1991

Identification and Control of Invasive Plant Species

- 1998 Annual Report -

Prepared For:

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PURPOSE & SCOPE

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The purpose of this research was to (1) identify all plant species present in the North Woodlot of the Fernald Environmental Management Project, (2) assess which species were non-indigenous and to evaluate their threat via relative abundance, (3) conduct a literature search for control methods, and (4) implement a three-year experimental study on species control.

The design of this research called for a four year timeline with two major phases. Phase-I (objectives 1 & 2) was to be completed in the first year and was directed primarily at the identification and assessment of invasive species along with site reconnaissance and refinement of experimental plans for Phase-II. Phase-II (objectives 3 & 4) was to begin in the second year and continue through the end of the fourth year. This annual report is for the first year of this study and focuses on Phase-I objectives.

Phase-I calls for a detailed floristic inventory. In the past, traditional floras were largely under the purview of academic botanists interested in taxonomy and biogeography; however, the use of floristic data has exploded in recent years and is now recognized as the cornerstone for many applied ecological studies. Floras have become increasingly important in impact assessment, management decisions, restoration efforts, and policy formulation (Palmer et al. 1995). Only recently have standards been proposed for the writing of floras (Palmer et al. 1995) and we have adopted these standards for this research.

METHODS AND PROGRESS

Study Area & Vegetation-Environment Relations

The first phase of this project required a detailed floristic inventory of the "North Woodlot" of the Fernald Environmental Management Project. The study area approaches 65 ha in size and lies NW of the old production facility, south of S.R. 126 and east of Morgan-Ross Road. Geographically, the area is centered roughly on coordinates 39° 18' 20" N × 84° 41' 50" W (USGS 1981). Elevations range from ca. 550 to 630 ft.

The study area is composed of a diversity of habitats including old-fields, previously mowed meadows, regenerating forest, and mature forest. Using recent aerial photographs supplied by FEMP, a generalized habitat map was constructed using AutoCADD (Figure 1). Ground truth points were located using a GPS and topographic maps. At each point we recorded the dominant overstory species and dominant understory species based on subjective visual evaluation of cover and density. The purpose of this vegetation map was to (1) provide a baseline map to use in the floristic analysis, (2) to generate a more explicit understanding of habitat distribution, and (3) to evaluate potential study areas for Phase-II. The dominant species are summarized in Table 1.

Old-field habitats were generally found on Ragsdale silty clay loam soils (Ra)(Lerch et al.

1980). These areas are nearly level and very poorly drained. They are subject to ponding which we witnessed throughout the spring season of 1998, and the surface soil showed distinct signs of anoxia. These soils were very poorly drained, exhibited slow permeability, and showed signs of surface cracking during the dry summer months. These habitats were dominated by Canadian Goldenrod (*Solidago canadensis*) and grasses and sedges (graminoids) with occasional interspersed trees often producing a savanna-like habitat. Most of the tree species present in the old-field are tolerant of saturated soils and included box elder (*Acer negundu*), slippery elm (*Ulmus rubra*), and green ash (*Fraxinus pennsylvanica*). Interestingly, these trees appeared to be acting as seed recruitment foci for perching birds. We plan to investigate this phenomenon in a subsequent research report, largely because the recruiting species generally appear to be non-indigenous.

Regenerating forests (age < 40 years) occurred on low to moderate sloping topography. Young stands on low sloping topography were generally found as island patches sitting in an old-field matrix and were dominated in the overstory by green ash, box elder, slippery elm, and black cherry (*Prunus serotina*). Young stands on moderately sloping topography were typically more diverse in the overstory and included the previous species along with hickories (*Carya* spp.), oaks (*Quercus* spp.), black locust (*Robinia pseudoacacia*) and other minor species. The midstory in these areas is typically dominated by Amur honeysuckle (*Lonicera maackii*) and ranged from ca. 75-100% cover. Thus, the understory has extremely low light levels, low soil moisture and a low species diversity. Honeysuckle is especially dominant in the northeasternmost patches of woodlands within the study area. The young forests generally occur on Miamian-Russell silt loams (MsC2) and Xenia silt loam (XeB & XeB2) soils (Lerch et al. 1980). MsC2 soils have moderately slow permeability and moderate drainage, but are reasonably well suited to tree growth. Because of their constituency, these soils are particularly susceptible to gully and till erosion. Erosion was clearly noticed in the northeasternmost woodland patches. The occurrence of grazing cattle in these patches further aggravated the problem. Xe series soils are similar to MsC series soils but tend to be a bit better drained though they are susceptible to surface crusting.

Embedded within the old-field vegetation matrix were previously mowed tracts or paths that were interspersed and often separating the regenerating forest islands. These areas are reminiscent of moist meadow conditions and are dominated by grasses and sedges. Because of their floristic dissimilarity they really represent habitats in their own right. These areas were frequently inundated with water, particularly in the spring, and were composed of many obligate and facultative wetland species of sedges and rushes.

Mature forest (age > 100 years) occurs predominantly along the east edge of Paddy's Run on the westernmost section of the study area. This section has a mature overstory, generally lacks a distinct midstory, and has a well-developed and diverse herbaceous understory characteristic of mature floodplain forests. The soils here are either MsC2 or Genesee loams (Gn). Soil type is largely correlated with microtopography and elevation. Lowland areas immediately adjacent to the stream are predominantly Gn and turn to MsC2 with increasing elevation away from the stream (Lerch et al. 1980). Gn soils are deep, well-drained soils of floodplains that exhibit high fertility and high site index values. Because of their fertility, there

are few forests in SW Ohio remaining on Gn substrates (most of which have been converted for agriculture). This stand represents a relatively high quality stand that needs to be the focus of conservation efforts. The overstory found on the Gn soils is dominated by sugar maple (*Acer saccharinum*), box elder, sycamore (*Platanus occidentalis*), bitternut hickory (*Carya cordiformis*), and black walnut (*Juglans nigra*). MsC2 soils are dominated by oaks, hickories, black maple (*Acer nigrum*), black walnut, and Ohio buckeye (*Aesculus glabra*). Unfortunately, Gn soils are very susceptible to soil compaction and easily degrade under poor grazing management. This is the situation at FEMP. Grazing cattle in the Paddy's Run area have destroyed the understory in certain areas and greatly modified it in all other areas. The grazing history here will have repercussions for plant diversity for many decades in the future.

