

Chemical

Glyphosate – Rodeo® is a formulation of glyphosate that lacks a surfactant and is approved for use in wetlands. The Invasive Plants Association of Wisconsin recommends using a 10% a.i. solution of Rodeo® to treat cut stems of purple loosestrife. They suggest using a paintbrush or sponge applicator for direct application. Apply glyphosate to the top 3 feet of the stem. Ideally, treatment should occur prior to seed set. If not, remove flower heads and discard them in plastic bags, being careful not to allow seeds to fall on the ground or in the water. The Wisconsin DNR recommends treating in late July or early August.

- **Treatment Plan**

The Whittlesey Creek NWR, in cooperation with the Great Lakes Indian Fish & Wildlife Commission and the Wisconsin DNR, has released *Galerucella calmariensis* and *G. pusilla* on an annual basis since 2002. Beetles have been released at several infested locations including the mouth of Whittlesey Creek on the shore of Lake Superior. Photographic records and visual observations indicate that flowering at release sites has been dramatically reduced, and most plants no longer flower or are dead after 3 to 4 years (Fig. 7). Because of this, beetles were not released at the mouth of Whittlesey Creek in 2006. Instead, they were released at 4 other sites throughout the IFZ.

Beetles have been observed in several areas where they have never been released, indicating they are capable of traveling to other infested sites. Visual observations indicate that native species such as boneset, swamp milkweed and joe-pye weed recolonized the mouth of Whittlesey Creek once loosestrife populations were controlled. Beetle releases will continue, especially at newer infestation sites with limited evidence of *Galerucella spp.* feeding damage.

Figure 7. Photos taken at the same location at the mouth of Whittlesey Creek in 2004 (left) and 2006 (right). Note the dead loosestrife plants in the photo on the right.

❖ **Monitoring**

Annual images from established photo points will document control.

Phalaris arundinacea
Reed canarygrass

Phalaris arundinacea is native to Europe, Asia, and North America according to recent studies. Due to its prolific growth and suitability for wet soils, it has been widely used for agriculture since the 19th century (Lyons, 1998). It produces high forage yields and serves as a nitrogen "sink" by utilizing large quantities of soil nitrogen. More recently, it has been planted for erosion control at construction and restoration projects and in waterways and drainage ditches. Although it is still commercially available as an agricultural crop, *P. arundinacea* is recognized as a serious threat to native plant communities and is classified as a pest species in nine states in the U.S. (Lavergne & Molofsky, 2006). In northern Wisconsin, *P. arundinacea* is common in roadside ditches, abandoned hay fields and is utilized as a high-yield forage crop.

P. arundinacea is one of the most abundant invasive species within the Invasive Free Zone, covering approximately 180 acres. The region's farming and land use history and the project area's wet soils contribute to the abundance of reed canarygrass. Eradicating this species will require a long-term integrated approach, and will likely involve experimentation to determine effective and efficient control techniques.

- **Biology**

  Phalaris arundinacea is a perennial cool-season, sod-forming grass which grows via a dense system of creeping rhizomes. It has hollow stems reaching up to 2 meters tall, and leaves approximately 0.5 m long and 0.5-2 cm wide (Lyons, 1998). It begins producing aboveground biomass in the first 5-7 weeks of spring, earlier than most native species, and develops an inflorescence in June. Studies have found that in colder climates, such as those of northern Minnesota and northern Wisconsin, seeds do not germinate until their second year (Lyons, 1998).

  Its root system carbohydrate storage cycle results in spring depletion as biomass is quickly produced. Carbohydrates accumulate after seeds have matured in late summer and fall. A study conducted near St. Paul, MN, (at a latitude roughly 120 miles south of the IFZ) found that *P. arundinacea* translocates carbohydrates into its rhizomes from late July through fall senescence (Reinhardt and Galatowitsch, 2004).

  One of the distinguishing characteristics of *P. arundinacea* is its prominent transparent ligule, which is generally not present on native grasses such as *Calamagrostis canadensis* (Canada blue-joint). *P. arundinacea* has a bright golden color during and after fall senescence, making this an easy time of year to distinguish *P. arundinacea* from other grasses.

- **Impacts of Invasion**

  Reed canarygrass can form dense monotypic stands which decreases plant diversity, thus posing a threat to native wetland plant communities, such as sedge meadows, and wildlife habitat. It can also increase sediment accumulation and alter wetland hydrology (Lyons, 1998). Cursory amphibian surveys in the IFZ have shown substantially less diversity and abundance in areas dominated by reed canarygrass.

❖ Control Methods

The following is a list of control options for *P. arundinacea*. To date there is no "silver bullet" for this species. Short-term suppression should not be confused with long-term control. Long-term success has typically been achieved by an integrated approach, using combinations of treatment methods. Reed canarygrass is a very persistent perennial that produces large quantities of seed. Therefore, successive years of treatment and monitoring are needed to ensure adequate control of established plants and new seedlings. In some cases, a single year of treatment may even stimulate growth. Also, different situations require different control techniques. A large monotypic stand should be treated differently than a small infestation occurring within an intact native plant community. The Wisconsin Reed Canarygrass Management Working Group has put together a table that recommends site-specific treatment methods based on several parameters. This valuable reference is available online at http://phalaris.pbwiki.com/f/rcg_table_1_10_07web.pdf.

Manual

Manual removal of *P. arundinacea* is generally not recommended due to the extensive dense rhizomes. Clipping seed heads before maturation was not effective in a study conducted by Apfelbaum and Sams in 1987. Repeated mowing twice a year for successive years slightly increased native species diversity, although not to the same level as original native communities.

Water Level Management

If water levels can be manipulated, several studies indicate that prolonged flooding will cause seed decomposition, thus reducing the seed bank. Lyons (1998) notes that most reed canarygrass seeds decayed after 3 months of flooding, but 48 months of continuous inundation was required for 100% seed mortality. Flooding to control reed canarygrass plants has produced mixed results. Reed canarygrass rhizomes can survive prolonged inundation. The Wisconsin Reed Canarygrass Management Working Group (2006) indicates that rhizomes can be killed by flooding to a consistent depth greater than 1' for at least one growing season. This method will impact native species that are not flood-tolerant, however. Repeated tillage to desiccate rhizomes followed by flooding can be effective. Tilled areas are flooded to a depth greater than 18" from early winter through mid June. Active restoration should follow as soon as conditions allow. Follow up herbicide treatment of surviving reed canarygrass plants is recommended.

Mechanical

Tilling or discing can be utilized to manage reed canarygrass. Studies suggest repeated tillage throughout the growing season, and most agree that 4-5 times is necessary unless combined with another treatment method. Tillage should be timed so that disturbed rhizomes are subjected to desiccation during hot dry weather. Note that 1-2 tillage treatments can *stimulate* growth, particularly in the early growing season. Before beginning this process, ensure that the necessary resources are available for 4-5 treatments. Also, in areas where reed canarygrass is patchy and native species are present, consider options that would not damage native plants.

Prescribed Fire

In addition to herbicides, burning is one of the most commonly used control methods for *P. arundinacea*. Late spring or early summer burns have been effective in Iowa (Drobney, pers. comm., 2006). Reinhardt and Galatowitsch (2004) found that relative to unburned areas, a spring burn initially increased biomass (aboveground) while reducing the seed bank. The increased biomass likely results from regrowth of established plants plus seedling growth. By burning the thick layer of dead plant material, seeds contact the soil, resulting in germination and seedling growth. The Invasive Plant Association of Wisconsin (see http://www.ipaw.org/) indicates that mature plants are not controlled by fire since burning does not destroy the thick sod layer including the rhizomes. The species does not burn particularly hot since sites tend to be wet and plants remain green for many months.

Targeting infestations after a burn, when the seed bank is depleted and biomass is concentrated aboveground, may provide an ideal opportunity for using additional control practices such as herbicides or tillage (particularly considering that burning eliminates much of the accumulated dead plant material). To be most effective, systemic herbicides (glyphosate) should be applied during late summer or fall when plants are translocating carbohydrates to their roots.

Biocontrol

There are no known biocontrol options for reed canarygrass.

Chemical

Glyphosate – Both formulations (non-aquatic and aquatic) have successfully controlled *P. arundinacea*. Reinhardt and Galatowitsch (2004) found that Rodeo diluted to 2% active ingredient, when applied between late August and late September, was more effective than applications in May. They suggest that this is due to the carbohydrate storage cycle; applying systemic herbicides to perennial plants when they are translocating carbohydrates to the roots typically maximizes plant mortality.
Grass-specific herbicides such as **sethoxydim** and **flauzifop** have been used with some success and will not kill sedges or forbs (Czarapata, 2005). These herbicides should only be applied to 6" to 12" tall plants. In general, established plants will only be suppressed while seedlings may be killed. These grass-specific chemicals should not be used if standing water is present.

