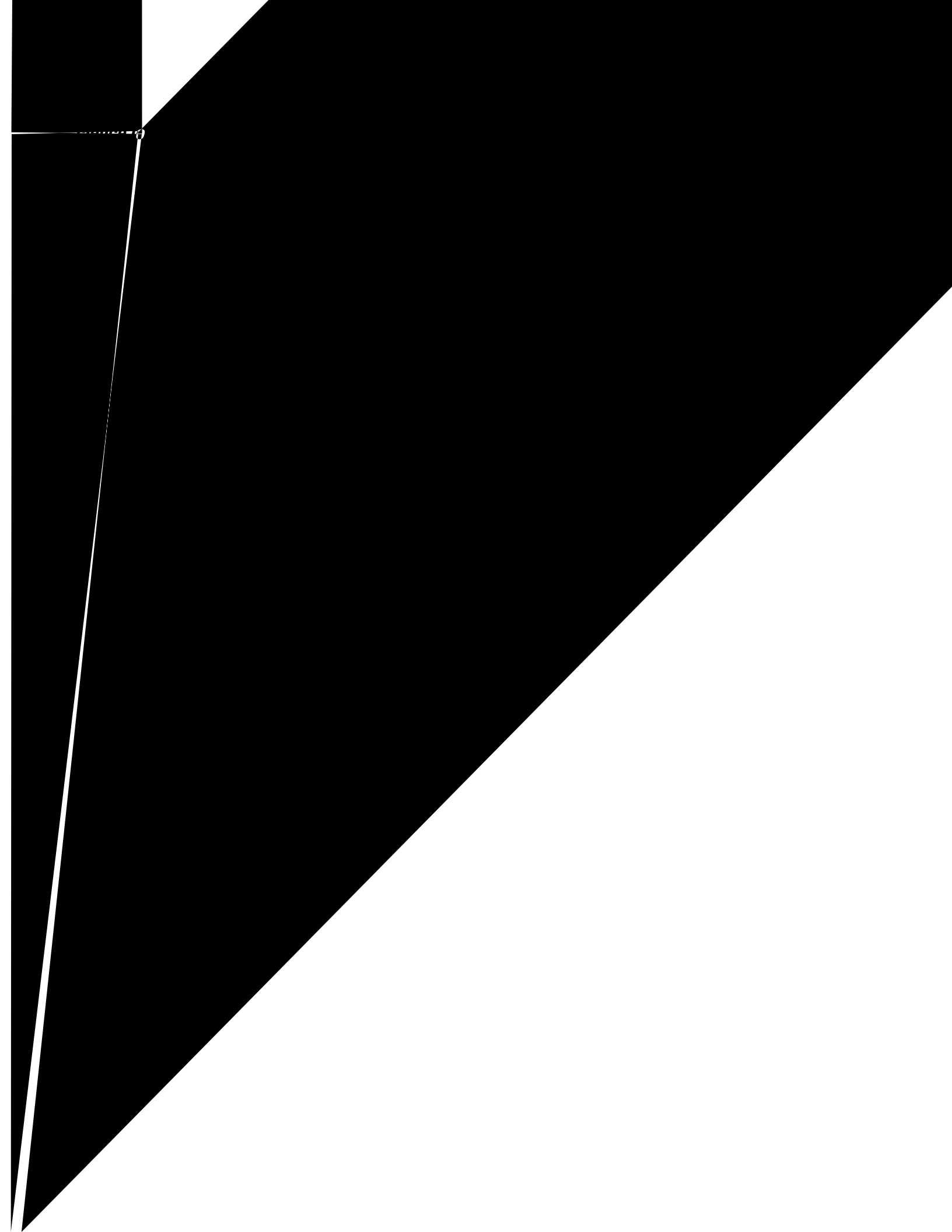


Suggested citation:

Pavlovic, N., K. M. Quinlan, and T. Ford. 2005. Developing rare and exotic plant geographic information system databases for Indiana Dunes and Sleeping Bear Dunes National Lakeshores. Great Lakes Inventory and Monitoring Network Report GLKN/2005/17.

FOIA NOTE

This document contains sensitive rare plant information and maps that are exempt

because of the extensive railroad corridor populations adjacent to the high quality savanna/woodland complex.

In addition to mapping both rare and exotic species, we also genotyped (native/nonnative) *Phragmites australis* plants using morphological characters. We discovered three populations of the native *Phragmites australis* ssp. *americanus* at Indiana Dunes. We recommend that these be protected while the pervasive alien is eradicated. At Sleeping Bear Dunes only the exotic common reed (*Phragmites australis*) was mapped, while the NPS exotic plant management team focused on other invasive plants. The majority of *Phragmites* was the native subspecies. Focused efforts to eliminate the minority alien subspecies should go far to protect the native subspecies in the park.

INTRODUCTION

Problem Statement

Managers of Great Lakes National Parks

In addition to detailed information on rare plants, digital maps of the distributions of non-indigenous invasive species are also becoming available for both INDU and SLBE. For both parks, the maps will be based on distribution interpolation among random sampling points (Klick et al. 1989, Loope and Pavlovic 1998). At INDU, maps currently are being developed of locations of purple loosestrife (*Lythrum salicaria*), garlic mustard (*Alliaria petiolata*), common reed (*Phragmites australis*), black locust (*Robinia pseudoacacia*), Japanese knotweed (*Polygonum cuspidatum*), multiflora rose (*Rosa multiflora*), and dame's rocket (*Hesperis matronalis*). At SLBE, species for which extensive digitized maps exist include leafy spurge (*Euphorbia esula*), purple loosestrife, and garlic mustard. Less detailed maps exist for sweet clover (*Melilotus* spp.) and baby's breath (*Gypsophila paniculata*) (Edwards 1995, Loope et al. 1995, Loope and Siterlet 2000).

Goals and Objectives

1. Map patches of Pitcher's thistle in the dune landscapes of both INDU and SLBE. The methodology was based on previous mapping at INDU and Pictured Rocks National Lakeshore (PIRO) in 1991 (McEachern 1992).
2. Compile information and map locations of populations of rare plants from fieldwork and from paper maps at INDU and SLBE (including Michigan Natural Features Inventory (MNFI) data). Appendices 1 and 2 list high priority species for INDU and SLBE, respectively. We proposed to digitize location data of approximately 35% (50/144) of the state listed species present at INDU, and 60% (12 /20) of the state listed species present at SLBE (further species were added beyond these: 23 SLBE rare and 19 conservative). The minimum goal was to document the occurrence of all federally listed rare species believed to occur within SLBE and INDU, as well as document the occurrence of the highest priority of all state listed rare plant species.

Beyond these two minimum goals, we hoped to fulfill the following objectives:

3. Document the recent occurrence information (reports, studies, databases, voucher specimens, observation cards, etc) for all rare plants believed to be present in each park.
4. Geographically locate and record the GPS coordinates of the populations of rare plants throughout each park with completion levels correlated with political status as shown below:
    - Federal Threatened – all known populations of Pitcher's thistle (complete at INDU and start survey at SLBE)
    - All G2 and G3 ranked species
    - State Endangered – 50% of known populations
    - State Threatened – 25% of known locations
    - Michigan Special Concern – 25% of known locations
    - Indiana Rare – 25%
    - Indiana Watch List – 25%
    - Plants that are locally rare at SLBE, but lack status – 25%
5. Search for some of the potential new plants for SLBE from the list created by Emmet Judziewicz (Appendix 3).
6. Map the patches of emerging and selected established invasive species at INDU and SLBE. Appendix 4 lists those species to be mapped by park. Collect specimens of common reed to identify the origin, native or exotic, of the patches, based on morphological characters.

GIS results may be used to identify areas needing immediate management for rare plants because of the threats from NIPs. The data may also be used to identify further gaps in our knowledge of rare and invasive species.

METHODS

Data collection methods for Pitcher's thistle (*Cirsium pitcheri*) mapping

A data dictionary and supplemental data sheet were created and field checked before mapping began. These were based loosely on data required for the MNFI program, and were taken directly from those used in the rare plant study (below). Locations for populations of Pitcher's thistle were taken from maps generated by A. Kathryn McEachern in 1991, and Dr. Pavlovic provided additional directions when needed.

A thorough search was made for Pitcher's thistle plants at each site. Searches were also conducted in areas near known populations that contained suitable habitat for Pitcher's thistle. Plants were flagged as they were found, and if plants were located in patches, their perimeters were flagged. Plant populations were then mapped using a Trimble GeoExplorer3, as follows. Individual plants were mapped using the "individual" data dictionary, which creates a point feature. Patches of plants smaller than 5 × 5 meters were mapped using the "small patch" data dictionary, which also creates a point feature; several populations larger than 5 × 5 meters were also mapped as small patches. One hundred twenty positions were logged for point features whenever possible. Patches of plants larger than 5 × 5 meters were mapped using the "large patch" data dictionary, which creates a polygon feature. Positions were logged as the data collector walked along the perimeter of the patch while pausing and logging at appropriate locations. A new file was created for each feature mapped. The data dictionary information was gathered while positions were logged when possible, as in point features, or after the positions were logged, as was common for large patches. A data sheet was also filled out for each feature mapped unless the data were identical for more than one feature, in which case they were combined onto one data sheet.

