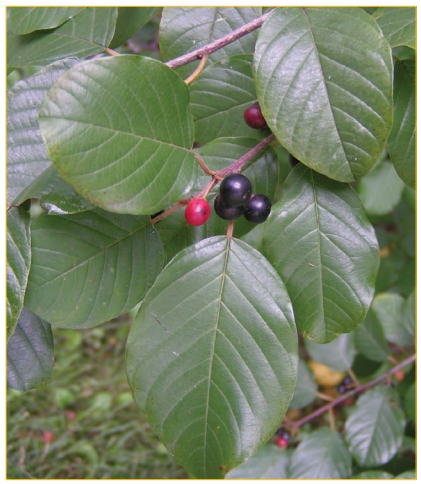
Mount Hope Wetland:

Invasive Species Control and Wetland Rehabilitation



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Contents

Project overview & purpose 3

Baseline conditions 4

Floristic Quality Assessment 5

Floristic Quality Index 5

East Management Area. 6

Central Management Area 6

West Management Area 7

Mount Hope Wetland photos 9

General Considerations 11

Prioritize phragmites, glossy buckthorn and Canada thistle for control 11

Treat a test area of reed canarygrass and narrowleaf and hybrid cattail 11

Minimize harmful inputs 11

Specific recommendations 12

Woody wetland invasive species—glossy buckthorn 12

Wetland herbaceous species—phragmites, reed canarygrass and hybrid cattail 13

Upland herbaceous species—Canada thistle and spotted knapweed 15

Planting native species. 15

Setting management goals and measuring success 16

Five Year Treatment Schedule. 18

Bibliography 21

Appendix A. 23

Table A 1 Plant species: East Management Area (Conservation easement)—border 25

Table A 2 Plant species: East Management Area (Conservation easement)—non-border 26

Table A 3 Plant species: East Management Area (Conservation easement)—all species 27

Table A 4 Plant species: Central Management Area—all species 29

Table A 5 Plant species: Western Management Area—all species 31

Table A 6 Plant species: Mt. Hope wetland—all species 33

Appendix B: General information on control techniques, permits, etc. 37

Appendix C: Species lists for wetland plantings. 41

Table C-1 Rushes, grasses and sedges for wetland plantings 42

Table B-2 Wildflowers for wetland plantings. 44

Table C-3 Shrubs for wetland plantings 45

Table B-3 Trees for wetland plantings 46

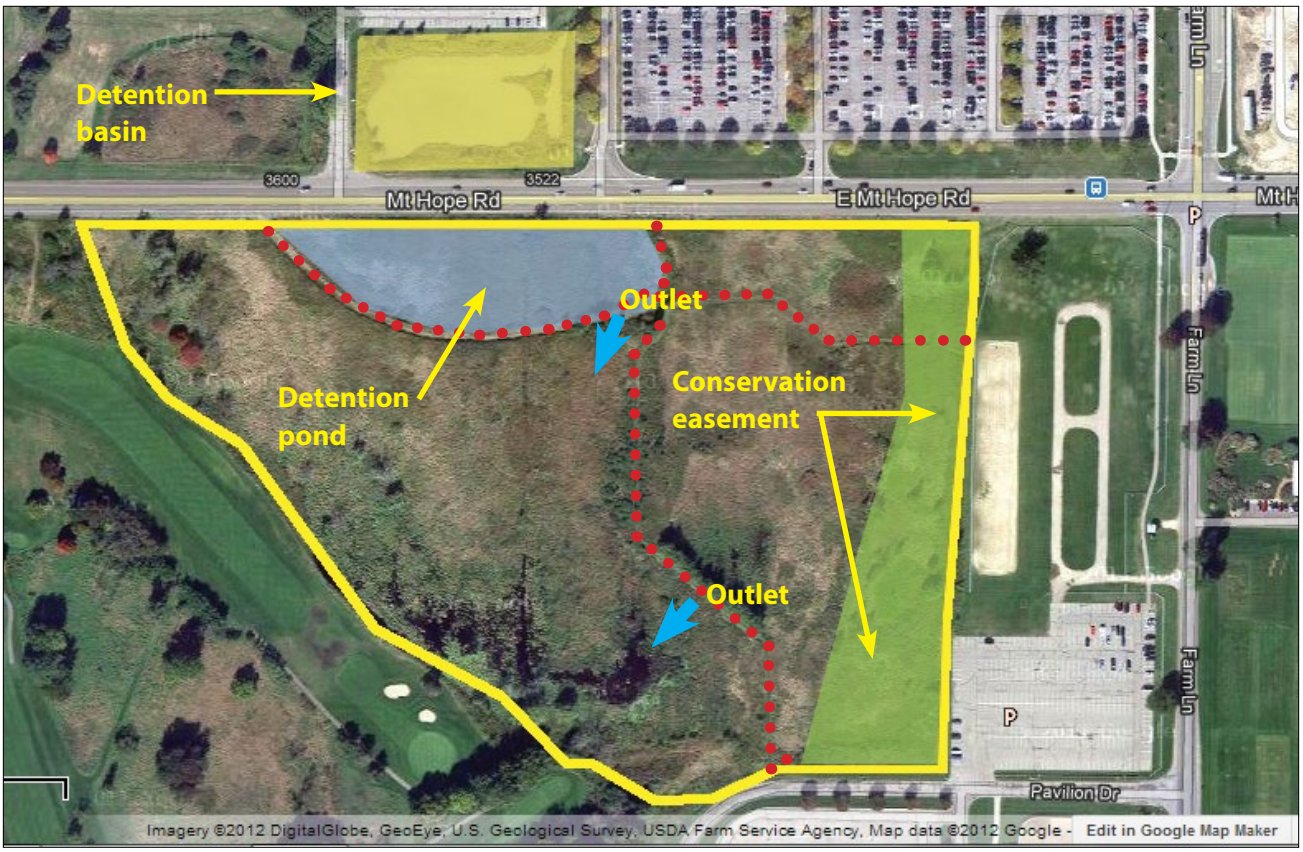
Project overview & purpose

The purpose of this project is for the Michigan Natural Features Inventory (MNFI), a program of the Michigan State University Extension (MSUE), to provide advice to the Michigan State University Police (MSUP) with respect to the feasibility of control of invasive plant species occurring in a wetland associated with Lot 89 of the MSU parking system. Being associated with the MSU parking system, the MSUP have management responsibility for the wetland, which also contains a conservation easement. The history of the wetland is somewhat complex and it is worthwhile to review some of that history to set the stage for going forward.

In 2001, a degraded wetland (the Mt. Hope Wetland) that lies south of Mount Hope Rd and west of Farm Lane was modified to retain and treat stormwater in conjunction with the expansion of a parking lot on the north side of the road (MSU Lot 89). As part of the parking lot expansion, a portion of a small wetland (0.42 acres) on the north side of Mt. Hope Road was filled to create an access to the expanded lot, and 0.63 acres were excavated to create a stormwater detention basin for the expanded lot; the water from this detention basin drains south under Mt. Hope Road to the larger Mt. Hope Wetland (Anonymous, 2002).

In order to prevent nutrients, road salt, heavy metals and oil and gasoline residues from entering the wetland south of the road, a shallow u-shaped berm was constructed around 1.85 acres along the road to contain and treat water coming from the parking lot in a shallow detention pond. Water leaves this area via a low spot in the berm in its southeast corner and enters the main wetland complex (URS, 2000). An additional 2.4 acres of wetland were created along the eastern edge of the site, as mitigation for the wetlands that were filled or modified as a result of the parking lot expansion. This portion of the site is protected by a conservation easement. Spoils were piled on upland areas that extended into the original wetland, creating berms, which help retain water later into the growing season. Water flows from east to west across a low point in these berms in the southern portion of the site (URS, 2000).

Figure 1. Mt. Hope Wetland features



One year after construction, Dennis Albert (MSU-MNFI) and Thomas Burton (MSU-Fisheries and Wildlife) sampled flora and fauna in the wetland along 12 transects that crossed herbaceous and shrub-dominated wetlands in both the original and newly created sections. **They found that although overall plant diversity was highest in the constructed wetland, native plant diversity was highest in the original wetland.** The existing wetland was dominated by cattail, reed canary grass and buckthorn, reflecting high levels of nutrient input. Phragmites was NOT noted at this time. Nutrients most likely originated from past agricultural practices, and current run-off from the adjacent golf course and parking lot. The constructed wetland was dominated by non-native upland species (Burton & Albert, 2002).

Dr. Burton and his students continued work on the site, focusing on three broad tasks: replacing invasive plants with natives and monitoring changes in biota during restoration. A large colony of glossy buckthorn next to Mt. Hope in the detention pond died after several years of elevated water levels. In the first few years following construction, contractors and MSU grounds crews planted prairie species that persist in the constructed wetland and at higher elevations along the berms today (Thomas Burton, 2012, personal communication).

In the intervening years, some glossy buckthorn was cut by MSU staff, but it has re-sprouted aggressively. In the fall of 2011, volunteers treated some of the phragmites with glyphosate, but they ran out of herbicide before all of the infestation was treated (Leslie Kuhn, 2012, personal communication).

Baseline conditions

Early land survey records indicate that pre-settlement vegetation on the site consisted of conifer swamp (Albert, et al. 2008). However, over its history the area of the Mt. Hope Wetland has been highly impacted by human activity. Aerial photos indicate that portions of the site were used for agricultural research, but were abandoned for that use at some point. As noted above, in 2001, prior to the manipulation and construction associated with the Lot 89 parking lot expansion, the site supported a low quality herbaceous and shrub wetland complex, which presumably developed after the end of the agricultural activities. Since 2001, the site has experienced an apparent increase in the number and abundance of invasive plant species, including in the conservation easement, providing the impetus for this project.

As a first step in developing a plan for management of the invasive species, MNFI conducted field surveys in the summer and fall of 2012 to assess the current conditions of the Mt. Hope Wetland. While Burton and Albert conducted quantitative studies of the flora and fauna, it was the opinion of the authors that, at least initially, a qualitative approach to assessing the flora would be more cost-effective than detailed quantitative studies. Consequently, floristic quality assessments (FQA), along with geographic positioning system (GPS) mapping, was conducted on the site to provide a baseline of the number of native and non-native plant species present, identification of which invasive species were most commonly represented in the flora, and production of geographic information system (GIS) maps of features of interest.

Low quality herbaceous and shrub wetland

Floristic Quality Assessment

We would like to provide a few comments on Floristic Quality Assessments (FQA), as well as the Floristic Quality Index that is included in the typical FQA. A Floristic Quality Assessment is a relatively objective means of assessing the quality of the vegetation of a particular site, or making comparisons among various sites with respect to vegetation. The basis of the FQA is a survey of the plant species that occur on the site, typically compiled during a meander reconnaissance (i.e. walkover) of the site in question. From this inventory, a list of species found is tabulated.

Each plant species native to Michigan has been assigned a "coefficient of conservatism" or "C" value. C Values range from 0 – 10 and represent "an estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be a pre-settlement condition." In other words, plants with a low numerical rating can be found in a wide range of habitats and areas of disturbance, while those with a high number are "almost always restricted to a pre-settlement remnant, i.e. a high quality natural area" (Herman, et al., 2001).

Floristic Quality Index

From the coefficients of conservatism for the species found on a site, an index, referred to as the Floristic Quality Index (FQI), can be calculated as follows:

$$FQI = [(\Sigma Ci)/n]\sqrt{n}$$

Where:

Ci – the coefficient of conservatism of each of the native species found on the site

n – the number of native species or the number of native and non-native species found on the site

As noted, the calculation can be done by considering only those species on the site which are native to Michigan, or by considering all of the species found, whether native or non-native. The latter approach helps to differentiate between sites with similar numbers of native species, but differing numbers of non-native species, thus providing a more objective measure of the floristic quality of a site.

Herman, et al. (2001) provide the following guidance with respect to FQIs:

> Most of the remaining undeveloped land registers floristic quality indices (FQI) of less than 20 and has minimal significance from a natural quality perspective. Areas with a FQI higher than 35 possess sufficient conservatism and richness that they are floristically important from a statewide perspective. Areas registering in the 50s and higher are extremely rare and represent a significant component of Michigan's native biodiversity and natural landscapes.