❖ **Treatment Plan**

Most of the IFZ will be restored to closed-canopy forest and shrubland habitat, and fortunately reed canarygrass is not shade-tolerant. As restoration proceeds, residual infestations will mainly be controlled by shading. New infestations are not likely to become established in restored closed-canopy plant communities (see *Restoration Goals – Former Golf Course parcel* for plans regarding restoration of closed-canopy forests).

Successful restoration must start with reed canarygrass control. Throughout the IFZ, reed canarygrass grows in isolated patches, monotypic stands, and inter-mixed with native species. Different treatment approaches should be used in different situations. Reemergence from seeds and dormant buds will require follow-up treatment for multiple growing seasons. Where herbicide is applied, glyphosate (13.45-27% a.i.) will be used

unless it is found to be ineffective after two growing seasons. At that point, a combination of other chemicals and control methods will be utilized.

In areas with *isolated patches*, an ATV-mounted (6¾' or 10½') weed wiper or backpack sprayer will be used. For sites that are inaccessible by ATV, two people can carry the 6¾' weed wiper or use backpack sprayers. If native plants do not re-populate these patches, active restoration will be initiated.

Areas with *mixed native plants and reed canarygrass* will also be treated with an ATV-mounted weed wiper early in the growing season when reed canarygrass is roughly 2' tall. This will minimize impact to the desired species. For wet sites that are inaccessible by tractor or ATV, carrying the weed wiper is an option. It is anticipated that native species will fill in spots which were occupied by reed canarygrass.

Monotypic stands will be treated using a tractor-mounted (10½' or 21') or ATV-mounted (6¾' or 10½') weed wiper. For sites that are inaccessible by ATV, the weed wiper can be carried as described above. Once established plants are controlled and the seed bank is depleted, native plant restoration should begin. Without restoration, sites will be vulnerable to reinvasion by reed canarygrass or other invasive species. Appendix B provides lists of adapted native species for different habitats within the IFZ. Most can be purchased as seeds or plants, or can readily be collected on-site.

As studies indicate, reed canarygrass control is very difficult. Given that, and its abundance within the IFZ, control will be an on-going challenge. Adaptive management will quite likely result in modified treatment techniques. For instance, if tractors and ATV's prove to be unsatisfactory, suitable track-driven units may be necessary. Although treating in late August through late September is recommended, plants can be 7' tall at this time, making application very difficult. From a practical standpoint, earlier treatment may be preferred. Trying various techniques and remaining flexible will be extremely important.

If prescribed fire is approved by the appropriate federal and state agencies, it will be used as part of an integrated strategy. In particular, monotypic stands will be treated with a combination of fire and herbicides. Once control is achieved, native plant establishment must occur quickly so that reinfestation is limited. Follow-up spot treatment will be needed.

Water level management is an unlikely control option. An extensive dike network with water control structures does not exist within the IFZ. Also, water would need to be pumped to flood reed canarygrass and to maintain the desired water depth.

- **Monitoring**

An application timing study began in 2006 using a weed wiper to apply glyphosate diluted with water at a concentration of 27% active ingredient. Studies were set up at 2 different IFZ sites, each having 3 timing treatments plus an untreated control (see Figure 8). One site was virtually homogenous reed canarygrass, while the second was a mix of reed canarygrass, cool-season forage grasses, native sedges and forbs. Soils at each site are similar.

Stem counts were collected in each plot in late spring (prior to the early-season application). Data were recorded from 20 random ½ m² quadrats per plot. Stem counts

and treatment applications will be repeated annually to monitor the long-term effect of application timing on control efficacy. Beginning in 2007, rhizomes will be dug from plot perimeters when stem counts are collected. Rhizomes will be cut, photographed and evidence of necrotic tissue will be noted. Similar studies will be established if other control techniques are utilized.

Plot 1	Plot 2	Plot 3	Plot 4
Control	Early-season application (June 22)	Mid-season application (July 6)	Late-season application (August 14)
	early headed	anthesis	ripe seed
10’ x 50’	**10’ x 50’**	**10’ x 50’**	**10’ x 50’**

Figure 8. Reed canarygrass plot diagram.

Approximately 10 acres of reed canarygrass were weed-wiped in 2006 in addition to the two study areas. Applications were made at several different sites during late August and September using glyphosate diluted 1:1 and 3:1 with water (27% and 13.45% a.i., respectively). Both formulations appeared to be effective based on visual observations of plant dieback. Treatment will continue annually and subsequent mapping will track effects on infestation patch size.

Besides the study described above, additional test plots could be established in order to experiment with other control methods. Alternatives such as fire, mowing, tilling, planting cover or smother crops (such as winter rye), herbicides and combinations of these methods could be tested for efficacy using sampling methods similar to those described above.

Phragmites australis
Common reed

Phragmites australis is found on every continent except Antarctica. Although its origin in North America was previously disputed, *P. australis* subsp. *americanus* has recently been recognized as a genetically distinct native subspecies (Saltonstall, et. al., 2004). Exotic strains are highly invasive. They can displace native species and even out-compete *invasive* species such as *Lythrum salicaria* and *Phalaris arundinacea* in certain growing conditions.

In the Midwest, *P. australis* invades disturbed wetland sites and pristine wetlands. Some municipalities in Wisconsin still use this species to dewater sewage sludge (Wisconsin Wetlands Association *Phragmites* survey, see http://www.wiscwetlands.org/phragmites.htm).

Although there is currently only one roadside patch (< ¼ acre) of *P. australis* within the Invasive Free Zone, this species is a high priority. The patch only became evident in the past few years, as have other nearby roadside patches. Based on characteristics noted below, the IFZ patch appears to be the native subspecies. However, land managers around the region have noted that *P. australis* appears to be quite opportunistic in recent years with patches expanding considerably for unknown reason.

❖ **Biology**

P. australis is a perennial wetland grass that grows up to 6 meters high. Leaves are 20-40 cm long and 1-4 cm wide, quite large compared to most native grasses. Flowers emerge in late July-September, and seed set occurs in late fall. *P. australis* grows in wetlands ranging from wet meadows (saturated soils, no standing water) to shallow marshes (up to 1m of standing water). It generally prefers full sun, though it is found in shaded areas in central Wisconsin according to a survey done by the Wisconsin Wetlands Association (WWA Phragmites website). Well-established clones are capable of reducing water levels, which can alter habitat for wildlife and native plants. It reproduces by seed and vegetatively through rhizomes.

❖ **Distinguishing Characteristics**

	Native	**Exotic Invasive**
Stem	• red to chestnut at base • scattered small black spots • flexible, smooth and shiny	• tan (rarely brown at base in winter) • ribbed and dull • rigid
Phenology	• flowers July – August • senesces in early fall	• flowers August – September • senesces in late fall
Inflorescence	• sparse, though not always	• dense
Growth	• slow expansion • intolerant of continuously inundated soils	• rapid expansion • tolerates relatively dry soils and continuously inundated soils

- **Impacts of Invasion**

  P. australis forms monotypic stands through a number of mechanisms. Dense rhizomes and adventitious roots can create an impenetrable mat. Dead plant material forms a thick layer above the soil, preventing sunlight from reaching smaller native plants. Tall stems with broad leaves further limit available sunlight. Well-established stands of *P. australis* can cause soil accretion which alters wetland topography and microhabitats. This can affect fish spawning sites and invertebrate communities (Saltonstall, Delaware conference proceedings, 2003).

- **Control Methods**

  Manual

  Like most grasses, *P. australis* growth is generally stimulated by clipping or cutting. Hand-pulling is impractical for this species due to its dense rhizomes and because root sections can resprout. Manual removal to a depth of 3 feet was effective on a small stand in New Jersey, however it was extremely labor-intensive (130 people-hours for 50 sq. ft). Soil disturbance resulting from hand-pulling may create an opportunity for further invasion by this species or others.

  Water Level Management

  If water levels can be manipulated, flooding for extended periods during the growing season is a control option. This method will impact native species that are not flood-tolerant, however.

  Mechanical

  In a survey by the Wisconsin Wetlands Association, Art Kitchen (U.S. FWS, Wisconsin) reported success by excavating to a minimum depth of 1 foot. Excavated materials were buried at a depth of 4 feet. This method is very expensive, and is not desirable for intact wetlands or small infestations.

  Prescribed Fire

  According to The Nature Conservancy, late summer burns can help reduce *P. australis*, while late spring and winter burns stimulate growth. In the WWA survey, natural resource professionals reported little success with fire unless it was combined with additional control techniques. Rice (2005) suggests using a combination of spray-burn-spray, in which the stand is treated with herbicide, followed by a dormant-season burn to remove leaf litter, and the germinating seeds are subsequently sprayed again. This method was used successfully in a Virginia study, although they did not specify the herbicide used (Rice, 2005).