In addition, we identified a small area (< 0.5 ha) at the southeastern corner of the study area (where access road passes gated entrance) that has had recent soil disturbance. The area paralleled the fence line for ca. 100 m. The disturbed areas had a markedly different floristic composition, as many annual and herbaceous perennials not present elsewhere were released from the seedbank.

On the basis of our preliminary vegetation study, we classified the vegetation into five major habitat types (Table 2): disturbed (D), moist meadow (MM), old-field (OF), open forest (OF), and thicket forest (TF). The disturbed area had evidence of recently modified soil conditions and included areas at the edges of the interior gravel access road. The moist meadow includes areas that were previously mowed and are now dominated by graminoids, often with saturated soils. The old-field consists primarily of perennial herbs and has been undisturbed for ca. 10 years. Old forest is the mature forested area immediately surrounding Paddy's Run. Thicket forest is the majority of young forested habitat found at the study area. These codes have been used for the subsequent floristic analysis.

Floristic Analysis

The floristic analysis is 90% complete as of the writing of this annual report. I and a graduate student (Darrin L. Rubino) visited the study area for 2-3 day periods on the following dates: 24-April, 22-May, 17-June, 10-July, 17-August, and 13-September 1998. Because of administrative reasons, the project began late, and thus we undersampled the early spring ephemeral flora. To remedy this situation, we will need to make additional visits in late March and early April 1999. During each field period in 1998, we systematically walked most of the study area. We made every effort to cover all habitat types in as many geographic areas as possible. A voucher specimen was collected for every plant identified. Most identifications were made in the field with fresh material. All specimens were pressed, dried, mounted, and deposited as vouchers in the Bartley Herbarium of Ohio University.

For each species, we coded its presence to as many of the above five habitats as applicable. We also used a relative abundance scale (Palmer et al. 1995) to rate each species (Table 3): 5 = abundant, 4 = frequent, 3 = occasional, 2 = infrequent, 1 = rare, 0 = absent. The abundance rating is provided for the entire study area and was not sub-divided by habitat.

Such a rating is important because it provides considerable additional ecological information that may be useful for environmental management decisions. An invasive non-indigenous plant with an abundance of 1 is ecologically very different than one with a rating of 5, yet both just show up as a line entry on a flora.

Taxonomic nomenclature for this investigation follows Gleason and Cronquist (1991) along with the companion manual (Holmgren 1998). The scope of the investigation was limited to vascular plant species. Thus, we limited ourselves to the Divisions Lycopodiophyta (lycopods), Equisetophyta (horsetails), Polypodiophyta (ferns & allies), Pinophyta (pines), and Magnoliophyta (flowering plants). The Ohio flora volumes were used as a secondary reference source and included Braun (1961), Braun (1967), Fisher (1988), and Cooperrider (1995). Gleason and Cronquist (1991) was also used to determine native ranges and to clasify a species as indigenous or non-indigenous.

The primary product of a flora is the checklist and associated summary statistics. To this date we have discovered 282 species in 176 genera and 71 families (Table 4). Of the 282 species, 71% are native. A 29% non-native proportion is relatively high and probably reflects the heavy anthropogenic disturbance, hydrologic stress, and grazing intensity. Most local floras rarely exceed 20%. Of the non-natives, only several might be considered "invasive," although a number are problematic. Amur honeysuckle is certainly a major pest species at this site and has dramatically influenced the understory of several stands of young thicket forest. Multiflora rose (*Rosa multiflora*) is problematic in the old-fields. Garlic mustard (*Alliaria petiolata*) has come in thickly (in patches) on the southern areas of the mature forest adjacent to Paddy's Run. Tall fescue (*Festuca elatior*) is dominant in many of the old-fields and grassy meadows. Lady's thumb (*Polygonum persicaria*) is abundant in the wet and disturbed areas.

We did not discover any State or Federally threatened or endangered species. We may have two county records (i.e., species identified in Hamilton County for the first time based on Ohio flora), but we would need to check local herbaria to confirm this. Oddly, we found essentially no "lower" vascular plant species. Only one fern was discovered in the old-fields (ebony spleenwort, *Asplenium platyneuron*), even though more were expected. We need to investigate the literature to determine the indicator status (sensitivity to pollution and/or radionuclides) of fern species (unfortunately these have not been as well studied as flowering plants). For example, lichens are known to be very responsive to industrial pollution. The only evergreen (gymnosperm) recorded was Eastern red cedar (*Juniperus virginiana*). All 280 other species were flowering plants (Magnoliopsida).

Given our sampling effort, we are fairly certain that we have recovered 85-90% of vascular plant species in the study area at FEMP. Non-vascular plants were not included in this flora since they are not relevant to invasive species identification and control. The final checklist is expected to exceed 300 species. Subsequent visits during the spring of 1999 will likely add an additional 5% of species (particularly in the violet family, Violaceae). Two additional visits during the summer months (late May and late June) will permit us to gain increased certainty on our sampling effort for the graminoids. I expect an additional 5% of species to

be added here. Because of chance events, not every species will be found. Migration, local extinction, herbivory, and ultimately sampling intensity always limit the checklist, but we will attempt an estimated 95+% recovery rate as is usual for most floras.

LITERATURE CITED

Braun, E.L. 1961. The woody plants of Ohio. The Ohio State University Press, Columbus, OH.

Braun, E.L. 1967. The Monocotyledonae: cat-tails to orchids. The Ohio State University Press, Columbus, OH.

Cooperrider, T.S. 1995. The Dicotyledonae of Ohio. Part 2. Linaceae through Campanulaceae. The Ohio State University Press, Columbus, OH.

Fisher, T.R. 1988. The Dicotyledonae of Ohio. Part 3. Asteraceae. The Ohio State University Press, Columbus, OH.

Gleason, H.A. and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. The New York Botanical Garden, Bronx, NY.

