

Identification and Control of Invasive Plant Species

- 1998 Annual Report -

Prepared For:

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PURPOSE & SCOPE

The purpose of this research was to (1) identify all vascular 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 of vascular plant species. 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 negundo*), 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 classify 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. It is possible that regional industrial pollution may contribute to the low abundance of ferns, as ferns are known to be quite sensitive to pollution. For example, recent literature states that a 50% increase in ground ozone resulted in more than a 50% decrease in fern spore germination (Bosley, A. et al. 1998). The Cincinnati area does have elevated ground ozone levels, though this idea would need to be evaluated further. Unfortunately ferns have not been as well studied as flowering plants. 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.

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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, <i>Rubus</i> 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		<i>Eleocharis</i> , sedges, rushes (wetland)
S	Sycamore, box elder, black walnut, slippery elm	multiflora rose

Table 1, continued

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 dioica*
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*

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

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 (<i>Lonicera maackii</i>), brambles (<i>Rubus</i> spp.), and roses (<i>Rosa</i> spp.)

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

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.

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")

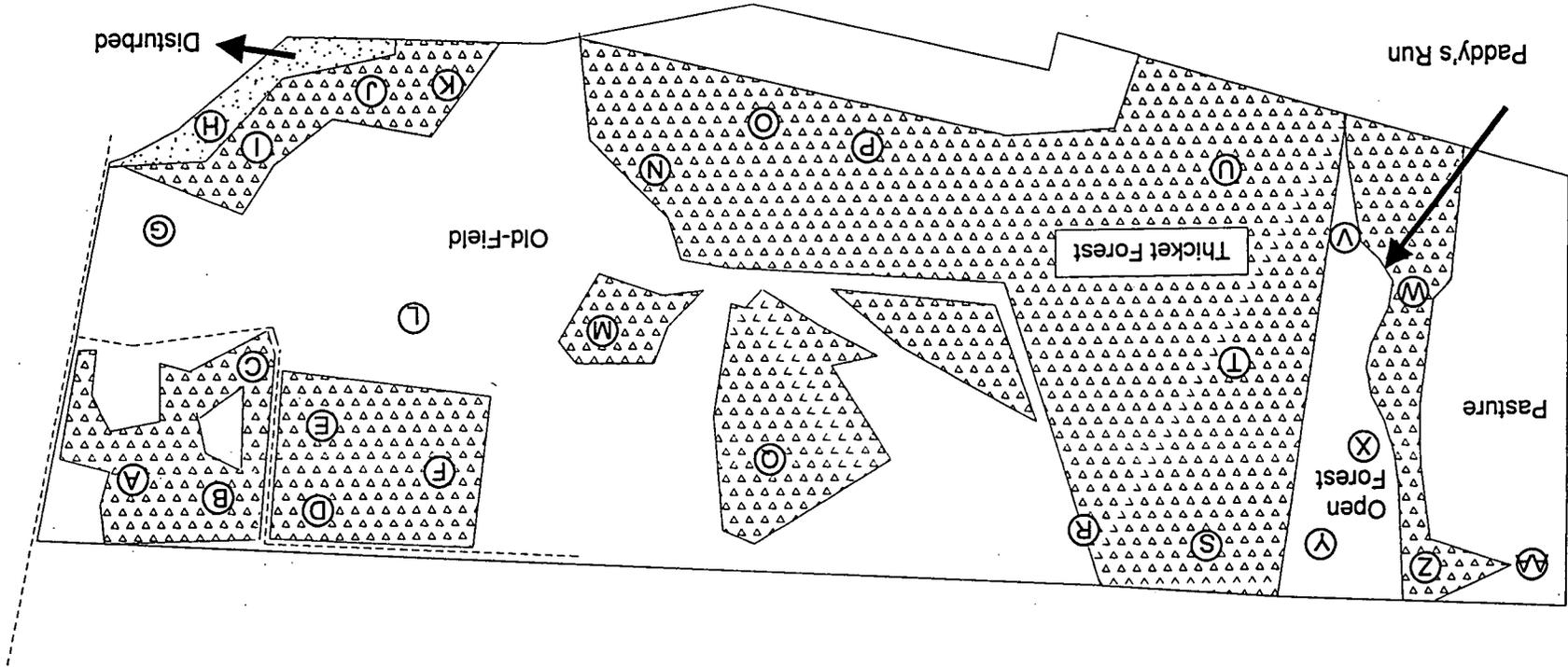
Magnoliophyta = flowering plants

 Magnoliopsida = dicots

 Liliopsida = monocots

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Figure 1.