  Biocontrol

  Research is being conducted on many European biocontrol species, however none are currently approved in Wisconsin. So far, research has not identified superior species. Since *P. australis* subsp. *americanus* is native to North America, approval for releasing biocontrol agents may be problematic.

Chemical

Glyphosate – The Nature Conservancy suggests applying glyphosate at label recommended concentrations after the tasseling stage when plants start translocating carbohydrates into the rhizomes.
The Exotic Plants Management Team (EPMT) of the National Park Service combines cutting and herbicide application. Stems are bundled using rope or twine, cut just above the rope, and exposed cut stems are immediately treated with concentrated glyphosate. The same method, used by the Wisconsin Department of Natural Resources, has been up to 98% effective.

❖ **Treatment Plan**

Based on the characteristics noted above and discussions with Carmen Chapin (NPS), it appears that the *Phragmites* within the IFZ is native. Plants from the IFZ and other area patches will be submitted to the Cornell University – Ecology and Management of Invasive Plants Program for positive identification (for more information on this free service, see http://www.invasiveplants.net/diag/diagnostic.asp).

If the IFZ infestation is identified as non-native Phragmites, plants will be bundled, cut and treated as noted above. Herbicide applicators should look for plants that are too short to bundle and treat those separately.

Rhamnus cathartica and Rhamnus frangula
Common Buckthorn and Glossy Buckthorn

Although they are two different species, *R. cathartica* and *R. frangula* will be discussed in one section of this document. Significant distinctions between the two will be noted throughout.

R. cathartica is native to most of Europe and parts of Asia. The native range of *R. frangula* is slightly larger, extending into North Africa and most of Asia (Converse, 1984). These species became naturalized in North America in the early 1900's, and now inhabit roadsides, ravines, forest edges and shrub-carr wetland communities (Converse, 1984). *Rhamnus cathartica* is an alternate host species for oat crown rust (USDA Agricultural Research Services website, see http://www.ars.usda.gov) and is no longer available through most commercial nurseries. However, *R. frangula* is available commercially in Wisconsin and commonly planted for hedges.

Common and glossy buckthorn occupy approximately 11 acres within the IFZ.

- **Biology**

  Three species of buckthorn are present in northern Wisconsin, two of which are invasive: *Rhamnus cathartica* (common buckthorn) and *Rhamnus frangula* (glossy buckthorn). A native buckthorn species, dwarf buckthorn (*R. alnifolia*), can generally be distinguished from the exotic buckthorns by its height; it only grows up to 3´ high, while both exotic species can reach up to 20´ tall (Converse, 1984).

  R. cathartica blooms in June, *R. frangula* blooms June through September (Converse, 1984). Seeds are primarily dispersed by wildlife such as songbirds, waterfowl, and small rodents. Water may also be a source of dispersal, particularly in areas with flooding in the fall and winter. Germination is quite variable within each species, and may require scarification, stratification, or both. Germination has been found to be more successful in areas with ample light and exposed soil (Converse, 1984), a characteristic exhibited by many opportunistic, invasive species.

  R. cathartica grows in well-drained sand, poorly drained calcareous soils, or clay (Converse, 1984). This makes it particularly well adapted for the Lake Superior basin where glacial and alluvial sands as well as lacustrine clays predominate.

  As noted with honeysuckle, buckthorn produces leaves very early in the spring and holds its leaves late into the fall. *R. cathartica* begins leaf-out from late April to mid-May, and *R. frangula* begins from mid- to late-May. In the fall, buckthorn retains its leaves late into October. In the Chequamegon Bay region, leaves can be present into November. By limiting the available light for co-occurring native species, particularly in the spring, buckthorn eventually takes over the canopy and reduces the seedling success of other species, particularly spring ephemerals which take advantage of abundant light in the spring (Converse, 1984).

  Plant communities susceptible to invasion by buckthorn range from woodland openings to shallow marshes (Converse, 1984 *R. cathartica* typically invades forest openings, woodland edges, lowland woods, and thickets near open areas. Although it is more adapted to drier sites, *R. frangula* can invade wet meadows, marshes, and tamarack swamps.

❖ **Distinguishing Characteristics**

	Rhamnus cathartica Common Buckthorn	*Rhamnus frangula* Glossy Buckthorn
Leaves	• minute teeth on leaf margins • dull green • ovate-elliptic • mostly opposite	• leaves have smooth edges (entire) • shiny dark green • ovate or elliptic • mostly alternate
Flowers	• four petals • greenish-yellow • axillary umbels	• five petals • yellowish-green • sessile umbels
Berries	• mostly black • ripen in September	• red, turning purple and/or black at maturity • ripen July through August

❖ **Impacts of Invasion**

Wildlife

The scientific name "*cathartica*" suggests that berries can cause diarrhea, vomiting and even death for birds. It has been suggested that birds feeding on common buckthorn fruit suffer from cathartic effects that may lead to malnourishment and dehydration (IPAW website; Foster & Duke, 1990).

As noted with honeysuckle, Schmidt and Whelan (1999) found reduced robin and wood thrush nesting success for birds using exotic buckthorn and honeysuckle rather than native hawthorn (*Crataegus spp.*) and *Viburnum* species.

Native Plants

Godwin and Lovely (cited in Converse, 1984) demonstrated that buckthorn affects co-occurring species. Woody species such as *Viburnum* and *Betula* may be replaced by buckthorn, and are not able to become established in existing buckthorn thickets. In a Wisconsin study, buckthorn altered herbaceous understory composition by reducing the available sunlight. The dense canopy of buckthorn also affected seedlings of woody species (Converse, 1984). A reduction in seedling growth has long-term implications for the health of native forest and shrub communities.

❖ **Control Methods**

Manual

There are special tools designed to pull large buckthorn plants and other woody species. They include the Weed Wrench®, the Root Talon® and others. Smaller plants can be hand-pulled but this method is unsuitable for large infestations. Extracting larger plants disrupts the roots of surrounding plants and creates soil disturbance that can favor buckthorn seedlings or other invasive species. This method is only recommended for

isolated buckthorn in areas with a robust native plant community that will re-seed the disturbed soil.

Stem girdling is a low-impact approach compared to many treatment options. Girdling involves removing the cambium layer from the base of a woody plant. The cambium is responsible for transferring water, nutrients, and carbohydrates throughout the plant. It is one of the outer-most rings within a shrub or tree, making it relatively easy to remove using a machete, a hatchet, or a specially-designed girdling tool. Girdling can be done during any season and provides control with or without the use of chemicals, making it an attractive alternative for those wanting to avoid herbicide use. Reed (1983) showed that *R. frangula* girdled at the base by a 2-3 cm wide strip did not resprout. Since it is time consuming, girdling is best suited to limited infestations.

Cutting buckthorn without using herbicide is not advised. Buckthorn will resprout with numerous shoots when herbicides are not applied to the cut stem, making future control efforts much more difficult.

Mechanical

Mowing can reduce seedling growth, but may not be compatible with restoring or managing native plant communities. Most sites with buckthorn are not conducive to mowing.

Prescribed Fire

Prescribed fire is not recommended as a buckthorn control method. A hot fire can kill the aboveground portion of the plant but resprouting is common and large areas dominated by buckthorn typically have an open understory with very few light fuels to support a "hot" fire. Additionally, wet soil conditions often present a challenge for prescribed burning. Finally, fire-exposed soils can be susceptible to invasion by buckthorn seedlings or other invasive species (Converse, 1984).

Biocontrol

A number of insects are being evaluated as biological control agents for buckthorn. The Center for Applied Bioscience International in Switzerland began this research in 2002 and the work continues (MN Dept. of Ag. website, see http://www.mda.state.mn.us). As noted above, *Rhamnus cathartica* is an alternate host species for oat crown rust. Since the disease can severely reduce oat yields, significant research continues to identify a suitable biocontrol agent. Biocontrol for *R. frangula*, a species used for ornamental hedges, has not been researched extensively.

Chemical

As with honeysuckle, spring and fall provide ideal times to distinguish buckthorns from native shrubs because the former retain their leaves longer than native species.

Glyphosate – Glyphosate mixed 1:1 with water (applied at 20.5-26.9% a.i.) has proven 90-95% effective within the IFZ when used as a cut stump treatment. Since multiple shoots arise from a single crown, and glyphosate is a systemic chemical, adequate control may be achieved by cutting a limited number of shoots per crown and applying glyphosate (Pergrams & Norton, 2006). Foliar treatment of small buckthorn plants is also effective and should occur late in the fall when native plants are dormant in order to minimize injury to non-target species.

