Appendix 4: Rare Plant Management Protocols

Mahlon Dickerson Reservation
Botanical Survey and Stewardship Assessment
Wild Ridge Plants, LLC
2015

Rare Plant Management Protocols

Species Selection

Three state-listed rare plant species identified at Mahlon Dickerson Reservation have been selected for individualized treatments elaborating specific monitoring and management practices.

Protocols have been developed for lesser purple fringed orchid (*Platanthera psycodes*), wood lily (*Lilium philadelphicum*), and bog willow-herb (*Epilobium leptopyllum*).

The species selected are each representative of important habitat types at the Reservation. For each species selected, a number of other rare plants that share similar habitats and locations at Mahlon Dickerson may also benefit from the practices enumerated in the protocols. A variety of threats are faced by the three species, ranging from deer overbrowse to *Phragmites* encroachment. Addressing threats to the three chosen species will benefit guilds of native plants, rare and less so, that face similar threats.

Robust treatments of each species in spreadsheet format follow below, after brief narrative summaries.

Species Summaries

Lesser purple fringed orchid (*Platanthera psycodes*) is a showy terrestrial orchid found along forested stream corridors and swamp edges at Mahlon Dickerson, associated with seeps and hydric soils. Its New Jersey rank is S2. At the Reservation, habitat for the orchid tends to be mature forest with little disturbance and intact hydrology. *Phegopteris connectilis*, *Clintonia borealis*, *Streptopus lanceolatus*, *Equisetum pratense*, and a number of other northern-affinity hydric soil rarities at Mahlon Dickerson possess some similarities in their management and habitat needs to the orchid.

Threats to *Platanthera psycodes* include habitat disturbance, hydrological alteration, deer browse, and poaching. Very dense tree canopy can also reduce plant productivity and reproductive success (optimal canopy cover provides dappled light with approximately 80% cover). However, invasive species such as Japanese stiltgrass are a threat that is amplified by increased canopy openness. Creating an

optimal canopy for the orchid may stimulate stiltgrass. This dynamic necessitates great care in implementing habitat improvements through canopy reduction.

Four current populations all number fewer than ten individuals, most significantly less. Number of reproductive stems is also limited. Further searching in appropriate habitats may yield more populations as suitable habitat is abundant.

Recommendations for management include achieving optimal thresholds for canopy and subcanopy cover, shrub/sapling layer cover, deer browse intensity, Japanese stiltgrass cover, and other invasive herbaceous species cover. The two most significant threats to existing population stability are deer browse and the possibility of poaching. The most fruitful management approaches for population expansion would entail selective thinning of shading woody plants and the careful control of competing vegetation. Native herbaceous plants adjacent to *Platanthera* occurrences are not necessarily to be understood as competing but rather as mutualistic associates that maintain habitat integrity.

Wood lily (*Lilium philadelphicum*) is a long-lived perennial forb that occupies open well-drained habitats such as trailsides, glades, shores, and utility ROWS. Its New Jersey rank is S2. The S3 species *Asclepias quadrifolia* shares similar habitats and two occurrences were found in proximity to wood lily.

Threats to *Lilium philadelphicum* include canopy closure, deer browse, and picking or poaching. Increasing light availability through practices such as girdling and other forestry practices may help some existing populations thrive.

Six current populations all number three individuals or fewer. A maximum of one reproductive stem was found, at three populations. Further searching in appropriate habitats may yield more populations as suitable habitat is abundant.

Recommendations for management include achieving optimal thresholds for canopy and subcanopy cover, shrub/sapling layer cover, invasive species cover, deer browse intensity, and % exposed bedrock or low (<12") cover.

Thresholds for "very good" canopy, subcanopy, and shrub/sapling cover were set at 25%. It is likely that overstory thinning and control of adjacent thick vegetation would benefit wood lily populations. Note however that the three populations with reproductive stems were found in relatively shady habitats, and the two populations in ROWs did not produce reproductive stems. Thus, a simple association of available light to species reproductive success may not be accurrate.

As with the orchid species above, the possibility of poaching or picking remains a threat for this showy species. A landscape context ranking of "very good" includes the criteria that populations be at least 100' from trails. Three populations are found along trails. This probably reflects both the likelihood of easier detection by botanists, and also the benefits of the regular low grade disturbance and enhanced light availability found along trails.

Bog willow-herb (*Epilobium leptophyllum*) was chosen as a representative of a guild of rare species associated with beaver ponds at Mahlon Dickerson. It is a perennial forb of wetland margins and hydric soils on the periphery of beaver and artificial impoundments.

Rare aquatic, emergent, and terrestrial wetland species that share an affinity for beaver ponds at Mahlon Dickerson include *Carex haydenii, Galium trifidum var trifidum, Galium palustre, Najas gracillima, Potamogeton illinoensis,* and *Ranunculus pensylvanicus*.

The primary threats to *Epilobium leptophyllum* and to the beaver pond guild enumerated above are hydrological alteration, cessation of beaver activity, and *Phragmites* encroachment.

There are three detected populations of *Epilobium leptophyllum*, all in the context of major waterbodies. One population contains over fifty individuals, a second 15-20, and a third has two individuals. Because the species is limited to beaver or human impounded areas, suitable habitat for the detection of more populations is limited. However, searching other areas of open water or marsh for the species could reveal more occurrences or individuals.

The primary recommendation for management of this species, and the guild of both rare and non-listed plant species it is found associated with, is the complete control of *Phragmites australis*.

Thresholds for "very good" canopy and sub-canopy cover are set at 10%, and shrub/sapling cover at 25%, reflecting this species' relative intolerance of shade. That said, the open water/marsh habitat of the species is generally pre-empting significant woody plant competition at this point, and canopy closure was not interpreted as a significant threat at any of the observed population locations.

