Environmental Assessment for Control of *Phragmites australis* In Western Lake Erie Coastal Marshes

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TABLE OF CONTENTS

APPENDICES

SUMMARY

The objective of the proposed project is to improve wetland habitat in the Michigan and Ohio portions of western Lake Erie coastal zone. The Nature Conservancy, along with public and private partners, proposes to manage 2,000 acres of invasive *Phragmites australis*. A large-scale approach to phragmites treatment is a critical step toward restoring native wetland plant communities, preserving fish and wildlife, increasing access for recreation, and improving water flow and wetland function along western Lake Erie.

Chemical control will be conducted using aerial and ground herbicide applications. The control work will be conducted by certified contractors specializing in wetland invasive plant management.

The alternatives considered in this Environmental Assessment include biological control, mechanical harvesting, hydrologic manipulation, prescribed fire, and no action. While the first four alternatives can be used somewhat successfully for managing phragmites, research and literature shows that herbicide treatment is the recommended primary control method and the first step toward effective management. No action to control phragmites will cause further degradation of coastal wetland habitats and the native species that inhabit them.

I. AUTHORITY AND PURPOSE

The purpose of this document is to describe the environmental effects of proposed management efforts for *Phragmites australis* in the coastal region of western Lake Erie (WLE), which includes portions of Michigan and Ohio. The Nature Conservancy (TNC) in Ohio was granted $497,331 from U.S. Fish and Wildlife Service (USFWS) to collaborate with a broad spectrum of public and private partners, including Winous Point Marsh Conservancy, USFWS-Private Lands, and Michigan DNR, to manage this invasive plant on approximately 2,000 acres of wetlands within the western Lake Erie basin, from the Maumee Bay to Sandusky Bay.

Grant funding for this project was awarded through the $475 million Great Lakes Restoration Initiative included in Public Law 111-88, the Department of the Interior, Environment, and Related Agencies Appropriations Act, 2010, which is a furtherance of President Obama's Great Lakes Restoration Initiative announced in February 2009.

II. BACKGROUND

A. General Plant information

Phragmites (*Phragmites australis*), also known as common reed, is an invasive plant that has proliferated and degraded marshes in numerous eastern and Midwestern states (Ailstock et al. 2001; MDEQ 2008; Saltonstall 2005). It typically grows in sunny coastal and interior wetlands, lakeshores and margins, riverbanks, roadside ditches, and other low, wet areas, although it can also be found in dry areas.

Although *Phragmites sp.* is native to North America, there is evidence that an introduction of a non-native genotype has occurred (Saltonstall 2002). Studies indicate that the introduced (European) variation has displaced native types and broadened the historical range of phragmites. The non-native type is not visually distinct from the indigenous, making this a "cryptic invasion" and difficult to fully understand the extent of the invasion.

Phragmites is a tall, coarse perennial grass with stout rhizomes that are deeply embedded in its substrate. The thick stalk (5-15 mm in diameter), which in optimal conditions can reach up to 4.5 meters tall, is leafy throughout, the sheaths overlapping with a large, dense, terminal panicle. The leaves are flat, stiff, 1 to 6 cm wide and up to 60 cm long, tapering to long-attenuate tips. Leaf margins are serrate. The panicle is terminal, plum-like, purplish or silvery, 15 to 50 cm long, with many branches. The flowers have long, silky hairs.

Phragmites spreads by seed and vegetatively through rhizomes (Mal & Narine 2004). Although the plant does produce seeds prodigiously, few are viable and they will not germinate in water depths greater than 5 cm (Marks et al. 1994). This means that phragmites most often spreads via its stout, creeping rhizomes, which can exceed 60 feet in length, grow more than six feet per year, and readily grow into new plants when fragmented (MDEQ 2008). If broken by natural actions such as waves, or human actions such as disking, the rhizomes can quickly take root in new locations. The rhizomes are often cited as one of the predominant reasons for phramgites' ability to colonize and form large monocultures (see Saltonstall 2005, Mal & Narine 2004, etc.).

B. Distribution and Range

Phragmites occurs in every state in the continental U.S. (USDA PLANTS database). However, the presence and subsequent spread of the nonnative, invasive strand into the Great Lakes appear to be a more recent phenomenon, although it is not known exactly when it initially invaded. The study of phragmites' expansion and historical distribution are complicated because both native and non-native populations, which are morphologically similar, exist in North America and the Great Lakes region (Lynch & Saltonstall 2002; Saltonstall 2002). Few studies have documented its presence or tracked the invasion process from the early stages to subsequent large-scale, plant-community changes (Lynch & Saltonstall 2002; Wilcox et al. 2003). This is in contrast to the numerous phragmites studies in wetlands along the East Coast of the United States (Weis & Weis 2003).