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

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

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

Brassicaceae

<i>Alliaria petiolata</i> (Bieb.) Cavara & Grande	4		+		+	+	FEMP 020 MR	NON-IND
<i>Barbarea vulgaris</i> R. Br.	4	+	+	+	+		FEMP 045 MR	NON-IND
<i>Cardamine concatenata</i> (Michx.) O. Schwarz	2					+	NO FEMP	IND
<i>Draba verna</i> L.	3		+				FEMP 060 MR	NON-IND
<i>Iodanthus pinnatifidis</i> (Michx.) Steudel	1				+		FEMP 094 MR	IND
<i>Lepidium campestre</i> (L.) R. Br.	3		+	+			FEMP 011 MR	NON-IND
<i>Lepidium virginicum</i> var. <i>virginicum</i> L.	1				+		FEMP 144 MR	IND
<i>Rorippa sylvestris</i> (L.) Besser	1				+		FEMP 137 MR	NON-IND
<i>Sisymbrium officinale</i> (L.) Scop.	1				+		FEMP 141 MR	NON-IND
<i>Thlaspi arvense</i> L.	1				+		FEMP 138 MR	NON-IND

Caesalpiaceae

<i>Cercis canadensis</i> var. <i>canadensis</i> L.	1					+	FEMP 310 MR	IND
<i>Gleditsia triacanthos</i> L.	3				+	+	FEMP 123 MR	IND
<i>Gymnocladus dioica</i> (L.) K. Koch	2					+	FEMP 041 MR	IND

Campanulaceae

<i>Lobelia inflata</i> L.	3		+			+	FEMP 264 MR	IND
<i>Lobelia siphilitica</i> var. <i>siphilitica</i> L.	3	+	+				FEMP 262 MR	IND

Caprifoliaceae

<i>Lonicera japonica</i> Thunb.	4		+	+	+	+	FEMP 048 MR	NON-IND
<i>Lonicera maackii</i> (Rupr.) Maxim.	5				+	+	FEMP 017 MR	NON-IND
<i>Sambucus canadensis</i> var. <i>canadensis</i> L.	2					+	FEMP 216 MR	IND
<i>Viburnum prunifolium</i> L.	1					+	FEMP 013 MR	IND

Caryophyllaceae

<i>Cerastium vulgatum</i> L.	4		+	+	+	+	FEMP 008 MR	NON-IND
<i>Dianthus armeria</i> L.	2		+	+			FEMP 087 MR	NON-IND
<i>Saponaria officinalis</i> L.	1					+	FEMP 293 MR	NON-IND
<i>Stellaria media</i> (L.) Villars.	5		+		+	+	FEMP 009 MR	NON-IND

Chenopodiaceae

<i>Chenopodium album</i> L.	1	+					FEMP 303 MR	NON-IND
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Commelinaceae

<i>Commelina communis</i> L.	3		+	+	+	FEMP 260 MR	NON-IND
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Convolvulaceae

<i>Calystegia sepium</i> (L.) R. Br.	3		+			FEMP 201 MR	IND
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<i>Ipomoea lacunosa</i> L.	1				+	FEMP 244 MR	IND
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<i>Ipomoea pandurata</i> (L.) G. Meyer	1				+	FEMP 236 MR	IND
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Cornaceae

<i>Cornus drummondii</i> C. A. Meyer	4				+	+	FEMP 107 MR	IND
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<i>Cornus racemosa</i> Lam.	2				+	+	FEMP 270 MR	IND
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Cyperaceae