Purple Fringed Orchid (*Platanthera psycodes*)
Individual Population / Element Occurrence Ranking Procedure

Category	Key Attribute	Indicator	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Size	Population size	Total Number of Adult Plants	< 3 plants	3 - 5 plants	5 - 10 plants	> 10 plants	Population defined as a diffuse area (e.g.., distance along streamside or wetland edge). Distinct populations should be defined as having > 100 yards apart from the nearest plants. For example, population R058 has multiple, scattered plants located within 100 yards of each other.
Condition	Reproductive Status	Number of individual plants flowering	0 plants	1 - 3 plants	4 - 5 plants	> 5 plants	Typical maximum if 50-75% of total plants in flower.
Condition	Reproductive Status	Number of individual plants fruiting	0 plants	1 - 3 plants	4 - 5 plants	> 5 plants	Flowering plants should be expected to produce fruit. Deer browse can be a critical factor to explain lack of fruit (notes at two other NJ populations, but not at MDR in 2015).
Condition	Plant community structure and composition	Mean combined rank of all plant community structure and composition ranks	Mean value: 0 - 1.75	Mean value: 1.76 - 2.9	Mean value: 3.0 - 3.75	Mean value: > 3.75	See "Plant Community Ranking" tab
Landscape Context	Landscape structure and composition	Mean combined rank of all landscape structure and composition ranks	Mean value: 0 - 1.75	Mean value: 1.76 – 2.9	Mean value: 3.0 - 3.75	Mean value: > 3.75	See "Landscape Context Ranking" tab

Future searching guide:

[redacted]

4) A common associate is Cardinal Flower (Lobelia cardinalis). Another potential common associate includes False Hellebore.
5) Soil associated with detected populations are provided in the existing populations table.
These soil types should be given higher searching priority. Generally, species requires slightly richer acid (but not strongly acid) soils.

Specific Search Area Recommendations
1) Section 15 [redacted]
2) Section 17
3) Section 18
4) Russia Bro

Purple Fringed Orchid (*Platanthera psycodes*)
Plant Community Composition & Structure Ranking Procedure

Indicator (Visual Estimates)	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Canopy and Sub-Canopy Cover (%)	< 50% and > 90%	50-75%	76-90%	80-90%	level of shade is appropriate for plant health. While this species occurs in open wetland habitats in the northern/core areas of its distribution, it only occurs in shaded conditions in NJ (dappled light, ca. 80% tree canopy is ideal). It might be speculated that warmer temperatures in New Jersey require the species to be 'protected' in shadier conditions. It is solely a montane species south of New Jersey.
Shrub / Sapling Layer Cover (%)	> 50%	26-50%	10-25%	< 10%	Plants are typically not associated with a dense shrub layer. There is a delicate balance between canopy cover and shrub density. Very open canopies would support more vigorous growth of shrubs (both native and non-native).
Deer Browse Intensity	Majority of native shrubs with new sprouts < 1 foot tall.	Majority of native shrubs with new sprouts 1-3 feet tall.	Majority of native shrubs with new sprouts 3-5 feet tall.	Majority of native shrubs with new sprouts greater than 5 feet tall.	This metric may not be assessable in all situations. Examples of native shrubs suitable for evaluation include Spicebush, Viburnum species and Winterberry Holly.
Japanese Stiltgrass Cover (%)	> 25%	11-25%	1-10%	Absent	Japanese Stiltgrass is particularly threatening as it may grow vigorously in streamside/wetland edge habitats. Canopy cover reductions may stimulate Stiltgrass growth.
Other Herbaceous Invasive Species Cover (%)	> 25%	11-25%	1-10%	Absent	MDR typically has low invasive species cover, but as described for Stiltgrass above, moist/edge habitats are more prone to infestation (e.g., Garlic Mustard, etc.).

Purple Fringed Orchid (*Platanthera psycodes*)
Landscape Structure and Composition Ranking Procedure

Indicator (Determined via GIS)	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Available stream / wetland edge habitat within 0.1 miles from occurrence	< 100 feet	100 - 200 feet	201 - 500 feet	> 500 feet	Great available habitat provides potential for population growth
Percent Natural Cover within 0.5 miles	< 10%	10 - 75%	76 - 95%	> 95%	Greater natural cover in the vicinity of a population is generally associated with reduced direct and indirect human impacts
Visibility from trails / Poaching Access	< 25 feet from trail	25 - 50 feet from trail	50 - 100 feet from trail	> 100 feet from trail	Poaching is of particular concern. Populations further from trails are less likely to be incidentally discovered.

Purple Fringed Orchid (*Platanthera psycodes*)
MDR Site-Specific Species Ranking Procedure

Category	Key Attribute	Indicator	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Size	Species Abundance	Total number of populations	No populations	1 - 2 populations	3 - 5 populations	> 5 populations	There are currently four populations at MDR. Additional searching may lead to more discoveries.
Condition	Population Condition	Mean combined viability ranking of each population	Mean value: 0-1.75	Mean value: 1.76 – 2.9	Mean value: 3.0-3.75	Mean value: > 3.75	Mean of each "individual population ranking" that considers size, condition and landscape context for each population.
Landscape context	Genetic Connectivity	Mean distance between populations	> 0.50 miles	0.26 - 0.50 miles	0.1 - 0.25 miles	< 0.1 miles	It is suspected that greater genetic communication (via seed dispersal and/or pollinators) between populations will increase vigor.