In addition to the FQA information and the "C" value for each plant species, we present a number of other characteristics for each species. These characteristics are: the wetland indicator status; whether the species is native or adventive (non-native), and the physiognomy of the species (i.e. whether the species is a tree, shrub, or wildflower ("forb")).

As MNFI anticipates that control of the invasive species at the Mt. Hope Wetland is likely to be implemented in a phased manner, we have initially defined three primary management areas and propose an initial focus on a subset of the invasive species present. The management areas, depicted in Figure 2, are designated the East Management Area (EMA), which consists of the conservation easement area; the Central Management Area (CMA); and the Western Management Area (WMA). In the future, these areas can be further subdivided if necessary. We conducted an FQA for each of the management areas and also conducted a FQA for the upland border of the EMA, as this border represents a distinctly different habitat from the remainder of the conservation easement area. Table 1 presents a summary of the FQAs and a discussion of the three areas follows. Detailed lists of the plant species found in the respective FQA areas are presented in Appendix A.

Table 1. Summary of the Floristic Quality Assessments of the Mt. Hope Wetland by Management Area

	East Management Area			Central Management Area	West Management Area	Entire Site
	Border	Non-border	Overall			
Total of C values =	46	81	92	92	52	148
Average C value =	2.88	3.12	2.97	3.17	2.26	3.08
Native Species Count =	16	26	31	29	23	48
% Native Species =	48%	76%	61%	74%	59%	60%
Total Species Count =	33	34	51	39	39	80
Area (ha) =			1.51	3.29	6.55	11.35
Native Species/ha =			20.5	8.8	3.5	4.2
Floristic Quality Index = (native species only)	11.5	15.9	16.5	17.1	10.8	21.36
Floristic Quality Index = (all species)	8.0	13.9	12.9	14.7	8.3	16.55

East Management Area

This area consists of a conservation easement on the site as delineated by the conservation easement boundary signs (Figure 1). Several different plant associations are present in the site and resemble southern wet meadow and emergent marsh, as defined by MNFI, along with "old field", though the latter is not recognized as a natural community type by MNFI. None of the areas would be considered quality examples of these natural community types. The north, east, and south borders of this area are several feet higher in elevation compared to the central portion of the area. Due to this difference in elevation and past plantings associated with establishment of the easement, the flora of the borders are fairly distinct from the central area and include more upland species, relative to the central portion. In the central portion of the easement 22 of the 34 plant species (65%) are wetland indicators, whereas 16 of the 33 species (48%) in the higher borders are considered wetland species. Additionally, of the 51 species found throughout the entire EMA, the central portion and the borders share only 17 species. Due to this difference, a separate plant list was compiled for this upland border area, as it is anticipated that management efforts for this border will differ somewhat from the central portion of the easement and are likely to be treated as sub-areas.

Substantial stands of invasive plant species occur in the EMA, including reed (Phragmites), Canada thistle, and reed canary grass, with smaller amounts of buckthorn and narrow-leaved and hybrid cattail.

Central Management Area

This area also contains components of southern wet meadow, emergent marsh and old field. The wetland and upland areas interdigitate to a considerable extent in this area, suggesting that subtle changes in typography are sufficient to shift between these community types. This observation suggests that the water table may be fairly near the surface of the ground in this area and is fairly stable, allowing for the small changes in typography to result in the observed vegetation patterns. Though clearly not a high quality ecological area, the CMA does have the highest percentage of native species, highest FQI, and highest average C value of the three management areas.

Though having a much smaller amount of Phragmites, the CMA has substantially more buckthorn than the EMA or the WMA. It also has scattered small stands of Canada thistle that were too small to effective delineate. It should be pointed out that in Figure 1, the stand of buckthorn represented by the polygon in the center of the CMA is qualitatively and quantitatively quite different than the other buckthorn stands

represented by the other polygons. In the center polygon, the buckthorn essentially covers virtually 100% of the area and occurs has dense stands of many small-stemmed plants, which may represent re-sprouts from earlier control measures. It may be necessary to areal spray this area to control the buckthorn. In the other polygons the buckthorn occurs as scattered individuals that are much more amenable to individual cutting and stump painting with herbicide for control.

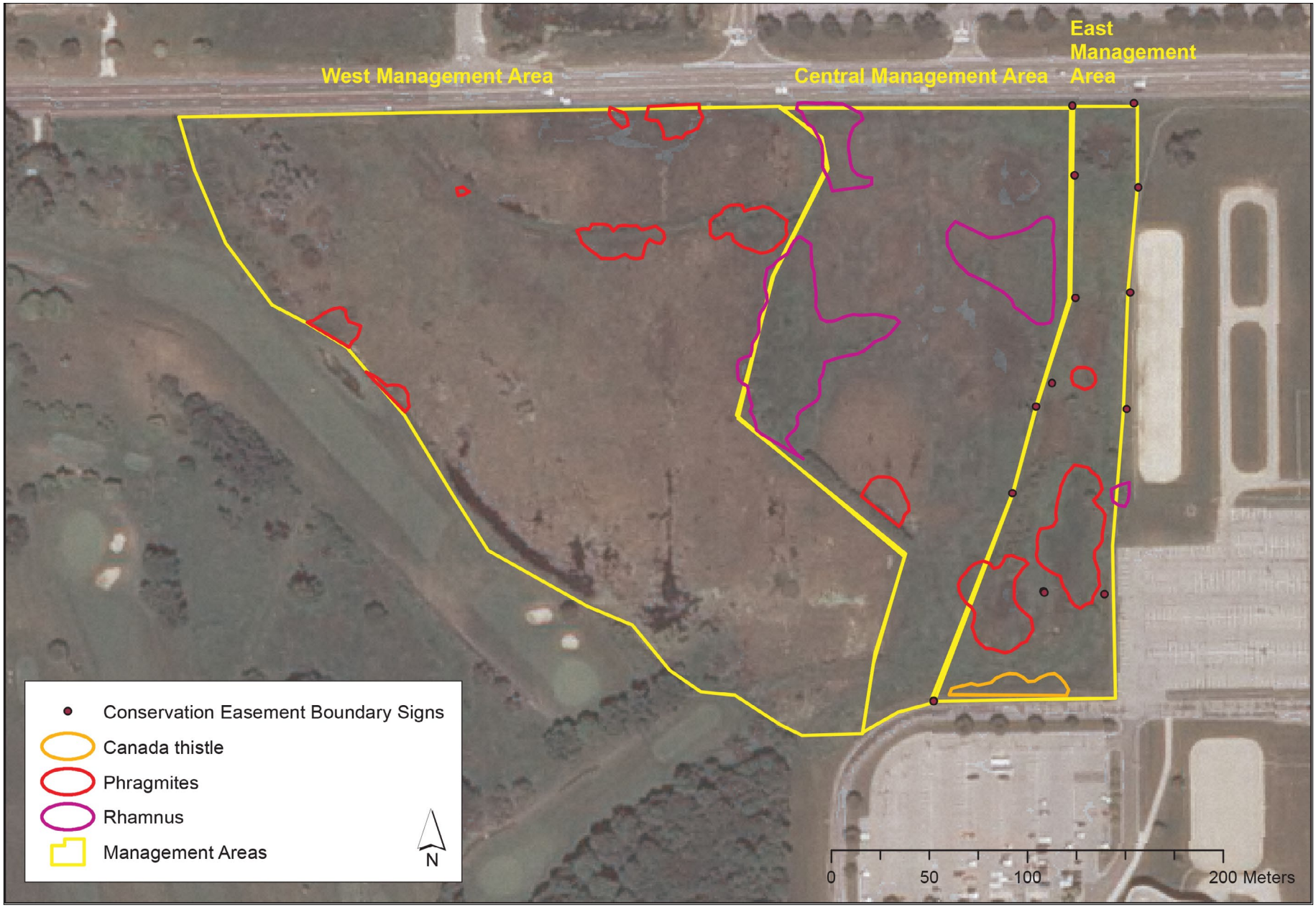
West Management Area

This is the largest of the three management areas and is qualitatively quite different than either the EMA or CMA. The WMA has very little area that could be considered old field, but rather consists of much more uniform stands of southern wet meadow and emergent marsh. As indicated in Figure 1, several stands of Phragmites exist in the area. Narrow-leaved cattail mixed with broad-leaved cattail and reed canary grass form extensive stands throughout the area and will present a significant challenge from an invasive species control standpoint. The WMA also contains some sub-areas that also differ substantially from any portion found in the EMA or CMA. One of these areas is located in the northern portion of the area, bordering Mt. Hope Road and delineated by the road and the semi-circular berm which also serves as a walking trail. The berm appears to be at least somewhat effective in retaining water in this area in the spring as evidenced by the dominance of cattails in the area and evidence of use by muskrats, though through most of the summer and fall there was no standing water evident in this area. Another sub-area in the WMA with a distinctly different character is the area in the southwest corner of the WMA and along golf course which appears as dark areas in Figure 1. The dark appearance is due to exposed muck soils. The lack of vegetation in these areas during the spring, along with the vegetation that develops in the area later during the growing season suggests that standing water exists in this area for a substantial portion of the spring and early growing season. While the vegetation in this area does have a substantial number of non-native species, none of those species are particularly invasive, but rather represent "colonizers", i.e. annual species that specialize in remaining in the seedbank until appropriate conditions exist, usually some disturbance that prevents perennial species from dominating the vegetation. In this particular case, it appears that the standing water may provide an annual disturbance allowing these species to persist.

In general, and as evidenced by the results in Table 1, none of the areas are of particularly high quality from a botanical or ecological standpoint. The FQI values are all below 20, which, as noted above, is considered the typical value for disturbed, unmanaged open space in the state.

That said, several invasive species present "low hanging fruit" with respect to control. These species include Phragmites, buckthorn, and Canada thistle. The current areal extent of these species as determined by GPS techniques are: Phragmites – 0.531 ha; buckthorn – 0.623 ha; and Canada thistle – 0.046 ha. Other invasive species, which will present a much greater management challenge include narrow-leaved cattail and reed canary grass. Control options for these species are discussed more extensively in other sections of the document.

Figure 1. Mt. Hope Wetland Management Areas and invasive species distribution



Mount Hope Wetland photos

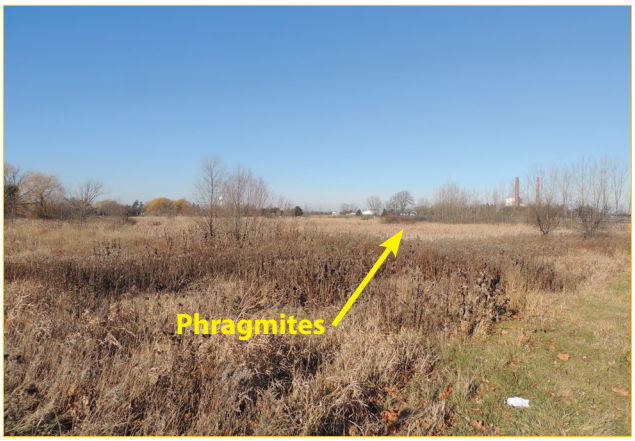
East Conservation Area = EMA, Central Management Area = CMA and West Management Area = WMA

View north from southeastern corner of wetland looking into the CMA (conservation easement).

View east along southern edge of wetland. Forbs along the edge include Canada thistle, which should be controlled.

View north from southern edge of wetland into eastern edge of CMA and western edge of EMA. Sign marks the boundary line.

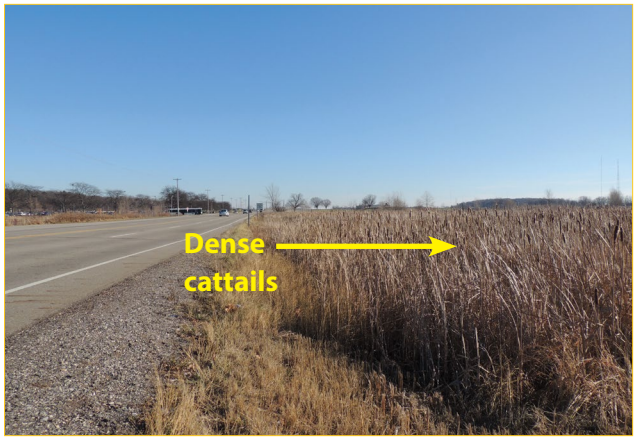
View north from southern edge of wetland along the mowed berm that separates the CMA and WMA.