Triclopyr – Garlon 4® is recommended as a cut-stump, basal bark or foliar treatment for buckthorn. The label notes that 3 to 4 parts oil must be added for dilution and as a surfactant. Various petroleum-based oils, or basal oil, are suggested. Basal oils are more expensive but are a more environmentally friendly biodegradable option. Cut stump and basal bark treatment can be effective year-round. The latter involves spraying the entire perimeter of the stems and is not effective on buckthorn larger than 6 inches in basal diameter.

- **Treatment Plan**

Approximately 9 acres of buckthorn have been mapped within IFZ. The infestations generally occur along fencerows, forest openings, woodland edges, and in riparian habitat. This might suggest that seasonal floods initially disperse seeds. Buckthorn infestations in the IFZ occur on sites with a wide range of soil moisture conditions.

During 2005 and 2006, the National Park Service–Exotic Plant Management Team treated buckthorn in the Invasive Free Zone as part of the work crew's initial training. They returned during the summer as their schedule allowed. They used the cut stump method, applying glyphosate with hand-held sprayers. Plants cut near the base were treated with glyphosate applied at 20.5-26.9% a.i. (mixed 1:1 with water). They noted that clippers, hand saws, brush saws, and chain saws all have advantages for stump cutting in particular situations.

Early spring and late fall cut-stump glyphosate treatment will continue as described above. This direct application method uses a minimal amount of herbicide and is highly effective. Tree-marking paint applied to stumps provides a quick visual means for evaluating control. Glyphosate will be applied to small seedlings as a foliar spray during late fall when non-target species are less likely to be injured. Treated areas should be re-visited multiple times at different seasons; some plants will inevitably be missed the first time a site is treated.

In order to spread out the seasonal workload, basal bark triclopyr (diluted with bark oil) will be used in the winter as conditions allow. Stems must be dry and the lower 12-15 inches must be free of snow, ice, or leaf litter. Direct basal bark application during the dormant season does not affect adjacent vegetation. This method does not require shrub cutting.

- **Monitoring**

As with honeysuckle, 100 random paint-marked stumps will be monitored for presence or absence of resprouts for the first 2 years after treatment. One hundred random glyphosate-treated cut stumps and 100 random triclopyr-treated (basal bark) stems will be monitored.

LOW PRIORITY SPECIES

Besides the 7 high priority species, 15 additional species, or suites of species, have been documented (as of November, 2006) and designated as "low priority species" within the IFZ. Although they appear to be less aggressive, they can displace native species and complicate ecosystem restoration. Mapping over time will indicate if infestations are expanding or becoming denser.

The following section summarizes treatment plans for each species. Plans are based on recommendations by the Wisconsin DNR, The Nature Conservancy, the Invasive Plants Association of Wisconsin and the experience of local natural resource managers and Refuge staff.

Low-Priority Species

Aegopodium podagraria
Bishop's goutweed

This perennial species is a common ornamental groundcover that can invade woodlands or natural areas. It spreads by rhizomes and seed, forming dense infestations that typically exclude all other plant species. Since root segments can resprout, hand-digging is only effective if all roots are carefully removed. According to the *Invasive Plants of the Upper Midwest* by Elizabeth Czarapata, glyphosate provides effective control.

There are three known patches of *A. podagraria* within the IFZ , totaling less than 0.1 acre. Two sites are along Whittlesey Creek, the third is at an occupied farmhouse near the NGLVC. None of the infestations appear to be spreading rapidly. As a horticultural species, Bishop's goutweed, often called snow on the mountains, is typically found near old or current building sites.

In 2006, goutweed was treated with undiluted glyphosate applied using a hand-held weed wiper. The treatment did not appear to affect the plants. Based on personal experience, frequent defoliation by mowing can control this species. Patches will be defoliated with mowers or weed trimmers for a few years. If this proves ineffective, the species will receive glyphosate applied at 13% a.i. as a broadcast spray using a backpack sprayer. This may prove more effective since foliar sprays produce more uniform herbicide coverage than weed wiper applications for monotypic infestations of short, dense species. If plants do not exhibit treatment effects within two weeks, a broad-leaf specific chemical such as triclopyr should be used.

Arctium minus
Common burdock

Burdock is an invader of disturbed areas such as gravel parking lots and soil piles. Considered a biennial species, in some cases it may bloom during its third or fourth year (Czarapata, 2005). Long stout taproots make it difficult to remove by hand, and enable the plant to resprout after cutting.

This species is found in several isolated patches throughout the IFZ in locations as described above. About 2 acres have been mapped and treatment began in 2005 using mowing, cutting or glyphosate diluted 1:1 and 3:1 (water:glyphosate). Glyphosate treated plants exhibited dieback and lack of regrowth. Biennials, or other short-lived species, can be controlled by preventing seed set for several consecutive years. Repeatedly mowing or cutting patches or isolated plants will prevent seed set and eventually control common burdock. Sites should be re-visited every few weeks with follow-up mowing or cutting as needed to remove any buds, flowers, or seed heads. To be effective, this will need to be conducted 2-3 times per year. Mowing and cutting will primarily be used to control common burdock starting in 2007. If this proves to be an ineffective after a few years, plants will be spot sprayed with glyphosate.

Cirsium vulgare
Bull thistle

Bull thistle is a biennial found in disturbed sites such as roadsides and soil piles. It forms a rosette the first year, then produces a flowering stalk the second year. It spreads by seed and typically occurs as individual plants rather than in patches.

C. vulgare is found throughout the IFZ, mostly in roadside ditches or near driveways. Roughly 2 acres have been mapped. Treatment began in 2005 using mowing, cutting or spot application of glyphosate. Glyphosate treated plants exhibited dieback and lack of regrowth. As with common burdock, this biennial species can be controlled by repeated mowing or cutting throughout the growing season to prevent seed set. Given the current abundance and distribution of bull thistle in the IFZ, it would be impractical to hand-cut each plant multiple times each year. However, once the population has been reduced, hand-cutting may become a viable control method. For 2007, glyphosate will be used to control bull thistle.

Cool-season forage grasses

Several perennial cool-season forage grass species occur within the IFZ. They include common timothy (*Phleum pretense),* Kentucky bluegrass (*Poa pratensis*), Canada bluegrass (*Poa compressa),* smooth bromegrass (*Bromus intermis*) and orchardgrass (*Dactylis glomerata*). These species typically occur in both active and abandoned pastures and hay fields, and along roadsides. Cool-season forage grasses, other than reed canarygrass, generally are not highly invasive. However, their competition can interfere with native species restoration.

Cool-season forage grasses occur in mixture with other grasses and forbs on approximately 200 acres within the IFZ. Control of these species will be targeted at individual sites. For example, on sites that will be reforested, grass can be controlled by repeated tillage. This technique was used successfully in 2003. Trees and shrubs seedlings were planted in tilled contour strips on a 12-acre site. Shading will ultimately control the untilled grasses. Occasional mowing may be needed for a year or two after planting in order to reduce competition and release tree and shrub seedlings. Chemical treatment can also control grasses and release seedlings. Cool-season grasses will be controlled with various techniques depending on site conditions and restoration goals.

Coronilla varia
Crown vetch

According to the *Invasive Plants of the Upper Midwest* by Elizabeth Czarapata, crown vetch is an "invasive plant of major concern." *C. varia* is a perennial legume that spreads by seeds and rhizomes and is commonly used for soil stabilization. It forms a dense mat of vegetation that grows over other plants and shades them out.

Three patches of crown vetch, totaling less than 0.1 acre, occur along roadsides within the IFZ. Patches were treated in 2006 with glyphosate applied at 13.5% active ingredient with a backpack

sprayer to attain a uniform broadcast foliar spray. This treatment produced dieback and lack of regrowth and will continue to be used as needed. Applications should be timed so that the chemicals have enough time to provide effective control before plants are subjected to mowing or tillage. Generally allow 10-14 days as indicated on the glyphosate label.

Hemerocallis fulva
Orange daylily

This horticultural species is a common perennial that can persist long after the gardener stops tending it. It reproduces by rhizomes and tuberous roots, forming dense infestations that typically exclude all other plant species. In some cases, it spreads into nearby natural areas and roadside ditches, replacing native plant species.

The IFZ has several small patches of daylily totaling less than 0.1 acre. In July of 2006, all known patches were sprayed with glyphosate diluted with 3 parts water. The treatment appeared to be effective since plants withered and turned brown within a week of herbicide application. This method will continue to be used on *Hemerocallis fulva*. Additionally, glyphosate diluted 1:1 with water can be applied to cut surfaces after plants are cut close to the ground. Fall tillage followed by removal of all plant parts provide control.

Hieracium species (non-native invasive)
Non-native hawkweed

Although there are several *native* hawkweed species, non-native species are invasive and may be allelopathic (exude chemicals which inhibit the growth of other plants). Non-native hawkweeds in the IFZ include *Hieracium aurantiacum* (orange hawkweed) and *H. caespitosum* (yellow hawkweed). These perennials reproduce by seed, rhizomes and stolons.