Purple Fringed Orchid (*Platanthera psycodes*)
Known Populations at MDR

GPS ID	Section ID	Population Name	Latitude	Longitude	Soil Symbols	Soil Description	Bedrock	Total Stems	Flowering Stems	Current Threats	Notes
[redacted]	13	[redacted]	[redacted]	[redacted]	RkgBc / RobCb	Ridgebury loam, 0 to 8 percent slopes, extremely stony / Rockaway sandy loam, 8 to 15 percent slopes, very stony	Pyroxene Alaskite	< 10	< 10	Deer, Poaching	[redacted]uals along ithAcer icolor, Lobelia cardinalis, Osmunda cinnamomea ; Probably more to be found
[redacted]	15	[redacted]	[redacted]	[redacted]	RkgBc / RomD	Ridgebury loam, 0 to 8 percent slopes, extremely stony / Rockaway-Rock outcrop complex, 15 to 25 percent slopes	Pyroxene Alaskite	3	< 3	Deer, Poaching	At top o [redacted] ith Veratrum , Thelypteris noveboracensis, Osmunda [redacted] On [redacted] irly
[redacted]	9	[redacted]	[redacted]	[redacted]	AdrAt / HhmBc	Adrian muck, 0 to 3 percent slopes, frequently flooded / Hibernia loam, 0 to 8 percent slopes, extremely stony	Pyroxene Alaskite	3	1	Deer, Poaching	Tsuga, Betula allegheniensis, Fagus grandifolia. Sparse shrub layer. Herbs include Carex bromoides, Impatiens capensis, Osmunda cinnamomea, Glyceria melicaria
[redacted]	19	[redacted]	[redacted]	[redacted]	AhcBc	Alden mucky silt loam, gneiss till substratum, 0 to 8 percent slopes, extremely stony	Pyroxene Granite	4	1	Deer, Poaching	rubrum, Fraxinus nigra, Betula allegheniensis, Ilex verticillata, Lindera benzoin, Osmunda cinnamomea, Carex bromoides. Streptopus lanceolatus and Clintonia borealis (state-listed spp.) nearby

Note:
Kerry Barringer has observed only three other populations in New Jersey. Two are are Tranquility Ridge (Passaic County Parks) and the third is located south of MDR in the Rockaway River Wildlife Management Area.

Purple Fringed Orchid (*Platanthera psycodes*)
Literature Notes

Source	Note	GIST
Kerry Barringer (personal communication)	Multiple comments/observations incorporated throughout EO Specs	See EO Specs
Steve Young (personal communication)	NY habitat observations include both open and shaded conditions, whereas species only occurs in shaded conditions in NJ. Larger populations may exceed 100 plants and smaller populations are 10-30 plants. Population size and shade condition were not tracked. Species is common in NY.	See EO Specs
North American Orchid Journal 14(4) - 2008	Population sizes large enough (and mixed with other Platanthera that flower simultaneously) to lead to hybrids occurs in Nova Scotia, New Brunswick, and especially western Newfoundland	Species probably has northern affinity
BBG Metro Flora	38 blocks containing species prior to 1990, only 2 blocks known after 1990 (neither are MDR)	Species dramatically declining
orchids of Iowa	"moist, open meadows and moist, low forests"; sandy soils?, Found in Maple-Basswood Forest, 'Great Lakes Forest' (White pine patches). Iowa is western limit of species	Not sure it's relevant…
FONAP	has possibly best species distribution map	Just info
Evans - Great Smoky Mountains - Univ. of Tennessee honors project	Effective pollinators include Colias eurytheme (butterfly), Bombus sp, noctuid moth, beetle -- Identified to species include: Sulphur Butterfly, Orange Sulphur, Eastern Tiger Swallowtail, Black Swallowtail, Silver Spotted Skipper, Drone Fly. No fruit production on flowers isolated from pollinators (preliminary result)	Species common in NJ can effectively pollinate it
http://link.springer.com/chapter/10.1007%2F978-1-4614-0592-4_11	Partially self-incompatible, autogamy absent; pollinated by smaller Lepidoptera	Small populations (like those at MDR) may suffer from lack of necessary cross-pollination
https://books.google.com/books?hl=en&lr=&id=y2kdkjcBfHMC&oi=fnd&pg=PA1&dq=%22platanthera+psycodes%22&ots=IkmSrnDGVu&sig=royGfyhuOdI3vEBicAW1ZATZzVg#v=onepage&q=psycodes&f=false	"Dot the open streamsides and less dense wooded wetlands" --- Maine	Reduced canopy better in northern portion of range.
http://agris.upm.edu.my:8080/dspace/handle/0/7847	"Temperate terrestrial orchids: population biology and conservation strategies" (includes P. psycodes) --potentially useful, but would have to pay for access….	
https://www.minnesotawildflowers.info/flower/lesser-purple-fringed-orchid	part shade, sun; moist woods, swamps, marshes, wet meadows, shorelines	Reduced canopy better in northern portion of range.
http://www.naturalheritage.state.pa.us/factsheets/15461.pdf	open swampy places, along roads, forest openings, along vernal pools - prefers acidic soil;	Reduced canopy better in PA?
Go Botany	Anthropogenic (man-made or disturbed habitats), fens, forests, meadows and fields, swamps, wetland margins (edges of wetlands)	Reduced canopy better in northern portion of range.
Chicago Botanic	found in shady or sunny sites. The rose-purple or lavender-pink flowers are very showy, with 20 to 125 of them clustered in a cylinder at the top of the stalk. The lip of each flower is further divided into three fringed fan-shaped segments. This orchid is pollinated by butterflies by day and moths by night.	Reduced canopy better in northern portion of range.
http://michiganflora.net/species.aspx?id=1837	Moist shores at borders of forests, marshes and wet meadows, stream borders and open wet ground generally; less often in sedge mats and tamarack swamps, depressions in deciduous forests, and swamps; rock ledges in the Lake Superior region. Rare now in southernmost Michigan.	Reduced canopy better in northern portion of range.
http://www.ashevillenatural.com/orchidpurplefringed.html	They grow only at high elevations in our area, preferring sunny damp spots - such as roadside ditches and mountain seepage slopes that are cool, moist, but get a lot of sun.	Reduced canopy better in montane habitats.
http://minnesotaseasons.com/Plants/small_purple_fringed_orchid.html	Wet meadows; sedge meadows; thickets; thin woods; and shallow, moist, roadside ditches. Areas that are wet in spring and after a rain but are otherwise moist. Full or partial sun.	Reduced canopy better in northern portion of range.
http://www.inaturalist.org/taxa/48030-Platanthera-psycodes	Like many other orchids it is a plant of wet habitats: sedge meadows, flatwoods, sphagnum bogs, cedar or alder swamps, on stream edges or the moist edges of coniferous forests. It is occasionally found in wet swales adjoining freshwater sandy beaches. Preferring cooler habitats, its range is being pushed northwards as global temperatures warm. Correll refers to locations of 1,500 foot altitudes in Vermont, 4,000 foot altitudes in Virginia and 6,500 foot altitudes in North Carolina and Tennessee.	Unfortunately prone to global warming.
http://www.ct-botanical-society.org/Plants/view/457	swamps, wet meadows, stream banks	Reduced canopy better in northern portion of range.

