U. S. Fish and Wildlife Service

Recovery Plan for the Pitcher's Thistle (*Cirsium pitcheri*)

PITCHER'S THISTLE

(*Cirsium pitcheri*)

RECOVERY PLAN

Prepared by

The Pitcher's Thistle Recovery Team

for

Region 3
U.S. Fish and Wildlife Service
Fort Snelling, Minnesota

Approved: Charlie Wooley
Regional Director, U.S. Fish and Wildlife Service

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EXECUTIVE SUMMARY

Current Status: Pitcher's thistle is listed as threatened by State and Federal governments. There are 173 known occurrences found in Michigan (90%), Indiana (5%) and Wisconsin (5%). Pitcher's thistle needs open Great Lakes sand dune habitat subject to natural disturbance processes. Its survival is threatened by shoreline development, dune stabilization, recreation, and invasive non-native plants and insects.

Habitat Requirements: Pitcher's thistle is endemic to the unforested dune systems of the western Great Lakes and requires active sand dune processes to maintain its early successional habitat. The highest ranked occurrences are on large, intact, active dunes. Pitcher's thistle is vulnerable to habitat loss by human development, construction, recreation, and by erosion when lake levels are high.

Recovery Objective: Delisting.

Recovery Strategy: Protect and manage occurrences and habitat.

Recovery Criteria: Delisting can occur when: 1) the essential habitat associated with a total of **115** priority occurrences representing each biogeographic region and dune type is protected and managed under a management plan for each management unit; 2) regular field surveys to verify occurrences and record new occurrences have been established; 3) landowner contacts have been initiated and protection has been investigated for the remaining (rank<BC) public and private occurrences; 4) monitoring of known sites shows a stable or increasing trend toward recovery, and that protective plans are being implemented; 5) restoration of two occurrences from among historical sites where sufficient habitat remains in Illinois, Indiana, Wisconsin, and southern Lower Michigan has been completed, and 6) research necessary to protect, manage and restore Pitcher's thistle has been conducted.

Actions Needed:

1. Protect and manage known occurrences and essential habitat.
1. Establish and conduct regular field surveys to verify known and record new occurrences.
3. Inform the public, recreationists, public land managers and private landowners.
4. Monitor occurrences for stable or increasing trends and implementation of protective plans.
5. Restore Pitcher's thistle populations on two appropriate sites within its historical range.
6. Conduct research necessary for protection, management and restoration.

Estimated Cost of Recovery ($ 000's)

Year	*Task 1*	*Task2*	*Task 3*	*Task 4*	*Task 5*	*Task 6*	*Total*
2003	113	26	26	78	92	164	499
2004	132	26	26	78	99	196	557
2005	132	26	26	78	99	189	550
2006	108	26	26	78	92	189	519
2007	108	26	26	78	92	189	519
2008	108	26	26	78	20	65	323
2009	108	26	26	78	20	65	323
2010	108	26	26	78	0	0	238
2011	108	26	26	78	0	0	238
2012	108	26	26	78	0	0	238
2013	108	26	26	78	0	0	238
2014	108	26	26	78	0	0	238
Total	1,349	312	312	936	514	1,057	4,480

Date of Recovery: Delisting should be initiated in 2014 if recovery criteria are met.

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I. Introduction

The Pitcher's thistle (*Cirsium pitcheri* (Eaton) Torrey & Gray, Asteraceae) is one of many rare or declining species inhabiting dunes of the Great Lakes region. Other species include dwarf lake iris (*Iris lacustris* Nutt.), Houghton's goldenrod (*Solidago houghtonii* A. Gray), piping plover (*Charadrius melodus* Ord.), and the Lake Huron locust *(Trimerotropis huroniana*). The number of dune species across different trophic levels exhibiting similar downward trends is a signal that the dune ecosystem is being affected by our management or lack of it. Knowledge of the larger dune ecosystem which influences the species' habitat and survival must be incorporated in recovery planning and implementation for the Pitcher's thistle.

Pitcher's thistle was proposed for listing as threatened under the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531-1544), in July 1987 (USFWS 1987) and listed as threatened in July 1988 (USFWS 1988). The Pitcher's thistle has been assigned a recovery priority of 8C indicating a moderate threat, a high recovery potential, and conflict with construction or other forms of economic activity. The species is classified as threatened in Canada (Keddy 1988). At the State level, it is listed as threatened in Indiana, Michigan, Wisconsin and Illinois. The species is extirpated in Illinois.

A. Description

This distinctive dune plant (Figure 1), often referred to as the dune thistle, was first noted by Dr. Zina Pitcher about 1827 at the Grand Sable Dunes of the Upper Peninsula of Michigan. The species was first described by Eaton (1829) as *Cnicus pitcheri* from the type specimen which was apparently collected in 1827 on or near Mackinac Island by Dr. Edwin James (Voss 1996). Pitcher's thistle is a monocarpic (flowers and sets seed only once), perennial, herbaceous plant, generally flowering after a 5-8 year juvenile stage (Loveless 1984). The stems and leaves of juveniles and adults are woolly-white, and the leaves are deeply pinnatifid with the lobes less than 1 centimeter (cm) wide and up to 4 cm long. Minute spines are concentrated along the edge of the leaf at its base, with a few spines between the lobes of the distal leaf margins. The flowering stems are up to 1 meter (m) tall and have several to a dozen widely scattered leaves. Individuals typically have a single branching flowering stem with terminal and axillary flowering heads of a cream or pinkish color. Juveniles and adults have a taproot that may reach 2 m in length (McEachern and Pavlovic pers. obs.).

B. Taxonomy and Genetics

Several hypotheses have been proposed for the origin of *Cirsium pitcheri*. Moore and Frankton (1963) suggested that *C. pitcheri, C. canescens* Nutt. (Platte thistle of

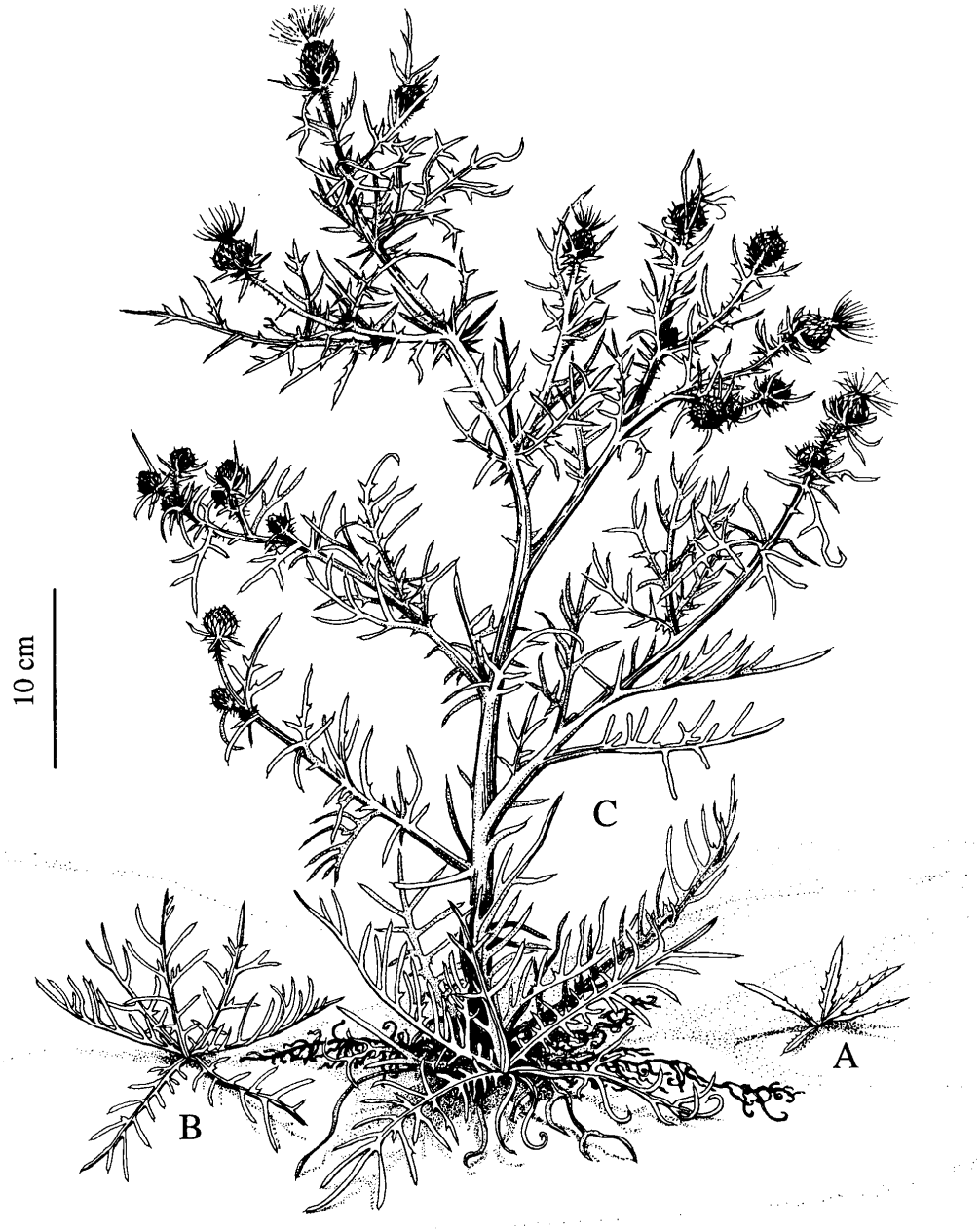

Figure 1. ***Cirsium pitcheri*** **(Eaton) Torrey & Gray**, A - seedling, B - juvenile, C - adult

Nebraska, Wyoming, Colorado, and South Dakota), and *C. canovirons* (Rydb.) Petrak (a more western species) originated from a common ancestor. They proposed that *C. pitcheri* originated in the Great Plains and dispersed to its present range through sandy habitats created by Wisconsin glacial meltwaters. Pitcher's thistle could have originated as a small population or from a single seed of *C. canescens* during the late Pleistocene (> 10,000 years ago) or Holocene (< 10,000 years ago)(Johnson and Iltis 1963). The closely related *C. canescens* and *C. pitcheri* have similar morphological, chromosomal, and ecological characters. Both species are members of the section Onotrophe, subsection Acanthopyta, and series Undulata of the *Cirsium* genus, and have the same primitive chromosome base number (n=17) (Moore and Frankton 1963, Ownbey and Hsi 1963). The two species grow on sandy soils, have white or cream-colored flowers, have white-tomentose leaves, and are monocarpic perennials (Johnson and Iltis 1963, Ownbey and Hsi 1963).

Genetic evidence suggests *C. pitcheri* originated directly from *C. canescens* (Loveless and Hamrick 1988). Starch gel electrophoresis was run on samples collected from 21 *C. pitcheri* and 16 *C. canescens* populations throughout their ranges. *Cirsium pitcheri* was found to be a genetically depauperate relative of *C. canescens* based on proportion of polymorphic loci, mean proportion of polymorphic loci per population, mean number of alleles per polymorphic locus, observed heterozygosity, and expected heterozygosity. The low values of these statistics demonstrate a low genetic diversity for Pitcher's thistle. All alleles in *C. pitcheri* were a subset of those of *C. canescens* and both species showed the same banding patterns for all loci. Only 4 out of 14 loci were polymorphic in *C. pitcheri* compared to 9 out of 10 for *C. canescens*. The observed differences in heterozygosity between the two species was statistically significant.

Pitcher's thistle populations were divided into five geographic groups and compared using Nei's genetic identity statistic. The groups were southern Lower Michigan, northern Lower Michigan, Straits of Mackinac, Upper Michigan, and Wisconsin (Loveless and Hamrick 1988). The northern populations were more similar to the southern populations than to the Straits of Mackinac populations. This differentiation was found to be due to variation in the EST locus and is consistent with the purported geographical isolation of the Straits populations from the mainland during the Lake Chippewa/Nipissing stages (respectively 10,000 years and 5-4,000 years before present (Hansel et al. 1985)). Considering all populations, the greater their geographic separation, the less similar they are genetically. These slight genetic differences suggest that recovery should include the preservation of occurrences by region and especially those in the Straits of Mackinac region.

A study of random amplified polymorphic DNA (RAPD) of Pitcher's thistle in the southern Lake Michigan Basin noted greater variation than revealed by the Loveless and Hamrick data (Kayri Havens, Chicago Botanical Garden, pers. comm.). She found that all sites sampled were significantly different in genetic variation except for two sites at

Warren Dunes Michigan. Samples within states (MI, IN and WI) were more similar than among states. Interestingly, variation in herbarium specimens collected in Illinois prior to extirpation in that state was more similar to Wisconsin plants. Despite this, Wisconsin plants at an Illinois Beach State Park restoration site had reduced vigor and survivorship of (Bowles and Bell 1998). These new data strengthen the importance of genetic criteria when conducting Pitcher's thistle restoration and reintroduction.

C. Distribution

Pitcher's thistle (*Cirsium pitcheri*) is endemic to the beaches and grassland dunes of Lakes Michigan, Superior, and Huron (Guire and Voss 1963). The majority of known sites of *Cirsium pitcheri* occur along the shores of Lake Michigan (Figure 2). The species ranges from the north shore of Lake Superior south to Indiana, and formerly occurred in northern Illinois, where it is has been experimentally reintroduced (Bowles et al. 1993; Bowles and McBride 1993, 1994; Bowles and Bell 1998). Distribution of the species extends along the Lake Michigan shoreline in Wisconsin. In the east it ranges through northern Lake Huron to the Manitoulin Island archipelago and southern Georgian Bay in Ontario. Pitcher's thistle extends as far south as Lambton County, Ontario, Canada on Lake Huron, as indicated by pre-1964 collections for two localities (White et al. 1983).

Pitcher's thistle occurrences are distributed along the Great Lakes dunes. However, individual Pitcher's thistle populations have not been delineated because available inventory information is insufficient to identify boundaries of separate populations. For instance, while progressing along a dune one may encounter a group, or patch, of Pitcher's thistle plants, followed by an unoccupied gap, followed by additional groups of plants, then gaps, and so on. Some groups of plants may contain hundreds of individuals, while others contain less than a dozen. In this context, element occurrences are recorded by State natural heritage programs. The data are specific locations (township, range, section and quarter section) where Pitcher's thistles were found. Maps of occurrences neither imply a completed survey for all Pitcher's thistle populations and plants, nor circumscribe the total potential habitat adjacent to the mapped population(s) on that dune system. Because mapped occurrences do not imply the identification of biological populations, we will use the term occurrence in this plan to identify the basic locations where Pitcher's thistle occurs. For the purposes of this recovery plan, an **occurrence** of Pitcher's thistle is defined as all Pitcher's thistle in an area within approximately one mile of each other, and at least one mile from the nearest Pitcher's thistle which would be part of another occurrence. Within one occurrence, two individual plants may be greater than one mile apart, but would have other Pitcher's thistle between them making the nearest neighbor distance less than one mile.

Occurrence data are not equally complete or current for all the states. Indiana data are from 1990-1991 (McEachern 1992; Cloyce Hedge, Division of Nature Preserves

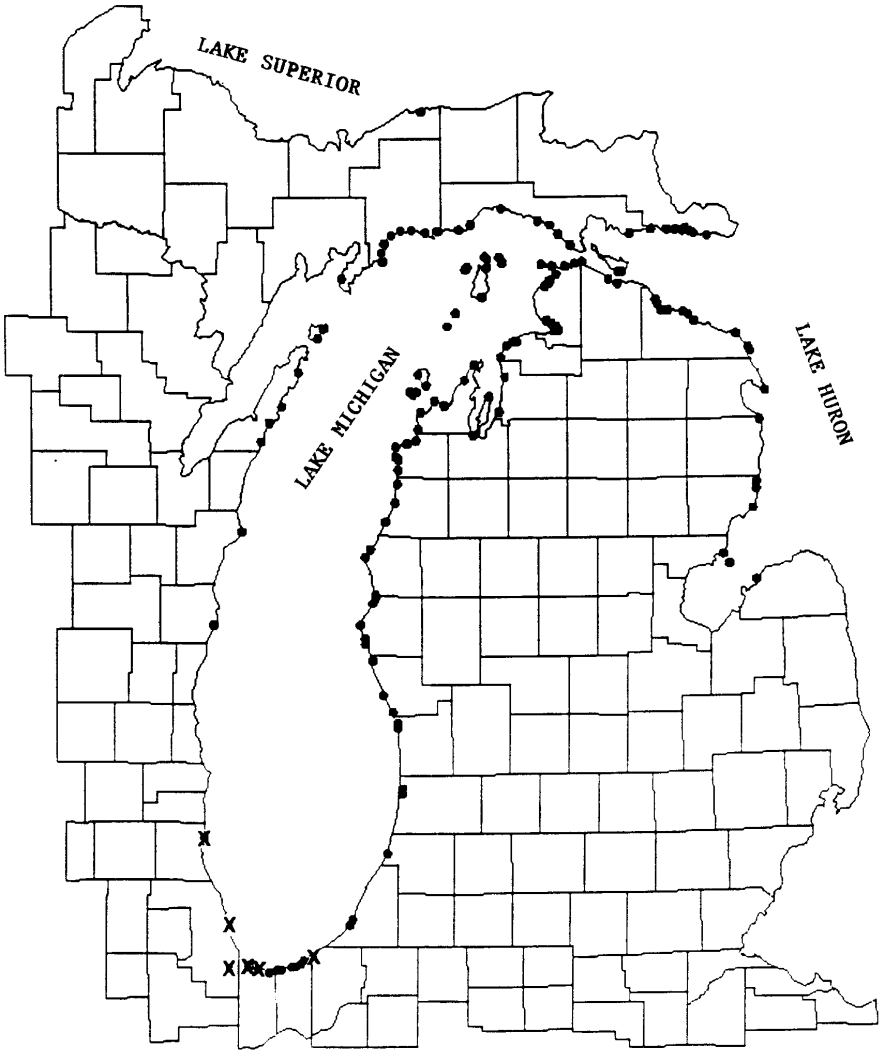

Figure 2. Distribution of *Cirsium pitcheri* in the United States. X marks known extirpated populations.

Indiana Department of Natural Resources, pers. comm.), Wisconsin data are from 1987 and 2001 (Dobberpuhl and Gibson 1987; Darcy Kind, Wisconsin Department of Natural Resources, pers. comm. 2001) and Canada data are from 1988 (Keddy 1988). Since Pitcher's thistle is extirpated from Illinois, occurrences are based on herbarium collections only. Most recent Michigan data are from 2001. Some Michigan sites have not been surveyed since the late 1800's and 1911, but the majority (142 out of 156 sites) have been observed since 1980. Occurrences were organized into six biogeographical regions (see Albert et al. (1986) for Michigan boundary definitions): 1) southern Lower Michigan, 2) northern Lower Michigan, 3) eastern Upper Michigan, 4) Indiana, 5) Illinois, and 6) Wisconsin.

To compare occurrences among states, the global ranking criteria developed by The Nature Conservancy (TNC), and now administrated by NatureServe, were used for assignment of element occurrence rank for all occurrences. The occurrence ranks were assigned on the basis of the quality of the plant community (Appendix B). Plant community quality was determined by the level of human disturbance and the condition of the plant community structure and composition. The ranks assigned are **A** (excellent), **B** (good), **C** (fair), and **D** (poor). Although the system is subjective, it is useful because it has been applied consistently. For all states, element occurrences are synonymous with occurrences as defined above. The Michigan Natural Features Inventory (MNFI) uses a size class ranking system, assigning values from one to five, based on the areal extent of the occurrence and the abundance of the species (Appendix C). Lower ranks have larger area and larger populations.

Public and private ownership have the following definitions. **Public ownership** is land owned by the Federal, State, county and city government. **Private property** includes private and corporate lands, and conservation organization owned lands.

1. Canada

Pitcher's thistle occurs at a total of 12 sites (Table 1) in Ontario (Keddy 1988). Pukaskwa National Park on the north shore of Lake Superior, in the Thunder Bay District of Ontario, is the northernmost population of this species. That population has been monitored for several years (Keddy 1988). The majority of Canadian occurrences are from Lake Huron, concentrated around Manitoulin Island and the Bruce Peninsula region.

2. United States

One hundred and ninety-one historic and existing occurrences are known in the United States, but 18 have been extirpated (Table 2). Pitcher's thistle probably occurred more commonly along the Great Lake shorelines prior to European settlement, but it is unknown how many occurrences were lost due to settlement and shoreline development. Most of the known extirpated occurrences are in Illinois and Indiana.

Table 1. The distribution of *Cirsium pitcheri* in Ontario, Canada (Keddy 1988).

Site Name	EO#[1]	Size Class[2]	Last Observed	Owner
Providence Bay	1	3	1987	?
Square Bay	2	3	1987	?
Portage Bay	3	4	1987	?
Sand Bay	4	3	1987	?
Carroll Wood Bay	5	5	1987	?
Pukaskwa National Park	6	4	1986	Federal
Pinery Provincial Park	7	5	1983	Province
Inverhuron Provincial Park	8	5	1981	Province
Carter Bay	9	?	1987	Province
Manitoulin Island	10	?	1984	?
Great Duck Island	11	?	1975	?
Cockburn Island	12	?	1974	?

[1] **EO#** - Element occurrence number used by heritage program.
[2] **Size Class** - Size class based on area or linear extent and qualitative or quantitative estimates of abundance (Appendix C). Largest size is 1 and smallest is 5.