Holmgren, N.H. 1998. Illustrated companion to Gleason and Cronquist's manual. The New York Botanical Garden, Bronx, NY.

Lerch, N.K., W.F. Hale, and D.D. Lemaster. 1980. Soil survey of Butler County, Ohio. United States Department of Agriculture, Soil Conservation Service. Washington, D.C.

Palmer, M.W., G.L. Wade. 1995. Standards for the writing of floras. BioScience 45:339-345.

United States Geological Survey. 1981. Shandon (OH) quadrangle, 7.5 minute series (topographic) map, 1:24000 scale. USGS, Reston, VA.

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Table 1. Dominant overstory and understory species associated with mapped reference points on vegetation survey (see Figure 1). Order within a species series reflects decreasing relative abundance. See checklist for species identification.

Ref Pt.	Overstory Dominants***	Understory Dominants
A	green ash, hackberry, box elder	amur honeysuckle, herbs
B	green ash, hackberry, box elder	amur honeysuckle
C	shellbark hickory	multiflora rose, amur honeysuckle
D	oak, green ash	amur honeysuckle
E	shellbark hickory	amur honeysuckle
F	slippery elm, black cherry, green ash, eastern redcedar	amur honeysuckle
G	mulberry, green ash, box elder	Canadian goldenrod
H		annual herbs
I	green ash	amur honeysuckle, multiflora rose, herbs
J	green ash	amur honeysuckle, multiflora rose, herbs
K	green ash, willow	
L		Canadian goldenrod, grasses, sedges
M	slippery elm, shingle oak, green ash, hickory	amur honeysuckle
N	sycamore	multiflora rose, *Rubus* spp.
O	slippery elm, green ash, black cherry	multiflora rose, amur honeysuckle, herbs
P	slippery elm, green ash, black cherry	multiflora rose, amur honeysuckle, herbs
Q	box elder, green ash, slippery elm, black cherry	multiflora rose, amur honeysuckle, herbs
R		*Eleocharis*, sedges, rushes (wetland)
S	Sycamore, box elder, black walnut, slippery elm	multiflora rose

Table 1, continued

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Ref Pt.	Overstory Dominants***	Understory Dominants
T	black maple, box elder, black cherry, sycamore, wild grape	multiflora rose, amur honeysuckle
U	black maple, box elder, black cherry, sycamore, wild grape	multiflora rose, amur honeysuckle
V	northern red oak, hickory, black maple.	garlic mustard
W	box elder, black walnut, silver maple, hackberry	Grasses / pasture
X	maple spp., black walnut, sycamore, bitternut hickory.	Herbs
Y	black walnut, sugar maple, oak, black cherry, Ohio buckeye,	Herbs
Z	box elder, black walnut, silver maple, hackberry	Grasses / pasture
AA	eastern cottonwood	Grasses / pasture

***Species List:

Overstory Species:
black cherry = *Prunus serotina*
black maple = *Acer nigrum*
black walnut = *Juglans nigra*
bitternut hickory = *Carya cordiformis*
box elder = *Acer negundo*
eastern redcedar = *Juniperus virginiana*
green ash = *Fraxinus pennsylvanica*
hackberry = *Celtis occidentalis*
hickory = *Carya* spp.
Kentucky coffeetree = *Gymnocladus dioicus*
mulberry = *Morus* spp.
northern red oak = *Quercus rubra*
oak = *Quercus* spp.
Ohio buckeye = *Aesculus glabra*
shellbark hickory = *Carya laciniosa*
shingle oak = *Quercus imbricaria*
silver maple = *Acer saccharinum*
slippery elm = *Ulmus rubra*
sugar maple = *Acer saccharum*
sycamore = *Platanus occidentalis*
wild grape = *Vitis* spp.
willow = *Salix* spp.

Understory Species:
amur honeysuckle = *Lonicera maackii*
Canadian goldenrod = *Solidago canadensis*
Eleocharis = *Eleocharis ovata*
Garlic Mustard = *Alliaria petiolata*
multiflora rose = *Rosa multiflora*