Wood Lily (*Lilium philadelphicum var. philadelphicum*)
Individual Population / Element Occurrence Ranking Procedure

Category	Key Attribute	Indicator	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Size	Population size	Total Number of Adult Plants	1	2 - 3 plants	4 - 10 plants	> 10 plants	Population defined as a diffuse area (e..g., distance along ROW, trail, other edge). Distinct populations should be defined as having > 100 yards apart from the nearest plants.
Condition	Reproductive Status	Number of individual plants flowering	0 plants	1 - 2 plants	3 - 5 plants	> 6 plants	Typical maximum if 50-75% of total plants in flower.
Condition	Reproductive Status	Number of individual plants fruiting	0 plants	1 - 2 plants	3 - 5 plants	> 6 plants	Flowering plants should be expected to produce fruit. Deer browse can be a critical factor to explain lack of fruit.
Condition	Plant community structure and composition	Mean combined rank of all plant community structure and composition ranks	Mean value: 1 - 1.75	Mean value: 1.76 - 2.9	Mean value: 3.0 - 3.75	Mean value: > 3.75	See "Plant Community Ranking" tab
Landscape Context	Landscape structure and composition	Mean combined rank of all landscape structure and composition ranks	Mean value: 1 - 1.75	Mean value: 1.76 – 2.9	Mean value: 3.0 - 3.75	Mean value: > 3.75	See "Landscape Context Ranking" tab

Future searching guide:

General Recommendations

[redacted]r wood lily might be expected to benefit this species as well.

5) More common species which may indicate suitable habitat include Pycnanthemum incanum, Diervella lonicera, Helianthus divaricatus, Desmodium spp.
6) Soil associated with detected populations are provided in the existing populations table.
These soil types should be given higher searching priority. Generally, species requires slightly richer acid (not extremely poor) soils.

Specific Search Area Recommendations

1) Section 11
1) Section 15
3) Section 16
2) Section 17 [redacted]

Wood Lily (*Lilium philadelphicum var. philadelphicum*)
Plant Community Composition & Structure Ranking Procedure

Indicator (Visual Estimates)	**Poor (1)**	**Fair (2)**	**Good (3)**	**Very Good (4)**	**Possible Treatment Recommendations**	**Notes**
Canopy and Sub-Canopy Cover (%)	>75%	50-74%	25-49%	<25%	*Girdle trees creating most shade*	Species prefers edges and open-canopy woods
Shrub / Sapling Layer Cover (%)	>75%	50-74%	25-49%	<25%	*Cut woody competitors to ground or remove*	Species low-statured, not competitive with woody plants
Invasive Species Cover (%)	> 25%	11-25%	1-5%	Absent	*Remove invasive species within 10 meters radius of plant*	Species thrives with moderate disturbance and some soil richness and may face competition from mugwort (as in Sect. 15 [redacted] and other upland invade
Deer Browse Intensity	Majority of non-ericaceous native woody plants with new sprouts < 1 foot tall.	Majority of non-ericaceous native woody plants with new sprouts 1-2 feet tall.	Majority of non-ericaceous native woody plants with new sprouts 2-3 feet tall.	Majority of non-ericaceous native woody plants with new sprouts greater than 3 feet tall.	*Intensify local deer management*	Radius of 25 meters around occurrence can be evaluated. See Forest Secchi protocols from Van Clef for a rapid evaluation method. Examples of non-ericaceous woody plants suitable for evaluation include oaks, hickory, mapleleaf viburnum, beaked hazelnut, etc. This metric may not be an appropriate barometer in utility ROWs.
% Exposed bedrock or low (<12") cover	Absent	1-5%	11-25%	> 25%	*Controlled burning*	Seeds are small, windborne and wafery. Radicle emergence and bulblet formation precedes above-ground cotyledon by one season. Need for ground contact and some degree of burial is presumed. Assumption is made that bare soil is an advantage for recruitment of new individuals. Also, areas of no or low vegetation around occurrence may reduce cover for voles, a primary predator of lily bulbs. However, occurrences in richer, more mesic habitats were also found, associated with fairly

Wood Lily (*Lilium philadelphicum var. philadelphicum*)
Landscape Context Ranking Procedure

Indicator (Determined via GIS)	**Poor (1)**	**Fair (2)**	**Good (3)**	**Very Good (4)**	**Notes**
Available well-drained open/edge habitat within 0.1 miles from occurrence	< 100 feet	100 - 200 feet	201 - 500 feet	> 500 feet	Greater available habitat provides potential for population growth
Acreage of open-type (edge or sun) primarily native vegetation assemblages	< 0.01 acres	0.01 - 0.1 acres	0.11 - 2 acres	> 2 acres	Species is associated with two "guilds" of native plants. 1 - open glade and meadow-type vegetation with moderately high CC values. 2 - open rich upland forest vegetation with high CC values. (CC = Coefficient of Conservatism)
Visibility from trails / Poaching Access	< 25 feet from trail	25 - 50 feet from trail	50 - 100 feet from trail	> 100 feet from trail	Poaching or picking is of some concern. Populations further from trails are less likely to be incidentally discovered.