However, the current distribution of phragmites has been documented, as have the ecological effects of its expansion. Near-monotypic stands of the non-native phragmites genotype have replaced high-quality, complex communities of native plants over thousands of acres of western Lake Erie wetlands and coastal areas (see MDEQ 2008, Getsinger et al. 2007, etc.), and this rapid expansion has resulted in adverse ecological impacts on the natural resources of such areas (Ailstock et al. 2001).

C. Invasive Nature and Effects of Phragmites Invasion

The western Lake Erie basin (WLEB) coastal marshes are among the most biologically significant within the Great Lakes. These wetlands function as critical modifiers of biotic and abiotic materials, and they have been shown to improve water quality, reduce floods, and protect shorelines.

Further, the WLEB coastal marshes have long been recognized for their significance in providing habitat for a wide variety of flora and fauna, and in particular for migratory birds. As an example, the coastal wetlands and inland marshes of Ohio alone support an estimated 500,000 itinerant waterfowl during fall migration, and WLEB is the premier stopover point in the Great Lakes for long-distance migratory shorebirds. The western Lake Erie marshes have also been recognized as a globally significant 'Important Bird Area' by the National Audubon Society because of the diversity and abundance of wading birds, waterfowl, landbirds, and shorebirds it supports throughout the year.

These populations are likely a microcosm of what originally habituated the once extensive coastal and marsh systems. Before European settlement of the region, far-reaching marshes occurred along the entire coast of the lake. The marshes, which extended from the Detroit River to Vermillion, Ohio, reached lakeward into water 1.5 m (5 feet) deep, and were 3 km (2 miles) wide in places (Albert 1995).

The western Lake Erie landscape has suffered much anthropogenic alteration over the last 200 years. Today, most of the region's marshes and wetlands have been drained or replaced by shoreline development or have been further degraded by altered hydrology and sediment deposition patterns. Only 5% of the original 121,000 ha (307,000 acres) of Lake Erie marshes and swamps in northwestern Ohio remains (Bookhout et al. 1989), and habitat loss continues, further reducing the amount of habitat available for diverse wetland plant and animal communities. Therefore, preservation and restoration of existing WLEB coastal marsh sites is imperative.

But progress toward restoring coastal marshes throughout the Great Lakes has been significantly undermined by the proliferation of non-native, invasive species. Over 180 non-native species – many of which out-compete natives, short-circuit food webs, and ultimately degrade habitats – presently exist in the Great Lakes. And, even though early detection and prevention is the most cost-effective approach to reduce their effects, some invasive species have become so prolific and damaging that widespread treatment is needed to enhance Great Lakes' ecosystem health.

For western Lake Erie coastal marshes, one of the most ruinous threats is recruitment and propagation of non-native common reed (*Phragmites australis*). This invasive variety of phragmites has become pervasive throughout the Great Lakes and, especially, in the remaining coastal WLEB wetlands. Phragmites alters the biotic and abiotic environment of wetlands, by excluding native species, reducing plant diversity, and modifying abiotic coastal processes. Consequently, near-monotypic stands of this invasive plant have replaced high-quality, complex communities over thousands of acres in WLEB wetlands and coastal areas (MDEQ 2008).

This rapid expansion of a monotypical plant community has resulted in adverse ecological, economic, and social impacts on the natural resources and people of the Great Lakes. Overall, phragmites has degraded the vitality of western Lake Erie marshes, which are some of the most productive and biologically diverse systems in the Midwest. Because phragmites replaces native vegetation, native sedges, rushes, and cattails are displaced, thereby degrading overall plant species richness and diversity. The loss of native plant diversity further results in the decline of wildlife habitat, including that needed to support migratory bird assemblages and native, resident animal species.

By out-competing native wetland plants, phragmites disrupts typical food webs for waterfowl and marshbirds, and the dense monotypical stands of this plant are not used by most of the regional Joint Ventures' focal species, like tundra swan, American black duck, blue-winged teal, and king rail (Soulliere et al. 2007 a,b). And since phragmites proliferates in shallow and moist soil wetlands, foraging substrate for dabbling ducks and long-distance migrant shorebirds, like American golden-plover, dunlin, and shortbilled dowitcher, are lost. The destruction of habitat and diversity are additionally compounded and multiplied by the fact that phragmites stands alter the water regime in marsh systems, which causes 'drying' of marsh soils through increased evaporation and trapping of sediments.

Phragmites proliferation carries negative social and economic consequences, too. Lake Erie property values can be reduced because shoreline views are blocked by tall, dense stands. Thick patches of phragmites also reduce access for swimming, boating, fishing, and hunting in WLEB coastal areas, and they create potentially serious fire hazards to structures due to the amount of dry biomass during the dormant season.