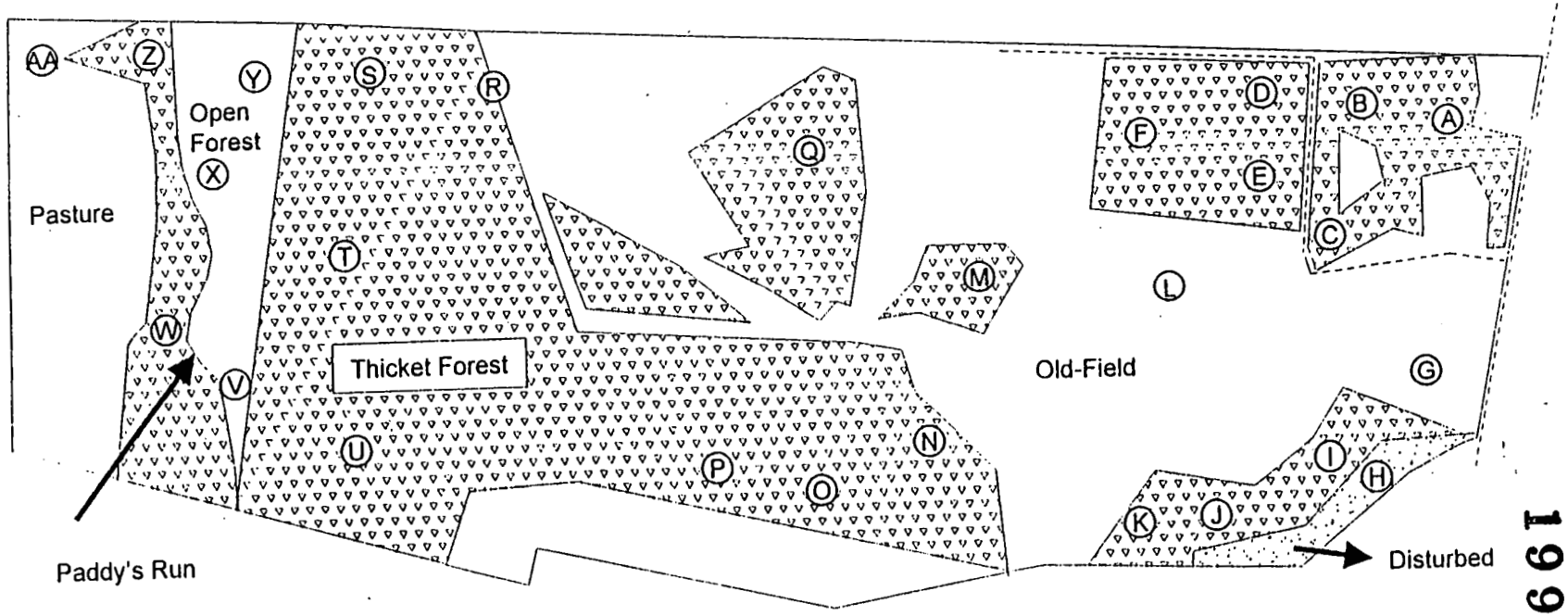

Figure 1.

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Table 2. Habitat type, code acronym, and detailed descriptions. 1991

Habitat Type	Code	Habitat Description
Disturbed	D	Areas where evidence of surface soil disturbance is present; dominated mainly by annuals and exotics
Moist Meadow	MM	Frequently mowed areas dominated by graminoids; seasonally wet, but not perennially wet
Old Field	OF	Un-mowed fields dominated by perennial vegetation; all old field areas appear ~ 10 years old
Open Forest	FO	Relatively mature, intact forest with a moderately open understory
Thicket Forest	FT	Relatively young forest, frequently found as small islands, often with a dense understory of Amur honeysuckle (*Lonicera maackii*), brambles (*Rubus* spp.), and roses (*Rosa* spp.)

Table 3. Abundance scale for the flora of FEMP. Modified from Palmer et al. (1995).

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Score	Abundance	Description
5	Abundant	Dominant or co-dominant in one or more habitats.
4	Frequent	Easily seen or found in one or more habitats, but not dominant in any habitat.
3	Occasional	Widely scattered but not difficult to find.
2	Infrequent	Difficult to find with few individuals or colonies, but found in several locations.
1	Rare	Very difficult to find and limited to one or very few locations.

Table 4. Summary statistics for the major taxonomic groups and proportion of native species identified at FEMP.

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Division*	Families	Genera	Species	%Native
Lycopodiophyta	0	0	0	---
Equisetophyta	0	0	0	---
Polypodiophyta	1	1	1	100
Pinophyta	1	1	1	100
Magnoliophyta				
Magnoliopsida	60	142	221	70
Liliopsida	9	32	59	73
Totals	71	176	282	71

Lycopodiophyta = lycopods
Equisetophyta = horsetails
Polypodiophyta = ferns
Pinophyta = cone-bearing plants ("pines")
Magnoliophyta = flowering plants
Magnoliopsida = dicots
Liliopsida = monocots

Taxa	Abundance Score[1]	Habitats Present[2]					FEMP Identification	Indigenous/ Non-indigenous[3]
		D	MM	OF	FT	FO		
FERN AND FERN ALLIES								
Aspleniaceae								
Asplenium platyneuron (L.) Oakes	2			+			FEMP 111 MR	IND
GYMNOSPERMS								
Cupressaceae								
Juniperus virginiana var. *virginiana* L.	4			+	+		FEMP 046 MR	IND
ANGIOSPERMS								
Aceraceae								
Acer negundo var. *negundo* L.	5			+	+	+	FEMP 028 MR	IND
Acer nigrum Michx. f.	5				+	+	FEMP 171 MR	IND
Acer rubrum L.	2		+	+			FEMP 176 MR	IND
Acer saccharinum L.	4		+	+	+	+	FEMP 108 MR	IND
Acer saccharum Marshall	4				+	+	FEMP 026 MR	IND
Amaranthaceae								
Amaranthus arenicola I. M. Johnst.	1	+					FEMP 301 MR	NON-IND
Amaranthus spinosus L.	2			+			FEMP 221 MR	NON-IND
Anacardiaceae								
Rhus glabra L.	2				+		FEMP 167 MR	IND
Rhus typhina L.	2				+		FEMP 174 MR	IND
Toxicodendron radicans (L.) Kuntze	5	+	+	+	+	+	No Collection[4]	IND
Apiaceae								
Aethusa cynapium L.	2				+		FEMP 153 MR	NON-IND
Chaerophyllum procumbens (L.) Crantz.	2		+	+		+	FEMP 025 MR	IND
Conium maculatum L.	2	+		+			FEMP 139 MR	NON-IND
Cryptotaenia canadensis (L.) DC	1					+	FEMP 095 MR	IND
Daucus carota L.	4		+	+			FEMP 212 MR	NON-IND