The data dictionary "Cirsium pitcheri.ddf" was used to collect data on Pitcher's thistle populations, in combination with data sheet "INDU/SLBE Rare Plant Study 2003." Data dictionary attributes are defined in Table 1, and data sheet attributes follow. Field procedures for gathering data, when not self-explanatory, are included in the descriptions.

Information on the following attributes was logged on paper data sheets:

Microhabitat: A brief description of the community and environment in which the plant or population is growing, including factors that may favor or limit the plant.

Associates: A list of the species growing in the immediate vicinity of the plant or population, broken into herbaceous, understory/shrub, and overstory/tree layers. Species may be included in more than one layer; for example, the presence of young trees might result in black oak being listed in both the shrub and tree layers. If an associate species could not be identified in the field, a sample was brought back to the office and keyed out. Abundance codes are a measure of how abundant an associate species is in the

community: D (Dominant) indicates a species that dominates all other species, C (Codominant) indicates a species that grows throughout the community but does not dominate, O (Occasional) indicates a species that has several or a few plants scattered throughout the community, and R (Rare) indicates a species that has only one or two plants present. If an associate was an exotic plant, a check was placed in the "Exotic?" column.

Table 1. Description of the data fields in the Pitcher's thistle data dictionary. The fields shown are those created for data collection in large patches, which is the most comprehensive data dictionary.

Field	Type	Description
Date	Date	Generated by the GeoExplorer3
Observers	Text	Enter initials of data collectors
Park	Menu	Choose INDU or SLBE
Slope	Numeric	Enter percent slope as measured with a clinometer
Aspect	Numeric	Enter the direction the slope is facing as measured with a 360 degree compass
Canopy cover	Menu	Choose open, <50%, >50%, or closed
Percent bare soil	Menu	Choose 0-25%, 25%, 25-50%, 50%, 50-75%, 75%, 75-100%, or 100%
Number of plants	Numeric	Enter exact count of plants in population being mapped
Number of adults	Numeric	Enter exact count of adult (flowering) plants in population being mapped
Number of juveniles	Numeric	Enter exact count of juvenile plants in population being mapped
Number of seedlings	Numeric	Enter exact count of seedlings in population being mapped
Dispersion	Menu	Choose scattered individuals, scattered clumps, clumped, or continous (See Figure 1 for definitions of dispersion types)
Vigor	Menu	Choose thriving, surviving, or poor

Disturbances: A brief description of any observable disturbances, natural or human, which could have affected the plant or population.

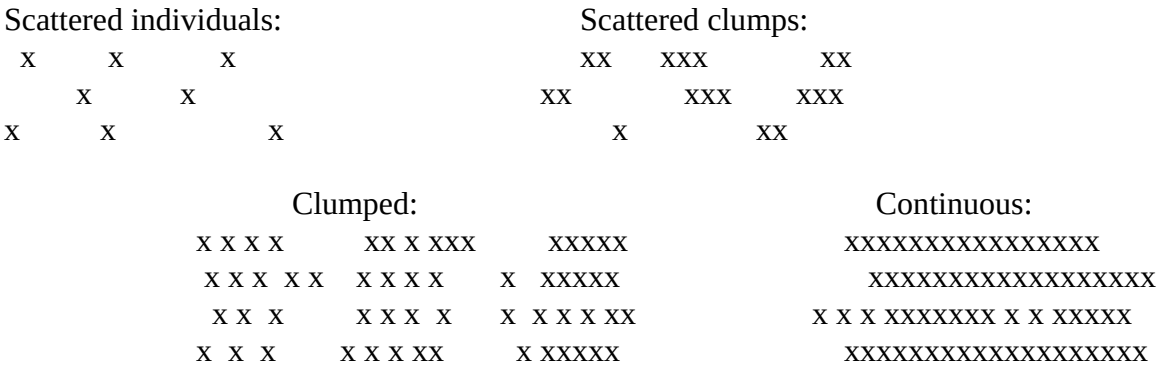
Immediate threats: A brief description of the presence of any factor that may threaten the plant or population in the immediate future.

Long-range threats or management needs: A brief description of the presence of any factor that may threaten the plant or population in the future, and any recommendations for management to ensure the continuing survival of the plant or population.

Additional notes: Anything else that was not described elsewhere in the data dictionary or data sheet.

Files were downloaded into GPS Pathfinder Office upon return from the field, and differentially corrected. Corrected files were viewed and points were edited as necessary. Files were then exported as ArcView shapefiles.

Figure 1. Dispersion of individuals in a population.



A file for one small patch in Cowles Bog could not be corrected, and so was digitized over the digital orthophoto based on a position provided by Quinlan. A second patch was hand digitized over the digital orthrophoto of the Cowles Bog area based on a map and position provided by the NPS Fire Monitoring staff.

Data collection methods for rare plants

A data dictionary and supplemental data sheet were created and field checked before mapping began as described above, under Pitcher's thistle mapping. A list of potential rare plants to be mapped at INDU was made from the file "Induflora2003.sav", a database maintained by Dr. Pavlovic. With assistance from Kim Struthers, GIS Specialist at SLBE, a similar list was generated for that park based on existing information from the MNFI. Priorities were discussed periodically by Dr. Pavlovic, Karen Quinlan, and Tom Ford, as well as with resource management staff from each park, as necessary during the field season. It was clear from the outset of this project that there would not be enough time to map all species on the list.

At INDU, locations for populations of rare plants were determined using several sources, including "Special Vegetation of the Indiana Dunes National Lakeshore" (Wilhelm 1990) and "An Assessment of the Monitoring Program for Special Floristic Elements at INDU" (Bowles et al. 1985, Bowles et al. 1986b, Bowles 1988, 1989). The INDU Sensitive Species Database and accompanying maps were also consulted, and Dr. Pavlovic provided additional directions when needed. At SLBE, Tom Ford was provided location information for many records from the MNFI; however, Tom'0.0002 Tc -0.0st SLs -20.l 178.195 0 T

target plants were located, data were recorded in the same manner as with Pitcher's thistle.

The data dictionary "rare plants.ddf" was used to collect data on rare plant populations, in combination with data sheet "INDU/SLBE Rare Plant Study 2003." Data dictionary attributes are defined in Table 2, and data sheet attributes follow. Field procedures for gathering data, when not self-explanatory, are included in the descriptions.

Upon return from the field, areas searched were marked on INDU 1:2400 base topographic maps, whether the target plant was found or not. If the plant was found, the number of populations mapped was noted on the map.

Table 2. Description of the data fields in the rare plant data dictionary. The fields shown are those created for data collection in large patches, which is the most comprehensive data dictionary.

Field	Type	Description
Date	Date	Generated by the GeoExplorer3
Observers	Text	Enter initials of data collectors
Park	Menu	Choose INDU or SLBE
Species	Text	Enter species name or code
Site	Menu	Choose new (if site has not been mapped previously), or resample (if it has)
Slope	Numeric	Enter percent slope as measured with a clinometer
Aspect	Numeric	Enter the direction the slope is facing as measured with a 360° compass
Canopy cover	Menu	Choose open, <50%, >50%, or closed
Soil type	Menu	Choose sand, gravel, loam, clay, muck, peat, or other
Soil type if other	Text	Enter type of soil if not on list above
Moisture	Menu	Choose dry, moist, wet, saturated, or inundated
Patch length	Numeric	Enter length of patch in meters (usually used only for small patches and smaller large patches)
Patch width	Numeric	Enter width of patch in meters (usually used only for small patches and smaller large patches)
Number of plants	Numeric	Enter exact count of plants in population being mapped if possible, or an estimate if not. If a total number of plants for the population cannot be accurately counted or estimated, the number of plants per square meter may be estimated and entered in the next field; enter 0 in this field if this procedure is followed
Plants m^{-2}	Numeric	Enter estimate after counting plants in representative square meter areas and averaging them
Count method	Menu	Choose estimate or actual count
What counted	Menu	Choose individuals or clumps
Dispersion	Menu	Choose scattered individuals, scattered clumps, clumped, or continous (See Figure 1 for definitions of dispersion types)
% vegetative	Numeric	Enter the percent of the population that is in vegetative form
% flowering	Numeric	Enter the percent of the population that is flowering
% fruiting	Numeric	Enter the percent of the population that is fruiting
Vigor	Menu	Choose thriving, surviving, or poor

Files were downloaded into GPS Pathfinder Office upon return from the field, and differentially corrected. Corrected files were viewed and points were edited as necessary. Files were then exported as ArcView shapefiles.

Seven patches of *Calla palustris* at Pinhook Bog (INDU) could not be accurately mapped because of difficult access; these were digitized over the digital orthophoto, based on various individual, small patch, and the6 populas14n v0patches of

Corrected files were viewed and points were edited as necessary. Files were then exported as ArcView shapefiles.