Wood Lily (*Lilium philadelphicum var. philadelphicum*)
MDR Site-Specific Species Ranking Procedure

Category	Key Attribute	Indicator	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Size	Species Abundance	Total number of populations	< 4 populations	4 - 5 populations	6 - 10 populations	> 10 populations	6 populations known at MDR, likely others could be discovered
Condition	Population Condition	Mean combined viability ranking of each population	Mean value: 1 1.75	Mean value: 1.76 – 2.9	Mean value: 3.0-3.75	Mean value: > 3.75	Mean of each "individual population ranking" that considers size, condition and landscape context for each population.
Landscape context	Genetic Connectivity	Distance between populations	> 0.50 miles	0.26 - 0.50 miles	0.1 - 0.25 miles	< 0.1 miles	It is assumed that greater genetic communicatoin (via seed dispersal and/or pollinators) between populations will increase vigor. However, a recent study failed to find adverse genetic effects in isolated populations (Horning and Webster, see Reference Notes). Also, species appears to be pollinated by butterflies esp. swallowtails so connectivity should be predicated on typical foraging ranges of primary pollinators.

Wood Lily (*Lilium philadelphicum var. philadelphicum*)
Known Populations at MDR

GPS ID	Section ID	Population Name	Latitude	Longitude	Soil Symbols	Soil Description	Bedrock	Total Stems	Flowering Stems	Current Threats	Notes
[redacted]	11	[redacted]	[redacted]	[redacted]	RomC	Rockaway-Rock outcrop complex, 8 to 15 percent slopes	Pyroxene Granite	3	0	Deer, Poaching	Three plants along [redacted] Section 11
	17				RobCb	Rockaway sandy loam, 8 to 15 percent slopes, very stony	Pyroxene Alaskite	2	1 in fruit	Deer, Poaching	Rich mixed forest within 50' of [redacted]
	15		[redacted]		RomD	Rockaway-Rock outcrop complex, 15 to 25 percent slopes	Quartz-Oligoclase Gneiss	1	0	Deer, Poaching	[redacted] growing on shallow small rock outcropping associated with northern bush honeysuckle, deerberry, black cherry, hawthorn, and whorled loosestrife
	15		[redacted]		RomC	Rockaway-Rock outcrop complex, 8 to 15 percent slopes	Quartz-Oligoclase Gneiss	1	1 in fruit	Deer, Poaching, Cessation of beaver activity, mugwort working northward along trail.	Well-drained but probably moist [redacted] Canopy
	16		[redacted]		HhmCa	Hibernia loam, 3 to 15 percent slopes, stony	Pyroxene Alaskite	2	1 in fruit	Deer, Poaching	[redacted] rences is a southerly slope with mesic, rich upland vegetation. The herbaceous layer and canopy are thick, diverse, and resilient, with light gaps thoroughly colonized by native species. Associates include abundant naked-flowered and pointed-leaved tick trefoil, stoneroot (Collinsonia canadensis), as well as the infrequently-encountered Lowrie's aster (Symphyotrichum lowreanum), poke milkweed, and abundant Laxiflora-type Carex species
	17				HhmBc	Hibernia loam, 0 to 8 percent slopes, extremely stony	Pyroxene Granite	1	0	Deer, Poaching	On [redacted] on a rocky ledge wit [redacted] d fern. Nearby are diverse meadow and glade spp. including hoary mountain mint, wild bergamot, upland boneset, Carolina rose, etc.