Of the 173 extant occurrences, 156 (90%) are in Michigan and the remaining 17 are divided between Indiana and Wisconsin. Seventy-eight percent of the occurrences are in the Lake Michigan basin, with one occurrence (<1%) in the Lake Superior basin and the remainder (21%) in the Lake Huron basin. Sixty (35%) extant populations are entirely in public ownership, 42 occurrences (24%) cover adjoining public/private lands, and 71 (41%) occur on private lands.

Occurrences are distributed unequally among ranks; 7% A, 6% AB, 13% B, 20% BC, 25% C, 11% CD, 10% D, and 8% unclassified. High quality sites (A, AB) and low quality sites (D, U) are under represented and moderate quality sites (B, BC, C) are over represented. An examination of Table 2 reveals that high quality sites tend to be in public ownership and are found mainly in Michigan. Lower quality sites tend to be in private ownership. The most frequent size class scores for the occurrence ranks are: A-1, AB-3, B-4, BC-4, C-5, CD-5, and D-5. High quality sites tend to have greater numbers of plants covering a larger area.

A majority of the 173 extant occurrences, 60% (96), are on simple linear dunes (dune types are defined in the Habitat and Ecosystem section); 14% (23) on complex continuous dunes; 18% (29) on complex discontinuous dunes; and only 8% (12) on

perched dunes. Occurrences found most frequently on perched dunes were ranked BC, ranked A on complex continuous dunes, and ranked C on complex discontinuous dunes and simple linear dune occurrences. These data illustrate that the occurrences on larger dune systems, i.e. perched and complex continuous, are higher quality than the occurrences on simple linear and complex discontinuous dune types. Nevertheless, high-quality occurrences exist for each dune type.

Table 2. Summary of *Cirsium pitcheri* occurrences in the United States.

State / Landowner[1]	Element Occurrence Rank[2]									
MICHIGAN	**A**	**AB**	**B**	**BC**	**C**	**CD**	**D**	**Und[3]**	**Ext[4]**	**Total**
Public	8	2	10	8	16	4	6	1		55
Public/Private	2	4	4	8	7		1	5		31
Private		4	7	15	19	12	7	6		70
SUBTOTAL	10	10	21	31	42	16	14	12		156
INDIANA	**A**	**AB**	**B**	**BC**	**C**	**CD**	**D**	**Und**	**Ext**	**Total**
Public				1	1	1	2		1	6
Public/Private			1			1	1			3
Unknown									3	3
SUBTOTAL			1	1	1	2	3		4	12
WISCONSIN	**A**	**AB**	**B**	**BC**	**C**	**CD**	**D**	**Und**	**Ext**	**Total**
Public/Private	2			3		1	1	1		8
Private		1								1
SUBTOTAL	2	1		3		1	1	1		9
ILLINOIS	**A**	**AB**	**B**	**BC**	**C**	**CD**	**D**	**Und**	**Ext**	**Total**
Unknown									14	14
SUBTOTAL									14	14
GRAND TOTAL	12	11	22	35	43	19	18	13	18	191

[1] **Landowner** - Public - public land ownership, Public/Private - occurrence covers public and private lands, Private - private land ownership.

[2] **Element Occurrence Rank** -Rank by habitat condition and population size and vigor (Appendix B).

[3] **Und** – undetermined

[4] **Ext** – extirpated

Michigan

The 156 Michigan occurrences of Pitcher's thistle (Table 3) are ordered hierarchically within each county by element occurrence rank and size class assigned by MNFI. The level of occurrence protection is summarized in the Status column by codes which are defined in Appendix D. Pitcher's thistle occurrences were updated from 1993, 1997 and 2001 surveys (Comer and Albert 1993; Penskar et al. 1993, 1997; Phyllis Higman, MNFI, pers. comm. 2001).

The northern Lower Peninsula of Michigan supports 106 (68%) of the Michigan occurrences. Seventy of these occurrences are concentrated in the following counties: Charlevoix (23), Emmet (17), Leelanau (15), and Mackinac (15). Many occurrences in Charlevoix and Leelanau counties are on island archipelagos. The majority of Lake Huron sites are concentrated in the north, with the most occurrences in Presque Isle (11) and Cheboygan (5) counties. Most northern Lower Peninsula occurrences are on simple linear dune systems, but all other dune types are represented. All but one of the perched dune occurrences is in this region.

The Upper Peninsula of Michigan has 38 sites, mostly found on the north shore of Lake Michigan on simple linear dune systems. Eleven of these are found along the Lake Huron shoreline of Chippewa (7) and Mackinac (4) counties. The northernmost site in Michigan consists of the large perched Grand Sable Dunes on Lake Superior at Pictured Rocks National Lakeshore.

The southern Lower Peninsula has 12 (8%) of the Michigan occurrences where five sites are located on discontinuous dunes and five are located on continuous dune complexes. The remaining two occurrences are on simple linear foredunes. None of the occurrences have a rank greater than B. Four of the 12 occurrences are on State owned land.

Slightly less than half of the Michigan occurrences (72) are currently ranked BC or higher, indicating good to excellent quality, and many sites support occurrences falling within larger size classes. Additionally, many of the highest ranked occurrences are on State and Federal lands and fall within State-regulated Critical Dune Areas (Table 3). Critical Dune Area designation protects dunes along the shoreline through the regulation of development and use. Many A-ranked occurrences fall within the 1-2 size class, and most of these are within public ownership. All but three A-ranked sites occur in Critical Dune Areas. The highest quality occurrences include the Grand Sable Dunes, Big Sable Point, Good Harbor Bay, Platte River Point, South Manitou Island, Sleeping Bear Point, Cathead Bay, and Hiawatha National Forest Dunes. Of the occurrences ranked BC or higher, 46 sites are wholly or partially held in public ownership, and an additional two are protected as private nature preserves.

Table 3. The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Negwegon State Park	127	Alcona/NL	S	C	4	1988	State	6/?	N	Occasional; needs detailed field survey
Grand Sable Dunes	2	Alger/UP	P	A	1	1989	NPS	6	N	Locally common; within outstanding natural feature designation
Saugatuck Dunes	4	Allegan/SL	C	C	3/4	1992	State/City	9/6	Y	Portion within dedicated Natural Area boundary
Gilligan Lake Dunes	112	Allegan/SL	D	C?	5	1981	Private	6	Y	Six plants noted in study plot in blowout area; needs further survey
North Point	95	Alpena/NL	S	BC	3/4	1996	Corp	0	N	Noted as occasional; 23 adults and 72 juveniles in 1996; needs field survey
Huron Bay	12	Alpena/NL	S	CD	5	1989	Private	0	N	About 50 plants observed on beach
Torch Lake	65	Antrim/NL	S	BC?	3/4	1981	Private	0	N	Noted as common on low foredunes; needs field survey
Palmer-Wilcox-Gates	10	Antrim/NL	S	C	3/4	1989	TNC	8	N	Population increasing following inundation from high lake levels; northern colony needs protection from trampling
Banks Township Park	82	Antrim/NL	S	C	5	1996	Multi. Private	0	N	24 adults and 59 juveniles; recreation pressure
Elk Rapids South	145	Antrim/NL	S	C	5	1997	Private	1	N	Construction of revetment will likely harm
South Charity Island	107	Arenac/NLI	S	C	4	1991	Private	0	N	Noted as very common along lakeshore; needs field survey; housing development imminent; 116 plants in 1991
Point Lookout	88	Arenac/NL	S	D	5	1951	Private	U	N	Noted as scarce in 1951; needs field survey
Platte River Point	5	Benzie/NL	C	A	1	1985	NPS	6	Y	Common on open dunes; possible National Natural Landmark candidate
Platte Bay	7	Benzie/NL	C	A	2	1985	NPS	6	Y	Observed as frequent; possible National Natural Landmark
Point Betsie	33	Benzie/NL	C	AB	3	1995	Private	8/0	Y	About 4000 plants and seedlings in 1995
Herring Lake Embayment	51	Benzie/NL	D	AB	3	1996	Private	0	Y	Common to abundant; robust even in erosional areas
Grace Road Dune	126	Benzie/NL	P	BC	4	1986	Private	0	Y	Uncommon
Watervale South	131	Benzie/NL	P	BC	4	1996	Multi. Private	0	Y	100 to 200 robust plants on lower third of bluff

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Frankfort Beach	34	Benzie/NL	S	BC	4	1992	City	0	Y	Small population vulnerable to severe trampling on public beach; estimated 400-500 plants to south; needs field survey to determine status
Warren Dunes	16	Berrien/SL	D	B?	3	1992	State	3?	Y	Needs thorough field survey
High Island Dunes	108	Charlevoix/NLI	D	AB	3	1986	State/Private	1?	Y	Common throughout dunes
Bonners Landing	9	Charlevoix/NLI	S	B	2/3	1980	State/Private	1?	N	Several hundred plants in undisturbed habitat
Fisherman's Island State Park	75	Charlevoix/NL	S	B	3	1992	State	0	N	Common, needs survey; in purchase boundary of Fish Island State Park
Lookout Point	143	Charlevoix/NLI	S	B	4	1998	Private	0	N	100s of plants; Inform, educate owners
Norwood	93	Charlevoix/NL	S	BC	3/4	1996	State/Private	0	N	Noted as frequent on beach; 168 adults and 239 juveniles in 1996; needs field survey
Sandy Bay	57	Charlevoix/NLI	S	BC	4/5	1989	State (CMU)	U	N	Determine protection status; needs field survey for assessment of population size and extent
McFadden Point	62	Charlevoix/NLI	S	BC	5	1987	State/Private	0	N	Needs field survey
McSauba Park	77	Charlevoix/NL	S	BC	4/5	1992	City/Private	0	N	1992: 87 adults and 131 juveniles; extensive dune field
Lett's Point	142	Charlevoix/NLI	S	C	5	1998	Private	0	N	Inform, educate owners
Sweat Lodge Swale	144	Charlevoix/NLI	S	C	5	1998	State	1	N	Small pop.; Mackinaw State Forest
High Island Bay	68	Charlevoix/NLI	D	C	3/4	1986	State	1?	N	About 50-100 plants observed
Hog Island	125	Charlevoix/NLI	S	C	5	1986	State	1?	Y	Uncommon; may need field survey
French Bay	129	Charlevoix/NLI	S	C	5	1989	Private	0	N	Resurveyed 1999; small population
Donnegal Bay	60	Charlevoix/NLI	S	C	4/5	1992	City	0	N	Resurveyed 1999; fragmented habitat
Little Sand Bay	58	Charlevoix/NLI	S	C?	4/5	1981	LTC/Private	0	N	Resurveyed 1999; small population, nice habitat
Horseshoe Island	99	Charlevoix/NLI	S	CD?	5	1951	State	0	N	Needs field survey
Charlevoix Beach	6	Charlevoix/NL	C	D	4/5	1992	City	0	N	1991 survey found only 24 plants; 1992: 2 colonies with 20 plants; diminished population
Jensen's Point	128	Charlevoix/NLI	S	D	5	1983	State	0?	N	Only one plant observed; needs survey
Iron Ore Bay	20	Charlevoix/NLI	S	D	5	1986	Pub. Sch.	U	N	Status unknown; needs field survey
Beaver Island Harbor	59	Charlevoix/NLI	S	D?	5	1981	Private/City	0	N	Needs field survey; little habitat may remain

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Northcutt Bay	105	Charlevoix/NLI	S	U	4/5	1983	State	0	N	Resurveyed 1999; small population
Cable Bay	54	Charlevoix/NLI	S	U	U	1981	Private/State	0	N	Needs field survey
Martin Point	56	Charlevoix/NLI	S	U	U	1981	Private	0	N	Needs field survey
Grass Bay	24	Cheboygan/NL	S	BC	3/4	1996	TNC	8	N	More than 359 plants counted in 1989
Nine Mile Point	102	Cheboygan/NL	S	C	5	1996	State/Private	0	N	1996: 6 adults and 9 juveniles in part
Cheboygan State Park	106	Cheboygan/NL	S	C	5	1996	State	1	N	1996: 20 adults and 64 juveniles
Point Nipigon	120	Cheboygan/NL	S	CD	5	1985	Private	2	N	Small population, very localized; may need further field survey
Albany Creek Mouth	70	Chippewa/UP	S	BC	3	1990	Private/MNA	8	N	MDOT owns to lakeshore; ca. 1000 plants or more
St. Vital Bay	67	Chippewa/UP	S	BC	3	1981	State	1?	N	Common to abundant
Albany Harbor Peninsula	91	Chippewa/UP	S	BC	4	1995	Private	U	N	100+ plants
Rice Point	86	Chippewa/UP	S	CD	5	1993	Private	0	N	Infrequent; needs field survey
Carleton Bay	76	Chippewa/UP	S	CD	4/5	1981	Private	0	N	Infrequent; needs field survey
Strawberry Island	53	Chippewa/UP	S	CD	5	1981	State	U	N	Very small local population; vulnerable to trampling by campers
Point De Tour	74	Chippewa/UP	S	CD	5	1981	Private	0	N	Small localized population; needs field survey
Fayette	18	Delta/UP	S	D?	5	1976	State	0?	N	Needs field survey to determine if extant
Big Stone Bay	15	Emmet/NL	S	AB	1	1991	State	6	Y	Common to frequent
Sturgeon Bay	47	Emmet/NL	C	AB	½	1991	State	1	Y	Common; future park plans for development could affect this population adversely
Paige Creek	79	Emmet/NL	S	B	4	1991	State/Private	U	N	1991: noted as abundant in Petoskey State Park
Sturgeon Bay Point	22	Emmet/NL	C	BC	3	1991	Twp./Private	0	Y	Infrequent to common; disturbed by ORV's; threatened with rapid development
Temperance Island	138	Emmet/NLI	S	BC	3/4	1996	State	1	N	100's and likely 1000's; cobbly sand NE portion of island; need survey
Trail's End Bay	66	Emmet/NL	S	BC	4	1991	Private	0	Y	Common to abundant; numerous cottages; highly susceptible to foot traffic
McCort Hill	50	Emmet/NL	S	BC	4	1990	Private/City	0	Y	A few plants noted in 1990; needs better survey

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Wycamp Creek Mouth	73	Emmet/NL	S	C	4/5	1989	Private/ State?	0	Y	Needs field survey
Sturgeon Bay South	111	Emmet/NL	C	C	4/5	1982	Private/Corp	0	Y	Very local; about 100 plants observed
Thorne Swift Preserve	119	Emmet/NL	S	C	5	1990	LTC/Private	8	N	14 plants observed by naturalist; needs field survey
Cecil Bay	14	Emmet/NL	P	C?	5	1980	Private	0	N	Locally common; may need field survey
Middle Village South	136	Emmet/NL	S	CD	5	1996	Multi. Private	0	N	One adult- others are probably on private land
M119 & Pike Road	137	Emmet/NL	S	CD	5	1996	Multi. Private	0	N	Two juveniles only; needs survey
Johnson Point	121	Emmet/NL	S	CD	5	1985	Private	2	N	Uncommon; needs field survey
Sevenmile Point	132	Emmet/NL	S	D	4/5	1990	Private	0	N	A few plants noted in 1990; needs survey
Old Mission Light	38	GrandTraverse/ NL	S	D?	5	1981	Twp.	0	N	Not found in 1989 field survey; possibly extirpated
Saginaw Bay	89	Huron/SL	S	CD	5	1996	State	0	N	Small population of two adults and juveniles found on low dunes; needs better survey; non-natives encroaching
AuSable Point	35	Iosco/NL	S	BC	5	1996	Private	0	N	Locally frequent; 16 adults & 13 juveniles; needs field survey
Oscoda North	36	Iosco/NL	S	CD	5	1996	Private	0	N	About 50 plants observed in 1981; none in 1996; needs field survey
Oscoda South	101	Iosco/NL	S	U	5	1963	Private	0	N	Status unknown; needs field survey; area becoming developed
South Manitou	17	Leelanau/NLI	P	A	½	1983	NPS	6	Y	Common on gravel plateau and dunes
Good Harbor Bay	29	Leelanau/NL	C	A	½	1987	NPS	6	Y	Very common to frequent; vulnerable to pedestrian damage
Sleeping Bear Point	28	Leelanau/NL	P	A	1	1991	NPS	6	Y	Common throughout the dunes
Cathead Bay	48	Leelanau/NL	C	AB	2	1987	State/Private	6/0	Y	Common; needs better survey
Glen Arbor	139	Leelanau/NL	S	AB	3	1996	Multi. Private/City	0	N	100's- likely 1000's; developed but foredunes largely with minimal disturbance
South Fox Island	43	Leelanau/NLI	P	AB	3	1986	Private	0	Y	Common to locally abundant
North Manitou Island	44	Leelanau/NLI	P	B	3	1983	NPS	6	Y	Frequent

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
South Manitou Island	52	Leelanau/NLI	S	B?	2/3	1983	NPS	6	Y	Scattered along foredune; vulnerable to high foot traffic
Donner Point	123	Leelanau/NL	P	B?	3	1983	NPS	6	Y	Locally common; needs field survey
Empire Bluffs	118	Leelanau/NL	P	BC	½	1986	NPS	6	Y	Common
North Fox Island	42	Leelanau/NLI	D	BC	3	1989	Private	1?	Y	Common to locally abundant in blowouts
Pyramid Point	45	Leelanau/NL	P	BC	3	1990	NPS	6	Y	Locally common; may be subject to trampling through use of site as a hang gliding area
Gills Pier	41	Leelanau/NL	S	BC	U	1996	Private	0	N	Needs field survey
South Manitou Island	110	Leelanau/NLI	S	C?	4	1982	NPS	6	N	Local; needs field survey
Peterson Park North	135	Leelanau/NL	S	D	5	1996	Private	U	N	3 adults at base of sandy cobbly dune
Hiawatha National Forest Dunes	90	Mackinac/UP	C	A	1	2001	MDOT/ USFS	2/2?	Y	Occasional to common; vulnerable to ORV and pedestrian traffic from US-2; common along US-2 MDOT ROW
Birch Point East West	23	Mackinac/UP	S	A	2	2001	State/Private	6	N	Common; proposed for dedication
Hughes Point	55	Mackinac/UP	S	A	3	2001	Corp./State	½	N	Common; state portion proposed for dedication; most occurs on Private portion
Point Aux Chenes	49	Mackinac/UP	C	AB	4/5?	1991	USFS/ Private	6/0?	N	Abundant on foredune; on or near proposed Research Natural Area; private inholdings need to be acquired
Poupard Bay	134	Mackinac/UP	S	B	3	2001	Private	1	N	One plant observed; 100's observed on nearby property; other properties need survey
Naubinway East	3	Mackinac/UP	S	C	4	2001	Private	0	N	Occasional to frequent; needs field survey
Big Knob Campground	100	Mackinac/UP	S	C	4	2001	State	6	N	Local; site proposed for natural area dedication
West Epoufette	133	Mackinac/UP	S	C	4	2001	State/Private	6/1	N	Several colonies on narrow foredune
Black River Road	156	Mackinac/UP	S	C	4	2001	State/Private	1	N	Sparsely distributed in patches along several miles of shoreline
Fox-Needle Point	154	Mackinac/UP	S	C	4	2001	State	2	N	Occasional to common in sandy flats and small foredunes; site recently acquired by State
McNeil Creek	130	Mackinac/UP	S	C	5	2001	State/Private	6/1	N	Modest population along foredune
Stevenson Bay	63	Mackinac/UP	S	CD	5	1995	TNC/Private	0	N	Infrequent along beach; needs field survey

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Point La Barbe	37	Mackinac/UP	S	D	5	1981	Corp.	0	N	Needs field survey. No plants observed in 2001
Manitou Payment	124	Mackinac/UP	S	D	5	1986	Private	0	N	Only one plant noted; may need field survey to determine if extant
Tower-Troy Preserve	21	Manistee/NL	C	AB	3	1994	TNC	8	Y	Locally abundant; more than 3000 plants counted in 1989; 60+ plants on dune slope in 1992
South Arcadia Beach	39	Manistee/NL	P	BC	2/3	1992	Corp.	0	Y	Common, 90 adults and 170 juveniles; restrict ORV use
Magoon Creek North	114	Manistee/NL	S	BC	4	1996	Cnty/Private	0	N	60 adults, 126 juveniles; a portion is heavily developed
Manistee River Mouth	13	Manistee/NL	S	C	4	1992	City/Private	0	N	Threatened by Harbor Village Development; >200 plants across separate colonies
Portage Point Dune	104	Manistee/NL	D	C	5	1992	Multi. Private	0	N	21 adults and 16 juveniles, estimates 50-100; minimize recreation
Big Sable Point	32	Mason/NL	C	A	1	1985	State/USFS	6/6	Y	Common to abundant; area may be proposed for natural area dedication
Cooper Creek Dunes	122	Mason/NL	S	CD	4	1985	USFS	U	Y	Occasional; site heavily disturbed by ORV's; needs field survey to determine population status
Bass Lake Dunes	31	Mason/NL	D	D	5	1981	Private	0	Y	One plant observed in 1981; needs field survey to determine status
Hoffmaster Natural Area	25	Muskegon/ Ottawa/SL	D	B	3	1983	State	9	Y	About 400 plants counted in 1982; dedicated Natural Area; monitor pedestrian traffic
Meinert Park	26	Muskegon/SL	C	B	4	1996	County	0	Y	Rare and local on open dunes; about 150-200 plants observed
Muskegon State Park	64	Muskegon/SL	C	C	4/5	1992	State	1	N	1 adults, 23 juveniles, maybe +100 plants
Mona Shores Forest	113	Muskegon/SL	D	D?	4/5	1979	Pub. Sch.	0	Y	Needs field survey
Camp Miniwanca	11	Oceana/NL	D	B	4	1995	Private	0	Y	1991: 750 plants counted by TNC staff; 1995: 608 plants
Driftwood Beach	27	Oceana/NL	D	BC	3	1985	Corp/Private	0	Y	Frequent in blowouts; scattered homes on these dunes
Pentwater	117	Oceana/NL	D	BC	4	1985	Private	0	Y	Common