Evelyn Greiner, the technician working with the Exotic Plant Management Team at INDU, digitized seven large patches of exotics (1 patch of *Celastrus orbiculatus*, 2 patches of *Phalaris arundinacea*, 2 patches of *Polygonum cuspidatum*, 1 patch of *Robinia pseudoacacia*, and 1 patch of *Rosa multiflora*) that could not be recorded using GPS. These were digitized over the appropriate digital orthophotograph.

Table 3. Description of th

Field	Type	Description
Disturbance	Menu	Choose right-of-way, railroad, utility corridor, ORV/road, trail, house site, wind/erosion, animal disturbance, flooding, irrigation/ditching, wildfire, fire suppression, grazing, recreation/visitors, mining/quarries, construction/development, other, or none apparent, to describe past and current disturbance at and around the population
Disturb2	Menu	Same choices as Disturbance to allow for multiple disturbance types
Disturb3	Menu	Same choices as Disturbance to allow for multiple disturbance types

ID number were printed. Printouts were placed into the bags containing the samples after a copy of the sample ID number page was made for the Phragmites folder.

At SLBE, data sheets downloaded from the Phragmites Diagnostic Service web page were used instead of the Phragmites data dictionary. In addition, all *Phragmites* sites were mapped as exotics. An exotic plant data sheet was filled out for each population, containing the GPS file number for the population as well as a unique identifier called Location ID. The Location ID was the File number assigned during sampling using the Phragmites data sheet, and was used to cross-reference the exotics.ddf file with the Phragmites.ddf file. Digital photographs were taken of each population; a CD was created and is on file with the data sheets. Photographs were also sent to Bernd Blossey.

One linear population of *Phragmites australis* in Tremont (INDU) could not be completely mapped due to abberant satellite reception and receiver behavior, and so was completed by digitizing it over the digital orthophoto.

Table 4. Description of the data fields in the *Phragmites* data dictionary.

Field	Type	Description
Date	Date	Generated by the GeoExplorer3
Site name	Menu	Choose Cowles Bog, Inland Marsh, Keiser Woods, Miller Woods, Pinhook Bog, Tolleston, West Beach, or other
Site if other	Text	Enter site name if not on list above
Sample number	Numeric	Enter sequential numbers for each site name
Habitat	Menu	Choose floating mat, marsh, swamp, fen, spring, bog, pond, lakeshore, upland, along stream/creek, roadside ditch, agricultural field, or other
Habitat if other	Text	Enter habitat type if not on list above
Growing conditions	Menu	Choose permanently flooded, periodically flooded, tidal, or rarely flooded

groupings: aspect, slope, canopy cover, soil type, soil moisture, patch area, number of plants, dispersion, vigor, and disturbance. Since the data taken for canopy cover, soil type, soil moisture, dispersion, vigor, and disturbance were descriptive rather than quantitative, they were transformed into numeric codes for entry into PC-ORD. A cluster analysis was also performed on the rare plant populations for each park, using the

RESULTS

Pitcher's thistle (*Cirsium pitcheri*)

All previously known and several new populations of Pitcher's thistle at INDU were located and their locations recorded using GPS (Appendix 6 - 1). A total of 6536 plants were found and mapped in 205 populations of three feature types: individuals (> 5 m from any other plant), small patches (< 5 × 5 m), and large patches (> 5 × 5m). Table 5 shows the distribution of adult (flowering), juvenile (vegetative), and seedling (first year) plants across the three features. A total of 828 adult plants, 3624 juveniles, and 2084 seedlings were mapped. Fifty-eight of the features mapped were single plants; of these, 17 were adults, 39 were juveniles, and 2 were seedlings. Forty-seven small patches were mapped, containing 157 plants: 35 adults, 100 juveniles, and 22 seedlings. Two small patches were digitized, but the plants within them were counted and included in the above summaries. One hundred large patches were mapped, containing 6321 plants: 776 adults, 3485 juveniles, and 2060 seedlings. Mean patch size was 384 m^2, with a range from 1 m^2 to 20,376 m^2 (Table 6). Most of the patches were smaller than 400 m^2, and contained fewer than 100 plants (Figure 2). The number of plants in a patch was strongly correlated with the size of the patch ($r = 0.809$, $P < 0.01$). The largest patch represents a different methodology, where the entire blowout was mapped as a single population regardless of the distance between plants; all other geographical areas were mapped according to the definitions of individuals, small patches, and large patches outlined in the methods section.

The ordination diagram for rare plants mapped at INDU showing communities delineated by cluster analysis (Figure 3) includes the populations of Pitcher's thistle

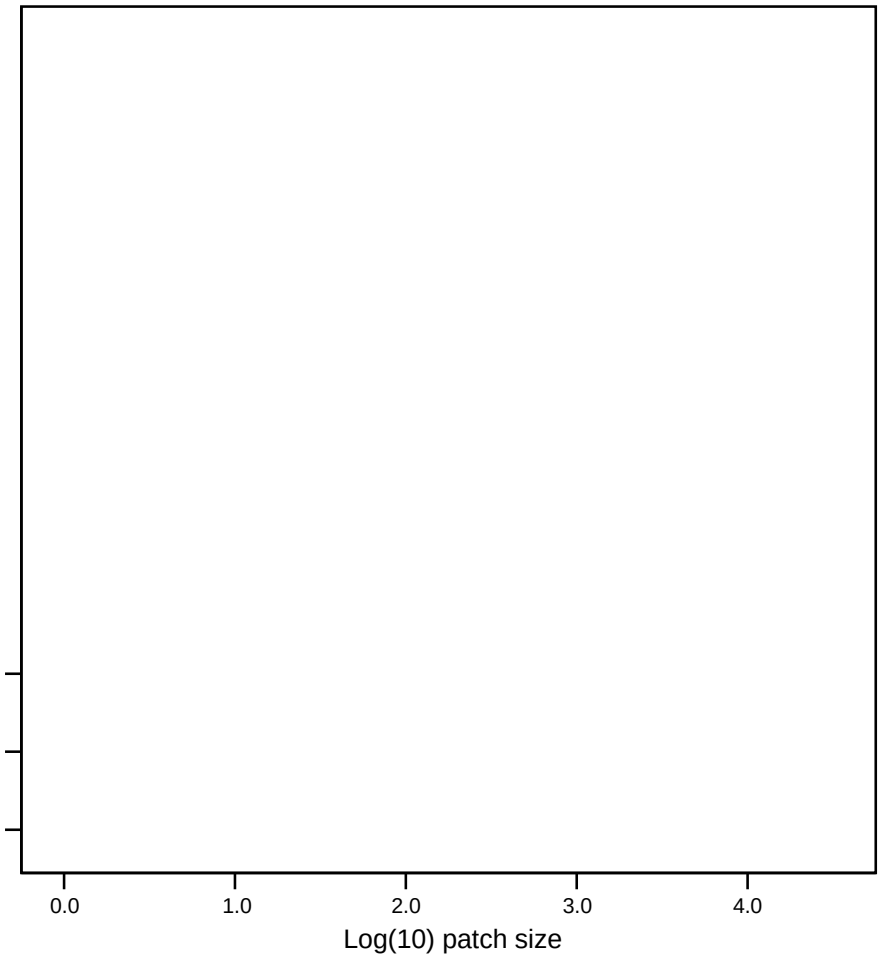
Table 5. INDU Pitcher's thistle summary statistics.

		Size classes			
Feature name	Statistics	adults	juveniles	seedlings	Total
Individual	Number in size class	17	39	2	58
Small patch	Size class means ± 1 SE	1 ± 0.13	2 ± 0.22	0	3
(n=47)	Size class range	0-3	0-6	0-6	2-15

Table 6. INDU Pitcher's thistle patch size summary statistics.

Feature	Number of patches	Mean patch size (m^2)

Figure 2. Distribution of Pitcher's thistle patch sizes at Indiana Dunes National Lakeshore.



The abundance classification scheme and scale that will be used is a modification of the methodology used by McEachern (McEachern 1992); densities will be converted to abundance classes based on the plot size.

Abundance class	Density (20x20m subplot)	Density (40x40m plot)
Absent	0 plants	0 plants
Rare	1 plant	<4 plants
Common	2 - 4 plants	4 - 16 plants
Abundant	> 4 plants	>16 plants

Abundance classes will then be color coded for display on maps of dune landscapes. This will allow managers to compare data from previous Pitcher's thistle studies, and to compare population dynamics from Pitcher's thistle data collected at INDU in 2003. SLBE's data will be shared with Dr. Pavlovic to help produce a more accurate model for determining Pitcher's thistle population dynamics.

Once Pitcher's thistle and invasive plants data have been collected, abundance polygons will be developed, using the Park's GIS, to demarcate the most abundant Pitcher's thistle and non-native plant zones. This information will provide a direct approach for rare and invasive plants management by targeting the overlapping areas that have abundant populations of both. In addition, the 2003 data on the location of MI threatened dune plants will be incorporated. This approach will maximize conservation of the park's rare resources throughout the 2,209 hectares of Lakeshore dunes by directing invasive plants management and visitor usage.