III. PREFERRED ALTERNATIVES

Given phragmites' profound impact on western Lake Erie, The Nature Conservancy (TNC), along with a broad partnership that includes Winous Point Marsh Conservancy (WPMC), U. S. Fish and Wildlife Service (USFWS), and Michigan's Department of Natural Resources (MDNR), proposes a regional approach to control and management of this invasive species. This effort will build from an existing program, initiated in 2009 by WPMC and USFWS, in which nearly 600 acres of wetland were treated through herbicide application (mostly aerially) near Sandusky Bay. A total of 800 acres was similarly treated during the summer of 2010.

Approximately 2,000 acres of phragmites across the western Lake Erie coastal zone has been planned for treatment in summer 2011. Most landowners listed below encompass only a few acres of spraying, although some properties take in larger amounts, including Ottawa Shooting Club (150 acres), Winous Point Marsh Conservancy (200 acres), Ere Marsh Preserve (300 acres), and Erie State Game Area (500 acres). Not all properties will be treated with the GLRI grant listed here; many may be enrolled in an invasive program managed by Ohio's Department of Natural Resources, but they have been included in this assessment since final assignments between the two programs have not been made.

Site and/or Landowner	***County, State***	***Township, Section, Range***
Arleane Bohling	Ottawa Co., OH	OH T7N R16E sec 27-28
B Marsh LLC	Erie Co., OH	OH T7N R24W sec 34
Ballast Island Co.	Sandusky Co., OH	OH T5N R15E sec 1
Bay Creek Hunt Club	Monroe Co., MI	MI T8S R8E sec 15
Bay Township Trustees	Ottawa Co., OH	OH T6N R16E sec 16
Beverly Tice	Ottawa Co., OH	OH T6N R15E sec 4
Bill Kihlken	Ottawa Co., OH	OH T7N R18E sec 8
Bob Grimm	Ottawa Co., OH	OH T7N R18E sec 2
Bob Lesniewetz	Ottawa Co., OH	OH T7N R15E sec 24
Bob Libben	Ottawa Co., OH	OH T7N R15E sec 23
Buehler Farms	Sandusky Co., OH	OH T6N R15E sec 30
Carl Hemminger	Ottawa Co., OH	OH T7N R15E sec 15
Charles Meachen farm	Ottawa Co., OH	OH T6N R16E sec 12
Danbury Township	Ottawa Co., OH	OH T6N R17E sec
Dave Zimmerman	Ottawa Co., OH	OH T7N R15E sec 3, 10
David York	Ottawa Co., OH	OH T7N R15E sec 2

David Zimmerman	Ottawa Co., OH	OH T7N R15E sec10
DeMars Hunt and Fishing Club	Ottawa Co., OH	OH T6N R16E sec20
Dennis Below	Ottawa Co., OH	OH T6N R15E sec 14
Dennis Floro	Ottawa Co., OH	OH T6N R15E sec 2
Dennis Howarth	Ottawa Co., OH	OH T6N R16E sec 12
Dennis Wagner	Ottawa Co., OH	OH T6N R16E sec 2, 3
Donald Baltes	Sandusky Co., OH	OH T6N R15E sec 25
Dutchman Company INC.	Erie Co., OH	OH T7N R24W
Ed Lamalie	Sandusky Co., OH	OH T6N R15E sec 1, 31
Ed Miller	Ottawa Co., OH	OH T6N R15E sec2
EngleField FW & BB	Ottawa Co., OH	OH T6N R16E sec 14
EPG2 LLC	Ottawa Co., OH	OH T7N R16E sec 10, 17
Erie Marsh Preserve	Monroe Co., MI	MI T8S R8E sec 23, 35-36
Erie State Game Area	Monroe Co., MI	MI T8S R8E sec 26-27
Francis Harris	Ottawa Co., OH	OH T8N R15E sec 35
Frank Rose	Sandusky Co., OH	OH T7N R15E sec 25
Franklin Rose	Ottawa Co., OH	OH T7N R15E sec 33
Fulkerts	Ottawa Co., OH	OH T7N R16E sec 29, 32
George Libben	Ottawa Co., OH	OH T6N R16 E sec 4
George Libben	Ottawa Co., OH	OH T6N R16E sec 4-5
George Trenchard	Ottawa Co., OH	OH T7N R15 E sec 7, 12
Gerald Rusk	Ottawa Co., OH	OH T6N R16E sec 12
Greg Dellinger	Ottawa Co., OH	OH T6N R16E sec 18
Hayward Inc.	Ottawa Co., OH	OH T7N R15E sec 3
Herbert Metzger	Sandusky Co., OH	OH T5N R16E sec 10-11, 2-3
Hilda Michel	Ottawa Co., OH	OH T6N R15E sec 3, 10
Holiday Harbor	Erie Co., OH	OH T7N R22W sec
Howard Miller	Ottawa Co., OH	OH T6N R14E sec 12
James Berlin	Ottawa Co., OH	OH T7N R16E sec19
James Daubel	Sandusky CO., OH	OH T5N R16E sec 3-4
James Reinbolt	Ottawa Co., OH	OH T7N R16E sec 28
James Schoenegge	Erie Co., OH	OH T6N R 23W
James Smith	Ottawa Co., OH	OH T7N R15E sec 1, 12
Janet Elmers	Ottawa Co., OH	OH T7N R13E 17-18
Jeff Adams	Ottawa Co., OH	OH T6N R16E sec 18
Jeff Davids	Ottawa Co., OH	OH T6N R16E sec 7
Jeffrey Adams	Ottawa Co., OH	OH T6N R16E sec 8
Jeffrey Nehls	Ottawa Co., OH	OH T6N R16E sec 12
Jenny Castillo	Ottawa Co., OH	OH T7N R15E sec 14
Jere Witt	Ottawa Co., OH	OH T8N R15E sec 35
Jim Brenner	Erie Co., OH	OH T7N R22W sec
Jim Sass	Ottawa Co., OH	OH T6N R17E sec 35
Jim Scranton	Sandusky Co., OH	OH T7N R16E sec 6