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Little Point Sable	116	Oceana/NL	C	C?	2/3	1985	State	1	Y	Rare on open dunes; history of heavy ORV disturbance
Pentwater Dunes	30	Oceana/NL	D	CD	4/5	1992	Private	1	Y	About 100 plants scattered over dunes; 1992: 12 juveniles; Camp manager supports protection
Kitchel Dunes	8	Ottawa/SL	C	C	5	1986	City	8	Y	Natural preserve; needs field survey to determine population size and quality
Rosy Mound	115	Ottawa/SL	C	CD	5	1985	Corp.	0	Y	Uncommon, only 12 plants observed; needs field survey
Thompson's Harbor	87	Presque Isle/NL	S	B	4	1989	State/Private	9/6/2	N	Frequent on open dunes; most on State land, part in dedicated area; 34 adults and 73 juveniles
Hoeft State Park	83	Presque Isle/NL	S	B?	2	1996	State/Private	1/0	N	Infrequent to abundant; needs field survey; 55 adults and 106 juveniles
Huron Beach	71	Presque Isle/NL	S	B	4/5	1989	State	0	N	Uncommon; needs field survey
Hammond Bay West	80	Presque Isle/NL	S	B	5	1996	Private/Corp	0	N	Common; needs field survey
Evergreen Beach	78	Presque Isle/NL	S	B	4	1996	Private	0	N	1996: 118 adults and 73 juveniles
Presque Isle Harbor	84	Presque Isle/NL	S	BC	4	1993	Private	2	N	Part of population protected and monitored in State marina construction site; several hundred plants between road and water; 1993: 37 adults and 158 juveniles
Besser Natural Area	85	Presque Isle/NL	S	BC	4	1989	State	9	N	Infrequent along dunes; dedicated natural area
Grace North	72	Presque Isle/NL	S	BC	4	1996	Corp.	0	N	Common on the point; needs field survey
Hammond Bay East	81	Presque Isle/NL	S	C	4/5	1996	USFS/ Private	0	N	Rare; 1996: 18 adults & 43 juveniles; needs field survey
Besser Natural Area South	141	Presque Isle/NL	S	C	5	1996	State	1	N	One adult & 15 juveniles in 1996

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Rockport North	140	Presque Isle/NL	S	C	5	1996	Private	0	N	21 juveniles in 1996
Gulliver Lake Dunes	46	Schoolcraft/UP	S	B	1	2000	Multi. Private	0	Y	Common on dunes; much residential development
Lake Superior State Forest Dunes	153	Schoolcraft/UP	C	B	4	2000	State	8	N	Sizeable pop., quality dunes, recommend informative signs
Michibay Rd. Twp. Park	148	Schoolcraft/UP	D	B	5	2000	Twp.	1	N	100s of plants, small dune complex, needs protection
Rocky Point West	152	Schoolcraft/UP	D	B	5	2000	Private	1	Y	Common, needs protection
Point Aux Barques	40	Schoolcraft/UP	S	BC	5	1981	Corp.	0	N	Locally common; needs field survey
Thompson Dunes	1	Schoolcraft/UP	S	C	4	2000	USFS/State	0	N	About 50-100 plants noted; control of ORV use is essential; development in dunes is increasing; bulldozing by private in holders has occurred
Snyder Creek	146	Schoolcraft/UP	S	C	5	2000	Private	1	N	Several dozen plants, site needs protection
Seoul Choix Point	155	Schoolcraft/UP	S	C	5	2001	Private	1	N	Good habitat, but only one plant found
Wiggins Point	147	Schoolcraft/UP	D	C	5	2000	Private	1	N	Growing on 2 shallow foredune ridges
Section 10 Dunes	149	Schoolcraft/UP	D	C	5	2000	Private	1	N	2 small colonies, control weeds and development in dune zone
Orr Creek	150	Schoolcraft/UP	S	C	5	2000	Private	1	N	Several clusters, narrow beach, needs protection
Manistique Boardwalk	151	Schoolcraft/UP	D	C	5	2000	City	1	N	Small pop. on city edge, keep ORVs out, control weeds
Covert	109	Van Buren/SL	D	BC	4/5	1991	State/Private	U	Y	Needs field survey to determine population size and status
Historical records (pre-1950 in non-urban northern Michigan; pre-1970 in southern Michigan or urbanized areas)										
Harbert	97	Berrien/SL	S	U	U	1919	Private	U	Y	Needs survey to determine if extant
Mackinaw City	94	Cheboygan/NL	S	U	U	1996	Private	U	N	Noted as "plentiful"; highly developed area; none observed in 1996; needs field survey
Bay View	61	Emmet/NL	S	U	U	1874	Private/City	U	N	Old record; highly developed area; may no longer be extant; quick survey should determine status
Harbor Point	103	Emmet/NL	S	U	U	1894	Private/City	U	N	Needs survey to determine if extant

Table 3 (cont.) The distribution of *Cirsium pitcheri* in Michigan.

Site Name	EO# [1]	County/ Region [2]	Dune Type [3]	EO Rank [4]	Size Class [5]	Last Obs.	Owner [6]	Status [7]	Critical Dune Area [8]	Comments
Traverse City	19	Grand Traverse/ NL	S	U	U	1969	Private/City	U	N	Area needs field survey; record not specific; likely extirpated
Scotty Bay	92	Mackinac/UPI	S	D	5	1927	Multi. Private	U	N	Single plant observed an collected in 1927; needs survey
Packard Point	96	Mackinac/UPI	S	U	U	1938	Multi. Private	U	N	Needs field survey
Point Aux Pins	98	Mackinac/UP	S	U	U	1947	State/ Multi. Private	U	N	Needs field survey
Orchard Beach	69	Manistee/NL	S	U	U	1951	State	U	N	Noted as abundant in 1951; needs field survey

[1] **EO#** - Element occurrence number used by State heritage program.
[2] **County/Region** - County and biogeographic region where UP - Upper Peninsula, NL - Northern Lower Peninsula, SL - Southern Lower Peninsula, I - Island.
[3] **Dune type** - S - simple linear beach foredunes, D - discontinuous dune complexes, C - continuous dune complexes, P - perched dunes
[4] **EO Rank** - Rank by habitat condition and population size and vigor (Appendix B).
[5] **Size Class** - Size class based on area or linear extent and qualitative or quantitative estimates of abundance (Appendix C). Largest size is 1 and smallest is 5, U is unknown.
[6] **Owner** - NPS - National Park Service, USFS - U.S. Forest Service, State, CMU - Central Michigan University, MNA - Michigan Natural Area, MDOT - Michigan Department of Transportation, Cnty. - County, Twp. - Township, City, Private, Multi. - Multiple parties, Corp. - Corporate, TNC - The Nature Conservancy, LTC - Little Traverse Conservancy, and Pub. Sch. - Public School.
[7] **Status** - 1 to 9 indicates the level of protection, 0 - no known landowner contact, U - undetermined if landowner contacted, ? - status uncertain (Appendix D).
[8] **Critical Dune Area** - Defined by the State of Michigan and mapped in the Critical Dunes Atlas (MDNR 1989).

More than half of Michigan's occurrences (84) rank C or lower, including sites that have an undetermined rank. Following a field assessment, however, one or more of the unranked sites may be ranked C or higher. Almost without exception, lower ranked occurrences consist of smaller populations in more disturbed, vulnerable habitat of size classes 4 or 5 (Table 3). Frequently, multiple landowners own the habitat supporting lower-ranked occurrences. Although ownership information is not complete, about 30 of the 70 privately-owned sites are on private nature preserves. Several State highways in northern Lower Michigan and Upper Michigan are next to the shoreline, and several occurrences lie at least partially within Michigan Department of Transportation (MDOT) rights-of-way (ROW).

Of all occurrences, 41 are ranked as A, AB, or B; and 30 of these are primarily in public or public/private ownership (Table 2). The remaining 11 occurrences are on private lands. Overall, the majority of Michigan's occurrences, 115 (74%), are located in 9 counties: Charlevoix (23), Emmet (17), Mackinac (17), Leelanau (15), Schoolcraft (12), Presque Isle (11), Benzie (7), Chippewa (6), and Manistee (6). Typically these occurrences are found on simple linear dunes along Lake Michigan. Within these 9 counties 22 sites are ranked A, AB or B, cover all size classes, and are located on public lands or on lands with public and private access. These occurrences represent 73% of the high ranking sites in the state growing on public lands or mixed public/private ownership.

Wisconsin

Pitcher's thistle is known from nine isolated sites in Wisconsin, of which six are from Door Co. (Table 4). The remaining three occurrences are at Point Beach State Forest in Manitowoc Co., Kohler-Andrae State Park in Sheboygan Co., and Wisconsin Point in Douglas Co. The two A ranked occurrences are in partial State ownership with the rest on private or county property. Five occurrences are on simple linear dunes, three on complex continuous dunes, and one on complex discontinuous dunes.

Indiana

Historically, Indiana had 12 occurrences of Pitcher's thistle, but only eight are known to exist today (Table 5). Of these eight, six are within the Indiana Dunes National Lakeshore, with three extending onto private property, and the remaining two are in the Indiana Dunes State Park. Early Indiana records (Cowles 1899, 1901; Pepoon 1927; Peattie 1930) suggest that the Pitcher's thistle was formerly common along beaches, but now is mostly confined to blowouts. Loss of a dune's stabilizing vegetation allows blowing sand to migrate inland causing a blowout. The loss of foredune populations is attributable to natural shoreline erosion processes that have been exacerbated by the construction of breakwaters, harbors, and revetments (Wood 1986) and to the intensive recreational use of beaches by people (Hultsman 1986). Prior to large-scale human

Table 4. The distribution of *Cirsium pitcheri* in Wisconsin.

Site Name	EO#[1]	County	Dune Type[2]	EO Rank[3]	Size Class[4]	Last Obsrv.	Owner	Status[5]	Comments
Whitefish Dunes	1	Door	C	A	3	2001	State/Private	6/1	Best site in state, but human trampling is a problem.
Sevastopol Beach	2	Door	S	AB	3	2001	Private	2	High quality site needing protection. Landowner contact made.
Sturgeon Bay Canal	3	Door	S	BC	3	2001	County/ Private	6/2	Severe trampling and patch-work of owners makes protection difficult. Sensitive to shoreline erosion.
Heins Creek County Park	5	Door	D	BC	4	1990/ 2001	County/ Private	6/0	Highly fragmented populations, diverse ownership, and heavy trampling and protection status uncertain. Sensitive to shoreline erosion.
Sand Dunes Beach	8	Door	C	CD	4	1999	County/ Private	6/1	Small, but best population on Washington Island. Decline on county land due to recreational use.
Lake Shore Drive	6	Door	S	D	5	1999	County/ Private	6/0	Highly degraded by adjacent road, trampling and presence of soil piles.
Wisconsin Point	NA	Douglas	S	?	U	1998	?	0	One immature plant on sandy beach. Herbarium specimen. Needs survey.
Point Beach State Forest	4	Manitowoc	C	A	3	2001	State/Private	6/0	High recovery potential if trampling is eliminated.
Kohler-Andrae State Park	7	Sheboygan	S	BC	4	2001	State/Private	6/1	Reduction of trampling and elimination of invasive non-natives may enhance long-term survival.

[1] **EO#** - Element occurrence number used by State heritage program.
[2] **Dune type** - S - simple linear beach foredunes, D - discontinuous dune complexes, C - continuous dune complexes
[3] **EO Rank** - Rank by habitat condition and population size and vigor (Appendix B).
[4] **Size Class** - Size class based on area or linear extent and qualitative or quantitative estimates of abundance (Appendix C). Largest size is 1 and smallest is 5, U is unknown.
[5] **Status** - 1 to 9 indicates the level of protection, 6 - land manager(s) are aware of occurrence, 0 - no known landowner contact (Appendix D).

Table 5. The distribution of *Cirsium pitcheri* in Indiana.

Site Name	EO#[1]	County	Dune Type[2]	EO Rank[3]	Size Class[4]	Last Obsrv.	Owner[5]	Status[6]	Comments
Miller High Dunes/USX	4, 16	Lake	D	CD	5	1990-2	NPS/Corporate	6/0	Combines occurrences 4 and 16 which are less then one mile apart with unsuitable habitat between. Respectively 70 plants in 1990 and 50 in 1992. Both are localized blowout populations with the former having a trail running through the north end.
Pine	3	Lake	C	-	-	1909	?	-	Extirpated. Collected by Blatchely (1902) and Umbach (1907 & 1909).
Indiana Harbor	2	Lake	C	-	-	1907	?	-	Extirpated. Collected by Deam at Indiana Harbor.
Edgemoore	14	Lake	C	-	-	1882	?	-	Extirpated. Collected by Davis.
Dune Acres East	10	Porter	D	B	4	1991	NPS/Private	6/0	High quality population on private and government ownership. Trampling is largely from local citizens. 550 plants in 1991.
Big Blowout	1	Porter	D	BC	3	1991	State	6	Best landscape metapopulation in state. Trampling from joggers and mountain bike enthusiasts may be a problem.
West Beach	5	Porter	D	C	4	1990	NPS	6	Scattered populations throughout a well used dune system. Trampling may be limiting population.
Keiser Blowout	7	Porter	D	CD	5	1991	NPS/State	6	70 scattered plants around NPS parking lot and on high dune towards Lake Michigan. Trampling may be a problem.
Ogden Dunes	9	Porter	D	D	5	1991	NPS	6	New small populations discovered by Bacone in 1991 survey in addition to those found by McEachern. Site of restoration experiment.
Dune Acres West	6, 12,13,15	Porter	D	D	5	1990-2	NPS/Private	6	Combine four State listed occurrences that are less then 1 mile apart: Dune Acres West, Little Lake Dune, Mineral Springs and Dune Acres Beach. Small remnant populations having respectively 15 (1990),11 (1991),17(1992) and 160 (1992) individuals.
Furnessville Blowout	11	Porter	D	D	5	1990	State	6	38 plants in 1990.
Tamarack	8	Porter	D	-	-	1978	NPS	6	Extirpation due to either high lake levels or demographic stochasticity.

[1] **EO#** - Element occurrence number used by State heritage program.
[2] **Dune type** - D - discontinuous dune complexes, C - continuous dune complexes
[3] **EO Rank** - Rank by habitat condition and population size and vigor (Appendix B).
[4] **Size Class** - Size class based on area or linear extent and qualitative or quantitative estimates of abundance (Appendix C). Largest size is 1 and smallest is 5.
[5] **Owner** - NPS - National Park Service, State, Private, Corporate.
[6] **Status** - 1 to 9 indicates the level of protection, 6 - land manager(s) are aware of occurrences, 0 - no known landowner contact (Appendix D).

caused disturbance, beach populations were probably maintained in part by seed dispersal from adjacent foredune and blowout populations. Local population extirpation occurred because the beach was the main corridor of travel from 1830 to 1890-1900 (Cook and Jackson 1978). The entire foredune system was eroded during high lake levels occurring in 1929, 1943, 1974, and 1986 (Olson 1958a, Larsen 1985, Wood 1986, Larsen 1987). The Pine and Edgemoore populations were probably destroyed by industrial/residential development, whereas the more recently extirpated Tamarack population was likely destroyed by either the 1986-87 shoreline erosion episode or by chance extirpation of small populations.

Historical Illinois

No natural Pitcher's thistle populations are known to exist in Illinois today. However, fourteen historical collections are known from Cook and Lake Counties (Table 6). Over 75% of these records are from Cook Co., where little or no suitable habitat now exists. All the remaining records are from "Waukegan" in Lake Co. and likely occurred in the vicinity of what is now Illinois Beach State Park. The Cowles collections from "Dunes, Thornton," Cook Co., are unique because they were located approximately 15 miles inland from the modern Lake Michigan shoreline. These dunes represent the Glenwood beach, the oldest and highest (640 ft) of three ancient beaches formed

Table 6. Herbarium information for extirpated Illinois *Cirsium pitcheri* collections.

County	Collector	Date	Herbarium[1]	Information
Cook	Moffatt	1895	ILL	Sandhills near Lake Michigan
Cook	Hill	1884	ILL	Shoreline at Lake Michigan
Cook	Babcock	1870	ILL	Cook Co.
Cook	Cowles	1896	ISM	Dunes, Thornton
Cook	Cowles	1906	ISM	Dunes, Thornton
Cook	Vasey	1862	F	Near Chicago
Cook	Babcock	n.d.	F	Chicago (printed label)
Cook	Gates	1905	F	Lakeview, Chicago, sand at Lake
Cook	Scammon	1862	GH	Chicago, sandy shoreline of Lake
Cook	Vasey	n.d.	SIU	Lakeshore, Chicago
Cook	Beal	1869	MO	Lakeshore, Chicago
Lake	Gates	1908	F, ILL	w/*Artemisia* & *Panicum*, Waukegan
Lake	Gleason	1906	ILL	Dry sand beaches, Waukegan
Lake	Benke	1919	F	Waukegan

[1] **Herbarium**: ILL - University of Illinois at Urbana, ISM - Illinois State Museum, F - Field Museum, GH - Gray Herbarium, SIU - Southern Illinois University, MO - Missouri Botanical Garden.

by glacial Lake Chicago as it retreated during the Wisconsin glaciation. The dunes at Thornton were formed in an embayment of Lake Michigan created during the higher lake level (Willman and Frye 1970, Hansel et al. 1985). The Illinois Natural Areas Inventory (White 1978) recognized several natural areas in the vicinity of Thornton, but none were found to contain *Cirsium pitcheri*. Cowles' collections were separated by a ten-year period, suggesting some stability, however no thistles have been relocated at Thornton.

D. Habitat and Ecosystem

Pitcher's thistle is one of a few plant species endemic to the post-Wisconsinan Great Lakes sand dunes. As geologic processes create new habitats the potential for the development of new species increases. Species restricted to these dune ecosystems are of considerable biological significance. Pitcher's thistle is part of a dynamic dune ecosystem with a myriad of interacting species. Healthy populations of Pitcher's thistle are an indication of the general well being of dune ecosystems. No species is known to depend completely on Pitcher's thistle. However, the rust, *Puccinia laschii* (Saville 1970) that is sometimes found on adult leaves may be host-specific, and therefore dependent on Pitcher's thistle. In addition, Pitcher's thistle is a food (pollen, nectar and seed) source for many organisms (Keddy and Keddy 1984, Loveless 1984).

Cirsium pitcheri is found most frequently in the near-shore plant communities, although it occurs in all non-forested areas of Great Lakes dune systems. Great Lakes dune systems are similar to coastal dunes worldwide (Figure 3). Generally, in undisturbed settings a low barrier dune ridge, or foredune, forms immediately inland from the beach (Buckler 1979). This ridge breaks the onshore winds, trapping sand as it blows shoreward from the beach. Frequently, on the landward side of the foredune is an interdunal trough, a topographically protected low area of varying depth and width. In some areas the interdunal trough is filled with groundwater, forming small interdunal ponds. Inland from the trough is a series of larger, secondary dunes that range in height from as much as 60 m at the southern tip of Lake Michigan to less than a 1 m in the north (Cowles 1899, Olson 1958a).