Currently this species occurs at low densities along roadsides, in gravel areas and at a sparsely vegetated site within an abandoned hay field. Czarapata (2005) recommends using clopyralid or 2,4-D. Treatment would require spot spraying individual plants while in the rosette stage. Tillage is also an effective control technique. Hawkweeds should be controlled by competition and shading from native plants used in IFZ restoration efforts.

Leucanthemum vulgare
Ox-eye daisy

This perennial species is typically found in abandoned farm fields and disturbed sites.

Mapping indicates 11 infested acres throughout the IFZ. Ox-eye daisy is found in scattered low-population patches. Within the project area, it does not appear to be very invasive on undisturbed sites. However, it was very dense within the prepared strips during the 1st year after tillage at the previously mentioned 2003 reforestation site. *L. vulgare* did not persist. This species should be controlled by competition and shading from native trees and shrubs used in IFZ restoration efforts. Mowing or herbicide treatment may be needed to release tree seedlings.

Lotus corniculatus
Bird's foot trefoil

Lotus corniculatus is a perennial legume that is used as a forage crop and for soil stabilization. It is commonly included in roadside seed mixes. It often grows beneath taller plants or is entwined in other plants, especially forage grasses. Bird's foot trefoil can form a dense mat that covers other vegetation and shades it out. A prolific seed producer, it readily self-seeds and is common in actively used and abandoned pastures and hay fields and along roadsides throughout the Midwest. Bird's foot trefoil is well adapted to wet, low pH, low fertility soils.

L. corniculatus occurs in mixture with other forbs and grasses on nearly 85 acres within the IFZ, occupying sites as described above. Although this species can be controlled using clopyralid, a broad-leaf specific herbicide or with a mixture of glyphosate and 2,4-D, such treatment is unlikely. As hay fields are reforested, this species will be controlled using, non-chemical methods similar to those noted for cool-season forage grasses.

Lupinus polyphyllus
Garden lupine

Garden lupine (giant or big-leaf lupine) is a perennial horticultural legume. Its showy flowers range from violet to pink to white. This species reproduces by seed that can lie dormant for many years. *L. polyphyllus* can thrive on sites with varying drainage characteristics, across a broad soil pH range and on low fertility soils.

Although locally abundant, there is only one small patch of garden lupine within the IFZ. It is located on the site of a former residence. In early July of 2006, this patch was sprayed with Cornerstone® diluted with 3 parts water (applied at 13.5% a.i.). This treatment appeared to be effective based on dieback and lack of regrowth. Control can be achieved by repeatedly mowing or cutting early flower-stage plants (mid- to late-June). Mowing and cutting will primarily be used to control this species starting in 2007. If this proves to be an ineffective after a few years, plants will be treated with glyphosate prior to seed set.

Melilotus alba and M. officinalis
White sweet clover and Yellow sweet clover

White and yellow sweet clover are biennial legumes that colonize disturbed areas. There is less than one acre of either species within the IFZ, making this an opportune time for eradication. Neither species has been treated to date. According to the *Invasive Plants of the Upper Midwest* and the Wisconsin DNR, control can be achieved by cutting the plants to 2 inches or less just before flowering. Revisit the infestation after a few days to ensure no plants were missed. After 2-3 years, this method should effectively eradicate sweet clover within the IFZ. Fire is also an effective option for this species. Annual burning can be used to kill second year plants prior to seed set and destroy new seedlings. Over time, the seed bank will be depleted (Rice, 2005). Mowing will be used to control sweet clovers starting in 2007.

Salix fragilis
Crack willow

Crack willows can grow up to 65' tall, with deeply furrowed bark and stout, short main trunks that divide into several large branches. It is common along streams and on disturbed, moist soil sites. Crack willow prefers sunny locations and rarely establishes under a shady canopy. This species is often confused with native willows such as black willow, *Salix nigra*. *S. fragilis* reproduces by seed, from root sprouts and by twig sections that root quite easily.

Crack willows are found within the IFZ, primarily along and adjacent to Whittlesey and Little Whittlesey Creeks. Most are about 40' tall and were planted during stream bank stabilization efforts in the 1950's and 1960's. In early September 2006, The National Park Service Exotic Plants Management Team used chainsaws to girdle several tree trunks to a depth of 2-3 inches, deep enough to expose the cambium layer. The exposed cambium was thoroughly sprayed with Rodeo® at full strength (53.8% a.i.). Several weeks after treatment, most trees appeared to have leaves that were wilting or dead and falling. Untreated trees retained their leaves into November. Trees will be monitored in 2007 to see if they survived. This approach will continue to be used.

Cut stump glyphosate application is also effective but is not the preferred option for several reasons. Cutting down large diameter willows is more time consuming and more dangerous than girdling them. Standing dead trees provide valuable wildlife habitat (nesting cavities, bird perches, etc.). If trees ultimately need to be removed for safety reasons, dry dead wood will be much easier to move. Willow control needs to be coordinated with native tree and shrub planting in the riparian areas. Trees and shrubs stabilize banks, reducing sediment inputs. A plant canopy shades the cold-water streams, reducing water temperature fluctuations. The canopy also provides habitat for terrestrial organisms that become food for fish and other aquatic species.

Tanacetum vulgare
Common tansy

Tanacetum vulgare is a perennial forb commonly found in disturbed upland sites. It reproduces by seed and expansion of short rhizomes.

Common tansy is frequently found in roadside ditches and abandoned hay fields within the IFZ, occupying about 18 acres in the project area. In 2006, while treating Canada thistle, several sparse patches of tansy were also sprayed with Cornerstone Plus® diluted with 3 parts water (applied at 10.25% a.i.). Based on dieback and lack or regrowth, both concentrations appear to have effectively killed tansy. The ATV-mounted weed wiper also produced similar results. Glyphosate will continue to be spot sprayed or applied with a weed wiper. Based on photographic records from 2006, weed wiper applications should begin in late June or early July when tansy grows taller than surrounding native species and prior to seed set.

Trifolium pratense and T. repens
Red clover and White clover

Red and white clover are perennial legumes commonly used for forage. Both reproduce by seed and *T. repens* also reproduces via stolons. After tillage, fields may be covered by clover seedlings emerging from seed that has been dormant for many years.

These species occur in mixture with other forbs and grasses in actively used and abandoned hay fields, roadsides, and other disturbed sites throughout the IFZ. It appears that they have not spread into undisturbed sites. Red and white clover can be treated with glyphosate or glyphosate mixed with 2,4-D. As hay fields are reforested, clovers will be controlled using, non-chemical methods similar to those noted for cool-season forage grasses.

Verbascum thapsus
Common mullein

Common mullein is a biennial plant with large, highly pubescent or wooly leaves. Second year plants can be 5 to 10 feet tall with a flower stalk densely covered by yellow flowers. It grows along roadsides and in gravelly or sandy sites. *V. thapsus* reproduces by seed that can remain dormant for decades.

This species occurs as very widely scattered sparse plants within the IFZ. Dilute solutions of glyphosate or triclopyr effectively treat first year rosettes or young second year plants. A non-ionic surfactant is added due to the highly pubescent leaves. As with other biennials such as common burdock and bull thistle, common mullein can be controlled by cutting to prevent seed set. Also, small plants can be easy to uproot in moist or coarse soils. Hand-cutting with machetes and hand-pulling will be used to control this species in the IFZ.

RESTORATION GOALS

A fundamental goal of the Invasive Free Zone project is restoration of native plant communities similar to those existing prior to 19th century European settlement. Specific habitat goals are outlined in Section 4 of the Whittlesey Creek National Wildlife Refuge Habitat Management Plan (2006) and in the Northern Great Lakes Visitor Center Interpretive Outdoor Classroom plan (2000).

The IFZ project will also utilize Public Land Survey (PLS) records as a reference for pre-settlement conditions[1], an approach taken by many other restoration projects (Bolliger et al., 2004). In 1976, these records were used by R. W. Finley to create a map of Wisconsin's original vegetation (see Figure 3). These sources, along with other historic records and nearby "relict" plant communities, serve as guides for IFZ restoration efforts.

Invasive species generally do not compete well with robust native plant communities. Therefore, native plant restoration is vital for *long-term* invasive species management. Before restoration efforts begin, however, invasive species must be reduced to levels that will not preclude native plants. This will be accomplished according to the treatment plans outlined in previous sections. Ongoing treatment will generally be required and will be modified as needed, with the goal of target species eradication.

Native plants will be re-established by two methods: 1) allowing natural succession to occur, or 2) actively seeding and/or planting native species. Each method is appropriate in different situations, and both methods can be used in combination. Existing knowledge and experience gained over time will guide the approach taken.