John Moore Farms	Ottawa Co., OH	OH T7N R15E sec 4, 9
John R. Culp	Ottawa Co., OH	OH T6N R16E sec 12
John Tibbels	Ottawa Co., OH	OH T7N R16E
Joseph Smith	Erie Co., OH	OH T7N R24W
Joyce Tettau	Ottawa Co., OH	OH T7N R16E sec 32
Judith Veres	Ottawa Co., OH	OH T6N R16E sec 2
Karen Rinas	Ottawa Co., OH	OH T6N R16E sec 4
Kent Floro	Ottawa Co., OH	OH T7N R16E sec 21
Kent Floro	Ottawa Co., OH	OH T7N R15E sec 11, 14
Kwest Group	Ottawa Co., OH	OH T6N R17E sec 3-4, 10-11
Lafarge	Ottawa Co., OH	OH T6N R17E sec
Laura McMurray	Ottawa Co., OH	OH T7N R17E sec 35
Leslie Boyer	Ottawa Co., OH	OH T7N R18E sec 3
Linda Dunn	Ottawa Co., OH	OH T6N R15E sec 2
Marian Clark	Ottawa Co., OH	OH T6N R15E sec 11
Mary Suchora	Ottawa Co., OH	OH T7N R15E sec 5
Michael Bohling	Ottawa Co., OH	OH T7N R16E sec 27-28
Moxley/Brunkhorst Shooting Club	Erie Co., OH	OH T7N R24W sec 34
Oak Harbor Conservation Club	Ottawa Co., OH	OH T7N R15E sec 7
Oliver J. Henry	Ottawa Co., OH	OH T7N R15E sec 11
Ottawa National Wildlife Refuge	Ottawa Co., OH	OH T10S R10E sec 4, 9-11
Ottawa Shooting Club	Sandusky Co., OH	OH T5N R16E sec 28, 33
Paul Gonya	Ottawa Co., OH	OH T6N R16E sec 17
Paul Lockwood	Ottawa Co., OH	OH T6N R17E sec 8-9
Penny Gottron	Ottawa Co., OH	OH T6N R16E sec 3
Phyllis Nuber	Erie Co., OH	OH T7N R24W sec 34
Pointe Aux Peaux State Wildlife Area	Monroe Co., MI	MI T6S R10E sec 29-30
Q&Q Inc.	Ottawa Co., OH	OH T7N R15E sec 11
Ralph Branum	Ottawa Co., OH	OH T8N R15E sec 35
Rich Thorbahn	Ottawa Co., OH	OH T7N R16E sec 19
Richard Kracer	Ottawa Co., OH	OH T6N R18E sec 12
Ricky Johannsen	Ottawa Co., OH	OH T6N R17E sec 7
Robert Libben	Ottawa Co., OH	OH T6N R16E sec 4-5
Robert Weibel	Ottawa Co., OH	OH T7N R15E sec 24
Roger Wagner	Ottawa Co., OH	OH T6N R16E sec 18
Sandusky River Company	Sandusky Co., OH	OH T5N R16E sec 5
Scott Denham	Ottawa Co., OH	OH T8N R13E sec 32
Snyder Enterprises	Ottawa Co., OH	OH T7N R17E sec
South Lake Hunt Club	Ottawa Co., OH	OH T7N R15E sec 32-33
Sweeny Marsh Inc.	Ottawa Co., OH	OH T7N R16E sec 28
Thomas Gonya	Sandusky Co., OH	OH T6N R16E sec 29-30
Thomas Lenz	Ottawa Co., OH	OH T7N R15E sec 11
Toby Tice	Ottawa Co., OH	OH T7N R14E sec 13