The coastal dunes of the Great Lakes formed as the last glaciers retreated from the lake basins 14,000 to 10,000 years ago (Hansel et al. 1985), and the larger dune systems formed 4,700 to 4,000 years ago during, higher, Nipissing shorelines. They were created by the agents of wind and water through processes continuing today. Shoreline erosion and river discharge brings sand into the Great Lakes. Once in the water, sand is picked up by long shore currents, transported along the coastline, and deposited by waves on sandbars and beaches. Onshore winds then rework the beach sands into dunes. Fluctuating lake levels may deposit and erode sand along the dune lines (Olson 1958a, Larsen 1985). However, sediment loads are lower today than during deglaciation. Therefore beaches and large dunes are not being formed at the same rates as in recent

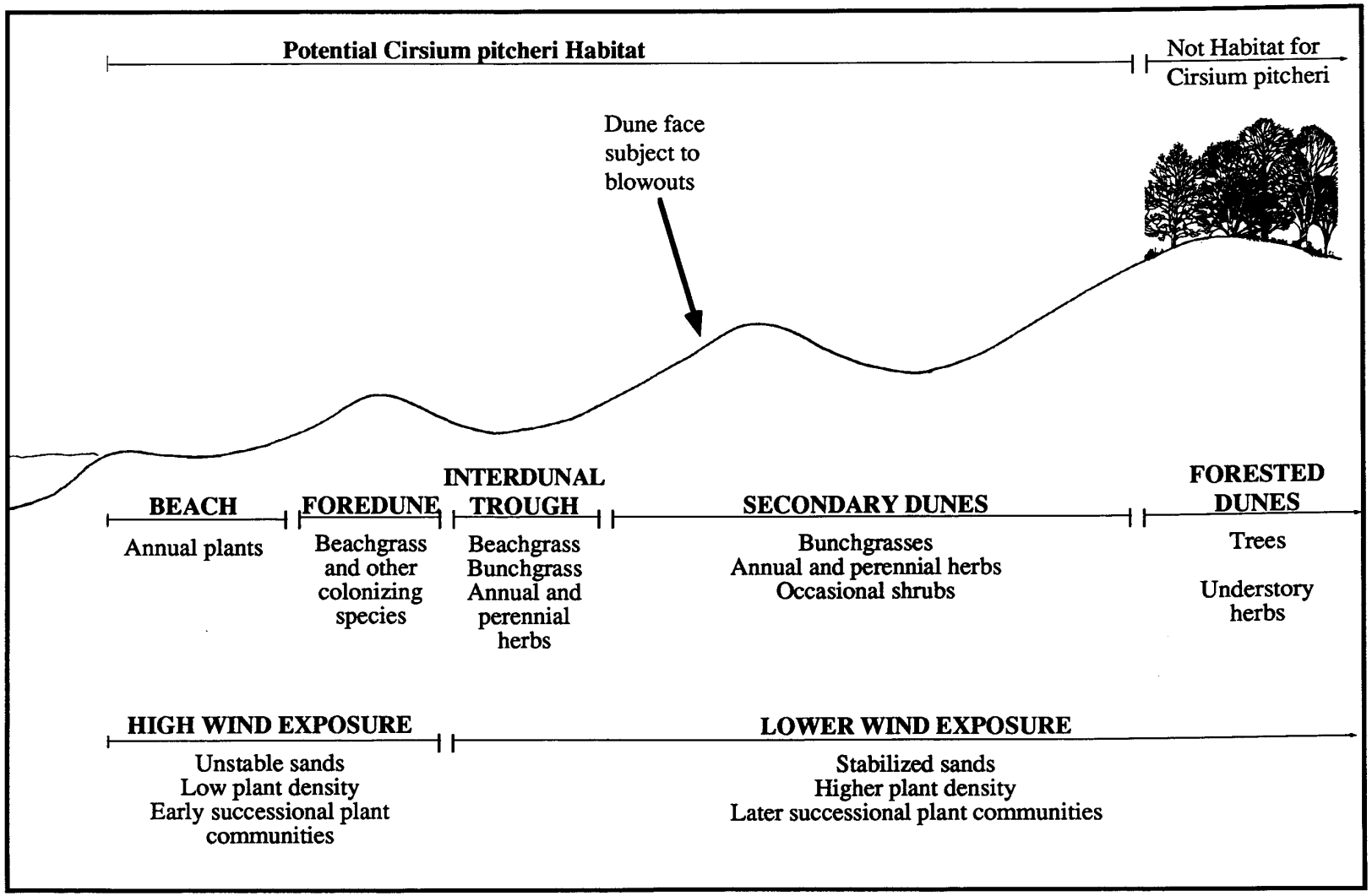

Figure 3. Generalized dune landscape providing *Cirsium pitcheri* habitat. (Figure from McEachern 1992)

geologic history (Buckler 1979). A different equilibrium now exists between the interacting forces of sand supply through long shore currents, dune formation and erosion by winds, and stabilization through plant establishment and succession. As a result of these dynamic interactions, the sizes and shapes of the Great Lakes dune systems vary with location and region, depending on the amount of sand brought to the beach by long shore drift and the orientation of the coastline relative to prevailing winds (McEachern 1992).

The Great Lakes dunes can be loosely categorized into four landscape types based on the opportunities they offer for *Cirsium* colonization and spread (Figure 4). The three **lake level** dune types are **simple linear beach foredunes**, **continuous**, and **discontinuous dune complexes**. The fourth type is the **continuous perched dune complexes** that are usually found on glacial moraines at high elevation above the lake. These four dune types each have unique geographic distributions corresponding to their glacial and post-glacial history.

Although present throughout the Great Lakes, **simple linear beach foredune systems** are found primarily adjacent to Lake Huron and on the northern and eastern shores of Lake Michigan. On simple linear dunes, the foredune is either backed by a wave-cut cliff, or it grades immediately into forested secondary dunes. Pitcher's thistle live on the foredunes of simple linear dune systems, as little or no *Cirsium* habitat occurs inland in simple linear dune systems. Because the foredune may be flooded, simple linear dunes do not have refugia during high lake levels. Consequently, Pitcher's thistle occurrences may be eliminated by natural or human disturbances concentrated on the beach and first dune. Such disturbances include erosion by high lake levels, alteration of sand movement by erosion control structures (groins and jetties), or repeated trampling of plants by people.

Continuous dune complexes contain refugia from disturbances in open grassland habitat inland from the foredune. Continuous dune complexes occur on the east and west shores of Lake Michigan, and have continuous expanses of *Cirsium* habitat for colonization. Pitcher's thistle locally extirpated from one portion of a continuous dune complex can be recolonized by seed from Pitcher's thistle on adjacent dunes. Chances for *Cirsium* persistence in these systems are high as long as the dune complexes remain large, unfragmented, and the processes of dune accretion and erosion, plant succession, and habitat turnover continue.

Discontinuous dune complexes are primarily found along the east and southeast Lake Michigan shore in Indiana and Michigan, and one in Wisconsin. On discontinuous dune complexes, the shoreline runs roughly perpendicular to prevailing northwest winter winds, and linear dunes are interrupted by blowouts that extend inland into forested dunes. The blowouts serve as habitat refugia for Pitcher's thistle. On discontinuous dune complexes, Pitcher's thistle are more buffered against extirpation than simple linear

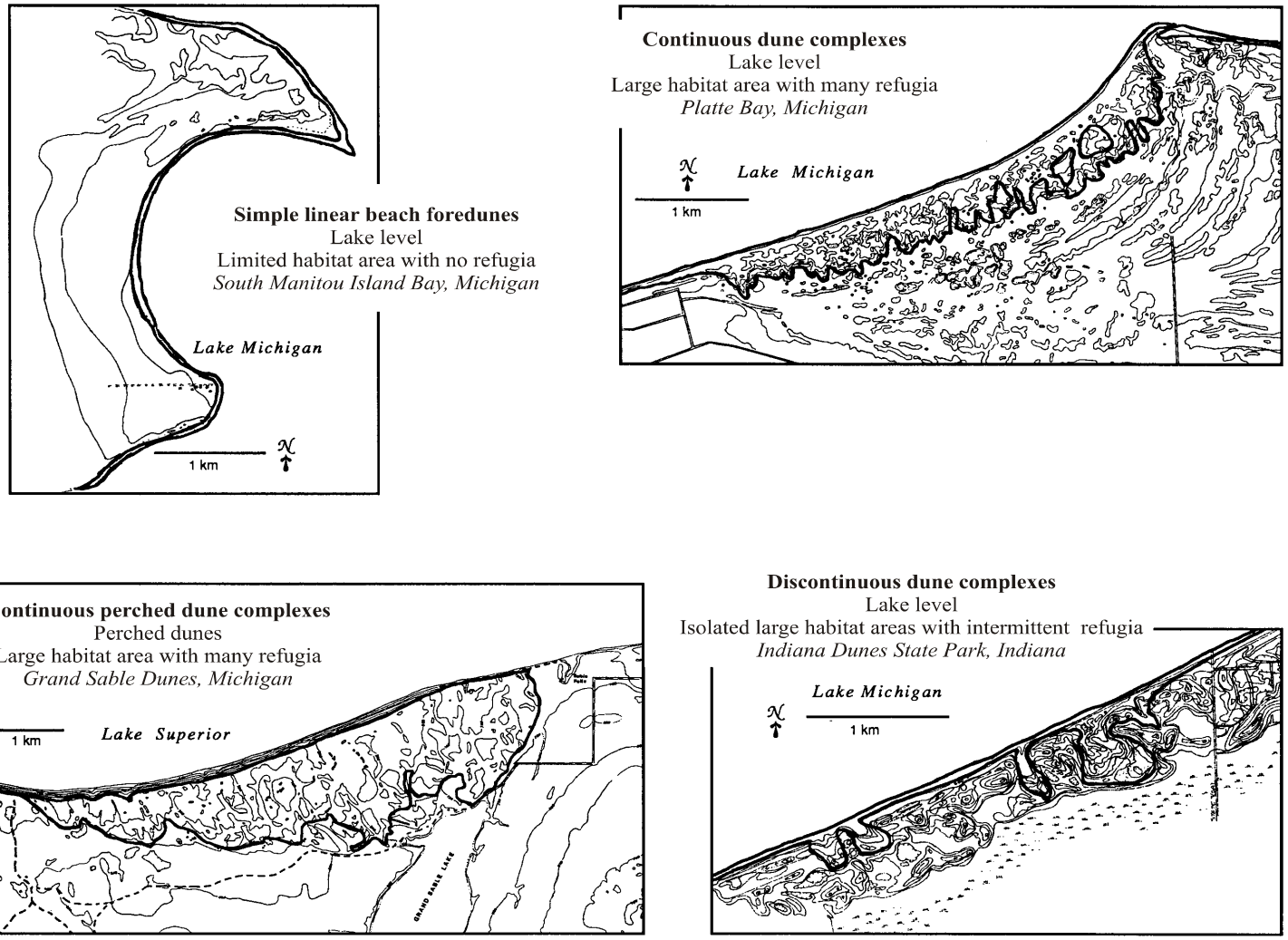

Figure 4. *Cirsium pitcheri* dune landscape habitat types (areas indicated by dark outlines). (Figure modified from McEachern 1992)

dunes. The blowouts extend open habitat suitable for Pitcher's thistle inland, away from potential flooding. However, blowouts are typically separated by several kilometers of unsuitable forested habitat. Following an event that extirpated foredune and some blowout occurrences, seed dispersal from remaining blow-out refugia would not likely disperse quickly to all dune habitat between the remaining occupied blowouts. Therefore, blowouts that lose *Cirsium* are less likely to be recolonized than areas in the continuous dune complexes.

Continuous perched dune complexes are found on the northwest Lower Michigan shoreline and at a single site on the Lake Superior shoreline. Continuous perched dune complexes are elevated on ancient glacial moraines with bluffs 30 to 120 m above the present lake level and can extend at least a mile inland. Perched dunes are nourished by sand blowing off nearby bluff faces when lake levels are high rather than from beaches when lake levels are low (Marsh and Marsh 1987, Anderton and Loope 1995). Due to their exposure to frequent high winds, perched dunes have highly mobile foredunes at the bluff edges.

Pitcher's thistle are most likely to persist long-term on three extensive dune landscape types: continuous dune complexes, discontinuous dune complexes, and perched dune complexes. These three types of dune systems formed hundreds of years ago after deglaciation produced abundant sand supplies. Because sediment accretion rates are lower now, these dune complexes cannot be recreated if they are destroyed, but they can be reinvigorated if sand supply periodically increases. Simple dune systems, however, are maintained by ongoing processes and can persist as long as sufficient sand is delivered to them via long shore currents, and long shore delivery is not interrupted by construction or stabilization. Because of these differences, dune type is an important parameter in considering the viability and restoration of Pitcher's thistle.

E. Life History and Ecology

Pitcher's thistle colonizes patches of open, windblown areas of the landscape, and gradually declines locally as the density of vegetation and ground litter increases through plant succession. *Cirsium pitcheri* is dependent on continually colonizing the mosaic of open habitats within the Great Lakes dunes. The species is patchily distributed with varying population sizes in all open zones of the dunes vegetation. Plant populations decline in stabilized, late successional secondary dune sites and in areas heavily used by people. *Cirsium pitcheri* density peaks in mid-successional habitats and requires 70% open sand for successful seedling establishment and survival (McEachern 1992). Population sizes may vary with habitat. While occurring on Indiana and Illinois beaches early in this century (Cowles 1899, 1901), the species is now seldom reported in surveys of beach flora (Bowles 1990). Researchers report its occurrence primarily in all other parts of dune systems studied in Michigan (Bach 1978; Nepstad 1981; Hazlett and Vande Kopple 1983, 1984; Loveless 1984; MNFI 1987; Loveless and Hamrick 1988), Indiana

(Wilhelm 1980, Bowles et al. 1985, McEachern et al. 1989, Bowles 1990), and Wisconsin (Alverson 1981, Dobberpuhl and Gibson 1987, Bowles 1990). In these dunes it is patchily distributed along foredunes and in blowouts, with declining numbers in stabilized, late-successional secondary dune sites and in areas heavily used by people. Insect herbivory appears to increase with successional advancement (Stanforth et al. 1997).

Environmental conditions for plant growth become less harsh with increasing distance from shore, resulting in zonation of plant communities paralleling the dune forms. Many fast-growing annual plant species (Appendix A), inhabit the loose, blowing sands of the beach between the wave-wash zone and the foredune. In years of high lake levels or intense summer storm activity this zone can be very narrow to nonexistent, while in other years it can be many meters wide. Therefore, these annual plants fluctuate greatly in number and distribution from year to year and depend on a store of dormant seeds buried in the sand to carry them through harsh years.

The foredune presents a similarly dynamic substrate for plant growth, as it grows and moves in response to weather patterns. When lake levels are low and the beach is wide, a large amount of sand is blown landward. The sand is trapped by the vegetation and the foredune builds rapidly. In years of narrow beach area, the foredune grows more slowly, or may even be undercut by high waves. Foredune vegetation is typically a near monoculture of rhizomatous beach grass (*Ammophila breviligulata*) growing with stress-tolerant shrubs and herbaceous species inhabiting the open, stabilized spaces between the grass stems. In wet springs foredune buildup may be caused by a flush of cottonwood regeneration and establishment (Poulson 1990, 1995). Foredune plants tolerate high amounts of sunlight and wind, and adjust their growth rates to accommodate the shifting sand substrate. In the interdunal trough zone this plant community becomes more dense and species less drought tolerant are found.

In secondary dunes, the greater distance from the shore allows lower wind speeds, more stable sand substrate, and more dense plant growth. Beach-adapted species are replaced by perennial grasses, such as little bluestem (*Andropogon scoparius*). Whereas ground cover can be as low as 6% in the foredunes, it commonly reaches 40-50% in the secondary dunes (McEachern 1992). The sands have incorporated more organic matter into the surface layer, and can support a greater amount of biomass (Olson 1958b). Plant species diversity is higher in the secondary dunes, with a greater variety of life forms, ranging from small herbaceous annuals to evergreen shrubs and small trees. This dune grassland typically grades into an oak, pine or beech-maple woodland on the older dunes. Ground-layer vegetation there receives little light, and the open dunes flora is completely replaced by shade tolerant forest understory plants.

When foredunes are breached by high winds, waves or human activities, parabolic blowouts push inland from the trough and windward face of the secondary dune. Recent

evidence suggests that blowouts are formed after some lake level highstands that occur at approximately 150 year intervals (Loope and Abrogast 2000). These blowouts range from several square meters to hectares in area. Blowouts and other disturbances in the secondary dunes provide foredune-like habitats for beach and foredune species such as Pitcher's thistle, if destabilizing effects of the disturbance are not too severe. Once stabilized, the blowouts eventually succeed to little bluestem dominated grassland, displacing the colonizing species.

By colonizing blowouts, Pitcher's thistle and other species characteristic of the beach and foredune locations persist for a time at scattered sites within the more protected secondary dunes. In years when the foredunes are truncated by high lake levels or storm activity, such sites may serve as refugia for those species, contributing to eventual beach and foredune recolonization (McEachern 1992). Beach and foredune plant species depend on a dynamic microhabitat for their persistence in the dune flora. Therefore, smaller dune fields, limited in their range of microhabitats, are more likely to lose these species than are larger dune fields richer in the mosaic of dune forms and early successional openings.

Seed Ecology

Cirsium pitcheri has the largest individual seeds, each weighing about 0.010 gm, among thistles in the eastern United States (Gleason 1952, Montgomery 1977). This large seed size may be advantageous for rapid seedling establishment by maximizing seedling root growth in the often hot, dry, and infertile dune sand substrate. Loveless (1984) found that average seed weight was greater at stabilized sites than in less stable foredune sites. Larger seed size may be selected for in stabilized sites because seedlings from larger seeds would be able to grow a deeper taproot in a shorter time to evade dry conditions. Moisture may be more available on the foredune due to proximity to the lake and ground water flow. Hamzé and Jolls (2000) found that Pitcher's thistle seeds were heavier at the Upper Peninsula sites compared to sites south of the Straits of Mackinac.

Seed dispersal commences in late July at the northern limits of its range (Keddy and Keddy 1984), but can occur from June to August (McEachern 1992). Seeds have a long (up to 25 mm) loosely attached pappus. Primary seed dispersal is through individual seeds blowing from the inflorescence head or by the whole plant and heads falling to the ground at the end of the flowering season. Maximum observed primary dispersal distances range from 1.83 to 4.00 m based on seed locations and on seedling distributions around previous year's adult plants (Keddy and Keddy 1984, Loveless 1984, Ziemer 1989). Secondary dispersal is effected by wind blowing seed and seed heads across the sand, snow or water surface (Loveless 1984).

Pitcher's thistle seeds are subject to various pre- and post-dispersal herbivory. Pre-dispersal herbivores include the artichoke plume moth larvae (***Platyptilia carduidactyla***),

ground squirrels, goldfinches (*Spinus tristis*), and deer. Sparrows and other ground feeding birds and small mammals may eat seeds after dispersal (Keddy and Keddy 1984, Loveless 1984, McEachern 1992, D'Ulisse and Maun 1996, Stanforth et al. 1997). Pre-dispersal seed predation can have a significant impact on Pitcher's thistle demography as evidenced by observed seed set reductions of 42 and 14% at the Canadian population on Lake Superior (Keddy and Keddy 1984; Loveless 1984; Svata Louda, University of Nebraska-Lincoln, pers. comm.). Loveless (1984) found pre-dispersal predation highest inland and density independent whereas Keddy and Keddy (1984) found it highly density dependent. Little is known concerning post-dispersal seed losses.

Pitcher's thistle appears to have a small between-year seedbank (Loveless 1984, McEachern 1992, Bowles and McBride 1996, Hamzé and Jolls 2000). McEachern (pers. comm.) has had seeds remain viable for three years. This suggests a buried seedbank may not strongly buffer population stability when plants are destroyed. Seed dispersal to nearby suitable habitats may be more important for population stability than the seedbank.

Seed Germination

Dormancy is broken by cold, moist stratification (Hamzé and Jolls 2000), with seed germination occurring in May and June (Loveless 1984). In field experiments, germination was higher for buried seeds than for exposed seeds (Loveless 1984). Germination of buried seeds did not vary with dispersion patterns, clumps of seeds vs. single seeds. Hamzé and Jolls (2000) found that germination was suppressed by light, increased by burial, and increased with seed size. Seed germination may vary yearly depending on rainfall. Episodic germination occurs in late-successional sites after moderate sand deposition (McEachern 1992).

Seedling Stage

Seedlings produce 1 to 6 leaves in the first season (Loveless 1984). Seedling densities are greater where bare ground is abundant (McEachern et al. 1989) than in stabilized sites with greater vegetation cover; however, there is greater seedling mortality in foredune sites relative to inland sites (Keddy and Keddy 1984, Loveless 1984). Greater mortality is found on inland-facing slopes relative to exposed foredunes at an inland embayment site. Inland facing slopes on the east side of Lake Huron face south to southwest and experience greater dessication (Ziemer 1989). After establishment, plant mortality decreases on foredunes, but remains lower and constant on more stabilized sites. Seedling mortality is caused by ant and wind excavation, drought, excessive burial in sand, and trampling (Keddy and Keddy 1984, Loveless 1984, Ziemer 1989, McEachern 1992).

Juvenile Stage

Juveniles typically consist of one rosette, unless they are grazed, trampled or buried where they may develop multiple rosettes. Juveniles may remain dormant for one or two years as a result of drought (McEachern 1992). The chances of juvenile mortality decrease as they increase in size. Causes of mortality include human and moose trampling (Keddy and Keddy 1984, Gibson 1988), sand deposition and erosion (McEachern pers. comm.; Steve Weller, University of California, Irvine, pers. comm.), drought, and rabbit herbivory (Weller pers. comm.). Root crown diameters of juveniles decreased when buried by sand (McEachern 1992). Juveniles grow or maintain a constant size throughout the growing season, but may diminish in size over the winter (Loveless 1984, McEachern 1992). Observations indicate juvenile plants in foredunes grow by increasing leaf number, whereas in inland stabilized habitats they grow by increasing leaf size (Loveless 1984). Larger leaves may be important in competitive habitats. These growth differences may be significant in determining the age when juveniles reach a critical flowering size. The probability of insect herbivory increased with juvenile size, large juvenile density, and population successional stage (Stanforth et al. 1997). This increase correlated with lower recruitment, larger plant size at maturity and greater abundance of large juveniles; therefore, Stanforth et al. (1997) hypothesized that insect herbivory increased time to maturity and decreased Pitcher's thistle persistence in late successional habitats. Similarly, Phillips and Maun (1996) found simulated intense deer herbivory in greenhouse grown plants reduced plant root dry weight. Pitcher's thistle plants may respond to intense herbivory by decreasing or delaying flowering efforts, having lower survivorship or decreased growth.

Adult Reproductive Stage

Age of reproduction ranges from 5 to 8 years and appears to be correlated with habitat. Loveless (1984) found that adults bloom sooner in more stabilized habitats than in foredunes. What specifically triggers blooming is unknown, but the length of the longest leaf (Loveless 1984) and the root crown diameter (McEachern 1992) were found to be significant predictors. However, flowering probably involves an interaction between plant size (growth rate) and age, as small plants have been observed to flower (Gibson pers. obs., McEachern pers. obs., Pavlovic pers. obs.). A garden-grown plant was observed in bloom in its first year (Weller pers. comm., unpublished Indiana Dunes research).