View looking into the WMA, from its southeastern corner.

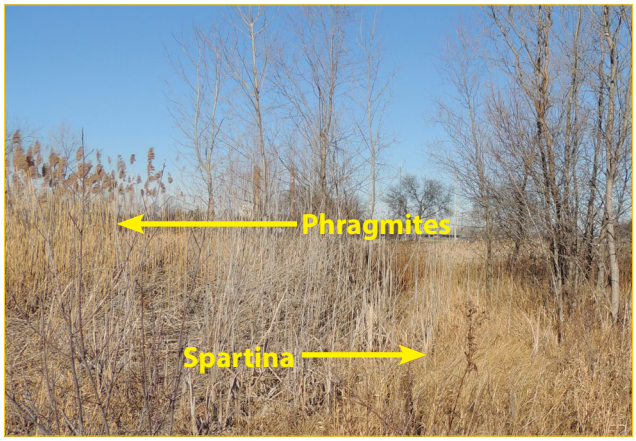
View west along the southern edge of the WMA, looking towards the golf course.

View northwest from southwestern corner of the WMA, adjacent to the golf course.



View east along the northern edge of the WMA along the detention pond near the outlet from the parking lot detention basin across the street.

Mowed berm along the southern edge of the detention pond in WMA.



South side of the detention pond berm, with salt-tolerant Spartina (tan grass) and phragmites where it drains into main wetland.

View north along berm that divides CMA and EMA. Dense colonies of glossy buckthorn.

View north along berm. Low point on berm reinforced at seasonal outlet from CMA into WMA.

General Considerations

Resources for invasive species control invariably fall short of the actual need, so it is important to prioritize targets for treatment and plan carefully. Assessing both the scope of the problem and any available resources is a critical first step. In developing these recommendations, we have considered a number of factors:

- Are each of the invasive species present widely distributed throughout the site? Or is their distribution limited to date? Are they sparsely scattered in otherwise native vegetation? Do they cover large expanses of low quality habitat?
- What are the values driving the restoration of the site? Stormwater handling capacity? Wildlife habitat? Legal obligations for a mitigated wetland?
- Are there harmful site inputs such as road salt or excessive nutrients? Can they be controlled?

Given this information, our strategy for control follows these guidelines:

Prioritize invasive species with relatively limited distribution first—those for which the likelihood of success is highest.

1. Treat invasive species with more extensive distribution only as resources permit.
2. Choose appropriate control methods, given site conditions and available resources.
3. Determine what permits are required (i.e. herbicide application in wetlands, prescribed fire).
4. Monitor to ensure desired results are being achieved; adapt management to improve success.

Prioritize phragmites, glossy buckthorn and Canada thistle for control

Initial control efforts at the Mount Hope wetland should focus on phragmites, glossy buckthorn and Canada thistle, as they present significant threats to wetland function and viability but are still limited in distribution and the likelihood of their successful control is high. A combination of mechanical and chemical controls are recommended including herbicide, prescribed fire, mowing and natural flooding where possible. It is important to bear in mind that controlling invasive species on degraded sites requires a long-term commitment, both in terms of monitoring and re-treatment, and also in the need for establishing native vegetation on the site once some measure of control has been achieved. Even when native vegetation has been established, regular re-treatment of invasive species will be required.

Treat a test area of reed canarygrass and narrowleaf and hybrid cattail

Reed canarygrass and narrow-leaf and hybrid cattail are also present and of concern. Reed canarygrass is widely distributed in the wetland and particularly difficult to eradicate. Similarly, hybrid cattail and narrow-leaf cattail are abundant in the wetland and dominate much of the western portion of the site. They are ubiquitous throughout the Great Lakes region and have only begun to be studied recently. Controlling these species throughout the entire wetland may or may not be feasible. In order to assess the potential for their control on this site, we recommend that they only be treated within the Eastern Management Area (EMA—the conservation easement) for the first few years. It is a relatively small area, and they can be treated in conjunction with the treatment of phragmites. The results of these initial efforts will help determine what control actions are feasible and likely to be successful throughout the entire wetland.

Minimize harmful inputs

In attempting to restore the site, it is critical to consider site conditions that lead to degradation, particularly excessive nutrients and road salt. Phragmites, reed canary grass and hybrid cat-tail thrive in high-nutrient settings and tolerate higher levels of salinity than most Michigan native plant species. In some cases, invasive species may grow rapidly and crowd out natives because they utilize nutrients more effectively.

In other cases, they simply move in as native species are killed off by excessive use of road salt. Every effort should be made to work with maintenance staff to minimize fertilizer runoff from the golf course and road salt from parking lots. Even if the invasive species can be controlled, if salinity levels are high enough, some native vegetation may not survive, particularly in low lying areas where salt concentrates. We recommend re-planting only within the EMA initially and assessing the results before planting more widely.

Specific recommendations

In developing a strategy for controlling invasive species in the Mt. Hope wetland, the species were combined into 3 treatment groups:

- wetland woody species,
- wetland herbaceous species and
- upland herbaceous species.

Species with similar control protocols can be treated simultaneously. Additional control options for individual members of each group that may be useful under some circumstances are noted as well. This section is followed by a table that lays out a five year program of control and re-vegetation. The table is not intended to dictate a rigid plan, but should be adapted as needed to meet management goals within the limits of available resources. More general information on control techniques, herbicides, adjuvants, and permits is included in Appendix B. In addition, the CD that is included at the back of this report includes product labels for all of the herbicides that are mentioned in this section and additional resources for controlling the species that are found in the Mt. Hope wetland.

Woody wetland invasive species—glossy buckthorn

At present, glossy buckthorn is the only invasive woody species on the site, but as bare soil is exposed while invasive species are killed off, others may appear.

Triclopyr provides effective control of broad-leaved plants including glossy buckthorn but does not kill grasses or some conifers. It is available in both amine (e.g., Garlon 3A®) and ester (e.g., Garlon 4 Ultra®)formulations. The amine formulation can be safely used in wetlands where standing water is present. In late summer, when parts of the wetland have dried up, the ester formulation may also be considered.

Cut-stump treatment

Typically, triclopyr is used with cut-stump treatment. Cut-stump treatment is useful for species like glossy buckthorn that normally re-sprout after cutting. It should be used with a wetland-approved non-ionic surfactant such as Cygnet Plus®. Treatments may be applied throughout the year including when snow is present. However, control effectiveness may be reduced in early spring when the sap is beginning to flow or during periods of drought in summer.

After the stems have been cut, they are painted with concentrated herbicide, using a squirt bottle or wicking applicator. The amine formulation must be painted onto the cut surface immediately or it will not be effective. Small stems can be cut several inches above the ground so that both the sides and the cut surface may be treated. On large stems, cuts should be made as close to the ground as possible and only the cambium—the thin layer where active growth occurs, just inside the bark—should be treated.

Product labels list what adjuvants may be used to increase effectiveness of the herbicide; penetrating oils only work with ester formulations, for example. Similarly, dyes, which are useful in keeping track of which stems have been treated, work with specific herbicide formulations.

Foliar herbicide application

Foliar application of triclopyr can be useful on sites with extensive glossy buckthorn populations and few

desirable natives. It may be particularly appropriate for use in the Mt Hope wetland on the shrubs which were cut previously and have since re-sprouted. Since they have grown back so densely, with numerous stems, it may be difficult to cut and paint them all—foliar herbicide application provides a useful alternative. It is also useful for treating re-sprouts from recently treated cut stumps.

Triclopyr should be applied after spring sap flow to actively growing plants, although during periods of drought or other stress, it may not be effective. It can be applied to glossy buckthorn foliage with squirt bottles, backpack sprayers or boom-mounted sprayers. The product label for the specific product being used provides essential information on coverage; how much of the foliage should be treated and how wet it should be. Herbicide labels also contain information on specific weather conditions, application modes, equipment types, nozzles etc. to provide the desired coverage and minimize the potential for volatilization.

Prescribed fire

In fire-adapted communities such as southern wet meadows, prescribed burning may enhance control of invasive species over the long term, but should always be considered as part of an integrated management plan for the site as it will stimulate many species including phragmites, buckthorn and reed canarygrass. When prescribed burning is initiated, it should be supplemented with other control methods.

Fire alone does not provide effective control of glossy buckthorn as it will only top-kill mature plants. Even small buckthorn saplings and seedlings seem to survive fire well. In dense buckthorn stands (including some of those present on site), there is not enough fuel present to carry fire through them. Fall fires stimulate vigorous re-sprouting. Early season fires, when root carbohydrate levels are low, are more effective. Prescribed fire also results in increased germination of seed from bird-dispersed fruits. In addition to the glossy buckthorn already on site, many of the woodlots on campus are edged with other invasive species including common buckthorn, bush honeysuckles and privet. All seeds germinate more readily on bare soils that have been exposed by fire. A plan for follow-up treatment with herbicide is required as there is initially insufficient fuel to kill these densely sprouting seedlings in a regular prescribed burn.

In spite of these limitations, fire has other benefits for fostering a healthy plant community that is better able to resist re-invasion. By reducing leaf litter and allowing light to reach the soil surface and stimulate seed germination, fire can play an important role in maintaining southern wet meadow seed banks. Fire plays a critical role in maintaining species richness by creating open microsites for small species. Given the desire to maintain the Mt. Hope site as an open wetland, another critically important attribute of fire is its ability to temporarily reduce shrub and tree cover.

Wetland herbaceous species—phragmites, reed canarygrass and hybrid cattail

Wetland herbaceous species such as phragmites, reed canarygrass and cattail can all be treated with the same herbicides. Although reed canarygrass and hybrid cattail are only being treated in the conservation easement (EMA) initially, this facilitates a single annual treatment for all three species.

Glyphosate provides effective control of wetland herbaceous species. It breaks down quickly and is available in formulations that are approved for use in wetlands (e.g. Refuge®). It can also be used in combination with a wetland approved formulation of imazapyr (e.g. Habitat®) for increased efficacy. Both herbicides are non-selective; they will kill both broad leaved plants and graminoids. Cygnet Plus®. a wetland approved non-ionic surfactant/activator, should be used with either product.

Both chemicals have advantages and disadvantages. Glyphosate is considerably less expensive. It breaks down quickly and does not persist in the soils. It should be applied to phragmites and cattail in the fall as the seeds begin to ripen, prior to the first frost. Reed canarygrass can be treated in spring or fall, when it is actively growing. In general, it should be treated in fall with the other two wetland species for convenience. Since it greens up early, however, it can be helpful to treat it with glyphosate before spring prescribed fire. It dies back quickly and burns readily, providing valuable fuel for the fire.

Imazapyr is more expensive and will remain active in the soil for a year or more. This may be an advantage or a disadvantage, depending on the site conditions. Where there is a seedbank of native wetland species, glyphosate may be the better choice. Where there is no native seedbank and the target species occur in a matrix of other invasive species, imazapyr may provide more effective control by remaining active longer and suppressing germination of weed seeds. It can be used at any time during the growing season once plants are actively growing and leaves are fully elongated. Note: Since reed canarygrass undergoes a period of dormancy in summer, it should not be used on this species at this time.

Imazapyr should be used with caution, as it can also move through the soil and kill valuable landscape trees and other desirable plants nearby. Once re-vegetation with native species begins, imazapyr is no longer appropriate for treating re-sprouts. Treated sites should not be planted or seeded until a year has passed since the last treatment with imazapyr. Glyphosate may still be used for spot treatment.

Grass-specific herbicides may also be useful under some conditions, particularly for spot treatment of reed canary grass once the site has been replanted; grass-specific herbicides such as sethoxydim (e.g. Vantage®) or fluazifop (e.g. Fusilade®) can be used without damaging native forbs. They can only be used when standing water is not present, however. If the wetland dries up by late summer, they may provide a useful alternative, particularly once native vegetation begin to establish on site.

Foliar herbicide application

Both herbicides are typically applied as a foliar spray, but glyphosate can also be hand-swiped onto individual plants as population densities decrease in following years. The product label for the specific product being used provides essential information on coverage; how much of the foliage should be treated and how wet it should be. Herbicide labels also contain information on specific weather conditions, application modes, equipment types, nozzles etc. to provide the desired coverage and minimize the potential for volatilization or drift.