<i>Carex albursina</i> Sheldon	1					+	FEMP 177 MR	IND
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<i>Carex blanda</i> Dewey	1					+	FEMP 093 MR	IND
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<i>Carex cephalophora</i> var. <i>cephalophora</i> Muhl.	1		+	+			FEMP 134 MR	IND
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<i>Carex cristatella</i> Britton	2		+				FEMP 101 MR	IND
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<i>Carex frankii</i> Kunth.	2		+				FEMP 321 MR	IND
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<i>Carex hystericina</i> Muhl.	1					+	FEMP 159 MR	IND
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<i>Carex jorii</i> L. Bailey	2					+	FEMP 075 MR	IND
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<i>Carex scoparia</i> Schk.	2		+	+			FEMP 320 MR	IND
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<i>Carex shortiana</i> Dewey	2		+	+			FEMP 089 MR	IND
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<i>Carex vulpinoidea</i> var. <i>vulpinoidea</i> Michx.	3		+	+			FEMP 073 MR	IND
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<i>Cyperus lancastris</i> Porter	2		+				FEMP 217 MR	IND
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<i>Cyperus strigosus</i> L.	2		+	+			FEMP 213 MR	IND
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<i>Eleocharis ovata</i> (Roth) Roemer & Schultes	2		+				FEMP 016 MR	IND
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<i>Scirpus atrovirens</i> var. <i>atrovirens</i> Willd.	2		+	+			FEMP 181 MR	IND
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<i>Scirpus lineatus</i> Michx.	2		+	+			FEMP 071 MR	IND
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Dioscoreaceae

<i>Dioscorea villosa</i> L.	2		+			+	FEMP 315 MR	IND
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Dipsacaceae

<i>Dipsacus sylvestris</i> Hudson	2		+			+	FEMP 210 MR	NON-IND
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Elaeagnaceae

<i>Elaeagnus angustifolia</i> L.	2		+	+	+		FEMP 047 MR	NON-IND
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<i>Elaeagnus multiflora</i> Thunb.	1			+	FEMP 283 MR	NON-IND
Euphorbiaceae						
<i>Acalypha rhomboidea</i> Raf.	3			+	FEMP 286 MR	IND
<i>Euphorbia dentata</i> Michx.	1	+			FEMP 297 MR	IND
<i>Euphorbia maculata</i> L.	1	+			FEMP 256 MR	IND
<i>Euphorbia nutans</i> Lagasca	1			+	FEMP 323 MR	IND
Fabaceae						
<i>Amorpha fruticosa</i> L.	1			+	FEMP 255 MR	IND
<i>Desmodium paniculatum</i> (L.) DC	2			+	FEMP 219 MR	IND
<i>Lespedeza violacea</i> (L.) Pers.	3			+	FEMP 247 MR	IND
<i>Melilotus officinalis</i> (L.) Pallas	2			+	FEMP 133 MR	NON-IND
<i>Robinia pseudoacacia</i> L.	2			+	FEMP 131 MR	IND
<i>Trifolium campestre</i> Schreber	2	+	+		FEMP 063 MR	NON-IND
<i>Trifolium dubium</i> Sibth.	3	+			FEMP 065 MR	NON-IND
<i>Trifolium hybridum</i> L.	2	+	+		FEMP 085 MR	NON-IND
<i>Trifolium pratense</i> L.	3	+	+		FEMP 064 MR	NON-IND
<i>Trifolium repens</i> L.	4	+	+		FEMP 067 MR	NON-IND
Fagaceae						
<i>Quercus alba</i> L.	3			+	FEMP 162 MR	IND
<i>Quercus bicolor</i> Willd.	4			+	FEMP 173 MR	IND
<i>Quercus imbricaria</i> Michx.	3		+	+	FEMP 117 MR	IND
<i>Quercus muehlenbergii</i> Engelm.	4			+	FEMP 118 MR	IND
<i>Quercus rubra</i> L.	3			+	FEMP 170 MR	IND
<i>Quercus x runcinata</i> (A. DC) Engelm.	1		+		FEMP 304 MR	IND
<i>Quercus shumardii</i> Buckley	3			+	FEMP 126 MR	IND
Fumariaceae						
<i>Corydalis flavula</i> (Raf.) DC	2			+	FEMP 042 MR	IND
<i>Dicentra cucullaria</i> (L.) Bernh.	2			+	FEMP 038 MR	IND
Hippocastanaceae						
<i>Aesculus glabra</i> var. <i>glabra</i> Willd.	2			+	FEMP 022 MR	IND