Tom Lenz	Ottawa Co., OH	OH T7N R15E sec 11
Toussaint Hunt Club	Ottawa Co., OH	OH T7N R16 E sec 7-8
U.S. Gypsum Co.	Ottawa Co., OH	OH T6N R17E sec 2, 11
US Gypsum	Ottawa Co., OH	OH T6N R17E sec
Walter Apling	Ottawa Co., OH	OH T7N R15E sec 9
Westlake Sportsmens Association	Ottawa Co., OH	OH T7N R15E sec 12-13
William Gallup	Ottawa Co., OH	OH T7N R15E sec 10
William Lamalie	Sandusky Co., OH	OH T6N R15E sec 1, 31
William McClure	Sandusky Co., OH	OH T5N R15E sec 31
Willow Beach	Ottawa Co., OH	OH T7N R16E sec 27
Willows Edge Properties	Ottawa Co., OH	OH T6N R16E sec 17
Winous Point Marsh Conservancy	Ottawa Co., OH	OH T6N R16E sec 21-23

The largest properties listed above are mapped in Appendix B. The area encompassed with this project, when combined with the roughly 1,000 acres to be treated at Point Mouillee State Game Area with NOAA stimulus funds, means that approximately 3,000 acres of phragmites in western Lake Erie coastal wetlands – from the Detroit River to Sandusky Bay – could be treated in 2011.

Research and literature shows that herbicide treatment is the recommended primary control method and the first step toward effective phragmites management (Marks et al. 1994). Roughly 80 percent of phragmites' biomass is underground as rhizomes. And because it spreads primarily by rhizomes, digging, tilling, and pulling phragmites can expedite its spread. Landscape fabric has been used by some to smother patches of phragmites; however, such plots are then not able to support the growth of other plants. Also, the roots of phragmites may spread outside of the covered areas.

Hence, the primary control method will be aerial systemic herbicide application (glyphosate and imazapyr), although some treatment will take place with contracted amphibious equipment, and follow-up applications will be conducted via ATV and/or backpack application (e.g., Cowie et al. 1992; Ailstock et al. 2001; Rickey & Anderson 2004).

No technique used alone can fully control phragmites, and reinvasion is likely to occur if management is not maintained. For greatest efficacy, control should begin in the first season in which phragmites is found, but, where the plant already exists in large well-established stands, multiple treatments using a combination of methods are required (see review in Marks et al. 1994). These may include such techniques as prescribed fire, mechanical treatment (e.g., mowing and raking), and water level manipulations. Follow-up methods will not only help provide multiple stresses on the plants, but will also prepare the site for subsequent years' herbicide treatments. This project will incorporate such follow-up regimes, making implementation a three-tiered approach:

(1) initial herbicide application (summer/fall of 2011)
(2) follow-up mechanical treatment and/or prescribed fire (late winter/early spring 2012)
(3) spot-treatment of sites where phragmites re-growth occurs (summer/fall 2012)

Two broad-spectrum herbicides, glyphosate and imazapyr (which are commercially available as Rodeo® and Habitat®, among others, respectively), are known to control phragmites. Both herbicides can be used individually or together and are approved by the USEPA for wetland use. Although the cost per gallon of imazapyr can be significantly higher than glyphosate, results from recent studies suggest that imazapyr used alone or in combination with glyphosate has a higher control rate and can prevent regrowth for a longer period of time (Mozdzer et al 2008). Further, imazapyr has a broader application time (i.e., summer up to the first killing frost). For these reasons, imazapyr has been selected as the primary herbicide, either alone or in conjunction (50/50 mix) with glyphosate, for initial treatments, with glyphosate employed for most follow-up and spot applications.

After initial spraying, prescribed fire and mechanical disturbances will be implemented in early spring 2012. Prescribed fire is a tool used after herbicide application to remove excess biomass, kill any living surface rhizomes, promote native plant growth, and eventually locate phragmites re-growth, which makes spot-treatment easier during the subsequent summer seasons.

Where burning is not feasible, mechanical treatments, like mowing and raking, will be employed post-herbicide application. As with prescribed fire, mechanical treatment removes dead phragmites stems, which promotes native plant growth, and also aids in the identification of new phragmites growth for subsequent herbicide spot treatments. Mechanical work will be limited to areas where phragmites is present and will be conducted in late winter and early spring of 2012 to minimize site disturbance.

IV. ALTERNATIVES TO THE PROPOSED ACTION

Research and literature shows that herbicide treatment is the recommended primary control method and the first step toward effective phragmites management (Marks et al. 1994). Roughly 80 percent of phragmites' biomass is underground as rhizomes. And because it spreads primarily by rhizomes, digging, tilling, and pulling phragmites can expedite its spread.

Alternatives for the control of this nuisance aquatic vegetation include:

A. Biological Control

Biological control is rarely a practical option for controlling phragmites because those organisms known to feed on this plant (moth larvae, aphids, leaf miners, gall midges, rodents, and birds) cause only incidental damage, with a few rare exceptions.

Regarding control with microorganisms and invertebrates, Cornell University researchers have tested over 150 different fungi, pathogens, and insects and have found only four wasp species that might control phragmites (see on-line review at phragmites.org). Testing of their effectiveness is still on-going, however, so practical implementation of phragmites via invertebrate bio-control is not feasible currently.