Prescribed fire

As mentioned previously, prescribed fire should always be considered as part of an integrated management plan for the site as it will stimulate many species including phragmites, buckthorn and reed canarygrass. When prescribed burning is initiated, it should be supplemented with other control methods.

In spite of these limitations, prescribed fire is extremely effective at removing standing dead material on site and is preferable to mowing in that respect. It facilitates treatment of new shoots, clears the soil effectively for reseeding and makes it easier to monitor what species are germinating on newly cleared sites—whether from the seedbank or from seeds that have been deliberately planted.

Cutting/mowing

Cutting or mowing phragmites, reed canary grass and hybrid cattail will not control them. In some (not all) cases it may prevent or minimize seed production but generally, these species benefit from increased light availability and grow back more densely unless treated with herbicide. If prescribed fire is not an option, mowing may be helpful in removing standing dead material and exposing new growth in the season after herbicide application, facilitating re-treatment. It can be used in conjunction with flooding, to stress vegetation also—see following section.

In wetlands, mowing may be most efficient in winter, when the ground is frozen and heavy equipment can be used without creating ruts or compressing soils. Specialized equipment such as a Marsh Master® can be useful if mowing must take place during the growing season.

Some MSU staff have expressed concerns that the mowing of the berms to date has effectively spread phragmites along them. Mowing should be coordinated with herbicide application to prevent this. Similarly, all equipment should be cleaned thoroughly before use on other sites to prevent further dispersal.

Flooding

Water levels cannot be strictly regulated at the Mt. Hope site, but they may be high seasonally in some areas. Both phragmites and hybrid cattail can withstand high water levels when their stalks, which convey oxygen are left standing. Hybrid cattail for example, can survive at water depths of over 18 inches. If they are cut or mowed in fall or winter, when the ground is frozen, they will be stressed by lack of oxygen and may begin to die back. Although the amount of water on site will vary from spring to spring, the wettest areas should be noted to determine if there is sufficient water on site to make mowing worthwhile.

Upland herbaceous species—Canada thistle and spotted knapweed

Canada thistle and spotted knapweed are both difficult species to control once they are established. Canada thistle forms dense clones and spreads via rhizomes. All plants in a clone must be treated for successful control. Spotted knapweed is not abundant around the Mt. Hope wetland yet, but it is allelopathic and can keep other plants from establishing nearby. Because it is still uncommon on the site, spotted knapweed is still a legitimate target for control by hand-pulling, particularly if volunteers are available. Since it can be controlled by the same herbicide as Canada thistle, it may be best treat the two species with herbicide simultaneously.

Aminopyralid (e.g. Milestone®) provides effective control of both Canada thistle and spotted knapweed. It is broadleaf-specific and will not harm grasses although it can kill desirable landscape plants and crops nearby. Legumes are particularly vulnerable. Although it is not approved for wetlands with standing water, it can be applied up to the water's edge and in seasonally dry wetlands.

Treatment for both species with a foliar spray is most effective in spring after the leaves are fully emerged. Canada thistle can be treated up until the oldest plants are in full flower stage. Spotted knapweed can be treated as a rosette and up until the time that it sends up a flowering stem. They can also both be treated effectively in fall, if spring treatment is not feasible, but not during summer.

Once populations of Canada thistle have been reduced ~ 90%, annual re-treatment can be combined with re-treatment of phragmites, reed canarygrass and hybrid cattail in fall.

Planting native species

As restoration proceeds, areas that were once occupied by invasive species may require seeding with native species to prevent re-invasion. Since the original upland plantings of native prairie species appear to have successfully established, replanting efforts should focus on wetland species in the lower areas. We propose to begin re-vegetation efforts in a limited test area—in the EMA (conservation easement) where reed canarygrass and hybrid cattail were also treated as a test to assess the potential for success elsewhere on the site.

Timing of replanting efforts is dependent on several factors including effectiveness of control efforts and the particular herbicides that are used. Sites that have been treated with imazapyr (Habitat) should not be planted for at least a year as it remains active in the soils for a long time—refer to the product label for specifics. Sites that have been treated with glyphosate-based products can be planted immediately as it breaks down quickly but it is important to evaluate control effectiveness before proceeding with any planting. Generally, treatment effectiveness is best assessed nine months to a year following treatment.

Ideally, the initial test planting in the EMA can be used to assess the suitability of particular species/species mixes before attempting to replant the entire area. Given both budget constraints and involvement of permanent University staff, this is actually an advantage. Similarly, if it is possible to enlist the assistance of University greenhouse staff, it may be useful to raise plugs of selected species and compare establishment success with areas that are direct-seeded. This may be particularly effective for showy wetland wildflowers.

For the majority of the area, however, direct seeding is far less expensive than planting plugs.

There are advantages and disadvantages for both spring and fall/winter seeding. Fall/winter seeding allows the seeds to sink into the soil as it cracks during freeze/thaw cycles. Seeds can germinate early, and establish before the heat of summer. When prescribed fire is incorporated into the restoration effort, however, seed cannot be sown until afterwards. The bare, newly exposed soil creates an ideal planting bed for the seeds, which can establish before weeds have a chance to take hold. Ultimately, site conditions should dictate timing specifics. In spring, if too much standing water is present, the seed will be washed about and not be distributed evenly. Accordingly, the ideal time for planting will likely vary throughout the site.

In selecting species to be used for re-vegetation, it is best to select hardy natives that can tolerate degraded site conditions. Later on, as they become established and harmful inputs can be eliminated, a much wider range of species may be introduced if desired. Historically, emergent wetlands in Ingham County would have contained a mix of rushes, sedges, a few grasses and forbs (wildflowers). Wildflowers, when used strategically, can enhance public appreciation of the site, while conveying critical ecological benefits, particularly for pollinators. Scattered trees and shrubs were also mentioned in the original plans, although the site was expected to remain relatively open. Proposed species lists for sedges, rushes and grasses, forbs, and trees and shrubs are located in Appendix C.

Setting management goals and measuring success

It is important to set realistic goals for invasive species management; glossy buckthorn, phragmites and Canada thistle will not be eradicated from the site after a single year of treatment, although their extent and density should be dramatically reduced. Phragmites and Canada thistle populations should be reduced by at least 70-80% one year after the first season's treatment. If all of the glossy buckthorn can be treated the first year, it may continue to re-sprout, but a 50-75% reduction in population size one year following treatment should be achievable. In following years, the level of effort required to treat these species should diminish annually. If control efforts are curtailed prematurely, however, their population levels will quickly rebound, and it should be noted that some level of maintenance will be required indefinitely.

We recommend initially treating a test area of reed canary grass and narrowleaf and hybrid cattail, before committing resources to treating these species on the entire site. If their populations are reduced by 50-60% and successfully replaced with native vegetation within 3 years in the test area, it would be worth treating these species throughout the site. If these levels of reduction cannot be achieved, a more realistic goal is simply to keep them from expanding into the areas where phragmites , glossy buckthorn and Canada thistle were treated.

Ideally, within 5 years, populations of phragmites, glossy buckthorn and Canada thistle should be reduced to the point that they can be spot-treated annually by a single person in one or two days. As additional information regarding the feasibility of reed canarygrass and narrowleaf and hybrid cattail control becomes available from the results of the control efforts the test area, simple, realistic management goals can be set for these species also.

Once management goals have been set, it is important to determine whether or not control efforts are having the desired effect on invasive plants on the site. Assessment protocols should be simple enough that they can be repeated annually. We have provided baseline data on the current extent of phragmites, glossy buckthorn and Canada thistle and annual mapping of their extent will provide a basis for comparison over time and a simple measure for determining treatment success. Once 95% reduction in the area occupied by these species has been achieved, intensive control efforts can be replaced with annual spot re-treatment as needed.

Similarly, Floristic Quality Analysis (see discussion on page 5) based on meander surveys through the site

each year will provide a simple measure for assessing site quality and species diversity. At present, the average coefficient of conservatism (Mean C) ranges from 2.26 to 3.17 between the various management areas. To provide some perspective, the Mean C for all native plant species in Michigan is 4.0. In other words, the site is presently dominated by species from the weedier end of the spectrum. Current native Floristic Quality Indices range from 10.8 to 17.1, again indicating a relatively disturbed site with low diversity. Both of these values can be expected to rise, as restoration proceeds, and when they do, more extensive assessment may be merited.

Finally, photo monitoring at strategically chosen points provides a simple and intuitive measure of change over time and should be considered as a third assessment method. We have included a copy of a simple protocol on the CD in the back of this report.

Five Year Treatment Schedule

A particular treatment may be administered in any of the months indicated by a square.

Table 2. Mount Hope Wetland : Invasive species control and wetland rehabilitation

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2013												
Treat buckthorn Cut and paint cambium with amine triclopyr formulation, e.g. Garlon 3A® **AND/OR** Foliar spray with triclopyr (e.g. Garlon 3A®)	■	■	■				■ ■	■ ■	■ ■	■ ■	■	■
Treat thistle, knapweed Foliar spray with amino-pyralid, e.g. Milestone					■	■			■	■		
Treat phragmites Foliar spray with glyphosate or glyphosate/ imazapyr mixture									■	■		
Treat test area (reed canary, cat-tail) Foliar spray in conjunction with phragmites treatment									■	■		
2014												
Prescribed fire Mowing may be substituted but is less effective	■	■	■									
Re-treat buckthorn Cut stump or basal bark spray as needed **AND/OR** Foliar spray of resprouts	■	■	■				■ ■	■ ■	■ ■	■ ■	■	■
Re-treat thistle, knapweed Foliar spray or hand swipe as needed					■	■			■	■		
Treat phragmites regrowth Foliar spray or hand swipe with glyphosate only									■	■		
Re-treat test area (reed canary, cat-tail) Foliar spray or hand swipe in conjunction with phragmites treatment									■	■		
Assess vegetation What is in the seedbank in treated areas? is it native?					■	■	■	■	■	■	■	

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2015												
Re-treat buckthorn Cut stump or basal bark spray as needed	■	■	■				■	■	■	■	■	■
AND/OR												
Foliar spray of resprouts							■	■	■	■		
Seed test area If control >75%	■	■	■	■								
Re-treat thistle, knapweed Foliar spray or hand swipe as needed					■	■			■	■		
Treat phragmites regrowth Foliar spray or hand swipe with glyphosate only									■	■		
Re-treat test area (reed canary, cat-tail) Foliar spray or hand swipe in conjunction with phragmites treatment									■	■		
Assess vegetation What is growing in the treated areas, is it native?					■	■	■	■	■	■	■	
2016												
Prescribed fire Avoid seeded areas while plants are young. Mowing may be substituted but is less effective	■	■	■									
Re-treat buckthorn Cut stump or basal bark spray as needed	■	■	■				■	■	■	■	■	■
AND/OR												
Foliar spray of resprouts							■	■	■	■		
Re-treat thistle, knapweed Foliar spray or hand swipe as needed					■	■			■	■		
Treat phragmites regrowth Foliar spray or hand swipe with glyphosate only									■	■		
Re-treat test area (reed canary, cat-tail) Foliar spray or hand swipe in conjunction with phragmites treatment									■	■		
Treat remaining areas (reed canary, cat-tail) **Optional**—if test area has responded well to treatment									■	■		

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2017												
Re-treat buckthorn Cut stump or basal bark spray as needed	■	■	■				■	■	■	■	■	■
AND/OR												
Foliar spray of resprouts							■	■	■	■		
Re-treat thistle, knapweed Foliar spray or hand swipe as needed					■	■			■	■		
Treat phragmites regrowth Foliar spray or hand swipe with glyphosate only									■	■		
Spot treat test area (reed canary, cat-tail) Include any newly treated areas. Foliar spray or hand swipe in conjunction with phragmites treatment									■	■		
2018												
Prescribed fire Avoid seeded areas until plants are well-established. Mowing may be substituted but is less effective	■	■	■									■
Seed treated areas As needed, following fire	■	■	■	■								
Re-treat buckthorn Cut stump or basal bark spray as needed	■	■	■				■	■	■	■	■	■
OR												
Foliar spray of resprouts							■	■	■	■		
Re-treat thistle, knapweed Foliar spray or hand swipe as needed					■	■			■	■		
Treat phragmites regrowth Foliar spray or hand swipe with glyphosate only									■	■		
Spot treat test area (reed canary, cat-tail) Include any newly treated areas. Foliar spray or hand swipe in conjunction with phragmites treatment									■	■		
Assess vegetation What is growing in the treated areas, is it native?					■	■	■	■	■	■	■	