For small infestations of less aggressive species, the best post-treatment option may be to allow native species to re-colonize the site. Recent reports suggest that native species which are present at a site *prior* to treatment are more likely to re-colonize the site than native species which are seeded or planted *after* treatment (Reinhardt and Galatowitsch, 2004). Large, dense infestations which have occupied highly-altered sites for a long time will pose the greatest challenge. For example, abandoned hay fields that are mainly reed canarygrass may not have enough existing native species, as plants or seeds, to re-populate a site. In such cases, anticipate capital-intensive and labor-intensive planting and seeding. To ensure success, all restoration efforts will require follow-up monitoring, possibly with additional control, planting or seeding as needed.

The following sections provide examples of site-specific plans for invasive species control and restoration within the Invasive Free Zone.

South 42 Parcel – NGLVC

This 42-acre parcel is part of the Northern Great Lakes Visitor Center property (owned by U.S. Forest Service). The north fork of Fish Creek runs through the southern portion of the tract. The South 42 Parcel includes a small forest, abandoned hay field, and flood plain forest. This high-profile location will receive considerable restoration effort.

[1] Public Land Survey records were written in the 1850's and 1860's (in northern Wisconsin) by the first surveyors who mapped the region. While establishing section lines, they documented tree species, understory species, soil conditions, and notable features such as streams or villages. The notes are not a comprehensive list of pre-settlement plant species.

According to the Interpretive Outdoor Classroom plan (2000) and recent planning efforts, this site will demonstrate various forms of land stewardship for the public. Invasive species control is a fundamental part of that endeavor. An interpretive trail has recently been constructed throughout the site, and tree seedlings have been planted in portions of the open field. Several small wetlands were added in 2005 and 2006. Such wetlands have been constructed within the IFZ in an effort to reestablish pitted topography and sheet-flow drainage patterns.

Buckthorn and honeysuckle have been treated in 2005 and 2006 using the cut stump technique. Based on visual estimates, control appears to be 90-95% effective. The focus for 2007 will shift to spot spraying seedlings that emerge from the seed bank. Active restoration is not planned. Overstory shading and succession should allow native plants to reestablish themselves.

Scattered dense patches of reed canarygrass are found throughout the old hay field and around the constructed wetlands. Infestations were treated during the fall of 2006 using an ATV-mounted weed wiper. This method will continue to be used, although steep wetland edges may need to be treated with a backpack sprayer or with a hand-carried weed wiper. When reed canarygrass control is adequate, appropriate native wetland species will be seeded and planted. Other portions of the site will be planted with mixed deciduous and coniferous species, swamp conifers, shrubs or will be left for natural succession (according to the Proposed Stewardship Plan for the NGLVC South 42, 2003). Site preparation via tillage will be used as needed for seeding and planting. Follow up invasive species treatment will be used as necessary to release newly established plants. Browse-sensitive species will be protected with repellents, exclosures, or tree shelters.

Mouth of Whittlesey Creek – Whittlesey Creek NWR and private land

In 2002, approximately 1 acre at the mouth of Whittlesey Creek was heavily infested with purple loosestrife. Since then, with the help of the Great Lakes Indian Fish & Wildlife Commission and the WDNR, the Whittlesey Creek NWR has been releasing loosestrife beetles at the site every year. In 2006, visual observations indicated that loosestrife had largely been replaced by species such as blue vervain (*Verbena hastate*), joe-pye weed (*Eupatorium maculatum*), boneset (*Eupatorium perfoliatum*), swamp milkweed (*Asclepias incarnata*) and monkey flower (*Mimulus ringens*). Loosestrife plants at the site no longer flower and will likely succumb to biocontrol. The mouth of Whittlesey Creek will be monitored for new infestations and beetles will be released if needed.

Interestingly, this area is an expanding sand delta. Through natural succession, native forbs noted above colonize new sand deposits. On older deposits farther from the water, forbs are replaced by shrubs such as speckled alder (*Alnus incana*), willow (*Salix spp.*), and red osier dogwood (*Cornus stolonifera*) and ultimately by trees including white cedar (*Thuja occidentalis*), black ash (*Fraxinus nigra*) and white spruce (*Picea glauca*).

Former Golf Course parcel – Whittlesey Creek NWR

The long-term goal for this site is to restore wetland forest and shrub species. Public Land Survey records describe this area as having swamp conifers (black spruce, tamarack, cedar). Shrub species such as speckled alder, willow and red osier dogwood are also characteristic of this habitat.

This site is nearly level and is part of an expansive floodplain along Whittlesey Creek and Terwilliger Creek. Prior land use has heavily impacted the area. Drainage ditches and large reed canarygrass infestations remain from the days when the site was used for agriculture. Irrigation ponds were dug during the early phases of golf course construction in the 1990's (discontinued in 1997). Spoils from the ponds and other local excavation projects were dumped or spread at various spots, which are now infested with reed canarygrass, Canada thistle, tansy, cool season forage grasses and other invasive species.

Hydrologic restoration began late in 2006 with construction of a 1-acre wetland and installation of numerous drainage ditch plugs. This work was done to reestablish pitted topography and sheet-flow drainage patterns in the floodplain.

Invasive species control was initiated in 2006 and focused on Canada thistle, burdock, and tansy. These efforts will continue with increased emphasis on reed canarygrass control. Tractor-mounted or ATV-mounted weed wiper glyphosate application will begin in 2007 as soon as most of the parcel is dry enough to support such equipment. Depending upon regrowth, reed canarygrass may be treated more than once per year. This process will need to be repeated for several years. Portions of the site, such as a sedge meadow, preclude tractor or ATV use and will be treated with a backpack sprayer or a hand-carried weed wiper. Where sedge meadows exist, it is critical to control the reed canarygrass "invasion front." This will become a priority starting in 2007. Prescribed fire may be a future option pending burn plan review and approval by appropriate federal and state agencies.

This site is suitable for evaluating various control methods such as those described in the *Reed canarygrass Treatment Plan* section. It features numerous contiguous acres that are easily accessible, with consistent soils, topography, and vegetation.

Restoration plantings and seeding will begin during 2007. This work will take place in the areas where soil was moved for the wetland and ditch plug work. In these areas, the lack of vigorous invasive species streamlines native plant restoration. Native trees, shrubs, sedges and forbs will be planted or seeded in appropriate locations (see Appendix B). A mounted weed wiper will be used as needed to release new seedlings and transplants from taller competing invasive species. A weed-whip, or herbicide sprayer will be used to reduce weed competition. Browse-sensitive species will be protected with repellents.

It is interesting to note the natural succession that is occurring on this parcel. Once the land was no longer cut for hay, new shrubs and trees became apparent along forest edges within a few years. North of the cedar-tamarack stand in Figure 9, for instance, speckled alder, tamarack, and spruce seedlings and saplings are advancing without active invasive species control or restoration efforts. If this continues, these species will ultimately shade-out reed canarygrass and provide long-term control of the species.

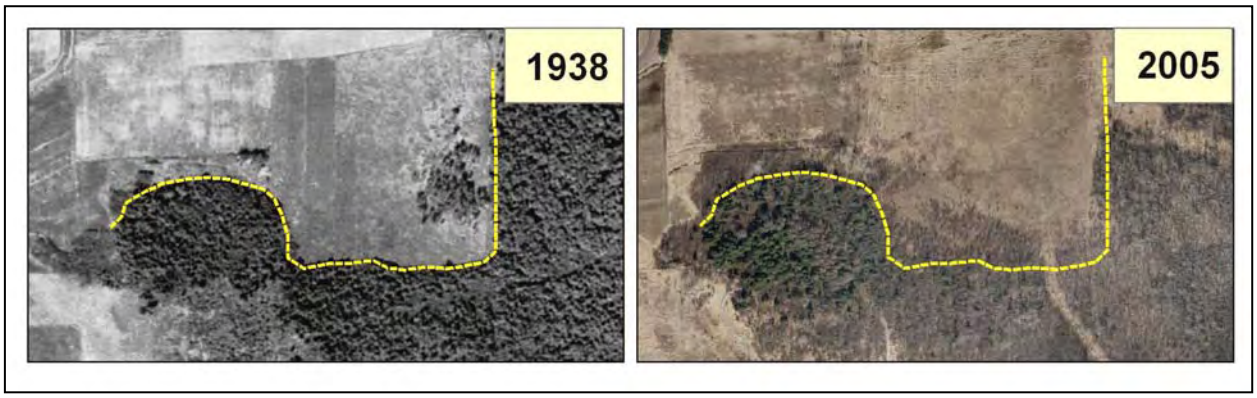

Figure 9. Natural succession of conifers and shrubs in an old hayfield. The yellow line indicates the extent of trees and shrubs in 1938. Note the trees and shrubs (dark area) above the yellow line in the 2005 photo.