Some breeding waterbirds and wetland mammals do use phragmites as a food supply, although this grazing is neither reliable nor pervasive enough for adequate control. American coots, for instance, consume young shoots in the immediate area of their nests. Considerable damage to phragmites shoots occurs locally by such species as muskrats and nutria, but like coot grazing, this is not an activity under the manager's control.

Controlled grazing has little effect on shoot density, but rhizomes that are repeatedly trampled will bear few shoots and recover slowly when grazing has ceased. If phragmites stands are grazed for two years or more, vigor is reduced considerably. Because the amount of grazing required to reduce these stands would be detrimental to desirable plant species as well, grazing is not a recommended control measure on wildlife management areas.

B. Mechanical Harvesting

Physical removal and mechanical control of phragmites stands may include tilling, discing, and mowing. Such cutting and/or harvesting can be quite beneficial, particularly where stand vegetation is dense and composed of a limited number of species, and immediate results are needed. However, these control methods can be very expensive, and, at least when harvesting, a need for a disposal site can be prohibitive, too. Since phragmites reproduces mostly via rhizomes, most of these methods will actually help spread the plant in treatment areas, so it should not be considered as primary control resource.

Although difficult, mechanical treatments are possible on sites that are flooded or consistently moist. A rotary ditch digger can be used in flooded areas to chop through rhizome-packed substrates and till over existing plants. On drier sites, bulldozers, brush-cutters, discs, roto-tillers, mowers, crushers, and plows can be practical. Unfortunately, most of these methods also tend to break up and spread rhizome fragments across a site, thereby helping propagate the plant in the future. Dredging may be effective in some situations, but potential effects on wetlands and aesthetic considerations will limit its use.
Even though it has been eliminated as a primary treatment method, mechanical manipulation is considered a helpful resource before conducting herbicide application, since mowing, brush-cutting, tilling, etc., can create openings in dense stands, thereby increasing the efficacy of herbicide (see Mal & Narine 2004, among others).

C. Hydrologic Manipulation

Water-level manipulation, where it can be used, can be a useful tool for controlling phragmites. Flooding will not alter established stands, but if water levels greater than 12 inches (30 cm) are maintained, colonies will not expand. At these depths, runners are unable to anchor and will float to the surface. Seedlings are easily killed by raising water levels, but timing of water-level manipulations must be carefully determined to be effective and to avoid conflicts with other management objectives.

Draining water from established stands often reduces plant vigor and allows more desirable species to compete, but drying may require several years to degrade a stand. On many wetland areas, however, drainage is neither practical nor desirable. The structures needed to drain wetlands (and then recharge, post-treatment) are expensive to build and are often not feasible. Land owners may have also objections to the alteration of their property or changes in current hydrologic flows. This method has been eliminated due to cost considerations, and its limited applicability.

D. Prescribed Fire

Fire used alone as a control measure has variable results depending on intensity of the burn, but is generally most effective in late summer. Generally, winter burning affords no control and often increases densities of spring crops unless a late spring freeze kills new buds. Spring burning without other control treatments is ineffective because the original stand is simply replaced with a more vigorous growth. In fact, burning in spring removes all dead stems and litter and scorches buds, stimulating multiple buds to develop and emerge. Early to midsummer burns are also ineffective because regrowth still replaces the original stand.

Burning phragmites late in the growing season reduces stand vigor temporarily because few replacement buds are available. Furthermore, reserve energy is in the rhizomes by then and cannot be used for winter bud production. Unfortunately, though, summer burns can have dire impacts on populations on nesting birds, herpetofauna, Lepidoptera, etc., particularly in such fragmented systems like WLE coastal marshes.

The limited efficacy and the temporal concerns associated with prescribed fire, along with the logistical challenges of implementation in wetlands (i.e., hydrology), renders this control method undesirable as a main control. However, it will be used to thin stands during late winter, in order to better prepare sites for summer herbicide application.

E. No Action

No action to control phragmites will cause further degradation of coastal wetland habitats and the native species that inhabit them. Due to lack of treatment over the last decades, near-monotypic stands of this invasive plant have replaced high-quality, complex communities over thousands of acres in WLEB wetlands and coastal areas (MDEQ 2008). This rapid expansion of a monotypical plant community has resulted in adverse ecological, economic, and social impacts on the natural resources and people of the Great Lakes. Overall, phragmites has degraded the vitality of western Lake Erie marshes, which are some of the most productive and biologically diverse systems in the Midwest. Because phragmites replaces native vegetation, native sedges, rushes, and cattails are displaced, thereby degrading overall plant species richness and diversity. The loss of native plant diversity further results in the decline of wildlife habitat, including that needed to support migratory bird assemblages and native, resident animal species.