8 Hydrophyllaceae

<i>Phacelia purshii</i> Buckley	2	+		+		FEMP 081 MR	IND
Iridaceae							
<i>Sisyrinchium angustifolium</i> Miller	1	+				FEMP 103 MR	IND
Juglandaceae							
<i>Carya cordiformis</i> (Wangenh.) K. Koch	3				+	FEMP 179 MR	IND
<i>Carya glabra</i> (Miller) Sweet	2				+	FEMP 152 MR	IND
<i>Carya laciniosa</i> (Michx. f.) Nutt.	5				+	FEMP 148 MR	IND
<i>Carya ovata</i> (Miller) K. Koch	1				+	FEMP 314 MR	IND
<i>Juglans nigra</i> L.	5				+	FEMP 130 MR	IND
Juncaceae							
<i>Juncus tenuis</i> var. <i>tenuis</i> Willd.	5	+	+	+		FEMP 083 MR	IND
Lamiaceae							
<i>Agastache nepetoides</i> (L.) Kuntze	1	+				FEMP 185 MR	IND
<i>Glechoma hederacea</i> L.	4	+	+	+	+	FEMP 004 MR	NON-IND
<i>Lamium purpureum</i> L.	4	+	+		+	FEMP 005 MR	NON-IND
<i>Mentha arvensis</i> var. <i>canadensis</i> (L.) Kuntze	3			+	+	FEMP 265 MR	IND
<i>Mentha x piperita</i> L.	1			+		FEMP 222 MR	NON-IND
<i>Prunella vulgaris</i> var. <i>vulgaris</i> L.	3		+	+	+	FEMP 211 MR	NON-IND
Lemnaceae							
<i>Lemna minuta</i> HBK	1				+	FEMP 129 MR	IND
Liliaceae							
<i>Allium canadense</i> var. <i>canadense</i> L.	2		+	+	+	FEMP 099 MR	IND
<i>Allium vineale</i> L.	3		+	+	+	FEMP 018 MR	NON-IND
<i>Trillium sessile</i> L.	1				+	FEMP 035 MR	IND
Malvaceae							
<i>Sida spinosa</i> L.	1	+		+		FEMP 243 MR	IND
Menispermaceae							
<i>Menispermum canadense</i> 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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<i>Bromus inermis</i> Leysser	2	+	+			FEMP 195 MR	NON-IND
<i>Bromus sterilis</i> L.	2	+	+			FEMP 194 MR	NON-IND
<i>Dactylis glomerata</i> L.	4	+	+	+		FEMP 077 MR	NON-IND
<i>Digitaria ischaemum</i> (Schreber) Muhl.	3	+	+	+		FEMP 245 MR	NON-IND
<i>Echinochloa crusgalii</i> var. <i>crusgalii</i> (L.) P. Beauv.	3	+	+	+		FEMP 278 MR	NON-IND
<i>Echinochloa muricata</i> var. <i>muricata</i> (L.) P. Beauv.	2	+	+	+		FEMP 226 MR	IND
<i>Elymus hystrix</i> L.	2			+	+	FEMP 149 MR	IND
<i>Elymus villosus</i> Muhl.	1			+		FEMP 198 MR	IND
<i>Elymus virginicus</i> L.	2				+	FEMP 227 MR	IND
<i>Eragrostis spectabilis</i> (Pursh.) Steudel.	2		+			FEMP 291 MR	IND
<i>Festuca elatior</i> L.	5		+	+		FEMP 069 MR	NON-IND
<i>Festuca subverticillata</i> (Pers.) E. Alexeev.	2		+	+	+	FEMP 151 MR	IND
<i>Glyceria striata</i> (Lam.) A. Hitchc.	3		+		+	FEMP 156 MR	IND
<i>Hordium pussillum</i> L.	1	+				FEMP 142 MR	IND
<i>Leersia oryzoides</i> (L.) Swartz	3		+			FEMP 308 MR	IND
<i>Leersia virginica</i> Willd.	4		+	+	+	FEMP 225 MR	IND
<i>Muhlenbergia schreberi</i> J. F. Gmelin	3		+		+	FEMP 311 MR	IND
<i>Panicum clandestinum</i> L.	4		+	+	+	FEMP 307 MR	IND
<i>Panicum lanuginosum</i> var. <i>implicatum</i> (Scribn.) Fern.	1		+			FEMP 324 MR	IND
<i>Panicum lanuginosum</i> var. <i>lanuginosum</i> Elliot	1			+		FEMP 106 MR	IND
<i>Paspalum pubiflorum</i> var. <i>glabrum</i> Vasey.	1	+				FEMP 280 MR	IND
<i>Paspalum setaceum</i> var. <i>ciliatifolium</i> (Mischx.) Vasey.	1	+				FEMP 196 MR	IND
<i>Paspalum setaceum</i> var. <i>muhlenbergii</i> (Nash) D. Banks	2	+	+			FEMP 322 MR	IND
<i>Phleum pratense</i> L.	1			+		FEMP 240 MR	NON-IND
<i>Poa annua</i> L.	3		+	+		FEMP 070 MR	NON-IND
<i>Poa compressa</i> L.	2		+	+		FEMP 072 MR	NON-IND
<i>Poa pratensis</i> L.	3		+	+	+	FEMP 061 MR	NON-IND
<i>Poa sylvestris</i> A. Gray	3				+	FEMP 096 MR	IND
<i>Setaria faberi</i> R. Herrm.	3	+		+		FEMP 231 MR	NON-IND
<i>Setaria glauca</i> (L.) P. Beauv.	3	+	+	+		FEMP 250 MR	NON-IND
<i>Tridens flavus</i> var. <i>flavus</i> (L.) A. Hitchc.	4		+	+		FEMP 234 MR	IND
Polemoniaceae							
<i>Phlox divaricata</i> var. <i>divaricata</i> L.	1				+	FEMP 032 MR	IND
Polygonaceae							
<i>Polygonum aviculare</i> L.	1	+	+			FEMP 207 MR	IND