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Appendix A

Key to abbreviations used in plant species lists

T/E Status Notes:

T – State Listed Threatened Species
E- State Listed Endangered Species
Ex – Extirpated from the State
SC – State Special Concern Species
(F) – Federally Listed Species

Wetland Indicator Status Notes:

OBL - Occur almost always in wetlands under natural conditions (>99-percent of the time)
FACW - Usually occur in wetlands (67 to 99-percent of the time) but occasionally found in non-wetlands
FAC - Equally likely to occur in wetlands or non-wetlands (34 to 66-percent of the time)
FACU Usually occur in non-wetlands (67 to 99-percent of the time) but occasionally found in wetlands
UPL - Occur almost always in non-wetlands under natural conditions (>99-percent of the time)
+ A frequency toward the higher end of a category (more frequently found
- A frequency toward the lower end of a category (less frequently found in wetlands)

Physiognomy Notes:

AD – Adventive (non-native) taxa
NT – Native taxa
A – Annual species
B – Biennial species
P – Perennial species
W – Woody (vine)

Table A 1 Plant species: East Management Area (Conservation easement)—border

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	Physiognomy
Ambrosia artemisiifolia	common ragweed	0	FACU		Nt A-Forb
ARCTIUM MINUS	common burdock	*	[UPL]		Ad B-Forb
Asclepias syriaca	common milkweed	1	[UPL]		Nt P-Forb
Aster lateriflorus	side-flowering aster	2	FACW-		Nt P-Forb
Aster novae-angliae	New England aster	3	FACW		Nt P-Forb
BROMUS INERMIS	smooth brome	*	[UPL]		Ad P-Grass
Carex lacustris	sedge	6	OBL		Nt P-Sedge
CIRSIUM ARVENSE	Canadian-thistle	*	FACU		Ad P-Forb
DACTYLIS GLOMERATA	orchard grass	*	FACU		Ad P-Grass
DAUCUS CAROTA	queen-Anne's-lace	*	[UPL]		Ad B-Forb
DIPSACUS FULLONUM	common teasel	*	[UPL]		Ad P-Forb
Erigeron annuus	annual fleabane	0	FAC-		Nt B-Forb
Euthamia graminifolia	grass-leaved goldenrod	3	FACW-		Nt P-Forb
LINARIA VULGARIS	butter-and-eggs	*	[UPL]		Ad P-Forb
LONICERA TATARICA	Tartarian honeysuckle	*	FACU		Ad Shrub
LYTHRUM SALICARIA	purple loosestrife	*	OBL		Ad P-Forb
Panicum virgatum	switch grass	4	FAC+		Nt P-Grass
Phalaris arundinacea	reed canary grass	0	FACW+		Nt P-Grass
Physalis virginiana	Virginia ground-cherry	4	[UPL]		Nt P-Forb
PLANTAGO LANCEOLATA	English plantain	*	FAC		Ad P-Forb
POA PRATENSIS	Kentucky bluegrass	*	FAC-		Ad P-Grass
Populus deltoides	cottonwood	1	FAC+		Nt Tree
RHAMNUS FRANGULA	glossy buckthorn	*	FAC+		Ad Shrub
RUMEX CRISPUS	curly dock	*	FAC+		Ad P-Forb
SILENE PRATENSIS	white catchfly	*	[UPL]		Ad A-Forb
Silphium perfoliatum	cup plant	10	FACW-	T	Nt P-Forb
SOLANUM CAROLINENSE	horse nettle	*	FACU-		Ad P-Forb
Solidago altissima	tall goldenrod	1	FACU		Nt P-Forb
Sorghastrum nutans	Indian grass	6	FACU+		Nt P-Grass
Typha latifolia	broad-leaved cat-tail	1	OBL		Nt P-Forb
VERBASCUM BLATTARIA	moth mullein	*	FACU-		Ad B-Forb
VERBASCUM THAPSUS	common mullein	*	[UPL]		Ad B-Forb
Vernonia missurica	Missouri ironweed	4	FAC+		Nt P-Forb

Floristic Quality Assessment	
Sum of C values =	46
Native Species Count =	16
Total Species Count =	33
Floristic Quality Index (native species only) =	11.5
Floristic Quality Index (all species) =	8.01

Table A 2 Plant species: East Management Area (Conservation easement)—non-border

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	PHYS
Asclepias syriaca	common milkweed	1	[UPL]		Nt P-Forb
Aster lateriflorus	side-flowering aster	2	FACW-		Nt P-Forb
Aster novae-angliae	New England aster	3	FACW		Nt P-Forb
Aster puniceus (A. lucidulus)	swamp aster	5	OBL		Nt P-Forb
CIRSIUM ARVENSE	Canadian-thistle	*	FACU		Ad P-Forb
DAUCUS CAROTA	queen-Anne's-lace	*	[UPL]		Ad B-Forb
Eupatorium perfoliatum	common boneset	4	FACW+		Nt P-Forb
Euthamia graminifolia	grass-leaved goldenrod	3	FACW-		Nt P-Forb
Fraxinus pennsylvanica	red ash	2	FACW		Nt Tree
Helenium autumnale	sneezeweed	5	FACW+		Nt P-Forb
Juncus dudleyi	Dudley's rush	1	[FAC]		Nt P-Forb
Lycopus americanus	water horehound	2	OBL		Nt P-Forb
LYTHRUM SALICARIA	purple loosestrife	*	OBL		Ad P-Forb
Monarda fistulosa	wild bergamot	2	FACU		Nt P-Forb
Panicum virgatum	switch grass	4	FAC+		Nt P-Grass
Penstemon digitalis	foxglove beard-tongue	2	FAC-		Nt P-Forb
Phalaris arundinacea	reed canary grass	0	FACW+		Nt P-Grass
Phragmites australis	reed	0	FACW+		Nt P-Grass
POA PRATENSIS	Kentucky bluegrass	*	FAC-		Ad P-Grass
Pycnanthemum tenuifolium	slender mountain mint	6	[FAC]		Nt P-Forb
RHAMNUS CATHARTICA	common buckthorn	*	FACU		Ad Tree
Salix exigua (S. interior)	sandbar willow	1	OBL		Nt Shrub
SALIX FRAGILIS	crack willow	*	FAC+		Ad Tree
Sambucus canadensis	elderberry	3	FACW-		Nt Shrub
Scirpus atrovirens	bulrush	3	OBL		Nt P-Sedge
Silphium perfoliatum	cup plant	10	FACW-	T	Nt P-Forb
Silphium terebinthinaceum	prairie dock	6	FACU		Nt P-Forb
Solidago altissima	tall goldenrod	1	FACU		Nt P-Forb
Sorghastrum nutans	Indian grass	6	FACU+		Nt P-Grass
TYPHA ANGUSTIFOLIA	narrow-leaved cat-tail	*	OBL		Ad P-Forb
Typha latifolia	broad-leaved cat-tail	1	OBL		Nt P-Forb
VERBASCUM THAPSUS	common mullein	*	[UPL]		Ad B-Forb
Verbena stricta	hoary vervain	4	[UPL]		Nt P-Forb
Vernonia missurica	Missouri ironweed	4	FAC+		Nt P-Forb

Floristic Quality Assessment	
Sum of C values =	81
Native Species Count =	26
Total Species Count =	34
Floristic Quality Index (native species only) =	15.89
Floristic Quality Index (all species) =	13.89

Table A 3 Plant species: East Management Area (Conservation easement)—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	Physiognomy
Ambrosia artemisiifolia	common ragweed	0	FACU		Nt A-Forb
ARCTIUM MINUS	common burdock	*	[UPL]		Ad B-Forb
Asclepias syriaca	common milkweed	1	[UPL]		Nt P-Forb
Aster lateriflorus	side-flowering aster	2	FACW-		Nt P-Forb
Aster novae-angliae (Virgulus n.)	new England aster	3	FACW		Nt P-Forb
Aster puniceus (A. lucidulus)	swamp aster	5	OBL		Nt P-Forb
BROMUS INERMIS	smooth brome	*	[UPL]		Ad P-Grass
Carex lacustris	sedge	6	OBL		Nt P-Sedge
CIRSIUM ARVENSE	Canadian-thistle	*	FACU		Ad P-Forb
DACTYLIS GLOMERATA	orchard grass	*	FACU		Ad P-Grass
DAUCUS CAROTA	Queen-Anne's-lace	*	[UPL]		Ad B-Forb
DIPSACUS FULLONUM	common teasel	*	[UPL]		Ad P-Forb
Erigeron annuus	annual fleabane	0	FAC-		Nt B-Forb
Eupatorium perfoliatum	common boneset	4	FACW+		Nt P-Forb
Euthamia graminifolia	grass-leaved goldenrod	3	FACW-		Nt P-Forb
Fraxinus pennsylvanica	red ash	2	FACW		Nt Tree
Helenium autumnale	sneezeweed	5	FACW+		Nt P-Forb
Juncus dudleyi	Dudley's rush	1	[FAC]		Nt P-Forb
LINARIA VULGARIS	butter-and-eggs	*	[UPL]		Ad P-Forb
LONICERA TATARICA	Tartarian honeysuckle	*	FACU		Ad Shrub
Lycopus americanus	water horehound	2	OBL		Nt P-Forb
LYTHRUM SALICARIA	purple loosestrife	*	OBL		Ad P-Forb
Monarda fistulosa	wild bergamot	2	FACU		Nt P-Forb
Panicum virgatum	switch grass	4	FAC+		Nt P-Grass
Penstemon digitalis	foxglove beard-tongue	2	FAC-		Nt P-Forb
Phalaris arundinacea	reed canary grass	0	FACW+		Nt P-Grass
Phragmites australis	reed	0	FACW+		Nt P-Grass
Physalis virginiana	Virginia ground-cherry	4	[UPL]		Nt P-Forb
PLANTAGO LANCEOLATA	English plantain	*	FAC		Ad P-Forb
POA PRATENSIS	Kentucky bluegrass	*	FAC-		Ad P-Grass
Populus deltoides	cottonwood	1	FAC+		Nt Tree
Pycnanthemum tenuifolium	slender mountain mint	6	[FAC]		Nt P-Forb
RHAMNUS CATHARTICA	common buckthorn	*	FACU		Ad Tree
RHAMNUS FRANGULA	glossy buckthorn	*	FAC+		Ad Shrub
RUMEX CRISPUS	curly dock	*	FAC+		Ad P-Forb
Salix exigua (S. interior)	sandbar willow	1	OBL		Nt Shrub
SALIX FRAGILIS	crack willow	*	FAC+		Ad Tree
Sambucus canadensis	elderberry	3	FACW-		Nt Shrub
Scirpus atrovirens	bulrush	3	OBL		Nt P-Sedge
SILENE PRATENSIS	white catchfly	*	[UPL]		Ad A-Forb

Table A 3 Plant species: East Management Area (Conservation easement)—all species (cont.)