This type of natural succession is seen at many other locations within the IFZ. The 1938 and 2005 aerial photos dramatically illustrate the transition from agricultural fields to shrubs and trees (Fig. 10). Native woody species have the ability to re-colonize abandoned fields within much of the IFZ, including areas infested by reed canarygrass in some cases.

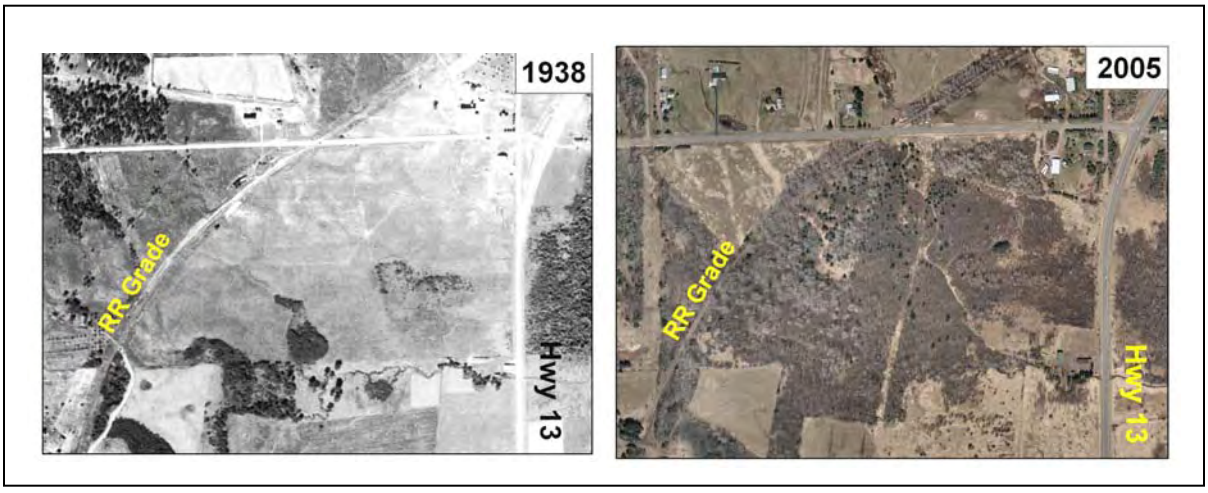

Figure 10. Aerial photos depicting natural succession within the IFZ (Whittlesey Creek NWR).

SUMMARY

This plan summarizes the findings of published scientific literature, online resources, recommendations from professional land managers and personal experience. Evolving science and experience will guide adaptive management decisions. Invasive species control and native plant restoration plans and strategies outlined in this document are likely to change.

Non-chemical treatment options have been carefully evaluated for individual species. Several invasive species within the IFZ will be controlled without chemicals. For some, non-chemical techniques will be used in combination with herbicides. For others, effective non-chemical control options currently do not exist. If herbicides are used, spot spraying, cut stump treatment, basal bark application and weed wiping are the primary techniques. All of these apply the herbicide to the target invasive plants with greater precision than a broadcast spray. Regardless of the control method, most treatment options will require multiple years of treatment. Rarely does one application eradicate an invasive species.

As stated in the *Introduction*, it is important to acknowledge that becoming and remaining entirely "invasive-free" may not be possible. New infestations, re-infestations and newly occurring species will pose a continuing challenge. The project strives to drastically reduce invasive populations and achieve a "monitoring and maintenance mode" in which ongoing monitoring will identify isolated infestations, and minimal maintenance will be required to control them before they expand into a long-term problem. **"Monitoring and maintenance mode" will serve as the benchmark for successful invasive species control and is defined as a 95% reduction of Net Infested Acres for individual invasive species.** To quantify the 95% reduction, mapping and in-field data collection of individual infestations will occur every 3-5 years (initial mapping of the entire project area has taken roughly 3 field seasons). Mapping frequency may be extended to every 5-7 years once target reductions have been achieved. During years when mapping is not occurring, infestations should be spot-checked as part of an "Early Detection, Rapid Response" strategy.

It is anticipated that findings and recommendations from this project will be applicable to areas beyond the boundaries of the IFZ. This management plan can serve as a template for others, with the realization that plans should be project-specific. An IFZ "case study" will provide additional guidance for such efforts. The case study will detail successes, challenges and experiences. Topics will include staffing needs, the complexities of securing funding, working with multiple agencies and private landowners, and experiences using various control techniques and herbicide application tools. The case study is expected to be finalized prior to the 2007 field season.

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Appendices

Appendix A

Invasive Species Treatment Calendar

Based on plant phenology
within the Invasive Free Zone
and recommended treatment timing

Invasive Species Treatment Calendar

Based on plant phenology within the Invasive Free Zone and recommended treatment timings

Species		April		May		June		July		August		September		October	
Scientific Name	Common Name	early	late	early	late	early	late	early	late	early	late	early	late	early	late
Aegopodium podagraria	bishop's goutweed						cut		cut		cut				
Arctium minus	common burdock						cut		cut		cut				
Centaurea sp.	knapweed						herbicide			late herbicide*					
Cirsium arvense	Canada thistle						herbicide			late herbicide*					
							wait until plants are at least 6-10" tall								
Cirsium vulgare	bull thistle				Alternative 1:		cut				cut				
					Alternative 2:		herbicide				late herbicide*				
	Cool-season grasses						*will be controlled by tillage and/or shading as part of habitat restoration*								
Coronilla varia	crown vetch						herbicide								
Hieracium sp.	hawkweed						*will be controlled by tillage and/or shading as part of habitat restoration*								
Hemerocallis fulva	orange daylily							herbicide							
Lonicera sp.	honeysuckle**	cut-stump herbicide											cut-stump herbicide		
Lotus corniculatus	Bird's foot trefoil						*will be controlled by tillage and/or shading as part of habitat restoration*								
Lupinus polyphyllus	garden lupine			Alternative 1:	mow										
				Alternative 2:	herbicide										
Lythrum salicaria	purple loosestrife			collect beetles				release beetles							
Melilotus sp.	sweet clover				cut						cut				
					(before flowering)						*(only necessary if flowering)*				
Phalaris arundinacea	reed canarygrass						herbicide		late herbicide*						

* A "Late herbicide" treatment is likely to kill the plant, but *not likely* to prevent seed set for that year.

** Note: Honeysuckle and buckthorn can be treated in winter as well. Cut-stump and basal bark treatments are both reported to be effective. See the sections on these species for more information.

Invasive Species Treatment Calendar (continued)

Species		April		May		June		July		August		September		October	
Scientific Name	Common Name	early	late	early	late	early	late	early	late	early	late	early	late	early	late
Phragmites australis	common reed	*will **not** be treated unless genetic testing indicates non-native populations are present*													
Rhamnus sp.	buckthorn**	cut-stump herbicide											cut-stump herbicide		
Salix fragilis	crack willow										girdle & spray				
Tanacetum vulgare	common tansy						herbicide								
Trifolium sp.	clover (red & white)	*will be controlled by tillage and/or shading as part of habitat restoration*													
Verbascum thapsus	common mullein							cut							

* A “Late herbicide” treatment is likely to kill the plant, but *not likely* to prevent seed set for that year.
** Note: Honeysuckle and buckthorn can be treated in winter as well. Cut-stump and basal bark treatments are both reported to be effective. See the sections on these species for more information.

Appendix B

Recommended Species for Restoration

Based on plant species observed
within the Invasive Free Zone, the surrounding area,
and Public Land Survey notes from 1852 to 1855

Recommended Northern Native Species for Restoration

Based on species observed within the Invasive Free Zone, the surrounding area and Public Land Survey notes from 1852 to 1855. This list is not exhaustive.