Wood Lily (*Lilium philadelphicum var. philadelphicum*)
Literature Notes

Source	Note	GIST
Local Botanists		
Roger Latham, personal communication	Distilled from extensive comments: Population of several dozen (variable #) plants at Pink Hill in cluster. Seem to be distinct individuals (none closer than 15 cm apart). However, rapid turnover in number from year to year and variation in flowering, new stems and old.For example, "Note that roughly one-third of the stems and one-third of the flowers in 2015 were plants not seen in 2014. " Seedlings are inconspicuous. Propagation efforts by Mt Cuba were successful. Possibility that occurence was planted (?)	Possibility of dense occurrence with many stems. Suggests unperceived activity at the bulb level. Propagation from seed possible for recovery of populations and enhancement of genetic variability.
Karl Anderson, personal communication	"I've seen single plants a couple of times, in dry open woods in NJ and NY State. I saw a population of several dozen (?) plants in an open, somewhat damp meadow near Dingmans Ferry, PA, many years ago; the site has since grown up to pine forest, no more lilies. In the Albany Pinebush, It seems to do well in open Sandy areas that are maintained by regular burning; it grows with lupine. I think of it as a meadow plant, not a forest plant."	Populations of several dozen possible in open meadow-type situations
Floras and Habitat Descriptions		
NY State Museum Annual Report - Report of The State Botanist 1902 p 78	Dry woods and thickets	Dry, semi-open habitats
Torrey Botanical Club: Bicknell Ferns and Flowering Plants of Nantucket	Nantucket - plants dwarfed (<12"), "flowers often in pairs, in one case, three together"	Preference for sandy soils.
Flora of the Allegany State Park Region	"In sandy, rocky, or gravelly woodlands, open slopes an benches"	well-drained woodlands and open habitats
Journal of the New York Botanical Garden No. 288 December 1923 "Botanical Observations in Northern Michigan"	Certain species of plants, on the other hand, flourish better after a reasonable amount of forest clearing…. In late June, every railroad track, as it crosses and arbor-vitae bog, is border with hundreds of plants of the wood lily (Lilium philadelphicum). It is quite probable that they have increased a hundred-fold...	Probably var. andinum. Can exist in very large quantities with anthropogenic clearing.
EFFECTS OF FIRE ON THREATENED AND ENDANGERED PLANTS: AN ANNOTATED BIBLIOGRAPHY National Biological Service Information And Technology Report 2	Several rare plant species in the Appalachian region of Kentucky have been found generally on sandy ridges of the southern Cliff Section in native grassy roadside vegetation or young brushy pine-oak (Pinus-Quercus) woods, and almost never in areas with less human disturbance. They include Agalinis decemloba, Aster concolor, Castanea pumila, Cirsium carolinianum, Eryngium yuccifolium, Gymnopogon ambiguus, Helianthus atrorubens, Liatris squarrosa, Lilium philadelphicum, Oenothera perennis,Parthenium integrifolium, Phlox amoena, Polygala polygama, Rhynchosia tomentosa, Robinia hispidavar. rosea, Sanicula marilandica(var. petiolulata), Schwalbea americana(a federally endangered plant species) and Sporobolus clandestinus. Most are concentrated in the southeastern United States, and several are typical of open pine or oak woods with frequent fire. Either these species have invaded roadsides and other disturbed areas after settlement, or they are relicts from openings that were maintained by fire, Indians, and large herbivores before settlement. The latter hypothesis is supported by the virtual absence of these species in recent clearings, suggesting low reproductive rates; some species have disappeared since 1950. Also, there are historical indications that fire did maintain some open pine-oak barrens, together with an associated federally endangered animal--the red-cockaded woodpecker (Picoides borealis).	Puzzle of origin, persistence, and lack of recruitment of relictual prairie-type species. "Either these species have invaded roadsides and other disturbed areas after settlement, or they are relicts from openings that were maintained by fire, Indians, and large herbivores before settlement.";"Virtual absence of these species in recent clearings"
BONAP range map	Best range map	Range primarily northerly and/or mountainous, also tallgrass prairie states (?)
Schneider, Greg. Lilium philadelphicum [Pamphlet]. Ohio Department of Natural Resources	"The var. *philadelphicum* typically occurs in woods and thickets"; " HAZARDS: Overgrowth by woody species as a result of succession" .	Can be succeeded out.
Gleason, H.A., and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. New York Botanical Garden, Bronx, New York.	Ours is var. philadelphicum: habitat is "dry open woods and thickets". As contrasted to var. andinum (Ohio to Minn., B.C. and N.M.): habitat is "in meadows and along shores".	Different range and habitat preferences for varieties.
Wiegand, K. M. and Eames, A.J. *Flora of the Cayuga Lake Basin, New York*. 1926	Dry or rarely damp gravelly or sandy non-calcareous woodlands and banks; frequent	Habitat information.
Hough, Mary. New Jersey Wild Plants.	Native, rare. Scattered throiugh north Jersey; rare on the Coastal Plain. Dry, open soil of woods and shaded edges.	Suggests less of a meadow species, more glades and woodlands.
Rhoads, A.F, and Klein, W.M. Jr., The Vascular Flora of Pennsylvania.	Dry, open woods and barrens. FACU+. Distribution primarily eastward from Appalachians.	
USDA PLANTS database	Listed in at least seven states. FACU in Eastern Mountains and Piedmont.	

Go Botany website.*Lilium philadelphicum*.	"Wood lily is North America's most wide ranging true lily, but it has been declining in the northeast as prairie habitat has disappeared, and as populations of white-tailed deer, that favor it as food, have increased. In New England it is pollinated by tiger swallowtail butterflies". Habitat is: "Anthropogenic (man-made or disturbed habitats), grassland, sandplains and barrens, woodlands "	Deer as threat, and disappearance of prairie-type habitats. Lists anthropogenic habitats and open habitats.
Minnesota Wildflowers website. Lilium philadelphicum.	In any given population, single plants are typically found scattered around the area. Typically 1 to 3 flowers at the top of the stem, occasionally up to 5	Distribution as scattered individuals
Illinois Wildflowers website.	"Each seed capsule has 3 cells, and each cell has 2 columns of flattened seeds. The root system consists of a scaly corm that occasionally forms clonal offsets; the bottom of the corm develops shallow fibrous roots.""Prairie Lily is normally found in high quality natural areas. Occasional disturbance that involves removal of woody vegetation is probably beneficial in maintaining populations of this plant. Because of the showy flowers, it is vulnerable to poaching, like many orchids.""The flowers are cross-pollinated primarily by large butterflies, including swallowtail butterflies (Papilionidae), the Monarch butterfly (Danaus plexippus), and Great Spangled Fritillary (Speyeria cybele). Other floral visitors include the Ruby-throated Hummingbird, hummingbird moths (Hemaris spp.), and Halictid bees. Most of these floral visitors suck nectar from the flowers, although the Halictid bees collect pollen (see Graenicher, 1907; Edwards & Jordan, 1992). Other insects feed destructively on Prairie Lily (Lilium philadelphicum andinum) and other closely related lilies (Lilium spp.). These insects include the introduced Lily Leaf Beetle (Lilioceris lilii), Crescent-marked Lily Aphid (Aulacorthum circumflexum), Purple-spotted Lily Aphid (Macrosiphum lilii), and larvae of the Golden Borer Moth (Papaipema cerina), Burdock Borer Moth (Papaipema cataphracta), and Stalk Borer Moth (Papaipema nebris); see Clark et al. (2004), Cranshaw (2006), Pepper (1965), Panzer et al. (2006), and Natural History Museum (2010). The larvae of these latter moths bore through the stems and corms of lilies. Mammalian herbivores readily consume the foliage of Prairie Lily and other closely related lilies, especially the White-tailed Deer. The corms are also eaten sometimes by voles."	Sometimes forms clonal offsets. Removal of woody vegetation beneficial. Vulnerable to poaching. Pollinator info. Consumed by deer, voles, other herbivores.
Weakley, A. Flora of the Southern and Mid-Atlantic States	*Lilium philadelphicum* Linnaeus *var. philadelphicum*, Wood Lily. Grassy balds, moist to wet meadows (especially in thin soils over rock), open woodlands. June-July; August-October.	"thin soils over rock"
Propagation and Seed Dynamics		
hort.net	Propagation information at https://www.hort.net/lists/prairie/feb99/msg00008.html	Hypogeal multi-stage germinators needing cold pre-treatment for radicle emergence.
Horning, M. and Webster, M. Conservation genetics of remnant Lilium philadelphicum populations in the Mdiwestern United States. Am. Midland Nat.	butterfly pollinated obligate outcrosser. Long-lived perennial. Threat of deer.	Fragmented populations maintained adequate genetic diversity in this study. However, plants are long-lived and most fragmentation occurred in last 150 yrs. Deer listed as threat.
Voles		
Howe, H. Vole herbivory shapes vegetation in experimental tallgrass prairie restorations	Voles consumed as much vegetation as ungulates, but by favor less dominant vegetation they reduced plant diversity by 37%	Voles are threat [inferred]. Less cover around Lily would reduced vole activity due to fear of predation.
Octoraro.com	A 2.5′-3′ diameter of control area is recommended to discourage voles.	
Pollinator		
https://en.wikipedia.org/wiki/Papilio_aristodemus	Schaus' swallowtail is capable of flying as far as 5.8 miles a day	Congener of primary pollinator (i.e. Tiger Swallowtail) ranges up to 5.8 miles per day
http://animaldiversity.org/accounts/Papilio_polyxenes/	Average territory size 70m2	Congener has small territory for males (note not same as foraging range for species)