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	Physiognomy
Silphium perfoliatum	cup plant	10	FACW-	T	Nt P-Forb
Silphium terebinthinaceum	prairie dock	6	FACU		Nt P-Forb
SOLANUM CAROLINENSE	horse nettle	*	FACU-		Ad P-Forb
Solidago altissima	tall goldenrod	1	FACU		Nt P-Forb
Sorghastrum nutans	Indian grass	6	FACU+		Nt P-Grass
TYPHA ANGUSTIFOLIA	narrow-leaved cat-tail	*	OBL		Ad P-Forb
Typha latifolia	broad-leaved cat-tail	1	OBL		Nt P-Forb
VERBASCUM BLATTARIA	moth mullein	*	FACU-		Ad B-Forb
VERBASCUM THAPSUS	common mullein	*	[UPL]		Ad B-Forb
Verbena stricta	hoary vervain	4	[UPL]		Nt P-Forb
Vernonia missurica	Missouri ironweed	4	FAC+		Nt P-Forb

Floristic Quality Assessment	
Sum of C values =	92
Native Species Count =	31
Total Species Count =	51
Floristic Quality Index (native species only) =	16.52
Floristic Quality Index (all species) =	12.88

Table A 4 Plant species: Central Management Area—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	PHYS
Ambrosia artemisiifolia	common ragweed	0	FACU		Nt A-Forb
Andropogon gerardii	big bluestem	5	FAC-		Nt P-Grass
ARCTIUM MINUS	common burdock	*	[UPL]		Ad B-Forb
Asclepias incarnata	swamp milkweed	6	OBL		Nt P-Forb
Aster lateriflorus	side-flowering aster	2	FACW-		Nt P-Forb
Aster novae-angliae (Virgulus n.)	New England aster	3	FACW		Nt P-Forb
BERTEROA INCANA	hoary alyssum	*	[UPL]		Ad A-Forb
CIRSIUM ARVENSE	Canadian-thistle	*	FACU		Ad P-Forb
Cornus foemina (C. racemosa)	gray dogwood	1	FACW-		Nt Shrub
DAUCUS CAROTA	queen-Anne's-lace	*	[UPL]		Ad B-Forb
Eragrostis capillaris	lace grass	4	[UPL]	SC	Nt A-Grass
Erigeron annuus	annual fleabane	0	FAC-		Nt B-Forb
Eupatorium perfoliatum	common boneset	4	FACW+		Nt P-Forb
Euthamia graminifolia	grass-leaved goldenrod	3	FACW-		Nt P-Forb
Helenium autumnale	sneezeweed	5	FACW+		Nt P-Forb
Juncus dudleyi	Dudley's rush	1	[FAC]		Nt P-Forb
Juniperus virginiana	red-cedar	3	FACU		Nt Tree
LINARIA VULGARIS	butter-and-eggs	*	[UPL]		Ad P-Forb
Lobelia cardinalis	cardinal flower	7	OBL		Nt P-Forb
Lobelia siphilitica	great blue lobelia	4	FACW+		Nt P-Forb
LONICERA TATARICA	Tartarian honeysuckle	*	FACU		Ad Shrub
Lycopus americanus	water horehound	2	OBL		Nt P-Forb
LYTHRUM SALICARIA	purple loosestrife	*	OBL		Ad P-Forb
Panicum virgatum	switch grass	4	FAC+		Nt P-Grass
Phalaris arundinacea	reed canary grass	0	FACW+		Nt P-Grass
Phragmites australis	reed	0	FACW+		Nt P-Grass
Populus deltoides	cottonwood	1	FAC+		Nt Tree
Pycnanthemum tenuifolium	slender mountain mint	6	[FAC]		Nt P-Forb
RHAMNUS CATHARTICA	common buckthorn	*	FACU		Ad Tree
RHAMNUS FRANGULA	glossy buckthorn	*	FAC+		Ad Shrub
Rubus allegheniensis	common blackberry	1	FACU+		Nt Shrub
Salix exigua (S. interior)	sandbar willow	1	OBL		Nt Shrub
Sambucus canadensis	elderberry	3	FACW-		Nt Shrub
SETARIA GLAUCA	yellow foxtail	*	FAC		Ad A-Grass
Silphium perfoliatum	cup plant	10	FACW-	T	Nt P-Forb
Solidago altissima	tall goldenrod	1	FACU		Nt P-Forb
Solidago ohioensis	Ohio goldenrod	8	OBL		Nt P-Forb
Sorghastrum nutans	Indian grass	6	FACU+		Nt P-Grass
Typha latifolia	broad-leaved cat-tail	1	OBL		Nt P-Forb

Table A 4 Plant species: Central Management Area—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Floristic Quality Assessment		
Sum of C values =		148
Native Species Count =		48
Total Species Count =		80
Floristic Quality Index	(native species only) =	21.36
Floristic Quality Index	(all species) =	16.55

Table A 5 Plant species: Western Management Area—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	PHYS
ABUTILON THEOPHRASTI	velvetleaf	*	FACU-		Ad A-Forb
Acer negundo	box elder	0	FACW-		Nt Tree
AMARANTHUS HYBRIDUS	green amaranth	*	[UPL]		Ad P-Forb
Asclepias incarnata	swamp milkweed	6	OBL		Nt P-Forb
Aster laevis	smooth aster	5	[UPL]		Nt P-Forb
Aster lateriflorus	side-flowering aster	2	ACW-		Nt P-Forb
Aster novae-angliae (Virgulus n.)	New England aster	3	FACW		Nt P-Forb
CIRSIUM ARVENSE	Canadian-thistle	*	FACU		Ad P-Forb
CIRSIUM VULGARE	bull-thistle	*	FACU-		Ad B-Forb
Cornus foemina (C. racemosa)	gray dogwood	1	FACW-		Nt Shrub
Cyperus strigosus	long scaled nut sedge	3	FACW		Nt P-Sedge
ECHINOCHLOA CRUSGALLI	barnyard grass	*	FACW		Ad A-Grass
Echinochloa muricata	barnyard grass	1	OBL		Nt A-Grass
Eragrostis capillaris	lace grass	4	[UPL]	SC	Nt A-Grass
Euthamia graminifolia	grass-leaved goldenrod	3	FACW-		Nt P-Forb
Juncus torreyi	Torrey's rush	4	FACW		Nt P-Forb
Lycopus americanus	water horehound	2	OBL		Nt P-Forb
LYTHRUM SALICARIA	purple loosestrife	*	OBL		Ad P-Forb
Onoclea sensibilis	sensitive fern	2	FACW		Nt Fern
Panicum virgatum	switch grass	4	FAC+		Nt P-Grass
Phalaris arundinacea	reed canary grass	0	FACW+		Nt P-Grass
Phragmites australis	reed	0	FACW+		Nt P-Grass
Phytolacca americana	pokeweed	2	FAC-		Nt P-Forb
Polygonum lapathifolium	nodding smartweed	0	FACW+		Nt A-Forb
POLYGONUM PERSICARIA	lady's thumb	*	FACW		Ad A-Forb
Populus deltoides	cottonwood	1	FAC+		Nt Tree
RHAMNUS CATHARTICA	common buckthorn	*	FACU		Ad Tree
RHAMNUS FRANGULA	glossy buckthorn	*	FAC+		Ad Shrub
Rubus allegheniensis	common blackberry	1	FACU+		Nt Shrub
RUMEX CRISPUS	curly dock	*	FAC+		Ad P-Forb
SALIX ALBA	white willow	*	FACW		Ad Tree
Salix babylonica	weeping willow	*			Ad Tree
Scirpus atrovirens	bulrush	3	OBL		Nt P-Sedge
SETARIA FABERI	giant foxtail	*	FACU+		Ad A-Grass
SOLANUM DULCAMARA	bittersweet nightshade	*	FAC		Ad P-Forb
SONCHUS ASPER	prickly sow thistle	*	FAC		Ad A-Forb
TYPHA ANGUSTIFOLIA	narrow-leaved cat-tail	*	OBL		Ad P-Forb
Typha latifolia	broad-leaved cat-tail	1	OBL		Nt P-Forb
Vernonia missurica	Missouri ironweed	4	FAC+		Nt P-Forb

Table A 5 Plant species: Western Management Area—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Floristic Quality Assessment		
Sum of C values =		52
Native Species Count =		23
Total Species Count =		39
Floristic Quality Index	(native species only) =	10.84
Floristic Quality Index	(all species) =	8.33

Table A 6 Plant species: Mt. Hope wetland—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	PHYS
ABUTILON THEOPHRASTI	velvetleaf	*	FACU-		Ad A-Forb
Acer negundo	box elder	0	FACW-		Nt Tree
AMARANTHUS HYBRIDUS	green amaranth	*	[UPL]		Ad P-Forb
Ambrosia artemisiifolia	common ragweed	0	FACU		Nt A-Forb
Andropogon gerardii	big bluestem	5	FAC-		Nt P-Grass
ARCTIUM MINUS	common burdock	*	[UPL]		Ad B-Forb
Asclepias incarnata	swamp milkweed	6	OBL		Nt P-Forb
Asclepias syriaca	common milkweed	1	[UPL]		Nt P-Forb
Aster laevis	smooth aster	5	[UPL]		Nt P-Forb
Aster lateriflorus	side-flowering aster	2	FACW-		Nt P-Forb
Aster novae-angliae (Virgulus n.)	New England aster	3	FACW		Nt P-Forb
Aster puniceus (A. lucidulus)	swamp aster	5	OBL		Nt P-Forb
BERTEROA INCANA	hoary alyssum	*	[UPL]		Ad A-Forb
BROMUS INERMIS	smooth brome	*	[UPL]		Ad P-Grass
Carex lacustris	sedge	6	OBL		Nt P-Sedge
CIRSIUM ARVENSE	Canadian-thistle	*	FACU		Ad P-Forb
CIRSIUM VULGARE	bull-thistle	*	FACU-		Ad B-Forb
Cornus foemina (C. racemosa)	gray dogwood	1	FACW-		Nt Shrub
Cyperus strigosus	long scaled nut sedge	3	FACW		Nt P-Sedge
DACTYLIS GLOMERATA	orchard grass	*	FACU		Ad P-Grass
DAUCUS CAROTA	queen-Anne's-lace	*	[UPL]		Ad B-Forb
DIPSACUS FULLONUM	common teasel	*	[UPL]		Ad P-Forb
ECHINOCHLOA CRUSGALLI	barnyard grass	*	FACW		Ad A-Grass
Echinochloa muricata	barnyard grass	1	OBL		Nt A-Grass
Eragrostis capillaris	lace grass	4	[UPL]	SC	Nt A-Grass
Erigeron annuus	annual fleabane	0	FAC-		Nt B-Forb
Eupatorium perfoliatum	common boneset	4	FACW+		Nt P-Forb
Euthamia graminifolia	grass-leaved goldenrod	3	FACW-		Nt P-Forb
Fraxinus pennsylvanica	red ash	2	FACW		Nt Tree
Helenium autumnale	sneezeweed	5	FACW+		Nt P-Forb
Juncus dudleyi	Dudley's rush	1	[FAC]		Nt P-Forb
Juncus torreyi	Torrey's rush	4	FACW		Nt P-Forb
Juniperus virginiana	red-cedar	3	FACU		Nt Tree
LINARIA VULGARIS	butter-and-eggs	*	[UPL]		Ad P-Forb
Lobelia cardinalis	cardinal flower	7	OBL		Nt P-Forb
Lobelia siphilitica	great blue lobelia	4	FACW+		Nt P-Forb
LONICERA TATARICA	Tartarian honeysuckle	*	FACU		Ad Shrub
Lycopus americanus	water horehound	2	OBL		Nt P-Forb
LYTHRUM SALICARIA	purple loosestrife	*	OBL		Ad P-Forb
Monarda fistulosa	wild bergamot	2	FACU		Nt P-Forb