Hydrocotyle americana L.	3		+		+		FEMP 312 MR	IND
Osmorhiza claytonii (Michx.) C. B. Clarke	1					+	FEMP 034 MR	IND
Pastinaca sativa L.	3		+	+			FEMP 088 MR	NON-IND
Torilis japonica (Houtt.) DC	1		+	+			FEMP 218 MR	NON-IND
Apocynaceae								
Apocynum cannabinum L.	3			+			FEMP 238 MR	IND
Aristolochiaceae								
Asarum canadense L.	1					+	FEMP 039 MR	IND
Asclepiadaceae								
Asclepias incarnata var. *incartata* L.	2			+			FEMP 276 MR	IND
Asclepias syriaca L.	2		+	+			FEMP 288 MR	IND
Asclepias tuberosa var. *interior* (Woodson) Shinners	2			+			FEMP 186 MR	IND
Asteraceae								
Achillea millefolium L.	3	+		+	+		FEMP 006 MR	NON-IND
Ambrosia artemisiifolia L.	4			+	+		FEMP 246 MR	IND
Ambrosia trifida var. *trifida* L.	1			+			FEMP 258 MR	IND
Arctium minus Schk.	3			+	+		FEMP 313 MR	NON-IND
Arctium tomentosum Miller	4	+		+			FEMP 242 MR	NON-IND
Aster novae-angliae L.	3		+	+			FEMP 271 MR	IND
Aster patens var. *phlogifolius* (Muhl.) Nees.	2			+			FEMP 275 MR	IND
Aster paternus Cronq.	4		+	+			FEMP 290 MR	IND
Aster pilosus var. *pilosus* Willd.	4			+	+		FEMP 277 MR	IND
Aster racemosus Elliott	2			+	+		FEMP 232 MR	IND
Bidens discoidea (T. & G.) Britton	2			+			FEMP 273 MR	IND
Bidens frondosa L.	3	+		+	+		FEMP 274 MR	IND
Carduus nutans L.	2			+			FEMP 136 MR	NON-IND
Cichorium intybus L.	3	+	+	+			FEMP 209 MR	NON-IND
Cirsium discolor (Muhl.) Sprengel	3	+		+			FEMP 239 MR	IND
Cirsium muticum Michx.	2		+				FEMP 287 MR	IND
Conyza canadensis var. *canadensis* (L.) Cronq.	3			+			FEMP 235 MR	IND
Eclipta prostrata (L.) L.	1	+			+		FEMP 267 MR	NON-IND
Erigeron philadelphicus L.	3	+	+	+	+		FEMP 084 MR	IND
Erigeron pulchellus var. *pulchellus* Michx.	1			+	+		FEMP 054 MR	IND

Eupatorium altissimum L.	1			+			FEMP 317 MR	IND
Eupatorium perfoliatum var. *perfoliatum* L.	2			+			FEMP 269 MR	IND
Eupatorium rugosum var. *rugosum* Houttuyn	5	+	+	+	+	+	FEMP 253 MR	IND
Eupatorium serotinum Michx.	2			+	+		FEMP 230 MR	IND
Euthamia graminifolia var. *graminifolia* (L.) Nutt.	4		+	+			FEMP 233 MR	IND
Helianthus tuberosus L.	2	+		+			FEMP 319 MR	IND
Lactuca saligna L.	1	+					FEMP 248 MR	NON-IND
Lactuca serriola var. *integrata* Gren. & Gordon	2			+			FEMP 292 MR	NON-IND
Rudbeckia triloba var. *triloba* L.	3		+		+		FEMP 263 MR	IND
Senecio obovatus Muhl.	1					+	FEMP 031 MR	IND
Senecio glabellus Poir.	1		+	+			FEMP 058 MR	IND
Solidago juncea Aiton	4			+			FEMP 237 MR	IND
Solidago canadensis var. *canadensis* L.	5			+			FEMP 281 MR	IND
Solidago canadensis var. *scabra* T. & G.	5			+			FEMP 282 MR	IND
Sonchus arvensis var. *glabrescens* (Guenther) Grab. & Wimmer	1	+		+			FEMP 143 MR	NON-IND
Taraxacum officinale Weber ex Wiggers	3	+		+		+	FEMP 002 MR	NON-IND
Tragopogon pratensis L.	1						FEMP 199 MR	NON-IND
Vernonia gigantea var. *gigantea* (Walter) Trel.	5			+	+		FEMP 241 MR	IND
Verbesina alternifolia (L.) Britton	2			+	+		FEMP 318 MR	IND
Verbesina helianthoides Michx.	2			+	+		FEMP 257 MR	IND
Xanthium strumarium var. *glabratum* (DC) Cronq.	4	+	+	+			FEMP 272 MR	IND
Balsaminaceae								
Impatiens capensis Meerb.	2				+	+	FEMP 166 MR	IND
Impatiens pallida Nutt.	2	+			+		FEMP 208 MR	IND
Berberidaceae								
Podophyllum peltatum L.	2	+				+	FEMP 024 MR	IND
Betulaceae								
Carpinus caroliniana var. *caroliniana* Walter	1					+	FEMP 040 MR	IND
Bignoniaceae								
Campsis radicans (L.) Seemann	2	+			+		FEMP 215 MR	IND
Boraginaceae								
Hackelia virginiana (L.) I. M. Johnston	1			+	+		FEMP 259 MR	IND

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Brassicaceae								
Alliaria petiolata (Bieb.) Cavara & Grande	4		+		+	+	FEMP 020 MR	NON-IND
Barbarea vulgaris R. Br.	4	+	+	+	+		FEMP 045 MR	NON-IND
Cardamine concatenata (Michx.) O. Schwarz	2					+	NO FEMP	IND
Draba verna L.	3		+				FEMP 060 MR	NON-IND
Iodanthus pinnatifidis (Michx.) Steudel	1			+			FEMP 094 MR	IND
Lepidium campestre (L.) R. Br.	3		+	+			FEMP 011 MR	NON-IND
Lepidium virginicum var. *virginicum* L.	1			+			FEMP 144 MR	IND
Rorippa sylvestris (L.) Besser	1			+			FEMP 137 MR	NON-IND
Sisymbrium officinale (L.) Scop.	1			+			FEMP 141 MR	NON-IND
Thlaspi arvense L.	1			+			FEMP 138 MR	NON-IND
Caesalpiniaceae								
Cercis canadensis var. *canadensis* L.	1				+		FEMP 310 MR	IND
Gleditsia triacanthos L.	3			+	+	+	FEMP 123 MR	IND
Gymnocladus dioica (L.) K. Koch	2				+	+	FEMP 041 MR	IND
Campanulaceae								
Lobelia inflata L.	3		+		+		FEMP 264 MR	IND
Lobelia siphilitica var. *siphilitica* L.	3	+	+				FEMP 262 MR	IND
Caprifoliaceae								
Lonicera japonica Thunb.	4		+	+	+	+	FEMP 048 MR	NON-IND
Lonicera maackii (Rupr.) Maxim.	5			+	+		FEMP 017 MR	NON-IND
Sambucus canadensis var. *canadensis* L.	2				+		FEMP 216 MR	IND
Viburnum prunifolium L.	1				+		FEMP 013 MR	IND
Caryophyllaceae								
Cerastium vulgatum L.	4		+	+	+	+	FEMP 008 MR	NON-IND
Dianthus armeria L.	2		+	+			FEMP 087 MR	NON-IND
Saponaria officinalis L.	1					+	FEMP 293 MR	NON-IND
Stellaria media (L.) Villars.	5		+		+	+	FEMP 009 MR	NON-IND
Chenopodiaceae								
Chenopodium album L.	1	+					FEMP 303 MR	NON-IND