Bog willow-herb (*Epilobium leptophyllum*)
Individual Population / Element Occurrence Ranking Procedure

Category	Key Attribute	Indicator	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Size	Population size	Total Number of Adult Plants	<5 plants	6-15 plants	16-30 plants	> 30 plants	Populations can be dense or diffuse as along a pond edge. Distinct populations should be defined as having > 100 meters apart from the nearest plants and being along a different waterway.
Condition	Reproductive Status	Number of individual plants flowering and fruiting	<5 plants	6-15 plants	16-30 plants	> 30 plants	Assumed that most plants should be reproductive
Condition	Plant community structure and composition	Mean combined rank of all plant community structure and composition ranks	Mean value: 1 - 1.75	Mean value: 1.76 - 2.9	Mean value: 3.0 - 3.75	Mean value: > 3.75	See "Plant Community Ranking" tab
Landscape Context	Landscape structure and composition	Mean combined rank of all landscape structure and composition ranks	Mean value: 1 - 1.75	Mean value: 1.76 – 2.9	Mean value: 3.0 - 3.75	Mean value: > 3.75	See "Landscape Context Ranking" tab

Future searching guide:

G[redacted]
1
2)
3) More common species which may indicate suitable habitat include Carex stricta, Persicaria sagitatta, Impatiens capensis.
4) Soil associated with detected populations are provided in the existing populations table.
These soil types should be given higher searching priority. Generally, species requires slightly richer acid (but not extremely poor) soils.

Specific Search Area Recommendations
1) Section 12B[redacted]
1) Section 15 ([redacted]ected here but suitable habitat
3) Section 19 ([redacted]
2) Section 17 ([redacted]

Bog willow-herb (*Epilobium leptophyllum*)
Plant Community Composition & Structure Ranking Procedure

Indicator (Visual Estimates)	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Possible Treatment Recommendations	Notes
Canopy and Sub-Canopy Cover (%)	>50%	25-49%	10-24%	<10%	Girdle trees creating most shade. Ideally tree removal is done by beavers.	Species prefers open wetlands
Shrub / Sapling Layer Cover (%)	>75%	50-74%	25-49%	<25%	Cut woody competitors to ground or remove. Cut stump application utilizing glyphosate (50%) may be considered.	Species low-statured, not competitive with woody plants
Phragmites Species Cover (%)	Dense patch present (> 0.25 acres)	Dense patch present (< 0.25 acres)	Scattered / Isolated individual stems only	Absent	Phragmites is particularly threatening as it may grow densely to the exclusion of other species. Ranking categories consider the potential for practical eradication. See Eradication Notes below.	Lythrum salicaria and Typha spp. are also possible threats

Eradication Notes:

General Notes
Wetland application permit required from NJDEP prior to treatment
Strongly consider hiring an experienced contractor familiar with control of Phragmites
Glyphosate is recommended below, but Imazamox is an alternative that can provide better results.

Scattered Individuals
In September, wipe individual stems with a soaked wand connected to backpack sprayer utilizing glyphosate (5%).
This method practically eliminates any non-target impacts when native species are co-occuring with Phragmites.

Dense Patch present (< 0.25 acres)
Cutting - If ground conditions allow, cut existing stems in April/May.

In September, treat via foliar application utilizing glyphosate (5%) with a wetland-approved surfactant.
Plants should be a minimum of 6 feet tall to assure adequate dosing to kill the root system.
Repeat as necessary until all dense patches have been eradicated (may require 2-3 applications to kill all stems)
If scattered individuals remain, see recommendation above.

Dense Patch present (> 0.25 acres)
Consider whether hydrological alterations may be beneficial to reduce Phragmites cover.
Cutting - If ground conditions allow, cut existing stems in April/May.
In September, treat via foliar application utilizing glyphosate (5%) with a wetland-approved surfactant.
Plants should be a minimum of 6 feet tall to assure adequate dosing to kill the root system.
Repeat as necessary until all dense patches have been eradicated (may require 2-3 applications to kill all stems)
If scattered individuals remain, see recommendation above.

Bog willow-herb (*Epilobium leptophyllum*)
Landscape Context Ranking Procedure

Indicator (Determined via GIS)	**Poor (1)**	**Fair (2)**	**Good (3)**	**Very Good (4)**	**Notes**
Available shallow pond edge (level banks), pond hummock, or open wetland habitat	< 0.5 acre	0.6 - 1 acres	1 - 3 acres	> 3 acres	Available habitat provides potential for population growth
Active beaver dams or lodges within same waterbo	absent	present	present	present	Beaver-modified habitats are attested to in literature and characterized all existing populations at Mahlon Dickerson.