Table A 6 Plant species: Mt Hope wetland—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Scientific Name	Common Name	C	W.I.	T/E Status	PHYS
Onoclea sensibilis	sensitive fern	2	FACW		Nt Fern
Panicum virgatum	switch grass	4	FAC+		Nt P-Grass
Penstemon digitalis	foxglove beard-tongue	2	FAC-		Nt P-Forb
Phalaris arundinacea	reed canary grass	0	FACW+		Nt P-Grass
Phragmites australis	reed	0	FACW+		Nt P-Grass
Physalis virginiana	Virginia ground-cherry	4	[UPL]		Nt P-Forb
Phytolacca americana	pokeweed	2	FAC-		Nt P-Forb
PLANTAGO LANCEOLATA	English plantain	*	FAC		Ad P-Forb
POA PRATENSIS	Kentucky bluegrass	*	FAC-		Ad P-Grass
Polygonum lapathifolium	nodding smartweed	0	FACW+		Nt A-Forb
POLYGONUM PERSICARIA	lady's thumb	*	FACW		Ad A-Forb
Populus deltoides	cottonwood	1	FAC+		Nt Tree
Pycnanthemum tenuifolium	slender mountain mint	6	[FAC]		Nt P-Forb
RHAMNUS CATHARTICA	common buckthorn	*	FACU		Ad Tree
RHAMNUS FRANGULA	glossy buckthorn	*	FAC+		Ad Shrub
Rubus allegheniensis	common blackberry	1	FACU+		Nt Shrub
RUMEX CRISPUS	curly dock	*	FAC+		Ad P-Forb
SALIX ALBA	white willow	*	FACW		Ad Tree
Salix babylonica	weeping willow	*	[UPL]		Ad Tree
Salix exigua (S. interior)	sandbar willow	1	OBL		Nt Shrub
SALIX FRAGILIS	crack willow	*	FAC+		Ad Tree
Sambucus canadensis	elderberry	3	FACW-		Nt Shrub
Scirpus atrovirens	bulrush	3	OBL		Nt P-Sedge
SETARIA FABERI	giant foxtail	*	FACU+		Ad A-Grass
SETARIA GLAUCA	yellow foxtail	*	FAC		Ad A-Grass
SILENE PRATENSIS	white catchfly	*	[UPL]		Ad A-Forb
Silphium perfoliatum	cup plant	10	FACW-	T	Nt P-Forb
Silphium terebinthinaceum	prairie dock	6	FACU		Nt P-Forb
SOLANUM CAROLINENSE	horse nettle	*	FACU-		Ad P-Forb
SOLANUM DULCAMARA	bittersweet nightshade	*	FAC		Ad P-Forb
Solidago altissima	tall goldenrod	1	FACU		Nt P-Forb
Solidago ohioensis	Ohio goldenrod	8	OBL		Nt P-Forb
SONCHUS ASPER	prickly sow thistle	*	FAC		Ad A-Forb
Sorghastrum nutans	Indian grass	6	FACU+		Nt P-Grass
TYPHA ANGUSTIFOLIA	narrow-leaved cat-tail	*	OBL		Ad P-Forb
Typha latifolia	broad-leaved cat-tail	1	OBL		Nt P-Forb
VERBASCUM BLATTARIA	moth mullein	*	FACU-		Ad B-Forb
VERBASCUM THAPSUS	common mullein	*	[UPL]		Ad B-Forb
Verbena stricta	hoary vervain	4	[UPL]		Nt P-Forb
Vernonia missurica	Missouri ironweed	4	FAC+		Nt P-Forb

Table A 6 Plant species: Mt Hope wetland—all species

(Capitalized scientific names indicate non-natives; C – Coefficient of Conservatism; W. I. – Wetland Indicator Status)

Floristic Quality Assessment		
Sum of C values =		148
Native Species Count =		48
Total Species Count =		80
Floristic Quality Index	(native species only) =	21.36
Floristic Quality Index	(all species) =	16.55

Appendix B: General information on control techniques, permits, etc.

In this section, we discuss the benefits and limitations of various control methods that might be used at the Mt. Hope wetland, with a particular emphasis on the specific herbicides and application methods that should be used to control phragmites, glossy buckthorn and Canada thistle, as well as reed canarygrass, cattail and spotted knapweed.

Effective control of an invasive species requires knowledge of its reproductive behavior and dispersal methods. For species such as glossy buckthorn, spotted knapweed and to a lesser extent, Canada thistle, that produce abundant seed, a primary goal is preventing seed production and dispersal. For other species that are as likely to reproduce vegetatively via stolons or extensive root systems such as phragmites, reed canarygrass, cattail and Canada goldenrod, to some extent, this is less productive. A variety of techniques including both mechanical and chemical controls may be most effective and should be tailored to the specific conditions on the site. It is critical to monitor the site to ensure that treated populations of invasive species do not re-establish and that the seedbank is exhausted.

For each of the invasive species under consideration, there are a number of different control techniques and herbicides that can be utilized, depending on site conditions. Fortunately, a number of these species can be treated simultaneously with the same protocols . Observations on the presence or absence of beneficial native species, and the location and persistence of standing water during the first year of treatment may lead to altered treatment regimes in later years.

Mechanical controls

In the very earliest stages of invasion, when only scattered seedlings and young plants are present, mechanical controls such as pulling and digging may be adequate to control or eradicate some species. Spotted knapweed, for example, is present around the Mt. Hope wetland in low numbers along the road and upland margins of the site and could be a suitable candidate for mechanical control. Other invasive species on the site are far too abundant for this to be effective, however.

Cutting/mowing

Cutting or mowing most invasive species will not control them. In some (not all) cases it may prevent or minimize seed production but generally, phragmites, reed canarygrass and cattail grow back more densely unless treated with herbicide. Mowing may be helpful in maintaining open areas by preventing the establishment of seedlings of woody plants such as glossy buckthorn. It can also be used to expose new growth in the season after herbicide application, facilitating re-treatment.

In wetlands, mowing may be most efficient in winter, when the ground is frozen and heavy equipment can be used without creating ruts or compressing soils. Specialized equipment such as a Marsh Master® can be useful if mowing must take place during the growing season.

Some MSU staff have expressed concerns that the mowing of the berms to date has effectively spread phramites along them. Mowing should be coordinated with herbicide application to prevent this. Similarly, all equipment should be cleaned thoroughly before use on other sites to prevent further dispersal.

Flooding

Water levels cannot be strictly regulated at the Mt. Hope site, but water levels may be high seasonally in-some areas. Hybrid cattail, for example, can survive at water depths of over 18 inches. If it is cut or mowed-before submersion, howerever, the plant is stressed and may begin to die back. Removing standing dead phragmites before flooding can also stress the plant.

Prescribed fire

In fire-adapted communities such as southern wet meadows, prescribed burning may enhance control of invasive species over the long term, but should always be considered as part of an integrated manage-

ment plan for the site as it will stimulate many species including phragmites, buckthorn and reed canarygrass. When prescribed burning is initiated, it should be supplemented with other control methods.

General considerations

Before initiating a program of prescribed burning, a written burn plan establishing the criteria necessary for starting, controlling, and extinguishing a burn is required. The burn plan includes details such as specific weather conditions, locations of control lines, ignition pattern, equipment and personnel needed, contingency plans, and important phone numbers. The burn plan is essentially the "prescription" for how to conduct the burn safely while accomplishing the management objectives. If other invasive species that are stimulated by burning are present on the site, planning should incorporate additional control methods to eradicate them. At one point, a burn plan was developed for the Mt. Hope wetland and could potentially be used again in the future although it might need some modification.

Prescribed fire specifics

Fire alone does not provide effective control of any of the invasive species of concern in the Mt. Hope wetland as it will only top-kill mature plants. Even small buckthorn saplings and seedlings seem to survive fire well. Phragmites, reed canarygrass and cattail benefit from the increased sunlight and re-sprout vigorously. In dense buckthorn stands (including some of those present on site), there is not enough fuel present to carry fire through them. Fall fires stimulate vigorous re-sprouting. Early season fires, when root carbohydrate levels are low, can be more effective.

Prescribed fire also results in increased germination of seed from bird-dispersed fruits. In addition to the glossy buckthorn already on site, many of the woodlots on campus are edged with other invasive species including common buckthorn, bush honeysuckles and privet. All seeds germinate more readily on bare soils that have been exposed by fire. A plan for follow-up treatment is required as there is initially insufficient fuel to kill these densely sprouting seedlings in a regular prescribed burn.

In spite of these limitations, prescribed fire is extremely effective at removing standing dead material on site and is preferable to mowing in that respect. It facilitates treatment of new shoots, clears the soil effectively for reseeding and makes it easier to monitor what species are germinating on newly cleared sites—whether from the seedbank or from seeds that have been deliberately planted.

Once invasive species have been successfully controlled, fire has other benefits for fostering a healthy plant community that is better able to resist re-invasion. By reducing leaf litter and allowing light to reach the soil surface and stimulate seed germination, fire can play an important role in maintaining southern wet meadow seed banks. Fire plays a critical role in maintaining species richness by creating open microsites for small species. Given the desire to maintain the Mt. Hope site as an open wetland, another critically important attribute of fire is its ability to temporarily reduce shrub and tree cover.

Permits

Permits are required for several activities that are typically used to control invasive species.

A permit is required before implementing a prescribed burn. Contact the local Fire Marshall for permits and more information. Some municipalities require insurance coverage before a permit is issued, to cover the cost of damages if the fire should escape.

A permit from the Michigan Department of Environmental Quality is usually required to apply herbicide to phragmites and other aquatic nuisance species where standing water is present—in wetlands, along streams, rivers or lakes, or over open water. **Permit applications must be submitted by August 15** and include information on the type and volume of herbicide being used, and the area being treated. Reports are required following treatment.

Permit forms are available online at:
www.mi.gov/anc

Additional information specific to phragmites is available at:
www.michigan.gov/aquaticinvasives

Chemical control

In almost every case, effective control of species such as phragmites, reed canarygrass and narrowleaf and hybrid cattails requires the use of herbicide. Factors that should be considered when selecting an herbicide for use on a particular site include proximity to water or wetlands, presence or absence of desirable native vegetation, potential for erosion and the effectiveness of the herbicide under consideration.

Anyone applying herbicides as part of their employment must become a certified pesticide applicator. In addition, certification is required for the use of some herbicides under any circumstances.

A number of adjuvants or additives may be used with herbicides to improve their performance including mixing agents, surfactants, penetrating oils and dyes . Some are included in premixed products while others must be added. Adjuvants do not work with all products; consult the product label to determine which adjuvants may be used with a specific herbicide formulation.

Dyes are useful in keeping track of which plants have been treated and making spills on clothing or equipment apparent. Some premixed herbicide include them or they can be added to others. Clothing dyes such as Rit® can be added to water soluble herbicides, while other products require oil-based dyes. Consult the product label for specific instructions.

Crop Data Management Systems, Inc. (CDMS) maintains a database of agro-chemicals that includes herbicide labels for specific products. Herbicide labels contain information on application methods and rates, specific weather conditions, equipment types, nozzles etc. to provide the desired coverage and minimize the potential for volatilization or drift.

Always read the entire label of the specific herbicide being utilized before use.
Follow all directions on the label.

Product labels are available online on the CDMS website at:
http://www.cdms.net/LabelsMsds/LMDefault.aspx?t=

In addition, digital copies of all of the herbicides that are discussed in this document are included in the accompanying CD for reference.

Appendix C: Species lists for wetland plantings

Table C-1 Rushes, grasses and sedges for wetland plantings

Scientific Name	Common Name	C	W	WET	PHYS
Calamagrostis canadensis	BLUE-JOINT	3	-5	OBL	Nt P-Grass
Carex alopecoidea	SEDGE	3	-4	FACW+	Nt P-Sedge
Carex aurea	SEDGE	3	-4	FACW+	Nt P-Sedge
Carex bebbii	SEDGE	4	-5	OBL	Nt P-Sedge
Carex brunnescens	SEDGE	5	-3	FACW	Nt P-Sedge
Carex comosa	SEDGE	5	-5	OBL	Nt P-Sedge
Carex cristatella	SEDGE	3	-4	FACW+	Nt P-Sedge
Carex echinodes	SEDGE	5	-3	FACW	Nt P-Sedge
Carex frankii	FRANK'S SEDGE	4	-5	OBL	Nt P-Sedge
Carex granularis	SEDGE	2	-4	FACW+	Nt P-Sedge
Carex grisea	SEDGE	3	-3	FACW	Nt P-Sedge
Carex hystericina	SEDGE	2	-5	OBL	Nt P-Sedge
Carex intumescens	SEDGE	3	-4	FACW+	Nt P-Sedge
Carex leptalea	SEDGE	5	-5	OBL	Nt P-Sedge
Carex lupulina	SEDGE	4	-5	OBL	Nt P-Sedge
Carex normalis	SEDGE	5	-3	FACW	Nt P-Sedge
Carex pellita	SEDGE	2	-5	OBL	Nt P-Sedge
Carex pseudo-cyperus	SEDGE	5	-5	OBL	Nt P-Sedge
Carex sartwellii	SEDGE	5	-4	FACW+	Nt P-Sedge
Carex stipata	SEDGE	1	-5	OBL	Nt P-Sedge
Carex stricta	SEDGE	4	-5	OBL	Nt P-Sedge
Carex tenera	SEDGE	4	-1	FAC+	Nt P-Sedge
Carex tribuloides	SEDGE	3	-4	FACW+	Nt P-Sedge
Carex utriculata	SEDGE	5	-5	OBL	Nt P-Sedge
Carex vulpinoidea	SEDGE	1	-5	OBL	Nt P-Sedge
Cyperus engelmannii	UMBRELLA SEDGE	4	-5	OBL	Nt A-Sedge
Cyperus squarrosus	UMBRELLA SEDGE	5	-5	OBL	Nt A-Sedge
Cyperus strigosus	LONG SCALED NUT SEDGE	3	-3	FACW	Nt P-Sedge
Eleocharis erythropoda	SPIKE-RUSH	4	-5	OBL	Nt P-Sedge
Eleocharis obtusa	SPIKE-RUSH	3	-5	OBL	Nt A-Sedge
Eleocharis palustris	SPIKE-RUSH	5	-5	OBL	Nt P-Sedge
Elymus riparius	RIVERBANK WILD-RYE	8	-3	FACW	Nt P-Grass
Elymus virginicus	VIRGINIA WILD-RYE	4	-2	FACW-	Nt P-Grass
Glyceria striata	FOWL MANNA GRASS	4	-5	OBL	Nt P-Grass
Juncus alpinoarticulatus	RUSH	5	-5	OBL	Nt P-Forb
Juncus articulatus	JOINTED RUSH	3	-5	OBL	Nt P-Forb
Juncus bufonius	TOAD RUSH	2	-4	FACW+	Nt A-Forb
Juncus dudleyi	DUDLEY'S RUSH	1	0	FAC	Nt P-Forb
Juncus effusus	SOFT-STEMMED RUSH	3	-5	OBL	Nt P-Forb