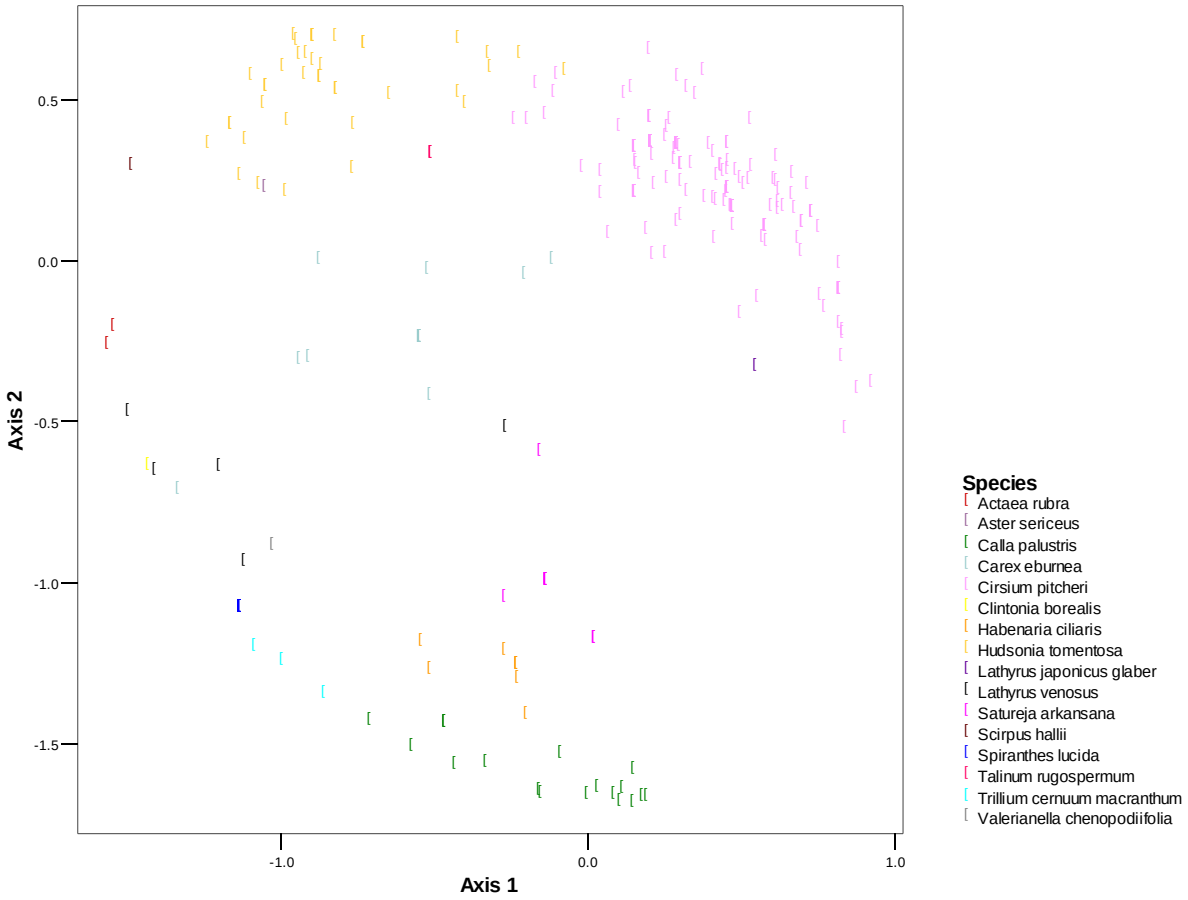
Rare plants

At INDU, 16 rare plant species (approximately 11% of the state-listed plants known to occur in the Park) were mapped (Table 7 and Appendix 6-2). An estimated total of 58,123 plants were mapped in 126 populations (Table 8). Mapped entities ranged in size from single plants to patches containing between 9 and 29,115 plants. Mean population size ranged from 2 to 29,115 plants, with a mean of 493 plants over the 126 populations mapped. For species with more than one population mapped, mean population size was between 2 and 365 plants with high variation for all species. The number of plants in most populations was counted as described in the Methods section, which ensured highly accurate results. However, several patches were so large that it was impractical to count individual plants across the entire population. In these cases, the number of plants in the patch was estimat

Table 8. INDU rare plant summary statistics, excluding Pitcher's thistle. Numbers of populations in bold font include populations in which the plant count is not known. Mean, standard deviation, smallest and largest population, and total number of plants for these species were calculated based on the number of populations where the plant count is known. The number of populations lacking counts are given in parentheses.

Species	Number of populations	Mean population size	Standard deviation	Smallest population	Largest population	Total number of plants
Actaea rubra (Ait.) Willd.	2	10	12.7	1	19	20
Aster sericeus Vent.	1	29,115	.	29,115	29,115	29,115
Calla palustris L.	**25** (17)	13	14.6	1	50	217
Carex eburnea Boott	18	210	262.2	9	907	3,778
Clintonia borealis (Ait.) Raf.	1	42	.	42	42	42
Habenaria ciliaris (L.) R. Br. ex Ait. f.	7	2	1.9	1	6	17
Hudsonia tomentosa Nutt.	40	365	1,534.9	1	9,662	14,610
Lathyrus japonicus Willd. var. *glaber* (Ser.) Fern.	1	2,989	.	2,989	2,989	2,989
Lathyrus venosus Muhl. ex Willd.	5	37	38.8	10	100	186
Phlox bifida Beck	2	250	70.7	200	300	500
Satureja arkansana (Nutt.) Briq.	8	139	348.2	1	1,000	1,113
Scirpus hallii Gray	1	4,930	-	4,930	4,930	4,930
Spiranthes lucida (H.H. Eat.) Ames	10	5	5.6	1	19	47
Talinum rugospermum Holz.	2	29	6.4	24	33	57
Trillium cernuum L. var. *macranthum* Eames & Wieg.	3	13	15.9	1	31	39

Figure 3. Ordination diagram for rare plant populations mapped in 2003 at Indiana Dunes National Lakeshore, showing species.



Of the habitat variables for which data were taken, soil moisture had the strongest relationship to the clustering of communities in the ordination; soil type was also important. Canopy cover and slope were less important (Figure 4). The sand mine and successional dune communities clustered at the dry end of the soil moisture gradient, as well as the end of the soil type gradient that represented sand. The foredune community was grouped more loosely near the dry sand ends of the soil moisture and soil type gradients. The sphagnum bog, moat, and

Table 9. Communities delineated by cluster analysis at Indiana Dunes National Lakeshore. The number of populations of rare species are shown for each community, as are the associate species with mean abundances ≥1. Prefixes before the species name in the associate column identify the strata where the species were found: H = herb layer, S = shrub layer, T = tree layer.

Community	Rare species	Number of populations	Associate species	Mean abundance

Number-9le.4T6 re 9le.4T6nr3speciociate species with mean abundances

Community	Rare species	Number of populations	Associate species	Mean abundance
Homesite	*Spiranthes lucida* (H. H. Eaton) Ames	10	H *Scirpus acutus* Muhl.	4.0
			H *Salix* L.	3.0
			H *Carex* L.	3.0
			H *Scirpus cyperinus* (L.) Kunth	3.0
			H *Carex lacustris* Willd.	3.0
			H *Eleocharis* R. Br.	3.0

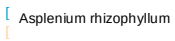
Table 10. Populations of rare plants threatened by human or animal disturbance at Indiana Dunes National Lakeshore.

At SLBE, 23 rare species were mapped (Appendix 6-3). One, *Mimulus glabratus* var. *michiganensis*, is federally endangered, eleven are state listed (representing 61% of the state-listed plants known to occur in the Park), four were SLBE rare, six were listed as conservative, and one was on the list created by Emmet Judziewicz of species may occur in the park. Table 11 shows the number of populations for each species, and the mean number of plants per population. Three populations that were missing GPS data, and therefore do not appear on the map, were included in the summary statistics: one each of *Asplenium rhizophyllum*, *Orobanche fasciculata*, and *Panax quinquefolius*. Although previously known populations of *Cypripedium arietinum*, *Mimulus glabratus* var. *michiganensis*, *Panax quinquefolius*, and

Table 11. SLBE rare plant summary statistics.

Species	Number of populations	Mean population size	Standard deviation	Smallest population	Largest population	Total number of plants
Asplenium rhizophyllum L.	9	140	119.8	9	300	1,262
Bartonia virginica (L.) B.S.P.	2					

Figure 5. Ordination diagram for rare plant populations mapped in 2003 at Sleeping Bear Dunes National Lakeshore, showing species.