V. FEDERALLY-LISTED THREATENED, ENDANGERED, PROPOSED, AND CANDIDATE SPECIES

No federally-listed threatened, endangered, proposed, and candidate plant or animal species are known to reside within the phragmites stands scheduled for treatment. Several of the focal areas – like Winous Point and Erie Marsh Preserve – have seasonal biological surveys that inform management decisions, with listed species documented when found, and this will be applied to the control methods described herein.

Because treatment areas are generally monocultural stands of phragmites, the likelihood of listed plant species being negatively impacted is small. In fact, past successful phragmites control programs have increased populations of some federally-listed plants, specifically eastern prairie fringed orchid, *Platanthera leucophaea* (Ron Huffman, Ottawa NWR biologist, personnel communication). The likelihood of any detrimental effects to threatened or endangered animals is remote due to the properties of the herbicides proposed for this application (see the following section). Conversely, elimination of dense stands of phragmites may provide feeding habitat for listed species such as piping plover.

A list of threatened, endangered, proposed, and candidate species under the jurisdiction of the U.S. Department of the Interior, Fish and Wildlife Service for the Ohio coastal counties of Erie, Lucas, Ottawa, and Sandusky, and for Monroe County, Michigan, are available in Appendix A.

VI. ENVIRONMENTAL IMPACTS

Material data safety sheets for each of the two brand names are included within the appendices; however, the following are syntheses (from TNC's Weed Control Methods Handbook, Tu et al. 2001), which briefly describe environmental toxicity of the active glyphosate and imazapyr application, the active herbicides within the brand manes Rodeo® and Habitat®, respectively. In short, both chemicals are of low toxicity to animal communities, although care must be taken if a surfactant is used in conjunction with Rodeo.

A. Glyphosate

Glyphosate is of relatively low toxicity to birds and mammals (Evans & Batty 1986). The LD50 of glyphosate for rats is 5,600 mg/kg and for bobwhite quail, >4,640 mg/kg. EPA's Reregistration Eligibility Decision states that blood and pancreatic effects and weight gain were noted during subchronic feeding studies with rats and mice (EPA 1993). Other studies show developmental and reproductive impacts to animals given the highest dose.

Newton et al. (1984) examined glyphosate residues in the viscera of herbivores following helicopter application of glyphosate to a forest in Oregon and found residue levels comparable to those found in litter and ground cover (<1.7 mg/kg). These residue levels declined over time and were undetectable after day 55 (Newton et al. 1984). Although carnivores and omnivores exhibited much higher viscera residue levels (5.08 mg/kg maximum), Newton et al. (1984) concluded that carnivores were at lower risk than herbivores due to the lower relative visceral weights and a proportionally lower level of food intake.

Batt et al. (1980) found no effect on chicken egg hatchability or time to hatch when an egg was submerged in a solution of 5% glyphosate. Sullivan and Sullivan (1979) found that black-tailed deer showed no aversion to treated foliage and consumption of contaminated forage did not reduce total food intake. Significant impacts to bird and mammal populations due to large-scale habitat alterations following treatment of forest clearcuts with glyphosate have been reported (Morrison & Meslow 1984; Santillo et al. 1989a, b; MacKinnon & Freedman 1993).

Glyphosate itself is of moderate toxicity to fish. The 96-hour LC50 of technical grade glyphosate for bluegill sunfish and rainbow trout are 120 mg/L and 86 mg/L, respectively. Fish exposed to 5 mg/L of glyphosate for two weeks were found to have gill damage and liver damage was observed at glyphosate concentrations of 10 mg/L (Neskovic et al. 1996). The technical grade of glyphosate is of moderate toxicity to aquatic species, and the toxicity of different glyphosate formulations can vary considerably. For example, Touchdown 4-LC® and Bronco® have low LC50s for aquatic species (<13 mg/L), and are not registered for aquatic use. On the other hand, Rodeo® has relatively high LC50s (>900 mg/L) for aquatic species and is permitted for use in aquatic systems. The surfactant in Roundup® formulations is toxic to fish; however, Rodeo has no surfactant, and is registered for aquatic use.

The surfactant X-77 Spreader®, which is often used in conjunction with Rodeo®, is approximately 100 times more toxic to aquatic invertebrates than Rodeo® alone (Henry et al. 1994). The surfactant MONO818 is included in Roundup® formulations because it aids the break-down of surface tension on leaf surfaces, but it may also interfere with cutaneous respiration in frogs and gill respiration in tadpoles (Tyler 1997 a,b). In addition, MONO818 is highly toxic to fish (Folmar et al. 1979; Servizi et al. 1987). The LC50 of MONO818 is 2-3 mg/L for sockeye, rainbow, and coho fry (Folmar et al. 1979; Servizi et al. 1987;

Tyler 1997 a,b). The LC50 of Roundup® for bluegill sunfish and rainbow trout is only slightly higher at 6-14 mg/L and 8-26 mg/L, respectively. Similarly for *Daphnia*, the 96-hour LC50 of glyphosate alone is 962 mg/L, but the LC50 of Roundup® drops to 25.5 mg/L (Servizi et al. 1987). Roundup® is therefore not registered for use in aquatic systems.