Table C-1 Rushes, grasses and sedges for wetland plantings (continued)

Scientific Name	Common Name	C	W	WET	PHYS
Juncus nodosus	JOINT RUSH	5	-5	OBL	Nt P-Forb
Juncus tenuis	PATH RUSH	1	0	FAC	Nt P-Forb
Juncus torreyi	TORREY'S RUSH	4	-3	FACW	Nt P-Forb
Leersia oryzoides	CUT GRASS	3	-5	OBL	Nt P-Grass
Leersia virginica	WHITE GRASS	5	-3	FACW	Nt P-Grass
Muhlenbergia frondosa	COMMON SATIN GRASS	3	-3	FACW	Nt P-Grass
Muhlenbergia mexicana	LEAFY SATIN GRASS	3	-3	FACW	Nt P-Grass
Panicum virgatum	SWITCH GRASS	4	-1	FAC+	Nt P-Grass
Phragmites australis	REED	5	-4	FACW+	Nt P-Grass
Poa palustris	FOWL MEADOW GRASS	3	-4	FACW+	Nt P-Grass
Schoenoplectus acutus	HARDSTEM BULRUSH	5	-5	OBL	Nt P-Sedge
Schoenoplectus pungens	THREESQUARE	5	-5	OBL	Nt P-Sedge
Schoenoplectus tabernae-montani	SOFTSTEM BULRUSH	4	-5	OBL	Nt P-Sedge
Scirpus atrovirens	BULRUSH	3	-5	OBL	Nt P-Sedge
Scirpus cyperinus	WOOL-GRASS	5	-5	OBL	Nt P-Sedge
Scirpus pedicellatus	WOOL-GRASS	5	-5	OBL	Nt P-Sedge
Scirpus pendulus	BULRUSH	3	-5	OBL	Nt P-Sedge
Spartina pectinata	CORDGRASS	5	-4	FACW+	Nt P-Grass

Table B-2 Wildflowers for wetland plantings

Scientific Name	Common Name	C	W	WET	PHYS
Alisma subcordatum	SOUTHERN WATER-PLANTAIN	1	-5	OBL	Nt P-Forb
Alisma triviale	NORTHERN WATER-PLANTAIN	1	-5	OBL	Nt P-Forb
Anemone canadensis	CANADA ANEMONE	4	-3	FACW	Nt P-Forb
Asclepias incarnata	SWAMP MILKWEED	6	-5	OBL	Nt P-Forb
Asclepias tuberosa	BUTTERFLY-WEED	5	5	UPL	Nt P-Forb
Bidens cernua	NODDING BEGGAR-TICKS	3	-5	OBL	Nt A-Forb
Boehmeria cylindrica	FALSE NETTLE	5	-5	OBL	Nt P-Forb
Chelone glabra	TURTLEHEAD	7	-5	OBL	Nt P-Forb
Cirsium muticum	SWAMP THISTLE	6	-5	OBL	Nt B-Forb
Epilobium coloratum	CINNAMON WILLOW-HERB	3	-5	OBL	Nt P-Forb
Eupatorium perfoliatum	BONESET	4	-4	FACW+	Nt P-Forb
Euthamia graminifolia	GRASS-LEAVED GOLDENROD	3	-2	FACW-	Nt P-Forb
Eutrochium maculatum	JOE-PYE-WEED	4	-5	OBL	Nt P-Forb
Galium boreale	NORTHERN BEDSTRAW	3	0	FAC	Nt P-Forb
Geum canadense	WHITE AVENS	1	0	FAC	Nt P-Forb
Helenium autumnale	SNEEZEWEED	5	-4	FACW+	Nt P-Forb
Helianthus giganteus	TALL SUNFLOWER	5	-3	FACW	Nt P-Forb
Helianthus grosseserratus	SAWTOOTH SUNFLOWER	2	-2	FACW-	Nt P-Forb
Hydrophyllum virginianum	VIRGINIA WATERLEAF	4	0	FAC	Nt P-Forb
Impatiens capensis	SPOTTED TOUCH-ME-NOT	2	-3	FACW	Nt A-Forb
Iris virginica	SOUTHERN BLUE FLAG	5	-5	OBL	Nt P-Forb
Lobelia cardinalis	CARDINAL-FLOWER	7	-5	OBL	Nt P-Forb
Lobelia siphilitica	GREAT BLUE LOBELIA	4	-4	FACW+	Nt P-Forb
Lobelia spicata	PALE SPIKED LOBELIA	4	0	FAC	Nt P-Forb
Ludwigia palustris	WATER-PURSLANE	4	-5	OBL	Nt P-Forb
Lycopus americanus	WATER HOREHOUND	2	-5	OBL	Nt P-Forb
Lycopus uniflorus	NORTHERN BUGLE WEED	2	-5	OBL	Nt P-Forb
Mimulus ringens	MONKEY-FLOWER	5	-5	OBL	Nt P-Forb
Ranunculus sceleratus	CURSED CROWFOOT	1	-5	OBL	Nt A-Forb
Rorippa palustris	YELLOW CRESS	1	-5	OBL	Nt A-Forb
Rudbeckia hirta	BLACK-EYED SUSAN	1	3	FACU	Nt P-Forb
Sagittaria latifolia	COMMON ARROWHEAD	4	-5	OBL	Nt P-Forb
Scutellaria galericulata	MARSH SKULLCAP	5	-5	OBL	Nt P-Forb
Scutellaria lateriflora	MAD-DOG SKULLCAP	5	-5	OBL	Nt P-Forb
Sisyrinchium angustifolium	STOUT BLUE-EYED-GRASS	4	-2	FACW-	Nt P-Forb
Solidago altissima	TALL GOLDENROD	1	3	FACU	Nt P-Forb
Solidago canadensis	CANADA GOLDENROD	1	3	FACU	Nt P-Forb
Sparganium eurycarpum	COMMON BUR-REED	5	-5	OBL	Nt P-Forb
Symphyotrichum firmum	SMOOTH SWAMP ASTER	4	-4	FACW+	Nt P-Forb

Table C-2 Wildflowers for wetland plantings (continued)

Scientific Name	Common Name	C	W	WET	PHYS
Symphyotrichum lanceolatum	PANICLED ASTER	2	-3	FACW	Nt P-Forb
Symphyotrichum lateriflorum	CALICO ASTER	2	-2	FACW-	Nt P-Forb
Symphyotrichum novae-angliae	NEW ENGLAND ASTER	3	-3	FACW	Nt P-Forb
Symphyotrichum puniceum	SWAMP ASTER	5	-5	OBL	Nt P-Forb
Teucrium canadense	WOOD-SAGE	4	-2	FACW-	Nt P-Forb
Thalictrum dasycarpum	PURPLE MEADOW-RUE	3	-2	FACW-	Nt P-Forb
Tradescantia ohiensis	COMMON SPIDERWORT	5	2	FACU+	Nt P-Forb
Verbena hastata	BLUE VERVAIN	4	-4	FACW+	Nt P-Forb
Vernonia missurica	MISSOURI IRONWEED	4	-1	FAC+	Nt P-Forb

Table C-3 Shrubs for wetland plantings

Scientific Name	Common Name	C	W	WET	PHYS
Alnus incana	SPECKLED ALDER	5	-5	OBL	Nt Shrub
Aronia prunifolia	CHOKEBERRY	5	-3	FACW	Nt Shrub
Cephalanthus occidentalis	BUTTONBUSH	7	-5	OBL	Nt Shrub
Cornus amomum	SILKY DOGWOOD	2	-4	FACW+	Nt Shrub
Cornus foemina	GRAY DOGWOOD	1	-2	FACW-	Nt Shrub
Cornus sericea	RED-OSIER	2	-3	FACW	Nt Shrub
Ilex verticillata	MICHIGAN HOLLY,	5	-4	FACW+	Nt Shrub
Physocarpus opulifolius	NINEBARK	4	-2	FACW-	Nt Shrub
Rosa palustris	SWAMP ROSE	5	-5	OBL	Nt Shrub
Rubus hispidus	SWAMP DEWBERRY	4	-3	FACW	Nt Shrub
Rubus strigosus	WILD RED RASPBERRY	2	-2	FACW-	Nt Shrub
Salix bebbiana	BEBB'S WILLOW	1	-4	FACW+	Nt Shrub
Salix discolor	PUSSY WILLOW	1	-3	FACW	Nt Shrub
Salix eriocephala	WILLOW	2	-3	FACW	Nt Shrub
Salix exigua	SANDBAR WILLOW	1	-5	OBL	Nt Shrub
Salix lucida	SHINING WILLOW	3	-4	FACW+	Nt Shrub
Salix petiolaris	MEADOW WILLOW	1	-4	FACW+	Nt Shrub
Sambucus canadensis	ELDERBERRY	3	-2	FACW-	Nt Shrub
Spiraea alba	MEADOWSWEET	4	-4	FACW+	Nt Shrub
Spiraea tomentosa	HARDHACK, STEEPLEBUSH	5	-3	FACW	Nt Shrub
Viburnum lentago	NANNYBERRY	4	-1	FAC+	Nt Shrub
Viburnum trilobum	AMERICAN HIGHBUSH-CRANBERRY	5	-3	FACW	Nt Shrub
Zanthoxylum americanum	PRICKLY-ASH	3	0	FACW	Nt Shrub

Table B-3 Trees for wetland plantings

Scientific Name	Common Name	C	W	WET	PHYS
Abies balsamea	BALSAM FIR	3	-3	FACW	Nt Tree
Acer negundo	BOX-ELDER,	0	-2	FACW-	Nt Tree
Acer rubrum	RED MAPLE	1	0	FAC	Nt Tree
Acer saccharinum	SILVER MAPLE	2	-3	FACW	Nt Tree
Carya cordiformis	BITTERNUT HICKORY	5	0	FAC	Nt Tree
Celtis occidentalis	HACKBERRY	5	1	FAC-	Nt Tree
Crataegus crus-galli	COCKSPUR THORN	5	0	FAC	Nt Tree
Crataegus mollis	HAWTHORN	2	-2	FACW-	Nt Tree
Fraxinus pennsylvanica	GREEN ASH, RED ASH	2	-3	FACW	Nt Tree
Larix laricina	LARCH, TAMARACK	5	-3	FACW	Nt Tree
Populus balsamifera	BALSAM POPLAR	2	-3	FACW	Nt Tree
Populus deltoides	COTTONWOOD	1	-1	FAC+	Nt Tree
Populus tremuloides	QUAKING ASPEN	1	0	FAC	Nt Tree
Quercus bicolor	SWAMP WHITE OAK	8	-4	FACW+	Nt Tree
Salix amygdaloides	PEACH-LEAVED WILLOW	3	-3	FACW	Nt Tree
Salix nigra	BLACK WILLOW	5	-5	OBL	Nt Tree
Thuja occidentalis	ARBOR VITAE,	4	-3	FACW	Nt Tree
Ulmus americana	AMERICAN ELM, WHITE ELM	1	-2	FACW-	Nt Tree
Ulmus rubra	SLIPPERY ELM, RED ELM	2	0	FAC	Nt Tree