Eleven distinct communities were delineated by the cluster analysis, five of which were variations of the northern hardwood forest type (see Table 12 for species composition of the eleven communities). Many of the species' placements in ordination space were closely related to the community clusters. For example, *Bromus pumpellianus* and *Orobanche fasiclulata* grouped exclusively in the open dune community, and *Triphora trianthophora* grouped exclusively in the oak-aspen community. *Eleocharis rostellata* and *Muhlengergia glomerata* grouped exclusively in the sedge mat community. *Platanthera blephariglottis* grouped exclusively in the sphagnum bog (SphagBog) community. All but two populations of *Cypripedium reginae* grouped in the cedar-tamarack swamp (CTSwamp); the lack of *Larix laricina* (tamarack) as an associate caused the other two populations to group in the cedar swamp-northern hardwoods community (CSwamp/ti00rae grouped ssiand *Triphora trianthophora*

Table 12. Communities delineated by cluster

Community	Rare species	Number of populations	Associate species	Mean abundance
TypicNH	*Botrychium campestre* W.H. Wagner & Farrar	2	H *Aralia nudicaulis* L. T *Acer saccharum* Marsh.	3.4 3.3

Community	Rare species	Number of populations	Associate species	Mean abundance
CoastFor	*Cypripedium arietinum* Ait. f.	20	T *Pinus banksiana* Lamb.	2.9
			T *Thuja occidentalis* L.	2.6
			T *Quercus rubra* L.	1.7
			S *Prunus virginiana* L.	1.5
			S *Arctostaphylos uva-ursi* (L.) Spreng var. *coactilis* Fern. & Macbr.	1.5
			H *Smilacina stellata* (L.) Desf.	1.4
			H *Zigadenus glaucus* Nutt.	1.3
			H *Taraxacum officinale* Weber	1.2
			S *Pinus banksiana* Lamb.	1.2
			T *Abies balsamea* (L.) P. Mill.	1.1
			H *Poa compressa* L.	1.0
			S *Toxicodendron radicans* (L.) Kuntze	1.0
			T *Pinus strobus* L.	1.0
CTSwamp	*Cypripedium reginae* Walt.	11	T *Thuja occidentalis* L.	3.7
	Sarracenia purpurea L.	5	T *Larix laricina* (Du Roi) K.Koch	2.6
			H *Thelypteris palustris* Schott	2.4
			H *Equisetum arvense* L.	1.6
			S *Alnus rugosa* (Du Roi) Spreng.	1.4
			H *Maianthemum canadense* Desf.	1.2
			S *Larix laricina* (Du Roi) K.Koch	1.1
			S *Toxicodendron radicans* (L.) Kuntze	1.1

Community	Rare species	Number of populations	Associate species	Mean abundance

Of the habitat data taken, canopy cover had the strongest relationship to the clustering of communities in the ordination; soil moisture was less important (Figure 6). The open dune and Sphagnum bog communities clustered at the low end of the canopy cover gradient, the oak-aspen and sedge mat communities grouped at its mid-range, and the northern hardwood-giant cedar community clustered at the high end; all the other communities were spread among these extremes. The cedar swamp-northern hardwoods, cedar-tamarack swamp, and sedge mat communities spread across the high end of the soil moisture gradient, the sphagnum bog community clustered at its mid-range, and the open dune and oak-aspen communities spread across its low end.

Several threats to populations of rare plants were noted (Table 13), although these threats were not as great as those at INDU. Several populations had hiking trails passing directly through them, and many others were either adjacent to or within a few meters of trails. These were often rogue trails, e.g. to one of the populations of

Figure 6. Ordination diagram for rare plant populations mapped in 2003 at Sleeping Bear Dunes National Lakeshore, showing communities delineated by cluster analysis and habitat variables influencing their grouping.

Table 13. Populations of rare plants threatened by human or

Exotic Plants

At INDU, 335 populations of exotic plants we

pseudoacacia, and *Rosa multiflora*, and 2 *Phalaris arundinacea* patches. These populations that lacked counts were not included in the analysis; this resulted in an artificially low estimate for the total number of plants for these species.

At SLBE, exotics were mapped by the Exotic Plant Management Team. Common reed was the only exotic plant species of which we recorded GPS coordinates for this project; results are presented in the next section. Two new exotics to the Park were seen and photographed: *Datura stramonium* and *Lamium galeobdolon* (Appendix 7).

Table 15. INDU exotic plant summary statistics. Numbers of populations in bold font include populations with zero values for number of plants. Mean, standard deviation, smallest and largest population, and total number of plants for these species were calculated based on the number of populations excluding the zero values (in parentheses).

Species	Number of populations	Mean population size	Standard deviation	Smallest population	Largest population	Total number of plants
Alliaria petiolata (Bieb.) Cavera & Grande	45	942	1,793.6	1	10,000	42,372
Celastrus orbiculatus Thunb.	**13** (12)	1,683	3,702.2	1	10,001	21,874
Centaurea maculosa auct. non Lam.	204	563	2,443.1	1	32,485	114,870

Common reed (*Phragmites australis*) sampling

At INDU, specimens from 27 patches of common reed were sent to the Phragmites Diagnostic Service web page. Four patches were determined to

Once we have obtained the population size data from 1991, we will perform a geospatial analysis of Pitcher's thistle patches on the dune landscape. We want to know how many patches have been extirpated, how many are new, and how many have remained generally the same of the 12 year period. These kinds of staitistics are important for the restoration and conservation of Pitcher's thistle metapopulations.

Carex eburnea, a species more common in the northern hardwoods region, was found primarily in jack pine stands, a later successional community within the sand dune complex. It was common at the limited sites in which it was found. At INDU, it is known to occur in several kinds of habitats, including low sand ridges, mesic sand forests on high dunes, and the edge of a panne (Bowles et al. 1985, Swink and Wilhelm 1994).

Calla palustris, Habenaria ciliaris, Satureja arkansana, and *Spiranthes lucida* were all

butterfly and other species. This species is now expanding along the NIPSCO right of way from the South Shore Train line tracks in the East Unit.

Despite the ubiquity of nonindigenous *Phragmites australis* (Cav.) Trin. ex Steud. in the wetlands of the park, a small percentage was found to consist of native genotypes. *Phragmites australis* subsp. *americanus* Saltonstall, P.M. Peterson & Soreng populations should not be eradicated (Saltonstall et al. 2004); however, they should be monitored to document whether they are aggressive. Now that the North American genotype has been elevated to the species level, some states are considering listing it as being endangered or threatened.

Sleeping Bear Dunes National Lakeshore

Based on data taken at 341 populations of rare plants at SLBE, some generalizations may be made about the populations and habitat specificity of the species that were mapped. *Bromus pumpellianus* and *Orobanche fasciculata* were found only on open dunes, in dry sand with no overstory canopy. The range of both species in Michigan is restricted to the shore of the lake,

Berula erecta, *Mimulus glabratus* var. *michiganensis*, and *Platanthera obtusata* were found only in cedar swamps and wet northern hardwood forests dominated by *Thuja occidentalis*, on wet to inundated soils under a partial canopy. *Berula erecta* populations were found in inundated sand and clay soils. This species usually occurs in calcareous soils, in cold streams, marshes, and tamarack swamps (Voss 1985), and at SLBE is known from springs (Hazlett 1991). *Mimulus glabratus michiganensis* grew in inundated sand. This species occurs in calcareous soils in marly springs, cold streams through cedar swamps, shores, and associated ditches (Voss 1996), and at SLBE is known from shore habitats (Hazlett 1991) . *Plantanthera obtusata* grew in wet loam soils. This species occurs in coniferous swamps and woods, boggy spots in mixed woods, and coniferous bog borders (Voss 1972), and at SLBE is known from cedar swamps (Hazlett 1991).

All populations of *Bartonia virginica* and *Trillium cernuum* var. *macranthum*, and all but one population of *Medeola virginiana* were found in mesic northern hardwood communities dominated by *Acer rubrum*. *Berula virginica* populations were found in wet peat soils atspwoods, boggy

and at SLBE has been known from rich northern hardwoods, particularly a grove known as "Giant Cedars" on South Manitou Island (Hazlett 1991).

The two populations of *Botrychium campestre* occurred in *Acer saccharum-Fraxinus americana* (white ash) dominated northern hardwoods on a perched dune, on moist sand under a fuller partial canopy. This species occurs in prairies, dunes, grassy railroad sidings, and fields over limestone (Flora of North America Editorial Committee 1993), and has been known from perched dunes at SLBE (Hazlett 1991).

Populations of *Panax quinquefolius* and *Polystichum lonchitis* were found in three distinct northern hardwood communities: a northern hardwood-giant cedar community dominated by *Acer saccharum*, a typical northern hardwood community dominated by *Acer saccharum* and *Fraxinus americana*, and a young northern hardwood community dominated by *Acer saccharum* and *Fagus grandifolia*. All populations of both species grew in moist sand under greater than 50% canopy cover, regardless of which northern hardwood community they were found in, with the exception of four populations of *P. quinquefolius* that were found in dry sand in the typical northern hardwood community. *Panax quinquefolius* occurs in rich even swampy forests throughout the state (Voss 1985). *Polystichum lonchitis* occurs mostly in boreal and subalpine forests or alpine regions, in rock crevices or at the base of boulders (Flora of North America Editorial Committee 1993). Both species are known to occur in rich hardwoods at SLBE (Hazlett 1991).