Adults are typically single stemmed, but multiple stemmed plants (2 to 30 stems) are known. Multiple stemming may be a result of apical meristem damage caused by many factors including trampling, grazing (Phillips and Maun 1996), sand burial, or predation by artichoke plume moth (Keddy and Keddy 1984, Loveless 1984, Gibson pers. comm.). The frequency of multiple-stemmed plants and stem counts per plant increases as site stabilization proceeds (Keddy and Keddy 1984, Loveless 1984, Gibson pers.

comm.), but McEachern (1992) found that multiple-rosetted juveniles did not necessarily produce multiple-rosetted or -stemmed adults. Multiple-stemmed plants tend to have more heads (McEachern 1992), but they are smaller than heads on single-stemmed plants.

The number of flowering heads per plant varies with habitat, latitude, plant size, and year (Keddy and Keddy 1984, Loveless 1984, McEachern et al. 1989), and is highly correlated with stem diameter (McEachern 1992). Adults at Indiana Dunes had, on average, fewer inflorescence numbers (7.3) than those at Sleeping Bear Dunes and Pictured Rocks, 27.1 and 26.2, respectively (McEachern et al. 1989, McEachern 1992). Seed head diameter is positively correlated with both viable and total seed number (McEachern 1992). Seed set fluctuated widely between years and between sites, but was highest at the foredune site (Loveless 1984).

Floral Biology

Pitcher's thistle blooms from May to September, with the date of peak anthesis occurring later with increasing latitude (mid-July at Sleeping Bear Dunes). Flowering is determinant and commences from the terminal head and proceeds downward. Smaller axillary flowering head buds located below the flowering inflorescence may bloom late in the season or if distal heads are damaged or removed. Floret number per head is positively correlated with head diameter and ranges from 30 to almost 300 florets (Keddy and Keddy 1984, Loveless 1984). Head diameter and floret number both decline as the season progresses.

Florets are bisexual and insect pollinated, with maturation proceeding from the outside of the head towards the center. Anthers of each floret produce mature pollen before the stigma is receptive. This intra-head and intra-floret phenology prevents self-pollination of florets, but allows pollination among inflorescence heads on the same plant. Thirty insect species from four orders (predominantly bees: Hymenoptera) have been observed visiting Pitcher's thistle, although which are legitimate pollinators is unknown. Inter-plant pollination predominates early and late in the blooming season, whereas intra-plant pollination dominates in mid-season (Loveless 1984).

Pitcher's thistle has a mixed mating system, with outcrossing ranging from 35 to 88% (Keddy and Keddy 1984, Loveless 1984). The species is apparently self compatible; however out crossed and open-pollinated heads have higher seed set than self-pollinated heads. Genetic neighborhoods are likely to be quite small. Whether inbreeding leads to the loss of fitness is unknown. A mixed mating system suggests that inbreeding depression could occur in small populations.

Metapopulation Dynamics

Metapopulation dynamics is important for the conservation of Pitcher's thistle (McEachern 1992). A **metapopulation** is a more or less continuous or loose collection of somewhat separate but potentially interacting and dynamic populations delimited by marked or discrete gaps in habitat or colony boundaries on a dune landscape (Figure 5). The relative separateness of populations leads to stability in a chaotic environment and affects genetic exchange among populations. As a species, Pitcher's thistle exhibits several characteristics of metapopulations (Levins 1970, Hanski 1989). First, patches of Pitcher's thistle are distributed across dune landscapes. Patches are connected by gene flow through seed and pollen dispersal to other patches, but those farther away are more loosely connected than those closer. In any dune landscape, not all suitable habitat patches are occupied by Pitcher's thistle. Second, Pitcher's thistle patches are dynamic and can be created or destroyed. For example, a patch can be destroyed by excessive sand deposition or erosion, especially near the shoreline. After conditions make the site suitable, it can be recolonized by seed dispersal from adjacent patches provided they are close enough (McEachern 1992). Third, disturbances that influence the patch's number of individuals, size, growth, and fate must be partially uncorrelated in space and time in large dune systems. For example, McEachern (1992) found that storms that destroyed near shore populations were less severe inland and actually contributed to population growth inland by causing light sand deposition which allowed the establishment of new plants.

At the ecosystem level, the sand dune habitat for Pitcher's thistle in the western Great Lakes is limited by the geomorphic processes that created the dunes. These habitats are often influenced by fluctuating lake levels due to severe seasonal weather patterns and regional climatic variation. Episodic sand deposition occurs in shoreline dunes when lake level is declining and in perched dunes when lake levels are increasing. Therefore weather events are unlikely to simultaneously destroy all Pitcher's thistle habitats.

Populations of Pitcher's thistle are relatively short-lived on dune landscapes, because they are prone to extirpation due to successional change, erosional loss and catastrophic events depending on their location. A shifting mosaic of dune processes on a large dune system landscape can ensure a species persistence so long as seed is available to disperse to existing or newly created adjacent suitable habitats. In the long-term, Pitcher's thistle populations will also shift on such a landscape. This metapopulation perspective clearly shows how human development on an unoccupied habitat could eventually fragment Pitcher's thistle connectivity and increase the probability of local extirpation of the species. Construction on a portion of a dune system where Pitcher's thistle is currently absent will, in the long, run fragment the dune system and increase the probability of population extinction by eliminating habitat available for recolonization.

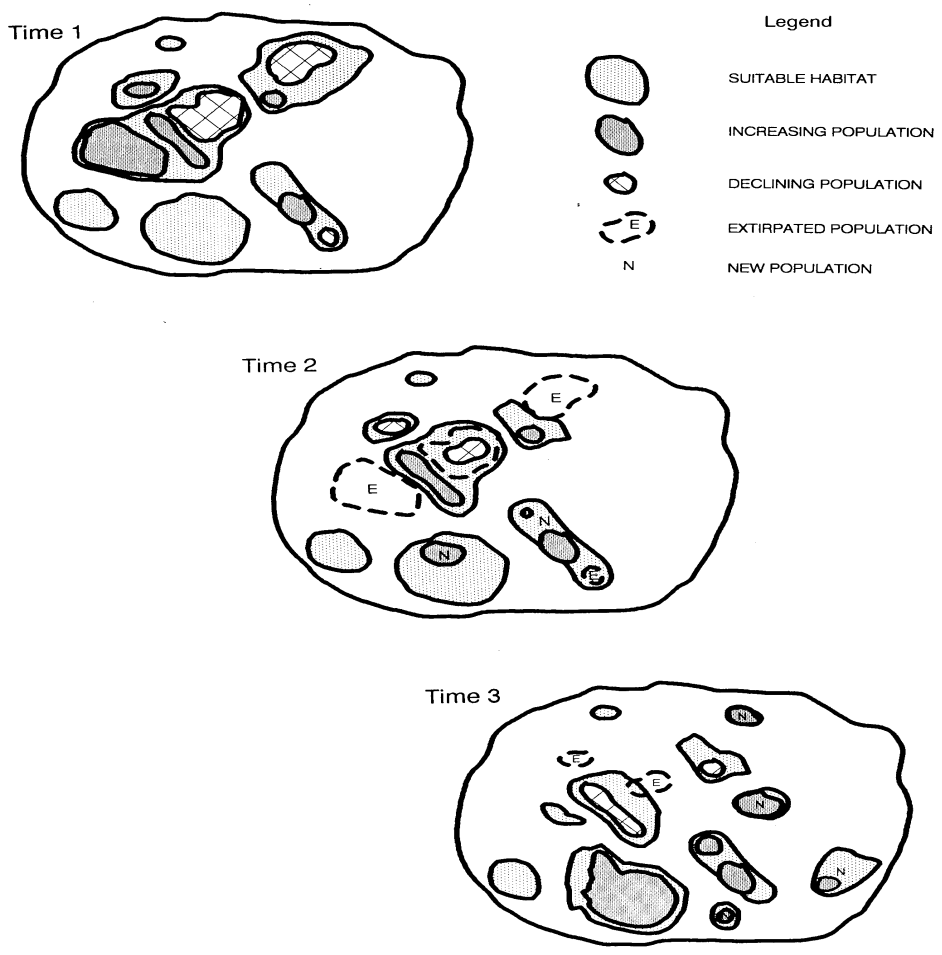

Figure 5. Metapopulation model for conservation of species like *Cirsium pitcheri*.

Sequence of three times illustrates various properties of metapopulation dynamics:

1. Not all suitable habitat patches are occupied in one time nor are they fixed in space. At Time 1, three suitable patches are unoccupied, two patches are unoccupied at Time 2 and three at Time 3. In the sequence, two suitable habitat patches decrease in size, one disappears and four are created.

2. For a species to fit a metapopulation model, populations must be weakly linked so their trends and growth rates are not synchronous among populations. In this model, some populations are declining while others are increasing. Also suitable habitats that are occupied are shifting in time and space.

Figure developed by McEachern and Pavlovic (1991) and modified from Pavlovic and Bowles (1996).

Dune landscape fragmentation effectively isolates populations and presents barriers to dispersal while changing dune processes.

The fates of local habitats and populations are determined by succession and disturbance. Similarly, Pitcher's thistle populations can fluctuate greatly in number, size class distribution, and growth rate between years (Loveless 1984, McEachern 1992) in response to a variety of natural and human factors that alter individual Pitcher's thistle death and reproductive rates. Generally, occurrences in areas of sustained, low-level sand deposition showed stable or increasing populations (McEachern 1992). One occurrence at Indiana Dunes differed from this pattern as chronic human trampling caused high seedling and juvenile mortality thus preventing population growth. That Indiana Dune occurrence declined over four years of study although present in an early successional community. In more recent years the population rebounded when trail use decreased temporarily.

For a particular occurrence of Pitcher's thistle to survive, disturbance must be frequent enough to prevent extirpation from succession and infrequent enough to allow juveniles to reach maturity; thus the Pitcher's thistle life history is finely tuned to a specific disturbance regime (McEachern 1992). Disturbances may eliminate local occurrences, but as long as those disturbances are not synchronous throughout the landscape, and occurrence creation exceeds decline, the species will persist (Pavlovic 1994). Persistence will be lowered by factors that increase the variability in population growth rate, lower the maximum population size ceiling, and/or lower the average population growth rate (Goodman 1987). While no variance-producing factor alone may be sufficient to cause extirpation, a combination of factors may drive an occurrence into an inescapable extinction vortex (Gilpin and Soulé 1986).

From an ecosystem perspective, protection and conservation of both lake level and perched dune systems will probably prevent extinction from climatically driven disasters because the two dune systems respond oppositely to the same climatic perturbations. From a landscape perspective, recovery of Pitcher's thistle will require the preservation of large unfragmented dune systems retaining dynamic dune processes and many local patches widely dispersed among multiple successional stages throughout the dune system.

F. Threats

Destruction, modification or curtailment of habitat or range

Development, sand mining, beach and dune stabilization projects, and certain types of frequent recreation have destroyed, modified or curtailed approximately 10% (18/191) of the Pitcher's thistle habitat, and reduced its range. For instance, seven Pitcher's thistle populations were extirpated from Indiana and Illinois, but the number lost elsewhere is not known.

Residential home construction, hotel and resort construction, road construction, condominium construction and marina construction have impacted Pitcher's thistle (Lake Michigan Development Commission 1987). At Manistee, Michigan, two small Pitcher's thistle populations were fenced at a condominium/marina development, but their long-term viability is uncertain. Permits are issued annually for home development in "critical dune areas" in Michigan by the Michigan Department of Environmental Quality (MDEQ). Many of these areas support Pitcher's thistle or potential habitat. Human disturbance along highway shoulders adjacent to existing thistle populations often encourages the short-term establishment of Pitcher's thistle; however, these plants are vulnerable to destruction from road maintenance mowing, grading, brush and tree removal, herbicide spraying and road improvements including road widening, pavement recycling, guardrail removal, slope flattening, culvert extensions, and vegetation removal for safety. Effects of snow removal and use of deicing salt are unknown. Maintenance and construction activities have encouraged a weedy flora along the highways. In addition to a demonstrated threat from past development and recreation, new developments are under construction or are planned.

Trampling from beach and dune visitors, and off-road vehicle (ORV) users also threaten Pitcher's thistle and their habitat, where such recreation is frequent and prolonged. For example, off-road vehicles destroy plants, create new blowouts and severely destabilize dunes that are accessible, such as along a highway or in municipal parks (USFWS 1988; Edward Voss, University of Michigan, pers. comm.). The Nature Conservancy (TNC) reports that ORV damage continues even after measures such as talking with local neighbors, involving local Department of Natural Resource (DNR) Conservation Officers, and extensive signing and barricading of their shoreline preserves (Dave Ewert, TNC, pers. comm.). Trampling from high visitor use causes a decrease in survival and reproduction of individual plants (Gibson pers. comm.) and can cause seed bed destabilization (McEachern et al. 1989, McEachern 1992). Direct human trampling occurs primarily during the growing season and is caused by people hiking, climbing dunes, and hang gliding (Davis and Wood 1980). Trampling and high visitor use is a significant issue at certain areas in Wisconsin (Dobberpuhl and Gibson 1987), Indiana, Michigan and potentially in Illinois where beach and dune zones are quite narrow. For instance, plant occurrences in areas of the Indiana Dunes West Beach where visitors can wander the dunes are fewer in number and smaller in area than occurrences at adjacent fenced and boardwalk areas (McEachern 1992, Pavlovic and Bowles 1996).

Shoreline stabilization projects such as jetties, sea walls and rip-rap change sand supply through the alteration of off-shore sand transport, which alters local dune geomorphic processes and precludes the creation and maintenance of Pitcher's thistle habitat (Dobberpuhl and Gibson 1987, McEachern et al. 1989). Erosion was measured at 5.2 m/yr down current and accretion at 7.9 m/yr up current from the Michigan City Harbor in Indiana (Wood and Davis 1987, Wood 1987). Sea walls and jetties were built along beaches containing *Cirsium pitcheri* in Wisconsin, Indiana and Michigan

(Dobberpuhl and Gibson 1987, McEachern et al. 1989). In 1987 hundreds of *Cirsium pitcheri* were destroyed when rip-rap was placed on the shoreline to maintain U.S. Highway 2 east of Brevort, Michigan.

Planting to stabilize dunes also alters dune building processes and may decrease habitat available to *Cirsium pitcheri* (Dobberpuhl and Gibson 1987, McEachern et al. 1989, Loope et al. 1995). For example, planting or invasion of beach grass (*Ammophila breviligulata*), northern white cedar (*Thuja occidentalis*), spotted knapweed (*Centaurea maculosa*), baby's-breath (*Gypsophila paniculata*) or sweet clover (*Melilotus alba*) stabilizes dunes, thereby reducing the creation of new Pitcher's thistle habitat (Dobberpuhl and Gibson 1987).

Foundry-sand mining operations are present along the Lake Michigan shore. In 2001 there were 14 sand dune mining permits listed as active (Paul Sundeen, MDEQ Geological Survey Division, pers. comm., 2002). The amount of sand mined has increased overall from 1.6 million tons in 1991 to 2.8 million tons in 2000 (MDEQ 2000). The impact on Pitcher's thistle is not known in the six counties with active sand mining permits and species occurrences. No *Cirsium pitcheri* sites are being mined in Indiana or Wisconsin.

Overutilization

At the time of listing, Pitcher's thistle was not known or suspected to be overutilized for commercial, recreational, scientific or educational purposes. Since 1988, however, interest in native plants has increased, and it is possible *Cirsium pitcheri* could become desirable for collection. A person was observed picking a dune thistle flower on one occasion, but the individual's intentions were not known (McEachern et al. 1989). Presently, overcollection does not appear to be a serious threat.

Disease and Predation

While species-specific diseases are not known to be a threat at this time, introduced species used for biological control appear to pose a substantial risk and are discussed later under the subsection listing other natural or manmade factors. Predation of seeds by birds, small mammals, and deer has been observed (Keddy and Keddy 1984, Loveless 1984, McEachern 1992, D'Ulisse and Maun 1996, Stanforth et al. 1997).

Inadequacies of Existing Regulatory Mechanisms

Government units below State level generally do not provide adequate protection for rare plants. Moran Township in Mackinac County, Michigan has recently passed zoning ordinances designed to protect some natural resources. However, other townships

have outdated zoning ordinances that leave the local governments ill equipped to deal with the current development.

Overall, 50 Michigan occurrences of Pitcher's thistle are at sites designated as Critical Dune Areas (Michigan Department of Natural Resources [MDNR]1989). These areas, which are found along much of Lakes Michigan and Superior shorelines, are subject to regulation under Part 353, Sand Dune Protection and Management, of The Natural Resources and Environmental Protection Act of 1994 (NREPA), as amended (MCL 324.35301-324.35326). Permits are issued annually for home development in Critical Dune Areas in Michigan by MDEQ. These permits currently include conditions to avoid immediate loss of existing plants, but Part 353 does not address fragmentation or potential alteration in dune-sustaining processes. Examples of development on dunes occur at Cross Village Shores near Sturgeon Bay in Emmet County and in the city of Manistee in Manistee County.

Under the Wisconsin Endangered Species Act (WI-ESA) State agencies do not have authority to protect listed species from impacts on private land unless the activity otherwise requires a Federal permit or funding. Michigan's Endangered Species Protection law, Part 365 of NREPA, protects listed plants on public and private land, both states provide measures to protect habitat of both endangered and threatened plants and animals. In addition, Part 365 does not regulate secondary or indirect impacts of actions on listed species. For example, the State of Michigan may permit construction of a facility near a population of Pitcher's thistle. Chronic maintenance and adjacent land use may pose significant long-term effects on the habitat of the plant and individuals. However, if the construction of the facility is not expected to cause direct impacts to the species, endangered species permits are not required from the State and the State has no authority to require protection of the plants from likely indirect effects.

Destruction of both populations and habitat continues due to insensitivity and lack of enforcement. For example, in 1987 MDOT spent over $50,000 in mitigation for the impacts of road construction to dwarf lake iris, Pitcher's thistle, and Lake Huron tansy (*Tanacetum huronense* Nutt.) along U.S. Highway 2 near Thompson, Schoolcraft Co., Michigan. However, these efforts were negated by the activity of a homeowner and MDOT's herbicide spraying, despite the presence of signs warning against such activities. In October 2000, numerous Pitcher's thistle plants were obliterated when road maintenance to remove or prevent drifting sand occurred along a 2 mile section of U.S. Highway 2 through Forest Service land signed as a "Protected Area". Improved interagency communication may help avoid such events. Public information and enforcement could help prevent destruction, although in some cases knowledge of the species presence prompts landowners to pull up plants so they may proceed with development (Steve DeBrabander, MDNR, pers. comm.).

Michigan wetland permit applicants often request transplanting and propagation in lieu of on-site protection for listed species. Under Michigan's NREPA transplanting is approved under "experimental" conditions only. However, the State has permitted transplantation with and without follow-up monitoring. Pitcher's thistle juvenile plants have been successfully transplanted at the Presque Isle State Mooring Facility in northern lower Michigan (Fahlsing 1993).

The Federal Endangered Species Act of 1973 (ESA), as amended, provides little protection for listed plants on private property except where Federal agency action is involved (see Conservation Measures). For instance, under section 7 of the ESA, U.S. Army Corps of Engineers wetland permits are reviewed for impacts on Federally listed species, including Pitcher's thistle. However, in many instances, no Federal permits or other Federal actions are involved and some of those actions not reviewed under ESA may impact Pitcher's thistle.

Other natural or manmade factors affecting its continued existence

Pitcher's thistle is threatened by fragmentation, and may be threatened by genetic introgression, non-native invasive weeds and non-native insect species accidentally introduced or deliberately introduced to control weedy thistles. Global warming may also pose a risk. As described previously, the long-term survival of Pitcher's thistle requires a shifting mosaic of suitable habitat available at all times so that, as areas are made unsuitable by succession, new areas of suitable habitat are created close enough for seed dispersal. Fragmentation prevents the creation of new areas of suitable habitat and likely interferes with seed dispersal.

Proximity of the common bull thistle (*Cirsium vulgare*) may present a potential threat of introgressive hybridization with *Cirsium pitcheri* (Dobberpuhl and Gibson 1987). *Cirsium vulgare* is also the adopted host of several microlepidoptera (moths) that feed on native *Cirsium* spp. (Louda 2000). *Cirsium vulgare* in the vicinity could increase populations of the moths and lead to increased feeding damage on Pitcher's thistle flowerheads, over and above the significant levels already seen at some sites (Louda and McEachern 1995, and unpublished data). Stabilization of large areas of the dunes by invasive non-native weeds, such as spotted knapweed, can also retard the natural maintenance of the shifting mosaic of suitable sand habitat. The magnitude of this potential threat should be monitored and quantified.

The flowerhead weevil (***Rhynocyllus conicus)*** was introduced into several North American sites to control species of Eurasian thistles (*Carduus* sp.). This flowerhead weevil has spread to many locations, and has become naturalized (Louda et al. 1997). The flowerhead weevil develops on multiple native *Cirsium* species in the United States (Goeden and Ricker 1986a, 1986b, 1987a, 1987b; Turner et al. 1987; Louda et al. 1997), including *Cirsium canescens,* the putative progenitor of Pitcher's thistle (Johnson and

Iltis 1963). Studies show that flowerheads of *Cirsium canescens* infested with flowerhead weevil bear only 14.1% as many seeds as flowerheads not infested with flowerhead weevil (Louda et al. 1997). Laboratory tests in the summer of 1999 demonstrated that this weevil will oviposit on Pitcher's thistle, and that it feeds and develops on Pitcher's thistle under common garden test plot conditions in Alberta, Canada (Louda et al. 2002). Thus, if the flowerhead weevil spreads to Pitcher's thistle range, and the Pitcher's thistle shows a comparable reduction in seed production, the flowerhead weevil poses a serious threat to Pitcher's thistle seed production and regeneration (Louda et al. 1997, Louda 2000). Other insects introduced for the biological control of non-native thistle species may also threaten native thistles, including close relatives of Pitcher's thistle (Louda and O'Brien 2002).