Commelinaceae								
Commelina communis L.	3		+	+	+		FEMP 260 MR	NON-IND
Convolvulaceae								
Calystegia sepium (L.) R. Br.	3	+		+			FEMP 201 MR	IND
Ipomoea lacunosa L.	1			+			FEMP 244 MR	IND
Ipomoea pandurata (L.) G. Meyer	1			+			FEMP 236 MR	IND
Cornaceae								
Cornus drummondii C. A. Meyer	4			+	+		FEMP 107 MR	IND
Cornus racemosa Lam.	2			+	+		FEMP 270 MR	IND
Cyperaceae								
Carex albursina Sheldon	1					+	FEMP 177 MR	IND
Carex blanda Dewey	1					+	FEMP 093 MR	IND
Carex cephalophora var. *cephalophora* Muhl.	1		+	+			FEMP 134 MR	IND
Carex cristatella Britton	2		+				FEMP 101 MR	IND
Carex frankii Kunth.	2		+				FEMP 321 MR	IND
Carex hystericina Muhl.	1				+		FEMP 159 MR	IND
Carex joorii L. Bailey	2			+			FEMP 075 MR	IND
Carex scoparia Schk.	2		+	+			FEMP 320 MR	IND
Carex shortiana Dewey	2		+	+			FEMP 089 MR	IND
Carex vulpinoidea var. *vulpinoidea* Michx.	3		+	+			FEMP 073 MR	IND
Cyperus lancastriensis Porter	2		+				FEMP 217 MR	IND
Cyperus strigosus L.	2		+	+			FEMP 213 MR	IND
Eleocharis ovata (Roth) Roemer & Schultes	2		+				FEMP 016 MR	IND
Scirpus atrovirens var. *atrovirens* Willd.	2		+	+			FEMP 181 MR	IND
Scripus lineatus Michx.	2		+	+			FEMP 071 MR	IND
Dioscoreaceae								
Dioscorea villosa L.	2		+		+		FEMP 315 MR	IND
Dipsacaceae								
Dipsacus sylvestris Hudson	2	+		+			FEMP 210 MR	NON-IND
Elaeagnaceae								
Elaeagnus angustifolia L.	2		+	+	+		FEMP 047 MR	NON-IND

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Elaeagnus multiflora Thunb.	1				+		FEMP 283 MR	NON-IND
Euphorbiaceae								
Acalypha rhomboidea Raf.	3				+		FEMP 286 MR	IND
Euphorbia dentata Michx.	1	+					FEMP 297 MR	IND
Euphorbia maculata L.	1	+					FEMP 256 MR	IND
Euphorbia nutans Lagasca	1				+		FEMP 323 MR	IND
Fabaceae								
Amorpha fruticosa L.	1				+		FEMP 255 MR	IND
Desmodium paniculatum (L.) DC	2			+	+		FEMP 219 MR	IND
Lespedeza violacea (L.) Pers.	3			+			FEMP 247 MR	IND
Melilotus officinalis (L.) Pallas	2			+			FEMP 133 MR	NON-IND
Robinia pseudoacacia L.	2				+		FEMP 131 MR	IND
Trifolium campestre Schreber	2		+	+			FEMP 063 MR	NON-IND
Trifolium dubium Sibth.	3		+				FEMP 065 MR	NON-IND
Trifolium hybridum L.	2		+	+			FEMP 085 MR	NON-IND
Trifolium pratense L.	3		+	+			FEMP 064 MR	NON-IND
Trifolium repens L.	4		+	+			FEMP 067 MR	NON-IND
Fagaceae								
Quercus alba L.	3				+	+	FEMP 162 MR	IND
Quercus bicolor Willd.	4				+	+	FEMP 173 MR	IND
Quercus imbricaria Michx.	3			+	+	+	FEMP 117 MR	IND
Quercus muehlenbergii Engelm.	4				+	+	FEMP 118 MR	IND
Quercus rubra L.	3				+	+	FEMP 170 MR	IND
Quercus x *runcinata* (A. DC) Engelm.	1			+			FEMP 304 MR	IND
Quercus shumardii Buckley	3				+	+	FEMP 126 MR	IND
Fumariaceae								
Corydalis flavula (Raf.) DC	2				+	+	FEMP 042 MR	IND
Dicentra cucullaria (L.) Bernh.	2					+	FEMP 038 MR	IND
Hippocastanaceae								
Aesculus glabra var. *glabra* Willd.	2				+	+	FEMP 022 MR	IND
Hydrophyllaceae								

Phacelia purshii Buckley	2		+		+		FEMP 081 MR	IND
Iridaceae								
Sisyrinchium angustifolium Miller	1		+				FEMP 103 MR	IND
Juglandaceae								
Carya cordiformis (Wangenh.) K. Koch	3				+	+	FEMP 179 MR	IND
Carya glabra (Miller) Sweet	2				+	+	FEMP 152 MR	IND
Carya laciniosa (Michx. f.) Nutt.	5				+	+	FEMP 148 MR	IND
Carya ovata (Miller) K. Koch	1				+		FEMP 314 MR	IND
Juglans nigra L.	5				+	+	FEMP 130 MR	IND
Juncaceae								
Juncus tenuis var. *tenuis* Willd.	5	+	+	+			FEMP 083 MR	IND
Lamiaceae								
Agastache nepetoides (L.) Kuntze	1	+					FEMP 185 MR	IND
Glechoma hederacea L.	4	+	+	+	+	+	FEMP 004 MR	NON-IND
Lamium purpureum L.	4	+	+			+	FEMP 005 MR	NON-IND
Mentha arvensis var. *canadensis* (L.) Kuntze	3			+	+		FEMP 265 MR	IND
Mentha x *piperita* L.	1			+			FEMP 222 MR	NON-IND
Prunella vulgaris var. *vulgaris* L.	3		+	+	+		FEMP 211 MR	NON-IND
Lemnaceae								
Lemna minuta HBK	1				+		FEMP 129 MR	IND
Liliaceae								
Allium canadense var. *canadense* L.	2		+	+	+		FEMP 099 MR	IND
Allium vineale L.	3		+	+	+	+	FEMP 018 MR	NON-IND
Trillium sessile L.	1					+	FEMP 035 MR	IND
Malvaceae								
Sida spinosa L.	1	+		+			FEMP 243 MR	IND
Menispermaceae								
Menispermum canadense L.	3		+		+		FEMP 079 MR	IND