Datura stramonium (Jimson-weed) and *Lamium galeobdolon* (yellow archangel) are new to the Park. *Datura stramonium* is an annual that thrives in cultivated fields and waste places; it is probably of American origin, and has become widespread across the United States and into southern Canada (Muenscher 1955, Gleason and Cronquist 1991, Voss 1996). It is distributed in

REFERENCES

Albert, D. A. 1992. A survey of lakes, streams, and wetlands of the Sleeping Bear Dunes National Lakeshore. Michigan Natural Features Inventory, Lansing.

Bowles, M. L. 1988. A report on special floristic elements at the Indiana Dunes National Lakeshore: New species monitoring and update of selected existing populations. The Morton Arboretum, Lisle, IL.

Bowles, M. L. 1989. A status report on endangered and threatened plants of the Indiana Dunes National Lakeshore: Monitoring of species new to the Lakeshore and re-monitoring of selected species. The Morton Arboretum, Lisle, IL.

Bowles, M. L., M. M. DeMauro, N. B. Pavlovic, and R. D. Hiebert. 1990. Effects of anthropogenic disturbances on endangered and threatened plants at the Indiana Dunes National Lakeshore. Natural Areas Journal 13:164-176.

Bowles, M. L., W. J. Hess, and M. M. DeMauro. 1985. An assessment of the monitoring program for special floristic elements at the Indiana Dunes National Lakeshore: Phase I. The endangered species. The Morton Arboretum, Lisle, IL.

Bowles, M. L., W. J. Hess, and M. M. DeMauro. 1986a. An assessment of the monitoring program for special floristic elements at the Indiana Dunes National Lakeshore: Phase II. The threatened and special concern species. The Morton Arboretum, Lisle, IL.

Bowles, M. L., W. J. Hess, M. M. DeMauro, and R. D. Hiebert. 1986b. Endangered plant inventory and monitoring strategies at Indiana Dunes National Lakeshore. Natural Areas Journal 6:18-26.

BrookJ0.0008 P0Td.15Aent

Herman, K. D., L. A. Masters, M. R. Penskar, A. A. Reznicek, G. S. Wilhelm, and W. W. Brodowicz. 1996. Floristic quality assessment with wetland categories and computer

Swink, F., and G. Wilhelm. 1994. Plants of the Chicago Region, 4th Edition edition. Indiana Academy of Sciences, Indianapolis.

USDA NRCS. 2004. The PLANTS database, Version 3.5 (http:\\plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, accessed January 6, 2005. *in*.

Voss, E. G. 1972. Michigan Flora: A Guide to the Identification and Occurrence of the Native and Naturalized Seed-Plants of the State. Part I. Gymnosperms and Monocots. Cranbrook Institute of Science and University of Michigan Herbarium, Bloomfield Hills, MI.

Voss, E. G. 1985. Michigan flora: A guide to the identification and occurrence of the native and naturalized seed-plants of the state. Part II. Dicots (Saururaceae-Cornaceae). Cranbrook Institute of Science and University of Michigan Herbarium, Bloomfield Hills, MI.

Voss, E. G. 1996. Michigan Flora: A Guide to the Identification and Occurrence of the Native and Naturalized Seed-Plants of the State. Part III. Dicots (Pyrolaceae-Compositae). Cranbrook Institute of Science and University of Michigan Herbarium, Bloomfield Hills, MI.

Wilhelm, G. S. 1990. Special vegetation of the Indiana Dunes National Lakeshore. Indiana Dunes National Lakeshore Research Program Report 90-02, Second edition. National Park Service, Department of Interior, Omaha, Nebraska.

Species	State Status	TNC Global Rank	TNC State Rank	Search	Map & GIS
Habenaria psycodes (L.) Spreng.	Rare	G5	S2		
Hemicarpha drummondii Nees	Extirpated	G4G5	SX		

Species	State Status	TNC Global Rank	TNC State Rank	Search	Map & GIS
Poa paludigena Fern. & Weig.	Watch List	G3	S3		X
Polygala paucifolia Willd.	Endangered	G5	S1	X	X
Polygonella articulata (L.) Meisn.	Rare	G5	S2		
Polygonum careyi Olney	Threatened	G4	S2		

Species	State Status	TNC Global Rank	TNC State Rank	Search	Map & GIS
Talinum rugospermum Holzinger	Threatened	G3G4	S2	X	X
Thuja occidentalis L.	Endangered	G5	S1		Done
Trichostema dichotomum L.	Rare	G5	S2		
Trillium cernuum var. *macranthum* Wieg.	Endangered	G5T4T5	S1	X	X
Utricularia cornuta Michx.					

Appendix 2. Michigan Federal, state, rare and conservative species for which surveys were proposed to be conducted at Sleeping Bear Dunes National Lakeshore. See Appendix 1 for an explaination of column headings.

Species	Status	TNC Global Rank	TNC State Rank	Search	Map
Megalodonta beckii (Torr. ex Spreng.) Greene	SLBE rare			X	X
Mimulus glabratus Kunth var. *fremontii* (Benth.) A.L. Grant	SLBE rare			X	X
Mimulus glabratus Kunth var. *michiganensis* (Pennell) Fassett	Federal endangered	G5T1	S1	X?	Done
Muhlenbergia glomerata (Willd.) Trin.	conservative species			X	X
Ophioglossum vulgatum L.	Michigan threatened	G5	S1	X	X
Orobanche fasciculata Nutt.	Michigan threatened	G4	S2	X?	X
Panax quinquefolius L.	Michigan threatened	G3G4	S2S3	X?	Done
Picea glauca (Moench) Voss	SLBE rare			X	X
Platanthera blephariglottis (Willd.) Lindl.	conservative species			X	X
Platanthera dilatata (Pursh) Lindl. ex Beck	conservative species			X	X
Platanthera obtusata (Banks ex Pursh) Lindl.	conservative species			X	X
Pogonia ophioglossoides (L.) Ker-Gawl.	SLBE rare			X	X
Polystichum lonchitis (L.) Roth	SLBE rare			X	X
Potamogeton oakesianus J.W. Robbins	SLBE rare			X	X
Potamogeton robbinsii Oakes	conservative species			X	X
Pterospora andromedea Nutt.	Michigan threatened	G5	S2	X?	X
Ranunculus longirostris Godr.	SLBE rare			X	X
Ranunculus reptans L.	SLBE rare			X	X
Rhynchospora capillacea Torr.	conservative species			X	X
Ribes hudsonianum Richards.	conservative species			X	X
Sarracenia purpurea L.	conservative species			X	X
Scheuchzeria palustris L.	conservative species	G5T1T2	S1	X	X
Selaginella rupestris (L.) Spring	SLBE rare			X	X
Sparganium fluctuans (Morong) B.L. Robins.	conservative species			X	X
Spiraea alba Du Roi	SLBE rare			X	X
Spirodela polyrhiza (L.) Schleiden	SLBE rare			X	X
Taxus canadensis Marsh.	SLBE rare			X	X
Thalictrum dasycarpum Fisch. & Avé-Lall.	SLBE rare			X	X
Thelypteris hexagonoptera (Michx.) Weatherby	SLBE rare			X	X
Thelypteris noveboracensis (L.) Nieuwl.	new to Mainland				
Trillium cernuum var. *macranthum* Wieg.	SLBE rare	G5T4			
Trillium flexipes Raf.	SLBE rare			X	X

Species	Status	TNC Global Rank	TNC State Rank	Search	Map
Triphora trianthophora (Sw.) Rydb.	Michigan threatened	G3G4	S1	X?	Done
Utricularia intermedia Hayne	conservative species			X	X

TNC Ranks:

Global: G1=critically imperiled globally, G2=imperiled globally, G3=globally rare or uncommon, G4=globally widespread and apparently secure, G5=globally widespread and secure.

State: S1=critically imperiled in state, S2=imperiled in state, S3=rare or uncommon in state, S4=widespread and apparently secure in state, S5=widespread and secure in state.

Appendix 3. List of plants that may possibly occur at SLBE and INDU by Emmet Judiewitz.