Introduction of the rust *Puccinia carduorum* from Turkey to control the weedy non-native thistle (*Carduus nutans)* is under consideration by the United States Department of Agriculture (Politis et al. 1984, Bruckart and Dowler 1986). In a greenhouse study with conditions optimal for rust infection, Pitcher's thistle seedlings, but not adults, were susceptible to the rust infection. In a field trial no Pitcher's thistle plants were infected (William Bruckart, Agricultural Research Service, USDA, pers. comm.). A determination cannot be made from present data as to whether Pitcher's thistle is susceptible to infection under natural environmental conditions. Introduction of this rust could be a threat to the survival of *Cirsium pitcheri*.

Global warming may increase drought frequency. Droughts may account for the poor success of *Cirsium pitcheri* populations at the Indiana Dunes National Lakeshore (McEachern et al. 1989) and at other southern locations. Global warming may affect the water table levels along the Great Lakes shorelines and impact Pitcher's thistle through altered shoreline processes.

G. Conservation Measures

Conservation measures provided to Pitcher's thistle include recognition, recovery actions, Federal protection, and prohibitions against certain practices. Recognition through listing encourages and results in conservation actions by Federal, State, and private agencies, groups, and individuals. The ESA allows for land acquisition in cooperation with the States if funds are available. The ESA requires the development of recovery plans for most listed species. The ESA section 7 obligations of Federal agencies and the section 9 prohibitions against certain activities involving listed plants are discussed, in part, below.

Section 7(a)(2) of the ESA requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to critical habitat, if any has been designated. Pitcher's thistle was listed as a threatened species without critical habitat designation. Regulations implementing section 7 interagency cooperation provisions of the ESA are codified at 50 CFR Part 402.

Section 7(a)(2) requires Federal agencies to ensure activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the Pitcher's thistle. If a Federal action is likely to adversely affect Pitcher's thistle, the Federal agency must enter into formal consultation with the U.S. Fish and Wildlife Service (Service). Thus, if any occurrence is on land that is administered by a Federal agency or for which a Federal permit is required or funding is used, procedures in section 7(a)(2) and 50 CFR Part 402 must be followed.

Sections 9 and 10 of the ESA and their implementing regulations found at 50 CFR 17.71 and 17.72 set forth a series of prohibitions and exceptions that apply to threatened plant species not covered by a special rule. No special rule has been published for Pitcher's thistle. These prohibitions, in part, make it illegal for any person subject to the jurisdiction of the United States to import or export; transport in interstate or foreign commerce in the course of a commercial activity; sell or offer for sale this species in interstate or foreign commerce; or to remove and reduce to possession this species from areas under Federal jurisdiction; maliciously damage or destroy this species on any area under Federal jurisdiction; or remove, cut, dig up, damage, or destroy this species on any other area in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law. "Plant" means any member of the plant kingdom, including seeds, roots, and other parts. Because Pitcher's thistle is a threatened plant species, seeds from cultivated specimens are exempt from these prohibitions provided that a statement of "cultivated origin" appears on their containers. Certain exceptions apply to agents of the Service and State conservation agencies. The ESA does not directly prohibit the taking of threatened plants on non-Federal land. Where Federal agency actions are involved, section 7, as discussed above, provides the Service a means to make recommendations for protection, management and conservation.

Section 10 of the ESA and 50 CFR 17.72 provide for the issuance of permits to carry out otherwise prohibited activities involving threatened species under certain circumstances. Such permits are available for scientific purposes or to enhance the propagation or survival of the species. In some instances, permits may be issued for a specified time to relieve undue economic hardship that would be suffered if such relief were not available. It is anticipated that few trade permits would ever be sought or issued as this species is not commonly cultivated. Requests for permit applications, copies of the regulations on plants and inquiries regarding them may be addressed to Permits Coordinator, Division of Endangered Species, U.S. Fish and Wildlife Service, 1 Federal Drive, Fort Snelling, MN 55111-4056 (phone 612-713-5350, fax 612-713-5292, TTY 800-877-8339). Information on permits and other endangered species issues also is available via the internet at http://midwest.fws.gov/Endangered/.

Section 6 of the ESA allows the Service to provide money to States for the conservation of species. The Service has funded the Michigan Natural Features Inventory, through the MDNR, to conduct a Landowner Contact Program to notify

landowners of the presence of Pitcher's thistle and other threatened or endangered plants, and to suggest methods for protecting the species on their lands.

State Efforts

The Wisconsin landowner contact program administered by the Bureau of Endangered Resources (BER) has protected 8 privately-owned Pitcher's thistle sites in Door, Manitowoc, and Sheboygan counties. All of the private owners of Pitcher's thistle tracts in Wisconsin have been contacted. Landowners who enter voluntary protection agreements with the BER director receive a plaque with a Pitcher's thistle print and the BER newsletter. The landowner annually provides information on the trends or threats for their occurrence. The system is maintained with continued landowner contact (David Kopitzke, Wisconsin Department of Natural Resources, pers. comm.).

Part 365, Endangered Species Protection, of Michigan's NREPA, Act 451 of the Public Acts of 1994, sections 324.36501 to 324.36507 of Michigan Compiled Laws Annotated, makes it illegal to take (collect, pick, cut, dig up, or destroy in any manner), possess, transport, import, export, process, sell or offer for sale, or buy or offer to buy any plant listed as endangered or threatened by the Federal government. "Plant" means any member of the plant kingdom, including seeds, roots, or other parts. State-designated special areas, such as Critical Dune Areas, Environmental Areas, Management Areas, Natural Areas, Nature Study Areas, and Wildlife Study Areas, all have additional protection. A permit is needed to disturb any plants in State Forests, and approval from the Park is necessary before disturbing any plants in State Parks. On other State land, all listed plants are protected by Part 365. The MDOT Special Plant Manual reiterates Federal and State protection afforded listed species. MDOT has agreed with the MDNR to place "PROTECTED AREA" signs at each listed species site in their right-of-ways (ROWs). The only routine maintenance activity officially permitted is shoulder mowing and sand grading. Impacts to Pitcher's thistle have been minimized on MDOT ROWs through mitigation as required by the MDNR and the Service for Federally funded projects. Violations have occurred and the program is under review to increase its effectiveness.

Reintroduction Experiments

Two Pitcher's thistle reintroduction experiments are underway, one at Indiana Dunes National Lakeshore and one at Illinois State Park (Bowles et al. 1993; Bowles and McBride 1993, 1994; McEachern et al. 1994). McEachern and Louda initiated a small experiment in 1994 to examine how habitat, seed source and method of seed sowing influence Pitcher's thistle reintroduction. Two habitats were used: 1) bare sand in a blowout, dune grass (*Ammophila breviligulata*) dominated dune, and 2) successional dune dominated by little bluestem (*Andropogon scoparius)*. Seeds were collected from three Indiana occurrences in 1993. In 1994, seeds were either broadcast or buried 1 cm deep in half of each plot. There were two replications within habitats. The blowout site

was completely buried in 1995, difficult to relocate and was not subsequently monitored. To date significant findings include: 1) More seedlings were found in the planted plots than the broadcast plots, and 2) There is at least a 2 year carryover of seeds in the seedbank. This single cohort reintroduction is being monitored.

Bowles first began reintroducing Pitcher's thistle in 1991 into suitable habitat south of Dead River at Illinois Beach State Park. In 1991, all introduced plants were greenhouse grown from seed collected in Wisconsin, Indiana, and southwest Michigan; however in 1993 seeds were also directly planted at the site. Survival for was lowest in the first year after planting (0 to 50%). All 1996 transplants were killed by the 1996 August drought. For all years, cohort survival varied from 0 to 23%. Wisconsin seedlings had smaller cotyledon sizes compared to Indiana and Michigan plants, suggesting a possible genetic differentiation among these populations. So far at this site, Indiana plants have survived more often than Wisconsin plants. Two four-year-old plants flowered, following a year of high rainfall. Numerous plants bloomed in 1997. Deer grazed about 50% of all adult plants, but seedlings from naturally dispersed seeds were observed in 1997.

Using reintroduction demographic data and matrix projection models, Bowles and Bell (1998) demonstrated that the population is not currently viable, but with supplemental planting of 14 individuals per year, birth rates would exceed mortality and the population would have a positive growth rate. Based on this model they cannot predict when this reintroduction will become viable; however they proposed five criteria to be met at the State level. First, populations must exhibit positive growth through seed production, 2) there must be three population units with greater than 200 plants per hectare, 3) multiple cohorts must be present with a juvenile to adult ratio > 1, 4) that there must be three or more viable populations, and 5) metapopulation dynamics are present.

H. Strategy of Recovery

The strategy for recovery must address both the biology of the species and threat factors previously discussed. In review, the most extensive dune landscape types on which Pitcher's thistle grows (complex continuous, complex discontinuous, and perched) were created largely by the unique combination of high sand supply and depositional processes present during the Holocene. Since the glacial and post-glacial processes that created the moraines and large sand deposits are no longer active, these complex and perched dune systems are irreplaceable. Conversely, geologic processes currently create and destroy simple linear dune systems in places where sufficient sand supply continues and the shoreline is unaltered by stabilization structures. Nevertheless, all four dune systems can be invigorated by sand blowing inland as lake levels fluctuate. Perched and complex continuous dune systems appear to harbor larger, more stable occurrences of Pitcher's thistle than simple linear and complex discontinuous dunes, because they are larger and have refugia within their more complex spatial configurations.

Long-term persistence of Pitcher's thistle requires a metapopulation perspective. Natural dune disturbance on large dune landscapes must occur so seed dispersal to newly created early successional habitats is likely to occur. Pitcher's thistle depends on the geomorphic processes that maintain dune systems to create sparsely vegetated habitats where successful population establishment and growth can occur. In the past, disturbance and successional processes have maintained shifting dunes and produced a mosaic of sites suitable and unsuitable for Pitcher's thistle. The mosaic changed over time, but suitable habitat was available at all times. In any occupied site, as dune succession proceeds, increased vegetation cover and litter reduce the Pitcher's thistle germination and survival. Thus, as succession makes present-day habitat unsuitable, existing population patches will eventually be locally extirpated from the areas they now occupy. For the species to persist, new open habitats relatively near to existing occurrences and patches must be continuously created for Pitcher's thistle to colonize.

Pitcher's thistle is threatened by the direct and indirect effects of development and recreational pressure on lakeshore dune landscapes. Occurrences are threatened by residential and marina development, recreational pressure, sand mining, and non-native species invasions or intentional introduction of harmful non-native species. Current development pressure is concentrated in Pitcher's thistle's last stronghold in Wisconsin, the Door Peninsula, and in its central distribution in the northern Lower Peninsula and the south shore of the Upper Peninsula of Michigan. Some of these threats fragment and alter the relationship between stabilizing and destabilizing processes thereby reducing habitat suitability. Other threats act directly on Pitcher's thistle individuals, decreasing survival or reproductive rates.

Because Pitcher's thistle appears to function as a metapopulation, recovery of the species will require the conservation of large intact dune tracts with large areas of occupied and unoccupied suitable habitat, the continuation of geologic and successional processes on which Pitcher's thistle depends, and the management of human activities. In addition, returning the Pitcher's thistle to its former range will require successful reintroductions.

Acquisition of essential habitat may be important for maintaining intra-population gene flow, establishing colonization sites for restoration, and protecting high quality sites, especially where occurrences are spatially separated or under multiple ownerships. Habitat protection through land purchase should be a last resort, used when high quality areas cannot be protected by any other means. Organizations such as The Nature Conservancy should investigate first rights of purchase or agree to inform the Service or appropriate State agencies when land is for sale or has changed hands.

Preservation of large intact dune tracts will require cooperation between the Service, State agencies and private landowners as well as the U.S. National Park Service and U.S. Army Corps of Engineers. Greater intra- and interagency coordination and

information exchange between State and Federal agencies would eliminate repetition of past communication problems and would serve to present a unified protection front.

II. Recovery

A. Objective and Criteria

The recovery objective is the delisting of the species once the following six criteria have been met.

Criterion 1. The essential habitat associated with a total of **115** priority occurrences representing each biogeographic region and dune type is protected and managed under a management plan, including:

a) all Federal and State owned essential habitat and occurrences,
b) all publicly and privately-owned essential habitat and occurrences having a rank of A, AB, B, or BC,
c) all occurrences in southern Lower Michigan, Indiana, and Wisconsin, and
d) all complex perched dune systems.

Criterion 2. Regular field surveys to verify occurrences and record new occurrences have been established.

Criterion 3. Landowner contacts have been initiated and protection has been investigated for the remaining (rank<BC) public and private occurrences.

Criterion 4. Monitoring of known sites shows a stable or increasing trend toward recovery and that protective plans are being implemented.

Criterion 5. Restoration of two occurrences from among historical sites where sufficient habitat remains in Illinois, Indiana, Wisconsin, and southern Lower Michigan has been completed.

Criterion 6. Research necessary to protect, manage and restore Pitcher's thistle has been conducted.

See Table 7 for a list of protection strategies for each occurrence. Table 7 occurrences without a Criterion 1 - a, b, c, or d reference did not meet the specific requirements listed in Criterion 1. For instance, the occurrence may cover a small area on private property and have a low element occurrence rank, therefore the occurrence will not be included in meeting the recovery (delisting) objective. Nevertheless, these occurrences shall have value and merit protection as indicated in Table 7 strategies.

The recovery objective can be achieved by the following actions.

1. Protect and manage known occurrences and essential habitat.
2. Establish and conduct regular field surveys to verify known and record new occurrences.
3. Inform the public, recreationists, public land managers and private landowners.
4. Monitor occurrences for stable or increasing trends and implementation of protective plans.
5. Restore Pitcher's thistle populations on two appropriate sites within its historical range.
6. Conduct research necessary for protection, management, and restoration.

Definitions

These definitions are included for clarification. However, because of the uncertainty surrounding the minimum size of a viable Pitcher's thistle population and incomplete occurrence survey records, these definitions are subject to revision as new surveys are completed and additional knowledge is acquired.

Protection is defined as implementation of actions necessary to maintain and perpetuate essential habitat, remove threats and enable Pitcher's thistle populations to be self-sustaining.

Essential habitat is all beach, foredune, secondary dune, blowout, and native grass dominated dune habitat in dune systems within or contiguous to one of the 115 priority occurrences (Table 7). In many cases, occupied and potential habitat contiguous to an occurrence is not contained within the boundaries of the occurrence as described or mapped in the database. The boundaries as described in databases or maps are not intended to convey the boundaries of a Pitcher's thistle population, or a viable unit of Pitcher's thistle, but rather generally delimit the boundaries of surveyed areas. As discussed earlier, the species depends on a shifting mosaic of habitat, and large areas of potential and occupied habitat which together function to provide long-term available habitat.

Suitable habitat for reintroductions and restorations is similar to other occupied habitat in the biogeographical region, and of sufficient type and area to allow persistence despite lake level fluctuations and other anticipated disturbances.

Table 7. Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
MICHIGAN									
Negwegon State Park	127	Alcona/NL	a	X	X	X			
Grand Sable Dunes	2	Alger/UP	a,b,d	X	X	X			
Saugatuck Dunes	4	Allegan/SL	c	X	X				
Gilligan Lake Dunes	112	Allegan/SL	c	X	X		X		
North Point	95	Alpena/NL	b	X	X		X		
Huron Bay	12	Alpena/NL		X	X		X		
Torch Lake	65	Antrim/NL	b	X	X		X		
Palmer-Wilcox-Gates	10	Antrim/NL		X	X		X		
Banks Township Park	82	Antrim/NL		X	X		X		
Elk Rapids South	145	Antrim/NL			X		X		
South Charity Island	107	Arenac/NLI		X	X				
Point Lookout	88	Arenac/NL		X	X		X		
Platte River Point	5	Benzie/NL	a,b	X	X	X			
Platte Bay	7	Benzie/NL	a,b	X	X	X			
Point Betsie	33	Benzie/NL	b	X	X		X		
Herring Lake Embayment	51	Benzie/NL	b	X	X		X		
Grace Road Dune	126	Benzie/NL	b,d	X	X		X		
Watervale South	131	Benzie/NL	b,d	X	X		X		
Frankfort Beach	34	Benzie/NL	b	X	X				
Warren Dunes	16	Berrien/SL	a,b,c	X	X	X			
High Island Dunes	108	Charlevoix/NLI	b	X	X			X	
Bonners Landing	9	Charlevoix/NLI	b	X	X			X	
Fisherman's Island State Park	75	Charlevoix/NL	a,b	X	X	X			

Table 7 (cont.) Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
Lookout Point	143	Charlevoix/NLI	b		X		X		
Norwood	93	Charlevoix/NL	b	X	X			X	
Sandy Bay	57	Charlevoix/NLI	b	X	X				
McFadden Point	62	Charlevoix/NLI	b	X	X			X	
McSauba Park	77	Charlevoix/NL	b	X	X			X	
Lett's Point	142	Charlevoix/NLI			X		X		
Sweat Lodge Swale	144	Charlevoix/NLI	a		X	X			
High Island Bay	68	Charlevoix/NLI	a	X	X	X			
Hog Island	125	Charlevoix/NLI	a	X	X	X			
French Bay	129	Charlevoix/NLI		X	X		X		
Donnegal Bay	60	Charlevoix/NLI		X	X				
Little Sand Bay	58	Charlevoix/NLI		X	X		X		
Horseshoe Island	99	Charlevoix/NLI	a	X	X	X			
Charlevoix Beach	6	Charlevoix/NL			X				
Jensen's Point	128	Charlevoix/NLI	a	X	X	X			
Iron Ore Bay	20	Charlevoix/NLI		X	X				
Beaver Island Harbor	59	Charlevoix/NLI		X	X			X	
Northcutt Bay	105	Charlevoix/NLI	a	X	X	X			
Cable Bay	54	Charlevoix/NLI		X	X			X	
Martin Point	56	Charlevoix/NLI		X	X		X		
Grass Bay	24	Cheboygan/NL	a	X	X	X	X		
Nine Mile Point	102	Cheboygan/NL		X	X			X	
Cheboygan State Park	106	Cheboygan/NL	a	X	X	X			
Point Nipigon	120	Cheboygan/NL		X	X		X		
Albany Creek Mouth	70	Chippewa/UP	b	X	X			X	
St. Vital Bay	67	Chippewa/UP	a,b	X	X	X			

Table 7 (cont.) Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
Albany Harbor Peninsula	91	Chippewa/UP	b	X	X		X		
Rice Point	86	Chippewa/UP		X	X		X		
Carleton Bay	76	Chippewa/UP		X	X		X		
Strawberry Island	53	Chippewa/UP	a	X	X	X			
Point De Tour	74	Chippewa/UP		X	X		X		
Fayette	18	Delta/UP	a	X	X	X			
Big Stone Bay	15	Emmet/NL	a,b	X	X	X			
Sturgeon Bay	47	Emmet/NL	a,b,d	X	X	X			
Paige Creek	79	Emmet/NL	b	X	X			X	
Sturgeon Bay Point	22	Emmet/NL	b	X	X			X	
Temperance Island	138	Emmet/NLI	a,b	X	X	X			
Trail's End Bay	66	Emmet/NL	b	X	X		X		
McCort Hill	50	Emmet/NL	b	X	X			X	
Wycamp Creek Mouth	73	Emmet/NL		X	X			X	
Sturgeon Bay South	111	Emmet/NL		X	X		X		
Thorne Swift Preserve	119	Emmet/NL		X	X		X		
Cecil Bay	14	Emmet/NL		X	X		X		
Middle Village South	136	Emmet/NL		X	X		X		
M119 & Pike Road	137	Emmet/NL		X	X		X		
Johnson Point	121	Emmet/NL		X	X		X		
Sevenmile Point	132	Emmet/NL		X	X		X		
Old Mission Light	38	GrandTraverse/ NL		X	X				
Saginaw Bay	89	Huron/SL	a,c	X	X	X			
AuSable Point	35	Iosco/NL	b	X	X		X		
Oscoda North	36	Iosco/NL		X	X		X		

Table 7 (cont.) Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
Oscoda South	101	Iosco/NL		X	X		X		
South Manitou	17	Leelanau/NLI	a,b,d	X	X	X			
Good Harbor Bay	29	Leelanau/NL	a,b	X	X	X			
Sleeping Bear Point	28	Leelanau/NL	a,b,d	X	X	X			
Cathead Bay	48	Leelanau/NL	b	X	X			X	
Glen Arbor	139	Leelanau/NL	b	X	X			X	
South Fox Island	43	Leelanau/NLI	b,d	X	X		X		
North Manitou Island	44	Leelanau/NLI	a,b,d	X	X	X			
South Manitou Island	52	Leelanau/NLI	a,b	X	X	X			
Donner Point	123	Leelanau/NL	a,b,d	X	X	X			
Empire Bluffs	118	Leelanau/NL	a,b,d	X	X	X			
North Fox Island	42	Leelanau/NLI	b	X	X		X		
Pyramid Point	45	Leelanau/NL	a,b,d	X	X	X			
Gills Pier	41	Leelanau/NL	b	X	X		X		
South Manitou Island	110	Leelanau/NLI	a	X	X	X			
Peterson Park North	135	Leelanau/NL		X	X		X		
Hiawatha National Forest Dunes	90	Mackinac/UP	a,b		X	X			
Birch Point East West	23	Mackinac/UP	b		X			X	
Hughes Point	55	Mackinac/UP	b		X			X	
Point Aux Chenes	49	Mackinac/UP	b	X	X			X	
Poupard Bay	134	Mackinac/UP	b		X		X		
Naubinway East	3	Mackinac/UP			X		X		
Big Knob Campground	100	Mackinac/UP	a		X	X			
West Epoufette	133	Mackinac/UP			X			X	
Black River Road	156	Mackinac/UP			X			X	