Molluginaceae								
Mollugo verticillata L.	1	+					FEMP 261 MR	NON-IND
Moraceae								
Maclura pomifera (Raf.) C. K. Schneider	1	+	+			+	FEMP 295 MR	NON-IND
Morus rubra L.	2			+	+		FEMP 132 MR	IND
Oleaceae								
Fraxinus americana L.	3				+		FEMP 165 MR	IND
Fraxinus pennsylvanica Marshall	5			+	+	+	FEMP 163 MR	IND
Fraxinus pennsylvanica var. *subintegerrima* (Vahl) Fern	5			+	+	+	FEMP 164 MR	IND
Onagraceae								
Circaea lutetiana var. *canadensis* L.	1					+	FEMP 178 MR	IND
Ludwigia alata Elliot	1		+				FEMP 086 MR	IND
Oenothera biennis var. *biennis* L.	2	+		+			FEMP 140 MR	IND
Oxalidaceae								
Oxalis dillenii Jacq.	2				+	+	FEMP 082 MR	IND
Oxalis stricta L.	3		+	+	+	+	FEMP 154 MR	IND
Phytolaccaceae								
Phytolacca americana L.	1	+					FEMP 200 MR	IND
Plantaginaceae								
Plantago lanceolata L.	4	+	+	+			FEMP 066 MR	NON-IND
Plantago major L.	4	+	+	+	+		FEMP 251 MR	IND
Plantago rugelii Decne.	3	+	+	+			FEMP 191 MR	IND
Platanaceae								
Platanus occidentalis L.	4			+	+	+	FEMP 175 MR	IND
Poaceae								
Agrostis perennans var. *perennans* (Walter) Tuckerman	5	+	+	+			FEMP 091 MR	IND
Alopecurus pratensis L.	2			+			FEMP 135 MR	NON-IND
Andropogon virginicus var. *virginicus* L.	2			+			FEMP 306 MR	IND
Bromus commutatus Schrader	2			+			FEMP 145 MR	NON-IND

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Bromus inermis Leysser	2	+	+				FEMP 195 MR	NON-IND
Bromus sterilis L.	2	+	+				FEMP 194 MR	NON-IND
Dactylis glomerata L.	4	+	+	+			FEMP 077 MR	NON-IND
Digitaria ischaemum (Schreber) Muhl.	3	+	+	+			FEMP 245 MR	NON-IND
Echinochloa crusgalii var. *crusgalii* (L.) P. Beauv.	3	+	+	+			FEMP 278 MR	NON-IND
Echinochloa muricata var. *muricata* (L.) P. Beauv.	2	+	+	+			FEMP 226 MR	IND
Elymus hystrix L.	2			+	+		FEMP 149 MR	IND
Elymus villosus Muhl.	1			+			FEMP 198 MR	IND
Elymus virginicus L.	2				+		FEMP 227 MR	IND
Eragrostis spectabilis (Pursh.) Steudel.	2		+				FEMP 291 MR	IND
Festuca elatior L.	5		+	+			FEMP 069 MR	NON-IND
Festuca subverticillata (Pers.) E. Alexeev.	2		+	+	+		FEMP 151 MR	IND
Glyceria striata (Lam.) A. Hitchc.	3		+		+	+	FEMP 156 MR	IND
Hordium pussilum L.	1	+					FEMP 142 MR	IND
Leersia oryzoides (L.) Swartz	3		+				FEMP 308 MR	IND
Leersia virginica Willd.	4		+	+	+	+	FEMP 225 MR	IND
Muhlenbergia schreberi J. F. Gmelin	3		+		+		FEMP 311 MR	IND
Panicum clandestinum L.	4		+	+	+		FEMP 307 MR	IND
Panicum lanuginosum var. *implicatum* (Scribn.) Fern.	1		+				FEMP 324 MR	IND
Panicum lanuginosum var. *lanuginosum* Elliot	1			+			FEMP 106 MR	IND
Paspalum pubiflorum var. *glabrum* Vasey.	1	+					FEMP 280 MR	IND
Paspalum setaceum var. *ciliatifolium* (Mischx.) Vasey	1	+					FEMP 196 MR	IND
Paspalum setaceum var. *muhlenbergii (Nash) D. Banks*	2	+	+				FEMP 322 MR	IND
Phleum pratense L.	1			+			FEMP 240 MR	NON-IND
Poa annua L.	3		+	+			FEMP 070 MR	NON-IND
Poa compressa L.	2		+	+			FEMP 072 MR	NON-IND
Poa pratensis L.	3		+	+	+	+	FEMP 061 MR	NON-IND
Poa sylvestris A. Gray	3				+	+	FEMP 096 MR	IND
Setaria faberi R. Herrm.	3	+		+			FEMP 231 MR	NON-IND
Setaria glauca (L.) P. Beauv.	3	+	+	+			FEMP 250 MR	NON-IND
Tridens flavus var. *flavus* (L.) A. Hitchc.	4		+	+			FEMP 234 MR	IND
Polemoniaceae								
Phlox divaricata var. *divaricata* L.	1					+	FEMP 032 MR	IND
Polygonaceae								
Polygonum aviculare L.	1	+	+				FEMP 207 MR	IND