Family	Species	Habitat	Park Status
Aceraceae	*Acer platanoides*		

Family	Species	Habitat	Park Status
Asteraceae	*Solidago ohioense*	Wetland	Unconfirmed
Asteraceae	*Solidago patula*	Conifer swamp	Present in Park
Asteraceae	*Sonchus asper*	Exotic	Unconfirmed
Asteraceae	*Symphyotrichum boreale*	Wetland	Unconfirmed
Asteraceae	*Symphyotrichum cordifolium*	Woodland	Unconfirmed
Asteraceae	*Tanacetum bipinnatum* ssp. *huronense*	Dunes	Unconfirmed
Asteraceae	*Tanacetum vulgare*	Exotic	Unconfirmed
Asteraceae	*Taraxacum laevigatum*	Exotic	Unconfirmed
Asteraceae	*Xanthium strumarium*	Dunes	Unconfirmed
Balsaminaceae	*Impatiens pallida*	Mesic Forest	Unconfirmed
Berberidaceae	*Berberis thunbergii*	Exotic	Unconfirmed
Berberidaceae	*Berberis vulgaris*	Exotic	Unconfirmed
Betulaceae	*C reh*		

Family	Species	Habitat	Park Status
Celastraceae	*Euonymus fortunei*	Exotic	Unconfirmed
Chenopodiaceae	*Chenopodium glaucum*	Exotic	Unconfirmed
Chenopodiaceae	*Chenopodium simplex*	Woodland	Unconfirmed
Chenopodiaceae	*Corispermum hyssopifolium*	Dunes	Present in Park
Chenopodiaceae	*Salsola tragus*	Dunes	Unconfirmed
Cistaceae	*Lechea intermedia*	Dunes	Unconfirmed
Clusiaceae	*Hypericum ascyron*	Wetland	Unconfirmed
Clusiaceae	*Hypericum boreale*	Wetland	Unconfirmed
Clusiaceae	*Hypericum prolificum*	Woodland	Unconfirmed
Convolvulaceae	*Calystegia spithamaea*	Woodland	Unconfirmed
Crassulaceae	*Penthorum sedoides*	Wetland	Unconfirmed
Crassulaceae	*Sedum sarmentosum*	Exotic	Unconfirmed
Cucurbitaceae	*Echinocystis lobata*	Wetland	Unconfirmed
Cuscutaceae	*Cuscuta cephalanthi*	Wetland	Unconfirmed
Cuscutaceae	*Cuscuta gronovii*	Woodland	Unconfirmed
Cyperaceae	*Carex albursina*	Mesic Forest	Present in Park

Me

Family	Species	Habitat	Park Status
Fabaceae	*Desmodium glutinosum*	Woodland	Unconfirmed
Fabaceae	*Gleditsia triacanthos*	Exotic	Unconfirmed
Fabaceae	*Lathyrus ochroleucus*	Woodland	Unconfirmed
Fabaceae	*Lathyrus tuberosus*	Exotic	Unconfirmed
Fabaceae	*Lespedeza cuneata*		Unconfirmed
Fabaceae	*Robinia hispida*	Exotic	Unconfirmed
Fabaceae	*Vicia americana*	Woodland	Present in Park
Fabaceae	*Vicia cracca*	Exotic	Present in Park
Fagaceae	*Quercus macrocarpa*	Woodland	Unconfirmed
Gentianaceae	*Gentianopsis crinita*	Wetland	Unconfirmed
Geraniaceae	*Geranium bicknellii*	Woodland	
Geraniaceae	*Geranium maculatum*	Mesic Forest	Present in Park
Geraniaceae	*Geranium pusillum*	Exotic	
Geraniaceae	*Geranium pyrenaicum*		Unconfirmed
Geraniaceae	*Geranium sanguineum*		Unconfirmed
Grossulariaceae	*Ribes lacustre*	Conifer swamp	Unconfirmed
Grossulariaceae	*Ribes rubrum*	Exotic	Unconfirmed
Haloragaceae			

Family	Species	Habitat	Park Status
Linaceae	*Linum perenne*	Exotic	Unconfirmed
Linaceae	*Linum sulcatum*		

Family	Species	Habitat	Park Status
Polygonaceae	*Polygonum douglasii*	Dunes	Unconfirmed
Polygonaceae	*Polygonum lapathifolium*	Wetland	Unconfirmed
Polygonaceae	*Polygonum pensylvanicum*	Wetland	Unconfirmed
Polygonaceae	*Polygonum scandens*	Woodland	Unconfirmed
Polygonaceae	*Rheum rhabarbarum*	Exotic	Unconfirmed
Portulacaceae	*Claytonia virginica*	Mesic Forest	Probably Present
Potamogetonaceae	*Potamogeton alpinus*	Aquatic	Probably Present
Potamogetonaceae	*Potamogeton epihydrus*	Aquatic	Probably Present
Potamogetonaceae	*Potamogeton perfoliatus*	Aquatic	Present in Park
Potamogetonaceae	*Potamogeton pusillus* var. *tenuissimus*	Aquatic	Unconfirmed
Potamogetonaceae	*Potamogeton vaginatus*	Aquatic	Probably Present
Primulaceae	*Lysimachia nummularia*	Exotic	Unconfirmed
Primulaceae	*Lysimachia punctata*	Exotic	Unconfirmed
Ranunculaceae	*Ranunculus flabellaris*	Aquatic	Unconfirmed
Ranunculaceae	*Ranunculus hispidus*	Wetland	Unconfirmed
Ranunculaceae	*Ranunculus repens*	Exotic	Unconfirmed
Rhamnaceae	*Frangula alnus*	Exotic	Unconfirmed
Rhamnaceae	*Rhamnus alnifolia*	Conifer swamp	Unconfirmed
Rhamnaceae	*Rhamnus carthartica*	Exotic	
Rosaceae	*Agrimonia striata*	Woodland	Unconfirmed
Rosaceae	*Amelanchier stolonifera*		Unconfirmed
Rosaceae	*Chaenomeles speciosa*	Exotic	Unconfirmed
Rosaceae	*Crataegus flabellata*	Woodland	Unconfirmed
Rosaceae	*Crataegus intricata*	Woodland	Unconfirmed
Rosaceae	*Crataegus pedicellata*	Woodland	Unconfirmed
Rosaceae	*Filipendula rubra*	Exotic	Unconfirmed
Rosaceae	*Geum macrophyllum*	Exotic	Present in Park
Rosaceae	*Malus sylvestris*	Exotic	Unconfirmed
Rosaceae	*Physocarpus opulifolius*	Wetland	Unconfirmed
Rosaceae	*Potentilla arguta*	Dunes	Present in Park
Rosaceae	*Potentilla inclinata*	Exotic	Unconfirmed
Rosaceae			

Family	Species	Habitat	Park Status
Rubiaceae	*Galium labradoricum*	Wetland	Unconfirmed
Rubiaceae	*Galium trifidum*	Wetland	Unconfirmed
Rutaceae	*Zanthoxylum americanum*		

Appendix 4. Proposed target alien plants that were to be mapped by park. Only *Phragmites australis* was mapped at SLBE since the Exotic Plant Management Team (EPMT) mapped exotics. At INDU, the technician worked closely with the EPMT program to coordinate and assist both projects.

Park	Species	Common Name	Notes	Season
INDU	*Alliaria petiolata* (M. Bieb.) Cavers & Grande	Garlic mustard	West Unit first	May
	Celastrus orbiculatus Thunb.	Oriental bittersweet	West Unit first	

ng Association (NAWMA) Mapping
Data Form, and the National Park

					NPS-NR Data Template Optional Fields	Office Variables	Field Variables
						X	
	Contac hone		Phone #			X	
	Regio					X	
	I&M N work					X	
	State					X	
	Count		County			X	

Location: Survey Unit		Quad Number				X	
		Quad Name				X	
		Survey Location				X	
Location: Weed Populations		Quad Number				X	
		Quad Name				X	
		Survey Location	Township, range, section			X	
	Hydrological Unit Code#					X	
Plant Information		Site number	Source code	LocationID		X	X
				RecordID			X
					Shape	X	
					Area	X	
					Name	X	
	Genus/Species		Species				X
		Intraspecific name	Species				X
	Authority		Species			X	
		Common name				X	X
	Plant code					X	
	Infested area		Habitat extent				X
		Gross area	Proportion of habitat occupied by species				X
	Canopy cover						X
	Density of stems		Total number of individuals				X
		Life form				X	
Category	NAWMA Required Fields	NAWMA Optional Fields	MNFI Fields	NPS-NR Data Template Required Fields	NPS-NR Data Template Optional Fields	Office Variables	Field Variables
		Species status				X	

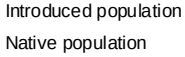
		Priority Species for Management				X	
	Ecological Status of Site						X
		Weed Distribution Throughout Site					X

					AccNotes		X
					Elevation		X
					Aspect		X
					Slope		X
					Notes		X
Site Environment	Vegetation Classification	Optional				X	X
					Description		X
	Dominant Associated Vegetation	Optional					X
			Associates				X
	Habitat type	Optional					X
			Microhabitat				X
	Seral stage	Optional					X
	Disturbance	Optional	Disturbance				X
	Elevation	Optional					X
	Aspect	Optional					X
	Slope	Optional					X
	% slope	Optional					X
	Soil type	Optional	Soil type				X
			pH				X
			Litter depth				X
			Organic content				X
			Light				X
			Moisture				X
	Landform	Optional					X

Category	NAWMA Required Fields	NAWMA

				EventID (tbl*project*Events)			X
					ObsInits		X
					TempC		X
					Wind		X
					Rain		X
					Clouds		X
					Noise		X