Table 7 (cont.) Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
Fox-Needle Point	154	Mackinac/UP			X				
McNeil Creek	130	Mackinac/UP			X			X	
Stevenson Bay	63	Mackinac/UP		X	X		X		
Point La Barbe	37	Mackinac/UP		X	X		X		
Manitou Payment	124	Mackinac/UP		X	X		X		
Tower-Troy Preserve	21	Manistee/NL	b	X	X		X		
South Arcadia Beach	39	Manistee/NL	b,d	X	X		X		
Magoon Creek North	114	Manistee/NL	b	X	X			X	
Manistee River Mouth	13	Manistee/NL		X	X			X	
Portage Point Dune	104	Manistee/NL		X	X		X		
Big Sable Point	32	Mason/NL	a,b	X	X	X			
Cooper Creek Dunes	122	Mason/NL	a	X	X	X			
Bass Lake Dunes	31	Mason/NL		X	X		X		
Hoffmaster Natural Area	25	Muskegon/ Ottawa/SL	a,b,c	X	X	X			
Meinert Park	26	Muskegon/SL	b,c	X	X				
Muskegon State Park	64	Muskegon/SL	a,c	X	X	X			
Mona Shores Forest	113	Muskegon/SL	c	X	X				
Camp Miniwanca	11	Oceana/NL	b	X	X		X		
Driftwood Beach	27	Oceana/NL	b	X	X		X		
Pentwater	117	Oceana/NL	b	X	X		X		
Little Point Sable	116	Oceana/NL	a	X	X	X			
Pentwater Dunes	30	Oceana/NL		X	X		X		
Kitchel Dunes	8	Ottawa/SL	c	X	X				
Rosy Mound	115	Ottawa/SL	c	X	X		X		
Thompson's Harbor	87	Presque Isle/NL	b	X	X			X	

Table 7 (cont.) Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
Hoeft State Park	83	Presque Isle/NL	b	X	X			X	
Huron Beach	71	Presque Isle/NL	a,b	X	X	X			
Hammond Bay West	80	Presque Isle/NL	b	X	X		X		
Evergreen Beach	78	Presque Isle/NL	b	X	X		X		
Presque Isle Harbor	84	Presque Isle/NL	b	X	X		X		
Besser Natural Area	85	Presque Isle/NL	a,b	X	X	X			
Grace North	72	Presque Isle/NL	b	X	X		X		
Hammond Bay East	81	Presque Isle/NL		X	X			X	
Besser Natural Area South	141	Presque Isle/NL	a	X	X	X			
Rockport North	140	Presque Isle/NL		X	X		X		
Gulliver Lake Dunes	46	Schoolcraft/UP	b		X		X		
Lake Superior State Forest Dunes	153	Schoolcraft/UP	a,b		X	X			
Michibay Rd. Twp. Park	148	Schoolcraft/UP	b		X				
Rocky Point West	152	Schoolcraft/UP	b		X		X		
Point Aux Barques	40	Schoolcraft/UP	b	X	X		X		
Thompson Dunes	1	Schoolcraft/UP	a		X	X			
Snyder Creek	146	Schoolcraft/UP			X		X		
Seoul Choix Point	155	Schoolcraft/UP			X		X		
Wiggins Point	147	Schoolcraft/UP			X		X		
Section 10 Dunes	149	Schoolcraft/UP			X		X		
Orr Creek	150	Schoolcraft/UP			X		X		
Manistique Boardwalk	151	Schoolcraft/UP			X				
Covert	109	Van Buren/SL	b,c	X	X			X	

Table 7 (cont.) Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
Historical records (pre-1950 in non-urban northern Michigan; pre-1970 in southern Michigan or urbanized areas)									
Harbert	97	Berrien/SL	c	X			X		
Mackinaw City	94	Cheboygan/NL					X		
Bay View	61	Emmet/NL		X				X	
Harbor Point	103	Emmet/NL		X				X	
Traverse City	19	Grand Traverse/ NL		X				X	X
Scotty Bay	92	Mackinac/UPI		X			X		
Packard Point	96	Mackinac/UPI		X			X		
Point Aux Pins	98	Mackinac/UP		X				X	
Orchard Beach	69	Manistee/NL	a	X		X			
INDIANA									
Miller High Dunes/USX	4, 16	Lake	c	X	X			X	X
Dune Acres East	10	Porter	b,c	X	X			X	
Big Blowout	1	Porter	a,b,c	X	X	X			X
West Beach	5	Porter	a,c	X	X	X			X
Keiser Blowout	7	Porter	a,c	X	X	X			
Ogden Dunes	9	Porter	a,c	X	X	X			X
Dune Acres West	6, 12,13, 15	Porter	c	X	X			X	
Furnessville Blowout	11	Porter	a,c	X	X	X			
WISCONSIN									
Whitefish Dunes	1	Door	b,c		X			X	
Sevastopol Beach	2	Door	b,c		X		X		
Sturgeon Bay Canal	3	Door	b,c		X			X	

Table 7 (cont.) Recommended protection strategies for each occurrence of *Cirsium pitcheri*.

Site Name	EO#[1]	County/ Region[2]	Criterion 1 Status [3]	Update Occurrence Information [4]	Develop and Implement Management Plans [5]	Identify Restricted Use Areas [6]	Inform Private Landowners [7]	Inform Multiple Owners [8]	Research and Restoration [9]
Heins Creek County Park	5	Door	b,c	X	X			X	
Sand Dunes Beach	8	Door	c		X			X	
Lake Shore Drive	6	Door	c		X			X	
Wisconsin Point	NA	Douglas	c	X	X				
Point Beach State Forest	4	Manitowoc	b,c		X			X	
Kohler-Andrae State Park	7	Sheboygan	b,c		X			X	
ILLINOIS									
Illinois Beach State Park	1	Lake	restoration	X	X	X			X

[1] **EO#**: Element occurrence number used by State heritage program.

[2] **County/Region**: County and, in Michigan, biogeographic region where UP - Upper Peninsula, NL - Northern Lower Peninsula, SL - Southern Lower Peninsula, I - Island.

[3] **Criterion 1 Status:** for 115 occurrences needed to satisfy Criterion 1, a - Federal and State lands, b - occurrence has a minimum rank of BC, c - occurrences in southern Lower Michigan, Indiana and Wisconsin, d - perched dune systems as noted in the recovery objectives. Occurrences without a letter do not meet the requirements listed in Criterion 1.

[4] **Update Occurrence Information** for those occurrences last visited prior to 1997 or with incomplete data.

[5] **Develop and Implement Management Plans** that assess fragmentation problems, visitor dune access and impacts, man-made structures that alter dune processes, informational needs, and management goals and actions.

[6] **Identify Restricted Use Areas** on State and Federal lands.

[7] **Inform Private Landowners** of occurrences.

[8] **Inform Multiple Owners** of occurrences.

[9] **Research and Restoration** of occurrences.

B. Step-Down Outline

1. Protect and manage known occurrences and essential habitat, giving priority to essential habitat.

    11. Coordinate, maintain and update information regarding known occurrences and essential habitat on a regular basis.

        111. Provide current site occurrence information to land managers.
        112. Update Federal lands records.
        113. Update State lands records.
        114. Update local, county and municipal records.

    12. Develop and implement management and long-term monitoring plans specific to the land manager; Federal, State, local, county and municipal.

    13. Where indicated by management plans, identify essential habitat as special restricted use areas.

    14. Encourage protection of occurrences on private land.

        141. Develop or continue landowner contact programs.
        142. Encourage conservation groups to work with private landowners.

    15. Promote coordinated protection and management of contiguous essential habitat in multiple ownerships.

        151. Develop and distribute maps of essential habitat patches for managers.
        152. Coordinate conservation and management among multiple owners within each patch of essential habitat.
        153. Coordinate permit reviews of shoreline area projects that may affect Pitcher's thistle.

2. Establish and conduct ongoing field surveys to verify known and record new occurrences.

    21. Estimate population size and age class distribution.
    22. Map metapopulations.

3. Inform the public, recreationists, public land managers, and private landowners.

    31. Develop and distribute informational materials pertinent to the habitat, biology, and protection of Pitcher's thistle.
    32. Communicate with user groups (*e.g.* ORV clubs) the need to protect Pitcher's thistle and how the group(s) can assist in these efforts.

4. Monitor occurrences for stable and increasing trends and implementation of protective plans.

    41. Monitor occurrences for population changes, to identify threats, and to re-evaluate protection priorities.
    42. Monitor implementation of management plans for all publicly-owned occurrences.

5. Restore Pitcher's thistle to an element rank of at least BC on at least one appropriate site within its historical range.

    51. Review historical records and select restoration sites.
    52. Develop and refine restoration protocols.

        521. Develop genetic guidelines.
        522. Develop propagation and establishment guidelines.

    53. Implement, monitor, and evaluate restoration projects.

6. Conduct research necessary for protection, management, and restoration.

    61. Study seedbank and seed dispersal.
    62. Use genetics to investigate breeding system and population viability.
    63. Evaluate Pitcher's thistle response to trampling.
    64. Investigate establishment and transplant techniques for restoration.
    65. Evaluate risk of flowerhead weevil and other biological control agents on seed production and, if necessary, possible methods of reducing risk.
    66. Study non-native weed invasion and determine the degree of threat.

C. Narrative

1. Protect and manage known occurrences and essential habitat, giving priority to essential habitat.

To ensure the long-term perpetuation of *Cirsium pitcheri*, planned protection for all 115 priority occurrences must occur and the remaining lower priority sites should receive some protection. Protection strategies will depend on cooperation between Federal and State agencies, private conservation organizations, regional planning councils, local jurisdictions, private developers and landowners. Principal cooperators include State and provincial resource agencies, The Nature Conservancy (TNC), The Nature Conservancy of Canada, the Center for the Great Lakes' Great Legacy program, the U. S. Forest Service (USFS), the National Park Service (NPS), and the U. S. Fish and Wildlife Service (Service). Working together should assure the highest level of protection for each site (Table 7).

11. Coordinate, maintain and update information regarding known occurrences and essential habitat on a regular basis.

Sharing information among public land managers as well as private landowners is necessary for the protection of known occurrences and essential habitat. Principal cooperators include: the Service, USFS, NPS, MDNR, WDNR, Indiana DNR, Illinois DNR, local municipalities, TNC, and private landowners.

111. Provide current site occurrence information to land managers.

Distribute site occurrence data from the State Heritage Program database.

112. Update Federal lands records.

Regularly update files of occurrences at regional and field offices of appropriate agencies. Current data will provide information relevant to permit application review and management activities such as trail building and beach designation.

113. Update State lands records.

Update occurrence data at all regional and field offices of State transportation, natural resource, environmental compliance and park departments. Awareness of *C. pitcheri* at proposed development sites will enable managers to implement conservation and protection measures.

114. Update local, county and municipal records.

Provide updated occurrence information via appropriate means.

12. Develop and implement management and long-term monitoring plans specific to the land manager; Federal, State, local, county and municipal.

Management plans should include monitoring of occurrences and habitat, and plan implementation. Monitoring results should be included as part of the decision processes outlined in the management plans.

In many cases, Federal and State agencies may be better able to take the lead in developing management guidelines for Pitcher's thistle occurrences, especially where occurrences cover multiple ownerships. County, city and private landowners can rely on the expertise of the lead agencies in developing management strategies. Presentation of management strategies could be in the form of a short brochure or report illustrating management problems and their solutions.

Management plans should address all known threats. Recognizing the unique features of each occurrence is important in managing Pitcher's thistle habitats. Planned structures should be designed to avoid adverse effects on Pitcher's thistle. For instance, structures should not impede natural dune formation processes, including long shore current, sand supply and natural cycles of dune erosion and building. Removal of existing structures that negatively impact Pitcher's thistle, such as buildings and roads, should be attempted wherever possible.

Management plans should call for restoration of dune plant communities where appropriate. Non-native plants may have long-term negative effects where human disturbance is frequent. Many sites, once protected, will require vegetation restoration to remove non-native plants such as spotted knapweed (*Centaurea maculosa*), baby's-breath (*Gypsophila paniculata*), and sweet clover (*Melilotus alba*). This will allow native plant establishment on formerly degraded areas.

Management plans may need to address recreation. Strategically placed barriers may reduce recreation impacts. Physical barriers may include guardrails, boulders, and fences, and may be combined with other psychological barriers, such as signs stating that sensitive species and/or communities are protected. Highly ranked and/or particularly high use sites should be identified for increased monitoring.

Dunes must be protected from fragmentation by carefully planning trails, roads, and structures. To prevent fragmentation such facilities must be at the periphery of all suitable habitat whether or not habitat is occupied. Existing unregulated access to the dunes should be directed to

beach access trails by the use of moveable boardwalks, judicious signing, information, and wooden rail fences.

Protection for the numerous occurrences within and along coastal road rights-of-way and rest stops is essential. Continued modification of road salting, shoulder grading, blading and mowing, as well as repairs to eroding shoreline reaches may be necessary to protect Pitcher's thistle along roads. Continued routine communication with road and highway maintenance agencies is appropriate. Mitigation to reestablish natural processes should be sought where road related habitat alteration occurs.

Multi-species sites should be addressed in management plans. The potential for occurrence of multiple Federal and State listed and other rare species along with Pitcher's thistle has been acknowledged in this plan, but detailed development of multi-species site indicators and management recommendations are beyond the plan's scope. Such information should be sought and considered in an ecosystem management context whenever site plans are developed or revisited.

13. Where indicated by management plans, identify essential habitat as special restricted use areas.

Where other means of protection (signs, fencing) are unlikely to be effective, essential habitat on Federal land should be identified as special use areas such as Nature Preserves, Research Natural Areas, and Conservation Zones. Within these areas, managers should restrict use, minimize development and institute proper management and enforcement.

14. Encourage protection of occurrences on private land.

Sixty-two occurrences (36%) of *C. pitcheri* are known to be on publicly owned land. Another 41 occurrences (24%) are known to cover land which is partially public and privately-owned. A single occurrence does not have recorded ownership data. The remaining 69 (40%) of the known occurrences are on private and presumably unprotected land potentially threatened by development and fragmentation. Many private landowners have little knowledge of *C. pitcheri*, its threatened status, or the need to apply for State permits when the plant populations may be disrupted by development.

Identifying private land sites as special recognition or management areas through conservation easements, registry agreements with The Nature Conservancy, management agreements and other guarantees to conserve the species and protect habitat is necessary to ensure protection. Agencies should secure voluntary informal protection and management

agreements with property owners through registry and explore the use of easements.

Priority should be given to privately-owned land with the highest likelihood of development. Priority should also be given to private land in northern Lower Michigan and the Upper Peninsula with other threatened or endangered plant and animal species, such as dwarf lake iris, Houghton's goldenrod*),*and piping plover.

141. Develop or continue landowner contact programs.

Implement a landowner contact program where the goals are to: 1) notify both public and private landowners of the presence of *C. pitcheri* on their property, 2) provide information about the species and its legal status, and 3) secure voluntary protection, monitoring and management for Pitcher's thistle on private lands. Landowners willing to protect their occurrences of *C. pitcheri*, and participating in a contact program, will be placed on a registry and given a plaque or similar expression of appreciation. Landowner contact programs are run by The Nature Conservancy in Indiana and Michigan, the Wisconsin DNR Endangered Species Program and the Illinois Nature Preserves Commission. These programs should encourage new contacts with landowners and follow up monitoring and management with those already registered.

142. Encourage conservation groups to work with private landowners.

Collaborate with The Nature Conservancy and other non-government conservation groups to negotiate conservation agreements, easements, or other voluntary protection and/or management plans for private lands within essential habitat. Encourage the purchase of essential habitat in private ownership where willing sellers and funding are available.

15. Promote coordinated protection and management of contiguous essential habitat in multiple ownerships.

Occurrences and potential and suitable habitat contiguous to occurrences on public land should be managed as a unit if possible. Where these areas are under multiple ownership, the public land managers should coordinate with other landowners to cooperatively manage lands to protect Pitcher's thistle.

151. Develop and distribute maps of essential habitat patches for land managers/stewards.

Based on occurrence data, generate maps of essential habitat patches for distribution to land managers. Management decisions will be made with current information regarding plant populations and affected landowners.

152. Coordinate conservation and management among multiple owners within each patch of essential habitat.

Identify where areas of contiguous essential habitat are under multiple ownership or management and where appropriate, recommend the areas for focus as cooperatively managed core refuges with a single land manager/steward coordinating the effort.

153. Coordinate permit reviews of shoreline area projects that may affect Pitcher's thistle.

Coordinate permit review procedures between and within agencies including the Service, NPS, USFS, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, appropriate State agencies, and county and local planning and zoning boards. Vertical as well as horizontal coordination within and among agencies will be required. The Service should explore other relevant permit or grant processes, such as the Coastal Zone Management Program administered by the National Oceanic and Atmospheric Administration. Consider the construction and placement of jetties, lake walls, abutments, revetments, docks and marinas that would impede offshore sand movement. If construction cannot be altered, then existing technology that allows near shore sand movement should be employed.

2. Establish and conduct ongoing field surveys to verify known and record new occurrences.

Pitcher's thistle is highly dependent upon the fluctuating environment of its lakeshore habitat. Therefore it is important to monitor the status of populations and habitats on a regular basis over periods of several decades to detect responses to fluctuating lake levels and habitat changes. Monitoring of sites is necessary for effective management. The monitoring should be designed to detect fluctuations in Pitcher's thistle population size and age class distribution and collect information on age at flowering. This will permit assessment of implemented management actions and determine if remedial action is required.

21. Estimate population size and age class distribution.

Seedlings, juveniles, and adults must be counted or estimated. Often only the adults are counted because they are easily seen. However, the age class distribution gives a possible indication of the future trend in the population.

22. Map metapopulations.

Map the metapopulation dispersion throughout the dune system in relation to vegetation successional stages. Sub-populations can be mapped on county blue-line aerial photos, USGS topographic maps or by using a global positioning system (GPS). The GPS data can be put into a geographic information system (GIS) for further analysis.

3. Inform the public, recreationists, public land managers, and private landowners.

Knowledgeable individuals are an important part of the recovery process. Informing managers, recreational groups and landowners about Pitcher's thistle, its status as a protected species, and protection methods is an important step toward cooperative protection and management. Accurate and current information can foster interest and appreciation for the Pitcher's thistle. Groups such as the Michigan Nature Association, Michigan Natural Areas Council, The Nature Conservancy, The Nature Conservancy of Canada, Center for the Great Lakes, the International Joint Commission, Federal, State, provincial and local resource agencies, and local Audubon groups and garden clubs should be kept informed of recovery efforts.

Federal land managers must be aware of the need to protect, and methods of protecting, Pitcher's thistle on Federal lands to facilitate decisions that will protect the species. Cooperators will develop, distribute, and update information and make recommendations for managers to protect Pitcher's thistle and its essential habitat. Information sent to individual managers will include the location of occurrences and essential habitat, as well as the specific known and suspected threats to the species under the manager's care.

Public utilities, with their promotion of environmental programs, may underwrite or sponsor public awareness campaigns. Resource agencies may encourage greater conservation through liaisons with public utilities.

31. Develop and distribute informational materials pertinent to the habitat, biology, and protection of Pitcher's thistle.

Informational materials must be developed for use in raising public awareness about dune ecosystems and Pitcher's thistle. Initial materials such as posters and brochures should be followed by color photographs

and videos. Materials should focus on the protection and preservation of dune ecosystems using Pitcher's thistle to illustrate threats, landowner responsibilities, appropriate recreational activities, and habitat restoration and enhancement methods.

Provide onsite information with brochures, other educational media, and interpretive signing to inform the public about the uniqueness, sensitivity and finiteness of the Great Lakes dunes and the conservation of Great Lakes dunes endemics including Pitcher's thistle, Houghton's goldenrod, and dwarf lake iris. For example, in 1994 the Natural Heritage Program of Michigan DNR Wildlife Division produced brochures for Pitcher's thistle and Houghton's goldenrod.

32. Communicate with user groups (*e.g.* ORV clubs) the need to protect Pitcher's thistle and how the group(s) can assist in these efforts.

Major groups currently impacting large landscapes should be selected for contact and informational presentations. These include developers, utilities, State and county road associations, commerce and tourist associations, ORV and biking clubs, engineering firms and marinas. A short video could be developed cooperatively with input from resource agencies focusing on deterrence of trespass, off-road vehicle (ORV) damage, trampling, habitat fragmentation and illegal "take" as well as methods to protect the species. The uniqueness of Pitcher's thistle and the ecosystem on which it depends should also be displayed to encourage voluntary conservation.

4. Monitor occurrences for stable and increasing trends and implementation of protective plans.

Protective management of Pitcher's thistle requires knowledge of its current status and threats. Inventory must incorporate population size, quality, and threats to be useful for scientific assessment and planning.