Trees:

Abies balsamea	balsam fir
Acer rubrum	red maple
Acer saccaharum	sugar maple
Betula alleghaniensis	yellow birch
Betula papyrifera	paper birch
Fraxinis nigra	black ash
Larix laricina	tamarack
Picea glauca	white spruce
Picea mariana	black spruce
Pinus resinosa	red pine
Pinus strobus	white pine
Quercus rubra	red oak
Thuja occidentalis	white cedar
Tsuga canadensis	eastern hemlock
Ulmus americana	American elm (disease resistant)

Shrubs:

Alnus incana	speckled alder
Amelanchier arborea	downy serviceberry
Aronia melanocarpa	black chokeberry
Cornus stolonifera	red osier dogwood
Corylus cornuta	beaked hazelnut
Iliex verticilata	winterberry
Physocarpus opulifolius	ninebark
Prunus serotina	black cherry
Salix exigua	sandbar willow
Salix discolor	pussy willow
Sorbus decorum	showy mountain ash
Taxus canadensis	Canada yew

Forest forbs, sedges, grasses:

(*these species will not be planted until a canopy has been restored*)

Aster macrophyllus	large-leaf aster
Aralia nudicaulis	wild sarsasparilla
Carex intumescens	bladder sedge
Cornus canadensis	bunchberry
Erythronium americanum	trout lily
Galium borale	northern bedstraw
Linnaea borealis	twinflower
Maianthemum canadense	Canada mayflower
Onoclea sensibilis	sensitive fern
Streptopus roseus	rose twisted-stalk
Trientalis borealis	starflower
Viola cuclata	wood violet

Open wetland forbs, sedges, grasses:

Acorus calamus	sweet flag
Asclepias incarnata	swamp milkweed
Asclepias syriaca	common milkweed
Aster firmus	swamp aster
Aster lanceolatus	panicled aster
Aster lateriflorus	calico aster
Aster puniceus	redstem aster
Aster umbellatus	flat-topped aster
Bromus ciliatus	fringed brome
Calamagrostis canadensis	Canada blue-joint grass
Carex hystericina	porcupine sedge
Carex lacustris	lake sedge
Carex stricta	tussock sedge
Carex vulpinoidea	brown fox sedge
Chelone glabra	turtlehead
Eleocharis sp.	spike rushes
Eleocharis palustris	great spike rush
Eleocharis obtusa	blunt spike rush
Eupatorium maculatum	Joe-Pye weed
Eupatorium perfoliatum	boneset
Iris versicolor	blue flag iris
Juncus effusus	soft rush
Mimulus ringens	monkey flower
Schoenoplectus acutus	hardstem bulrush
Schoenoplectus tabernaemontani	softstem bulrush
Scirpus atrovirens	dark green bulrush
Scirpus cyperinus	woolgrass
Verbena hastata	blue vervain

Appendix C

Tools for Controlling Invasive Species

Comments and suggestions
from IFZ staff

brush saw (gas-operated)

- great for buckthorn because you can keep away from the thorns
- great for honeysuckle because you don't have to crawl under the plant to reach the stems
- blades with many small teeth cut brush better than blades with few large teeth

bow saw

- works well for 1-3" diameter shrubs, works OK for 3-4" or under 1" diameter

loppers

- work great for buckthorn or honeysuckle up to 1½" in diameter

heavy duty walk-behind weed whip

- works well on thistles
- should work on grasses that aren't too tall and fibrous
- burdock wreaks havoc with this machine; the tough stalk fibers get wrapped around the string spool's drive staff and bind it up; fibers are quite difficult to remove

Swiper® (hand-held) herbicide sponge applicator

- allows for very accurate herbicide placement on individual plants
- best suited to selectively treating scattered plants mixed with desirable vegetation
- difficult to manage flow of herbicide with this particular model
- have to refill often (reservoir is too small)
- other hand-held selective applicators may feature improved design and function

pressurized spray bottles

- spray mechanism is easy on your hands even after hours of use
- easy to control spray volume with pressure pump
- be careful not to bump the "hold/lock" button (maintains constant flow), it is easy to accidentally lock it in without noticing
- 1.5 qt bottle requires few refills when spot spraying fairly large areas
- nozzle can be adjusted from a stream to a mist spray

squirt bottles

- work great for cut stump treatment; small bottles are lighter and less bulky than 1.5 qt pressurized bottles; small capacity isn't a problem since cut stump treatment uses very little herbicide
- can wear out your hand after hours of squeezing; pressurized spray bottles or backpack sprayers are better for long days of spot spraying or cut stump treatment (respectively)

pressurized backpack sprayers

- a favorite for doing spot treatment
- sprays for hours without refilling
- comfortable with padded harnesses and waist belt
- easy to control spray volume and rate with pressure pump
- many nozzle options; stream, mist spray, flat fan, etc.
- long hose and wand mean little bending for accurate spot spraying, cut stump or basal bark application
- capable of broadcast spraying with single nozzle wand or multi-nozzle boom options

Speidel Weed Wipers

Whittlesey Creek NWR began using Speidel weed wipers in 2006. We like the design and function of this selective herbicide applicator much more than rope-wick or other applicators. They are an excellent inexpensive tool for controlling weeds that are taller than the desired vegetation. The design is quite simple. See information at http://www.acrsales.com/speidel.htm. Additional literature and instructions are shipped with the applicators and should be available by contacting the distributor noted on the website. Below find a list of thoughts and suggestions based on our experience using a Speidel weed wiper for one growing season.

- We purchased a 6 ¾ ' wiper and an ATV mount. The mounting system allows for height adjustment of roughly 20"-60" off the ground. Adjustment is done using a manual screw crank, so "on-the-fly" adjustment is not possible as with a hydraulic lift system. Although the mounting system comes with screw bolts to attach the wiper to the frame, we purchased small hitch pins for quicker, easier assembly (very handy when you're wearing herbicide-resistant gloves).
- We also purchased two 10 ½ -foot wipers and had a frame fabricated so that both sections can be fastened to a tractor bucket. This will allow "on-the-fly" height adjustment. We haven't used this configuration yet.
- The applicators can be mounted to marsh masters, skid steers, boats or many other power units.
- We've had 2 people carry our 6 ¾' weed wiper through steep or wet terrain where it is difficult or impractical to drive.
- Wipers are typically front-mounted so weeds aren't driven over or flattened prior to treatment.
- Herbicide in the tube saturates the outer canvas through two rows of small holes in the PVC. These holes need to be oriented towards the leading edge of the tube. Mark the PVC end caps with arrows to easily orient the wiper with the direction of travel.
- When using a Spiedel weed wiper, turn the air valve so that the opening points backwards (towards the operator) and cover the opening with thin, porous fabric to keep debris out of the tube. We used cut-up t-shirts or paper towels fastened with a zip-tie. Even small debris can clog holes in the tube, or bind with active ingredients in the herbicide making it less effective.
- Make sure the wicking canvas gets saturated before you start. This is *critical* with a brand new wiper. We mix extra solution and use a paint brush to wet the canvas while the valve is open to ensure saturation and initiate wicking.
- Once it is wet and wicking, experience and observation will allow you to adjust the air valve to minimize dripping while assuring saturation. Check the canvas wetness regularly in the field with the back of a gloved hand. You probably won't see the solution on the vegetation, but don't be concerned as along as the canvas is wet. You don't need much chemical on the plants since you're using a concentrated solution. Treatment

effects will become apparent as with other glyphosate application techniques (may take as long as 7-10 days).

- A little solution can go a long way, so don't premix much too much until you gain experience.
- Make 2 passes in opposite directions in thick and/or tall vegetation. Always drive slowly. The glyphosate label indicates speeds no greater than 5 mph, slower in thick and/or tall vegetation.
- When the applicator is set low to the ground be careful not to snag an end.
- When you're done for the day, close the air valve *in the field* and go back through treated areas to wipe excess solution from the canvas.
- Don't leave solution in the applicator for more than a few days because it can gum up the holes. Pour the unused solution through a filter funnel and store for future use. Always use a filter funnel when filling the wiper.
- Once the excess solution is drained, the unit can be rinsed by adding a little water, sloshing it, and then going back over treated vegetation with the air valve opened quite far. Follow this procedure 2 or 3 times for effective rinsing. We carry 5-gal. water jugs with us in the field for rinsing as needed when we run out of solution. If you have a wash pad or deal with rinse water differently, cleanup will be easier.
- If the Spiedel weed wiper will be stored for more than several days, it should be thoroughly cleaned to maintain the canvas and prevent the holes from clogging. This process takes 30-45 minutes once you establish a routine. Begin by opening the air valve and hooking a hose to it (you'll need a male-to-male hose coupler). Back-flush the wiper until the rinse water coming out of the small holes stops foaming and is clear. Store the wiper in a spot where it will stay clean, dry and out of sunlight. Also, make sure it is supported and not flexed too much.
- We've only used glyphosate in our weed wipers. The manufacturer indicates that this is the chemical the unit is designed for and cautions against using other compounds including dyes and wetting agents.
- Read the glyphosate label carefully! It specifically notes numerous species that weed wipers are effective at controlling, but the list likely isn't comprehensive. Phenological stage can be very important for certain species. This information is noted in the label as well – use it for guidance. However, evaluating control at different phenological stages may give you a larger "window" for effective application timing.
- For weed wipers, glyphosate labels recommend using a 2:1 (water:chemical) solution all the way to full strength. However, don't use full strength glyphosate in the Spiedel weed wiper – it is too viscous to wick properly. We've used glyphosate (Rodeo®, Cornerstone®, and Cornerstone Plus®) mixed 1:1 and 3:1, both formulations were effective on reed canarygrass. Results after one season indicate excellent burn-down of Canada thistle, burdock, tansy, and reed canarygrass. We established monitoring plots so we can evaluate long-term control. Reed canarygrass control will likely require a few consecutive seasons of application. We will have considerably more experience to report after the '07 season.