Appendix 6. Maps

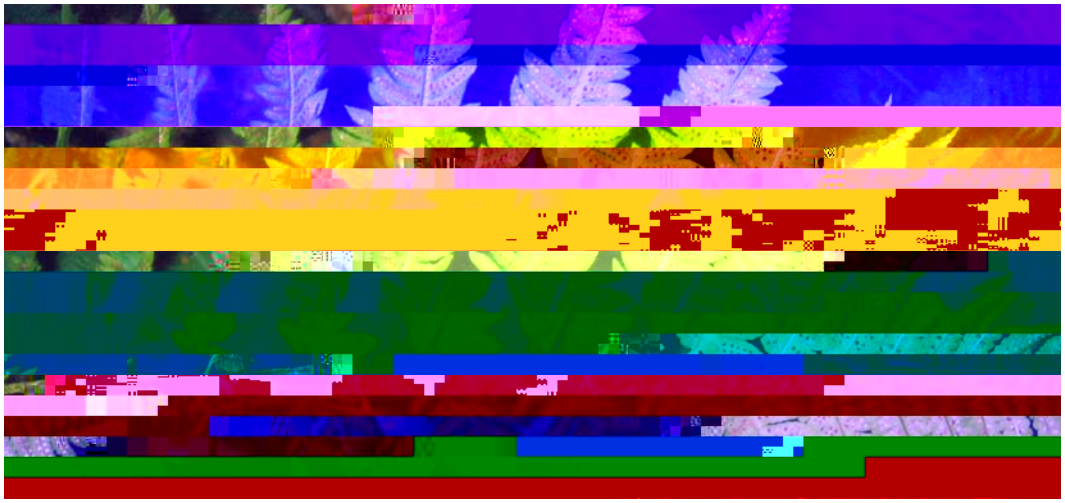

Introduced population
Native population

Introduced population

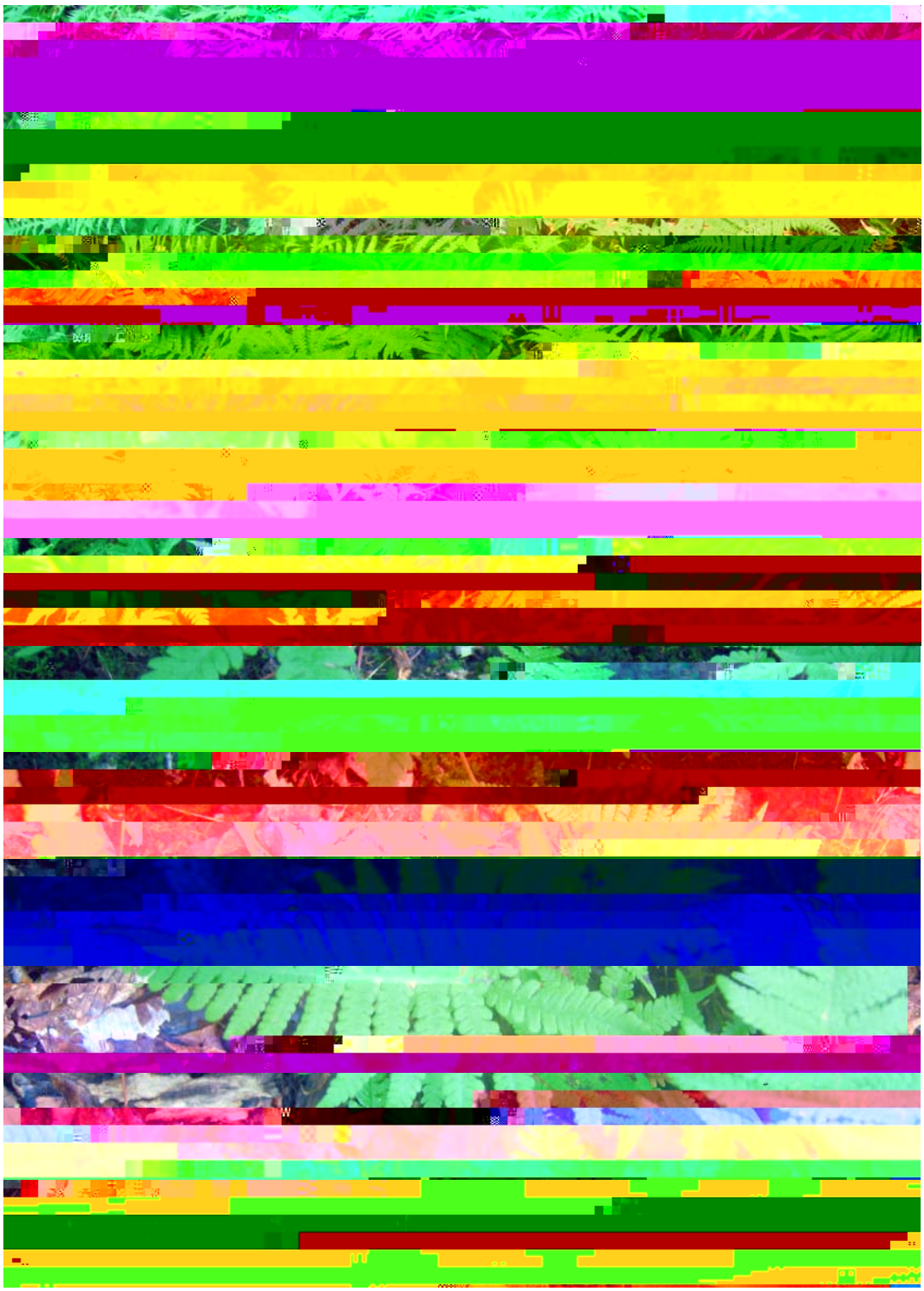
Native population

Appendix 7. Voucher photographs for new ferns to SLBE.

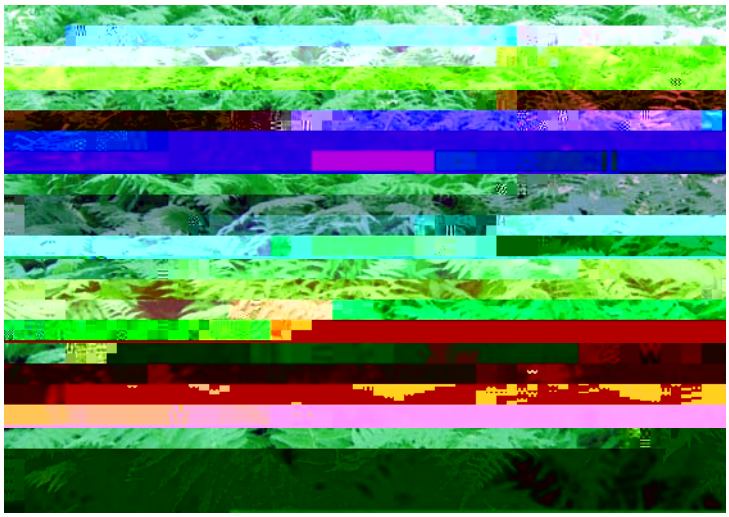
Dryopteris goldiana (Hook. Ex Goldie) A. Gray – Goldie's woodfern

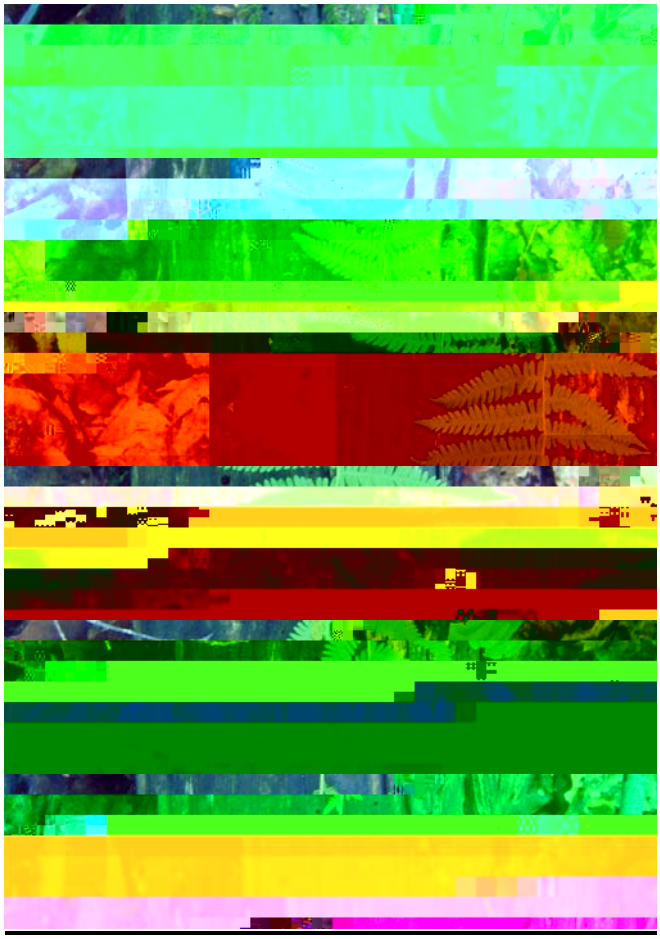


Phegopteris connectilis (Michx.) Watt – long beechfern



Thelypteris noveboracensis (L.) Nieuwl. – New York fern





Appendix 8. Voucher photographs for new exotic populations found at SLBE.

Datura stramonium L. – Jimson weed