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Polygonum cespitosum var. *longisetum* (De Bruyn) Stewart	2				+		FEMP 124 MR	NON-IND
Polygonum hydropiper L.	2				+		FEMP 155 MR	NON-IND
Polygonum pennsylvanicum L.	4	+	+	+			FEMP 298 MR	IND
Polygonum persicaria L.	5		+	+	+		FEMP 249 MR	NON-IND
Polygonum punctatum var. *punctatum* Elliott	2		+		+		FEMP 224 MR	NON-IND
Polygonum scandens var. *cristatum* (Englem. & A. Gray) Gleason	1				+		FEMP 254 MR	IND
Polygonum virginianum L.	3				+	+	FEMP 252 MR	IND
Rumex crispus L.	2			+			FEMP 074 MR	NON-IND
Rumex obtusifolius L.	1				+		FEMP 158 MR	NON-IND
Portulacaceae								
Claytonia caroliniana Michx.	4		+	+	+	+	FEMP 036 MR	IND
Primulaceae								
Lysimachia nummularia L.	4	+	+	+	+		FEMP 015 MR	NON-IND
Samolus floribunds HBK	1		+				FEMP 302 MR	IND
Ranunculaceae								
Ranunculus abortivus var. *abortivus* L.	4		+	+	+	+	FEMP 001 MR	IND
Rosaceae								
Agrimonia parviflora Aiton	4			+	+		FEMP 214 MR	IND
Crataegus crus-galli L.	1		+				FEMP 051 MR	IND
Crataegus x *disperma* Ashe	1			+			FEMP 146 MR	IND
Crataegus mollis (T. & G.) Scheele	1			+			FEMP 203 MR	IND
Duchesnea indica (Andrews) Focke.	1				+		FEMP 055 MR	NON-IND
Fragaria vesca var. *americana* Porter	1				+		FEMP 125 MR	IND
Geum vernum (Raf.) T. & G.	2		+		+	+	FEMP 050 MR	IND
Geum virginianum L.	1				+		FEMP 160 MR	IND
Potentilla recta L.	2	+		+			FEMP 187 MR	NON-IND
Prunus avium L.	1				+		FEMP 289 MR	NON-IND
Prunus hortulana L. H. Bailey.	1		+				FEMP 052 MR	IND
Prunus monsoniana Wight & Hedrick	1			+			FEMP 202 MR	IND
Prunus serotina Ehrh.	4				+	+	FEMP 014 MR	IND
Pyrus communis L.	1		+	+			FEMP 053 MR	NON-IND
Rosa carolina L.	3	+		+	+	+	FEMP 056 MR	IND
Rosa multiflora Thunb.	5	+	+	+	+	+	FEMP 033 MR	NON-IND

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Rubus allegheniensis T. C. Porter	3			+	+		FEMP 076 MR	IND
Rubus flagellaris Willd.	2			+			FEMP 305 MR	IND
Rubus occidentalis L.	2		+	+			FEMP 104 MR	IND
Rubiaceae								
Galium aparine var. *aparine* L.	3		+	+	+		FEMP 023 MR	IND
Galium triflorum var. *triflorum* Michx.	3		+		+		FEMP 044 MR	IND
Salicaceae								
Populus deltoides var. *deltoides* Marshall	2	+		+	+		FEMP 184 MR	IND
Salix eriocephala Michx.	1		+				FEMP 147 MR	IND
Salix exigua var. *angustissima* (Anderson) Reveal & Broome	1				+		FEMP 316 MR	IND
Salix nigra var. *nigra* Marshall	2			+			FEMP 279 MR	IND
Saxifragaceae								
Penthorum sedoides L.	1		+				FEMP 266 MR	IND
Solanaceae								
Solanum carolinense L.	3	+	+	+			FEMP 188 MR	NON-IND
Solanum nigrum L.	1	+					FEMP 299 MR	IND
Scrophulariaceae								
Agalinis tenuifolia (M. Vahl) Raf.	3		+	+			FEMP 229 MR	IND
Mimulus alatus Aiton	2		+				FEMP 220 MR	IND
Penstemon digitalis Nutt.	2			+			FEMP 127 MR	IND
Verbascum blattaria L.	3	+	+				FEMP 161 MR	NON-IND
Verbascum thaspus L.	2	+					FEMP 183 MR	NON-IND
Veronica anagallis-aquatica L.	1		+				FEMP 128 MR	NON-IND
Veronica arvensis L.	3		+				FEMP 062 MR	NON-IND
Veronica serpyllifolia var. *serpyllifolia* L.	3		+				FEMP 059 MR	NON-IND
Simaroubaceae								
Ailanthus altissima (Miller) Swingle	2				+		FEMP 204 MR	NON-IND
Smilacaceae								
Smilax hispida Muhl.	2			+	+	+	FEMP 150 MR	IND

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Tiliaceae								
Tilia americana var. *americana* L.	1				+		FEMP 284 MR	IND
Ulmaceae								
Celtis occidentalis L.	5				+	+	FEMP 120 MR	IND
Ulmus americana L.	3			+	+		FEMP 268 MR	IND
Ulmus rubra Muhl.	5			+	+	+	FEMP 113 MR	IND
Urticaceae								
Boehmeria cylindrica (L.) Swartz	2				+		FEMP 157 MR	IND
Pilea pumila (L.) A. Gray	3	+			+	+	FEMP 228 MR	IND
Valerianaceae								
Valerianella umbilicata (Sulliv.) A. Wood.	2			+	+	+	FEMP 080 MR	IND
Verbenaceae								
Verbena urticifolia var *urticifolia* L.	3			+	+		FEMP 223 MR	IND
Violaceae								
Viola pubescens Aiton	3					+	FEMP 030 MR	IND
Viola sororia Willd.	4		+	+	+	+	FEMP 012 MR	IND
Vitaceae								
Parthenocissus quinquefolia (L.) Planchon	3				+	+	FEMP 043 MR	IND
Vitis labrusca L.	3					+	FEMP 300 MR	IND
Vitis vulpina L.	5			+	+		FEMP 102 MR	IND

[1] See Table 3 for Abundance Scores
[2] See Table 2 for Habitat descriptions; a "+"+A347 indicates a species' presence in the habitat
[3] IND = Indigenous
NON-IND = Non-indigenous
[4] Not collected due to toxicity