Despite these toxicity levels, Hildebrand et al. (1980) found that Roundup® treatments at concentrations up to 220 kg/ha did not significantly affect the survival of *Daphnia magna* or its food base of diatoms under laboratory conditions. In addition, Simenstad et al. (1996) found no significant differences between benthic communities of algae and invertebrates on untreated mudflats and mudflats treated with Rodeo® and X-77 Spreader®. It appears that under most conditions, rapid dissipation from aquatic environments of even the most toxic glyphosate formulations prevents build-up of herbicide concentrations that would be lethal to most aquatic species.

B. Imazapyr

Imazapyr is of relatively low toxicity to birds and mammals. The LD50 for rats is > 5,000 mg/kg, and for bobwhite quail and mallard ducks is >2,150 mg/kg (WSSA 1994). American Cyanamid reports that studies with rats indicate that imazapyr was excreted rapidly in the urine and feces with no residues accumulating in the liver, kidney, muscle, fat, or blood (Miller et al. 1991). Imazapyr has not been found to cause mutations or birth defects in animals, and is classified by the U.S. EPA as a Group E compound, indicating that imazapyr shows no evidence of carcinogenicity.

Imazapyr is of low toxicity to fish and invertebrates. The LC50s for rainbow trout, bluegill sunfish, channel catfish, and the water flea (*Daphnia magna)* are all >100 mg/L (WSSA 1994). As of September 2003, imazapyr (tradename Habitat®) is registered for use in aquatic areas, including brackish and coastal waters, to control emerged, floating, and riparian/wetland species. A recent study from a tidal estuary in Washington showed that imazapyr, even when supplied at concentrations up to 1600 mg/L, did not affect the osmoregulatory capacity of Chinook salmon smolts (Patten 2003). Similarly, the Washington State Department of Agriculture reported that the 96-hour LC50 for rainbow trout fry to be 77,716 mg/L (ppm) -22,305 ppm of the active ingredient- which represents a greater concentration of imazapyr than found in commercially-sold containers (J. Vollmer, pers. comm.).

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Appendix A. USFWS Listed Species That Occur in Monroe County, Michigan, and Lucas, Ottawa, and Sandusky Counties, Ohio

State	County	Species	Status	Habitat
Michigan	Monroe	Indiana bat (*Myotis sodalis*)	Endangered	Summer habitat includes small to medium river and stream corridors with well developed riparian woods; woodlots within 1 to 3 miles of small to medium rivers and streams; and upland forests. Caves and mines as hibernacula.
Michigan	Monroe	Karner blue butterfly (*Lycaeides melissa samuelis*)	Endangered	Pine barrens and oak savannas on sandy soils and containing wild lupines *(Lupinus perennis)*, the only known food plant of larvae.
Michigan	Monroe	Northern riffleshell (*Dysnomia torulosa rangiana*)	Endangered	Large streams and small rivers in firm sand of riffle areas; also occurs in Lake Erie
Michigan	Monroe	Rayed bean (*Villosa fabalis*)	Candidate	
Michigan	Monroe	Eastern prairie fringed orchid (*Plantathera leucophaea*)	Threatened	Mesic to wet prairies and meadows
Ohio	Lucas, Ottawa, Sandusky	Indiana bat (*Myotis sodalis*)	Endangered	Summer habitat includes small to medium river and stream corridors with well developed riparian woods; woodlots within 1 to 3 miles of small to medium rivers and streams; and upland forests. Caves and mines as hibernacula.
Ohio	Lucas, Ottawa, Sandusky	Piping plover *(Charadrius melodus)*	Endangered	Beaches along shorelines of the Great Lakes
Ohio	Lucas, Ottawa, Sandusky	Eastern massasauga (*Sistrurus catenatus*)	Candidate	
Ohio	Lucas	Rayed bean mussel (*Villosa fabalis*)	Candidate	
Ohio	Lucas	Karner blue butterfly (*Lycaeides melissa samuelis*)	Endangered	Pine barrens and oak savannas on sandy soils and containing wild lupines *(Lupinus perennis)*, the only known food plant of larvae.
Ohio	Lucas, Ottawa, Sandusky	Eastern prairie fringed orchid (*Plantathera leucophaea*)	Threatened	Mesic to wet prairies and meadows
Ohio	Ottawa	Lake Erie water snake *(Nerodia sipedon insularum)*	Threatened	Shorelines of islands in western Lake Erie
Ohio	Ottawa	Lakeside daisy *(Hymenoxys herbacea)*	Threatened	Dry rocky prairies; limestone rock surfaces including outcrops and quarries

Appendix B. Map of Focal Areas Proposed for Treatment