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

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<i>Rubus allegheniensis</i> T. C. Porter	3		+	+	FEMP 076 MR	IND
<i>Rubus flagellaris</i> Willd.	2			+	FEMP 305 MR	IND
<i>Rubus occidentalis</i> L.	2		+	+	FEMP 104 MR	IND
Rubiaceae						
<i>Galium aparine</i> var. <i>aparine</i> L.	3		+	+	+	FEMP 023 MR
<i>Galium triflorum</i> var. <i>triflorum</i> Michx.	3		+		+	FEMP 044 MR
Salicaceae						
<i>Populus deltoides</i> var. <i>deltoides</i> Marshall	2		+		+	+
<i>Salix eriocephala</i> Michx.	1		+			
<i>Salix exigua</i> var. <i>angustissima</i> (Anderson) Reveal & Broome	1					+
<i>Salix nigra</i> var. <i>nigra</i> Marshall	2				+	
Saxifragaceae						
<i>Penthorum sedoides</i> L.	1		+			
Solanaceae						
<i>Solanum carolinense</i> L.	3		+	+	+	
<i>Solanum nigrum</i> L.	1		+			
Scrophulariaceae						
<i>Agalinis tenuifolia</i> (M. Vahl) Raf.	3			+	+	
<i>Mimulus alatus</i> Aiton	2			+		
<i>Penstemon digitalis</i> Nutt.	2					+
<i>Verbascum blattaria</i> L.	3		+	+		
<i>Verbascum thaspus</i> L.	2		+			
<i>Veronica anagallis-aquatica</i> L.	1			+		
<i>Veronica arvensis</i> L.	3			+		
<i>Veronica serpyllifolia</i> var. <i>serpyllifolia</i> L.	3			+		
Simaroubaceae						
<i>Ailanthus altissima</i> (Miller) Swingle	2				+	
Smilacaceae						
<i>Smilax hispida</i> Muhl.	2			+	+	+

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

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