Bog willow-herb (*Epilobium leptophyllum*)
MDR Site-Specific Species Ranking Procedure

Category	Key Attribute	Indicator	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Notes
Size	Species Abundance	Total number of populations	< 4 populations	4 - 5 populations	6 - 10 populations	> 10 populations	4 populations known at MDR, likely others could be discovered
Condition	Population Condition	Mean combined viability ranking of each population	Mean value: 1-1.75	Mean value: 1.76 – 2.9	Mean value: 3.0 3.75	Mean value: > 3.75	Mean of each "individual population ranking" that considers size, condition and landscape context for each population.
Landscape context	Genetic Connectivity	Distance between populations	> 0.50 miles	0.26 - 0.50 miles	0.1 - 0.25 miles	< 0.1 miles	Greater genetic communication (via seed dispersal and/or pollinators) between populations assumed to increase vigor.

Bog willow-herb (*Epilobium leptophyllum*)
Known Populations at MDR

GPS ID	Section ID	Population Name	Latitude	Longitude	Soil Symbols	Soil Description	Bedrock	Total Stems	Flowering Stems	Current Threats	Notes
[redacted]	19	[redacted]	[redacted]	[redacted]	FmhAt	Fluvaquents, loamy, 0 to 3 percent slopes, frequently flooded	Pyroxene Granite	2	?	Lythrum, Phragmites	of trail. Two plants found, with Leersia oryzoides, Lycopus virginicus, Persicaria sagitatta, Carex stricta, C lurida, C scoparia, Lythrum salicaria, Galium trifidum
[redacted]	12C	[redacted]	[redacted]	[redacted]	AhcBc	Alden mucky silt loam, gneiss till substratum, 0 to 8 percent slopes, extremely stony	Pyroxene Granite	50+	?	Lythrum, Phragmites	scattered subpopulations numbering up to 30+ individuals. With Carex stricta, Impatiens capensis, Typha latifolia (not dense), Solidago gigantea, Persicaria sagitatta, Mikania scandens, Spiraea tomentosa, Galium trifidum
[redacted]	19B	[redacted]	[redacted]	[redacted]	RkgBb / Waters Edge	Ridgebury loam, 0 to 8 percent slopes, very stony	Pyroxene Granite	15-20	15?	Phragmites	with Carex stricta, C atlantica, C folliculata, Impatiens capensis, Triadenum virginicum. [redacted] shallow beaver pond. Phragmites [redacted] um palustre.

Bog willow-herb (*Epilobium leptophyllum*)
Literature Notes

Source	Note	GIST
Floras and Habitat Descriptions		
https://gobotany.newenglandwild.org/species/epilobium/leptophyllum/	Anthropogenic (man-made or disturbed habitats), bogs, fens, marshes, meadows and fields, swamps, wetland margins (edges of wetlands)	Habitat: wetlands with full sun, some disturbance
http://michiganflora.net/species.aspx?id=1750	Wet ground, including bogs (on mats) and marshes, swamps (cedar, tamarack, or mixed cover, especially on cleared, burned, or otherwise disturbed areas), wet shores and streamsides, sedgy meadows.	Habitat: wetlands with full sun, some disturbance
http://bonap.net/MapGallery/County/Epilobium%20leptophyllum.png	Range is primarily northerly	Northerly range
http://www.fs.fed.us/ne/delaware/ilpin/1193.co	wetland, marsh, bog, sedge meadow, border of lake. Other good technical summary.	Good technical summary
http://explorer.natureserve.org/servlet/NatureServe?searchName=Epilobium+leptophyllum	Listed in at least 9 states. Synonym(s): Epilobium palustre var. gracile	Species is rare in at least nine states
Beaver & Disturbance		
http://vegbank.org/vegbank/views/commconcept_detail.jsp;jsessionid=80E83EEA48DACA785FA498ABF6DEE20C?view=std&wparam=23648&entity=commconcept&params=23648	Name: Sparganium americanum - Epilobium leptophyllum Herbaceous Vegetation; Reference: Southeastern Ecology Working Group; Description: Wet, bog-like areas, with seasonal flooding, especially areas formerly flooded by beavers. Sparganium americanum strongly dominates the dense herb layer. Other species may include Epilobium leptophyllum, Epilobium coloratum, Polygonum punctatum, Potamogeton sp., Ludwigia palustris, and others.	Species is associated with beaver-flooded areas
Plant Community Responses to Prescribed Burning In Wisconsin Sedge Meadows. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.374.7198&rep=rep1&type=pdf	Responded favorably to burning. Occurred preferentially in a flooded field vs. non-flooded. "because litter removal promotes recruitment of shorter-lived forbs, prescribed fire can enhance sedge meadow diversity by allowing plant species with different life histories to temporarily share dominance with the more abundant graminoids"	May be short-lived, disturbance dependent
McMaster & McMaster, Vascular Flora of beaver wetlands in Western Massachusetts	Beavers create diversity through 1. steep hydrological gradients 2. spatial heterogeneity 3. temporal heterogeneity of beaver and flood disturbance. Diversity declines after 20 years unoccupied by beaver. Lythrum and Phrag primary invaders (though not much seen in study sites).	Beaver create ideal conditions for hydric disturbance-dependent forbs
Wright et al. An ecosystem engineer, the beaver, increases species richness at the landscape scale	Ecosystem engineering by beaver leads to the formation of extensive wetland habitat capable of supporting herbaceous plant species not found else- where in the riparian zone. In the central Adirondack region of New York, beaver ponds are relatively short lived habi- tats, and are typically occupied for <10 years... asscoaited meadows can persist for 50 years.	Beaver-modified patches contribuet significantly to landscape scale species diversity, up to 25% of the flora obligate to beaver-altered patches