41. Monitor occurrences for population changes, to identify threats, and to re-evaluate protection priorities.

Changes can be noted through estimates of total population size, the area of vegetation successional types including grassland, foredune, and blowouts and areas of essential Pitcher's thistle habitat.

Identify threats by noting observations and population trend data which can provide insights into management problems. Problems can be either at the metapopulation (global) level or the sub-population (local) level. Metapopulation problems may include a habitat area that is too small to contain multiple sub-

populations, extreme separation among sub-populations, disruption of dispersal along corridors from heavy use or development, or alteration of dune formation processes from groins or jetties that prevent dune sand replenishment.

Local problems may include: 1) a sub-population that is so small that demographic stochasticity and genetic stochasticity threaten its viability; 2) habitat that is too small for the sub-population to reach a large size; 3) the sub-population is so small that a normal environmental event such as predation threatens extirpation, and 4) a deterministic process is eliminating plants. Preferably, management intervention should be at the global scale unless there is some indication that the metapopulation is declining or unless the occurrence is effectively a metapopulation of only one sub-population. This consideration is to prevent unnecessary management of normal sub-population declines within metapopulations. To guide managers, McEachern and Pavlovic (see also McEachern et al. 1994) have developed pertinent queries focusing on global and local problems with possible solutions (Appendix F).

Protection priorities will need to be evaluated as occurrences are visited and data may suggest a change in rank. Population declines, habitat loss, or degradation of essential habitat at particular occurrences may necessitate corrective action through various means.

42. Monitor implementation of management plans for all publicly-owned occurrences.

Managers of publicly owned occurrences should monitor management agreements and protection plans for each occurrence within their jurisdiction. Effective communication among agency staff regarding management plans for each occurrence will ensure a cohesive protection effort.

5. Restore Pitcher's thistle to an element rank of at least BC on at least two appropriate sites within its historical range.

C. pitcheri has been extirpated from parts of its natural range, so restoration is necessary to recover Pitcher's thistle throughout the area addressed in the recovery objective. Restoration is intended to recolonize sites where the species formerly occurred and cannot be used as justification or mitigation for destruction of an existing high quality occurrence elsewhere. Restoration planning should be integrated with ongoing interagency coordination and should be complementary and reinforcing. Restoration guidelines are needed in order to meet the objective of preserving populations throughout the species range.

51. Review historical records and select restoration sites.

Potential restoration sites in each state should be selected from field inventories and historical records. Restoration objectives are to establish metapopulations in each biogeographical region and dune type to sites formerly possessing, but now lacking extant populations (Table 7). The first priority is to determine if former population occurrence sites are suitable, or potentially suitable, and can be managed to maintain viability. Such sites should be free of the factors that may have led to original population decline. Populations should be established on permanently protected properties. Specific habitat selection should replicate, to the extent possible, the known requirements for *C. pitcheri*. Potential sites for restoration include:

1. Illinois Beach State Park - 3 sites.
2. Indiana Dunes National Lakeshore and Indiana Dunes State Park - foredune and blowout sites.
3. Southern Lower Michigan - sites to be identified after resurvey has been completed.
4. Wisconsin - site(s) to be recommended by Endangered Resources Program staff.

52. Develop and refine restoration protocols.

For restoration to be successful, several goals need to be met through specific restoration protocols. These include selection of genetically appropriate seed stock and development of methods for reintroduction and augmentation of declining occurrences.

521. Develop genetic guidelines.

Because genetic similarity and distance between populations are negatively correlated, sites should be replanted with genotypes from the nearest populations. However, genetic diversity should be maximized in restored occurrences in order to minimize the potential effects of low genetic diversity in small outcrossing populations. When acquiring seeds for reintroduction into a particular area, use sources from extant occurrences within the biogeographic region in which the restoration is to occur. If there are no such extant occurrences, then occurrences in the nearest adjacent biogeographic region should be used. At least three separately occurring populations should be used as genetic stock for restorations. For example, in restoring an Illinois population, seed stock should be obtained from southern Wisconsin, Indiana, and southwestern

Michigan. At each collection site, seed collection should maximize genetic diversity to the extent possible by collecting seeds from as many plants as possible. Avoid overcollection of seeds.

522. Develop propagation and establishment guidelines.

Although research and reintroduction experiments are providing data on germination, propagation, and establishment of *C. pitcheri*, more research is needed to provide guidance for restoration. Seeds apparently germinate in nature after winter stratification. This can be replicated by moist stratification over the winter period (McEachern pers. comm.). Seeds can be pre-planted and the pots stored in refrigeration, or the seeds stored in bulk. Germinating seeds require full sun and have been grown in greenhouse or field conditions.

Because of rapid taproot growth and the potential to become pot bound, seedlings should be outplanted the first year of growth. Planting should be delayed until plants are large enough to survive herbivory, but not so late that root establishment will not occur. Other measures may be required to regulate herbivory and insect damage. More information is becoming available as restoration efforts in Illinois and Indiana progress (Bowles and McBride 1993, 1994, 1996; Pavlovic pers. comm.).

Population establishment should require replication of a naturally occurring cohort distribution pattern in time and space. Planting densities should replicate natural populations and population sizes. At least three cohorts should be established over a three year period to ensure that the first flowering cohort will be followed by flowering of second and third artificially established cohorts.

53. Implement, monitor, and evaluate restoration projects.

All artificially established cohorts should be monitored through flowering, seed production, and recruitment stage of second generation to ensure population turnover and viability. The monitoring through all phases of growth and reproduction will span approximately 15 years. Evaluations of results, methods, and conditions should be used for adaptive improvement of new and ongoing restorations.

6. Conduct research necessary for protection, management, and restoration.

Answers to questions related to seed production, viability, dispersal distances, and predation would allow managers to assess risk to the species from different management scenarios. Improved understanding about the needs of

Pitcher's thistle would focus management goals for the species and lead to better protection of Pitcher's thistle habitat.

61. Study seedbank and seed dispersal.

Research results indicate that *C. pitcheri* maintains a seedbank with roughly a two-year viability, but further research on the seed phase of the life history is needed to clarify recolonization potential in sites where the thistle has been recently extirpated. This information could allow a better prediction of the likelihood that the seedbank may supply viable seeds to grow on suitable sites where other life-stages of Pitcher's thistle are no longer present. Further research about seed dispersal will aid in modeling metapopulation dynamics.

There is now some evidence that pre-dispersal and post-dispersal seed predation may decrease seed output of both the progenitor species (Louda and Potvin 1995) and Pitcher's thistle (Louda and McEachern 1995). There is strong evidence that insect herbivory can limit juvenile growth (Stanforth et al. 1997), survival and subsequent seed production of Pitcher's thistle (Bevill 1998, Bevill and Louda 1999). Studies quantifying the variation in these effects within and among sites and habitat subdivisions will be useful in managing populations that are approaching their minimum viable population size. With a minimum population size predation might have proportionally great effects on population structure, as well as small populations that are being established in restoration efforts.

62. Use genetics to investigate breeding system and population viability.

To protect genetic diversity and further restoration efforts, research and quantify the degree of genetic distance of island and Straits of Mackinac populations from other populations throughout the thistle's range. This is especially important given the few allozyme loci studied by Loveless (1984) and recent advancements in genetic analysis techniques. Breeding system studies would further clarify self-pollination potential, indicating chances for viable seed production in small, isolated habitat patches. These studies could identify the degree to which inbreeding depression in small populations is a problem and how much genetic variation is needed for viable restoration.

63. Evaluate Pitcher's thistle response to trampling.

Circumstantial evidence strongly suggests that extensive human trampling has a deleterious effect on Pitcher's thistle populations (Keddy

and Keddy 1984, McEachern et al. 1989, Pavlovic and Bowles 1996, Gibson pers. comm.). Analyses of plant response and mortality due to variation in the intensity of trampling by dune visitors are needed to provide guidelines for visitor management and site use design at recreation sites. Sociological studies documenting visitor numbers, seasonality of habitat use, and the manner of habitat use can help in the development of visitor awareness programs.

64. Investigate establishment and transplant techniques for restoration.

Researchers have experienced mixed results in attempting to germinate *Cirsium pitcheri* seeds. Germination experiments on seed collected from A ranked occurrences, such as those at Sleeping Bear Dunes, could identify the best seed storage, pre-germination and post-germination techniques. In addition, various establishment treatments need to be conducted to determine the best methods for restoration and augmentation projects. Given the evidence that insects feed on and reduce seed production significantly under some conditions (Louda and McEachern 1995, Bevill 1998, Bevill and Louda 1999), plant protection experiments could identify post-establishment techniques to enhance survival, growth, and reproduction in restorations.

65. Evaluate risk of flowerhead weevil and other biological control agents on seed production and, if necessary, possible methods of reducing risk.

The research to date suggests that flower heads and seed production of Pitcher's thistle could be vulnerable to feeding, oviposition and larval development by the flowerhead weevil. Further research is needed to determine the potential magnitude of the weevil's effect on seed production and seedling regeneration of Pitcher's thistle, particularly in relation to the sometimes significant feeding and damage by native insects (Keddy and Keddy 1984, Louda and McEachern 1995, Stanforth et al. 1997, Bevill 1998, Bevill and Louda 1999, Louda and McEachern, unpublished data). Research should also be directed to discovering if other present or potential biocontrol agents pose a similar threat to Pitcher's thistle. Methods to prevent establishment and population growth of the flowerhead weevil in the dune habitat of Pitcher's thistle, and to control or mitigate damage if it occurs, should be investigated and developed.

66. Study non-native weed invasion and determine the degree of threat.

Several non-native weeds have invaded portions of the Pitcher's thistle habitat in several major preserves. These non-native weeds include both black knapweed (*Centaurea nigra*) and baby's breath, which appear to be increasing in several major areas of the habitat at Sleeping Bear Dunes (S. Yancho and S. M. Louda, pers. obs.). As populations of such non-native weeds increase they stabilize sand movement in the dunes by increasing vegetation cover. Such stabilization could reduce recruitment and undermine population viability and persistence of Pitcher's thistle, within its protected habitat preserves. Research is needed to quantify and monitor the magnitude of the threat and to develop weed control methods that do not harm Pitcher's thistle.

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III. Implementation Schedule

The implementation schedule outlines actions and estimated costs for the recovery plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs to fulfill the recovery objective outlined in part II of this plan. These actions, when accomplished, should bring about the recovery of the species and protect its essential habitat. The estimated funding needs for all parties anticipated to be involved in recovery are identified. The estimated recovery cost for the 12 year program is $ 4,480,000.

The costs presented are the estimates of the contributors and the Service, based on experience with costs of similar work. They are not based on budgets prepared for individual sub-tasks. Actual costs may be higher or lower than costs indicated in the implementation schedule.

Priorities are assigned for the lowest order of tasks within each major task. Definitions of each priority are as follows:

Priority 1. An action *must* be taken to prevent extinction or to prevent the species from declining irreversibly in the *foreseeable* future.

Priority 2. An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3. All other actions necessary to meet the recovery objectives.

Task numbers are taken from the recovery step-down outline and narrative. The acronyms of the parties responsible for implementation are listed below.

BOT GAR	Botanical Garden
INDNR	Indiana Department of Natural Resources
MDNR	Michigan Department of Natural Resources
MNFI	Michigan Natural Features Inventory
NPS	National Park Service
TNC	The Nature Conservancy
UNIV	University
USFS	U. S. Forest Service
USFWS	U. S. Fish & Wildlife Service
USGS	U. S. Geological Service
WDNR	Wisconsin Department of Natural Resources

Table 8. Implementation schedule for the *Cirsium pitcheri* recovery plan.

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Cost Estimates ($000) FY 03	04	05	06 -14	Comments
1	12	Develop and implement management and long-term monitoring plans specific to the land manager; Federal, State, local, county and municipal.	ongoing	NPS,USFWS USFS,USGS, MDNR,WDNR INDNR	13	26	26	180	
1	65	Evaluate risk of flowerhead weevil and other biological control agents on seed production and, if necessary, possible methods of reducing risk.	5	BOT GAR, UNIV,USGS, USFS,	65	65	65	130	
2	111	Provide current site occurrence information to land managers.	ongoing	MNFI,MDNR, WDNR, INDNR	13	13	13	117	
2	112	Update Federal lands records.	ongoing	NPS,USFWS USFS,USGS	7	7	7	63	
2	113	Update State lands records.	ongoing	MNFI,MDNR, WDNR INDNR	7	7	7	63	
2	114	Update local, county and municipal records.	ongoing	MDNR,WDNR INDNR	7	7	7	63	
2	13	Where indicated by management plans, identify essential habitat as special restricted use areas.	ongoing	NPS,USFWS USFS,USGS, MDNR,WDNR INDNR	7	13	13	117	
2	141	Develop or continue landowner contact programs.	ongoing	MDNR,WDNR INDNR	13	13	13	117	
2	142	Encourage conservation groups to work with private landowners.	ongoing	MDNR,WDNR INDNR,TNC	13	13	13	63	
2	151	Develop and distribute maps of essential habitat patches for managers.	ongoing	MDNR,WDNR INDNR,TNC	13	13	13	63	

Table 8 (cont.) Implementation schedule for the *Cirsium pitcheri* recovery plan.

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Cost Estimates ($000) FY 03	04	05	06 -14	Comments
2	152	Coordinate conservation and management among multiple owners within each patch of essential habitat.	ongoing	MDNR,WDNR INDNR,TNC	13	13	13	63	As ownership changes new owners will need to be contacted.
2	153	Coordinate permit reviews of shoreline area projects that may affect Pitcher's thistle.	ongoing	NPS,USFWS USFS,USGS, MDNR,WDNR INDNR	7	7	7	63	
2	21	Estimate population size and age class distribution.	ongoing	MNFI,MDNR, WDNR INDNR,TNC	13	13	13	117	
2	22	Map metapopulations.	ongoing	MNFI,MDNR, WDNR INDNR,TNC	13	13	13	117	
2	31	Develop and distribute informational materials pertinent to the habitat, biology and protection of Pitcher's thistle.	every 2 years	MDNR,WDNR INDNR,TNC	13	13	13	117	
2	32	Communicate with user groups (*e.g.* ORV clubs) the need to protect Pitcher's thistle and how the group(s) can assist in these efforts.	ongoing	MDNR,WDNR INDNR,TNC	13	13	13	117	
2	41	Monitor occurrences for population changes, to identify threats, and to re-evaluate protection priorities.	every 5 years	MNFI,MDNR, WDNR INDNR,TNC	65	65	65	585	
2	42	Monitor implementation of management plans for all publicly-owned occurrences.	ongoing	NPS,USFWS USFS,USGS, MDNR,WDNR INDNR	13	13	13	117	
2	66	Study non-native weed invasion and determine the degree of threat.	5	BOT GAR, UNIV,USGS, USFS	13	13	13	26	

Table 8 (cont.) Implementation schedule for the *Cirsium pitcheri* recovery plan.

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Cost Estimates ($000) FY 03	04	05	06 -14	Comments
3	51	Review historical records and select restoration sites.	2	BOT GAR, UNIV,USGS, USFS	0	7	7	0	
3	521	Develop genetic guidelines.	7	BOT GAR, UNIV,USGS, USFS	20	20	20	80	
3	522	Develop propagation and establishment guidelines.	5	BOT GAR, UNIV,USGS, USFS	7	7	7	14	
3	53	Implement, monitor, and evaluate restoration projects.	5	BOT GAR, UNIV,USGS, USFS	65	65	65	130	
3	61	Study seedbank and seed dispersal.	5	BOT GAR, UNIV,USGS, USFS	33	33	33	66	
3	62	Use genetics to investigate breeding system and population viability.	7	BOT GAR, UNIV,USGS, USFS	33	65	65	260	
3	63	Evaluate Pitcher's thistle response to trampling.	5	BOT GAR, UNIV,USGS, USFS	13	13	13	26	
3	64	Investigate establishment and transplant techniques for restoration.	2	BOT GAR, UNIV,USGS, USFS	7	7	0	0	

IV. Appendices

Appendix A. Common habitat and locations of plant species associated with *Cirsium pitcheri* (Cowles 1899, McEachern et al. 1989, Ziemer 1989).

Scientific Name	Common Name	Beach	Foredune Sleeping Bear Dunes N.L.	Foredune Grass Bay Nature Preserve	Inland Blowout Indiana Dunes N.L.	Blowout Sleeping Bear Dunes N.L.	Perched Blowout Pictured Rocks N.L.
Achillea millefolium	yarrow						X
Agropyron dasystachyum	slender wheatgrass			X			
Agropyron trachycaulum	slender wheatgrass						X
Agrostis hyemalis	tickle grass						X
Ammophila breviligulata	beach grass		X	X	X	X	
Andropogen scoparius	little bluestem		X	X	X	X	
Anemone multifida	anemone					X	
Arabis lyrata	sand cress		X		X		X
Arenaria stricta	rock sandwort					X	
Artemisia caudata	wormwood		X	X	X		
Cakile edentula	sea rocket	X	X				
Calamovilfa longifolia	sand reed grass		X	X	X		
Coreopsis lanceolata	coreopsis					X	
Corispermum hyssopifolium	jointweed	X			X		
Cornus stolonifera	red osier dogwood		X				
Equisetum variegatum	horsetail			X			
Euphorbia polygonifolia	beach spurge	X	X				
Fragaria virginiana	wild strawberry						X
Hieracium spp.	hawkweed						X
Juncus balticus	Baltic rush			X			
Juniperus communis	common juniper						X
Koeleria macrantha	junegrass					X	
Lathyrus japonicus	beach pea		X				

Appendix A (cont.) Common habitat and locations of plant species associated with *Cirsium pitcheri* (Cowles 1899, McEachern et al. 1989, Ziemer 1989).

Scientific Name	Common Name	Beach	Foredune Sleeping Bear Dunes N.L.	Foredune Grass Bay Nature Preserve	Inland Blowout Indiana Dunes N.L.	Blowout Sleeping Bear Dunes N.L.	Perched Blowout Pictured Rocks N.L.
Lilium philadelphicum	Philadelphia lily					X	
Lithospermum carolinense	hoary puccoon		X		X		
Melilotus alba	yellowsweet clover					X	
Panicum virgatum	switch grass				X		
Phlox spp.	phlox						X
Pinus banksiana	jack pine						X
Poa pratensis	Kentucky bluegrass					X	
Populus deltoides	cottonwood	X					
Prunus pumila	sand cherry		X		X		
Rumex acetosella	sheep sorrel						X
Salix cordata	dune willow			X			
Salix myricoides	willow			X			
Silene cucubalis	bladder campion					X	
Smilacena stellata	starry Soloman's seal						X
Solidago nemoralis	old-field goldenrod					X	
Solidago racemosa	dune goldenrod				X	X	X
Tanacetum huronense	Huron tansy			X			X
Zigadenus glaucus	dune lily					X	

Appendix B. The NatureServe Element Global Ranking Criteria for *Cirsium pitcheri*

Rank Specifications	Habitat	Population and Vigor
A	Extensive, dynamic dune systems of more than 250 acres in size and greater than two miles in length, with a broad foredune. Dune processes have not been altered in any unnatural way, nor are threatened by any immediate unnatural event (development, offshore construction, etc.). Dune stabilization by plants is minimal and temporary and is part of a dynamic ecosystem.	A population consisting of more than 5000 individuals. Existing plants occupy both juvenile and adult cohorts, indicating successful population maintenance.
B	Dune system 100-250 acres in size and 2-4 miles in length. Dune habitat is dynamic and open, without sign of alterations in natural dune system processes. Stabilization by plants is minimal; OR, habitats of more than 250 acres in size that show moderate signs of stabilization and other hindrances of dune dynamics.	A population of 500-5000 individuals occupying both juvenile and adult cohorts. Population structure is such as to maintain or enhance existing populations.
C	Dune systems 50-100 acres in size and 0.5-2 linear miles of dune system habitat. Habitat of this size may begin to show problems associated with maintenance of appropriate *C. pitcheri* habitat. Fracturing of habitat due to development pressure, etc. may be noticeable, particularly in the smaller sizes.	A population of 100-500 individuals.
D	Dune systems of less than 50 acres in size and less than 0.5 miles in length. In such systems, dune processes have likely ceased to function adequately in maintaining the dynamic nature of the habitat. Off-shore and shoreline structures, fracturing of the landscape by development, fence and retaining wall construction, etc., may have added additional degradation to the site. Excessive stabilization by *Andropogon scoparius*, *Ammophila breviligulata* and shrubs may have occurred in available habitat. Little likelihood of future recovery exists.	A population of less than 100 individuals; OR, populations larger than 100 individuals in which maintenance as indicated through inappropriate age structure, is doubtful or of serious concern.

NatureServe. 2001. Natural Heritage Central Databases. Arlington, VA. USA. This information is provided by NatureServe (www.natureserve.org) and its natural heritage member programs, a leading source of information about rare and endangered species, and threatened ecosystems.

Appendix C. *Cirsium pitcheri* Size Classes

Element Occurrence Size Class	Aerial extent acreage / linear mile	Abundance qualitative / quantitative (target)
1	>500 acres / > 4 mi. linear with broad foredune	common or better / >10,000
2	250-500 acres / 2-4 mi. linear with broad foredune	common or better / 5,000-10,000
3	250-500 acres / 2-4 mi. linear with broad foredune OR	less than common / 500-5,000
	100-250 acres / ½-2 mi. linear	common or better / 500-5,000
4	50-250 acres / ½-2 mi. linear OR	less than common / 100-500
	20-100 acres / 1/4-1/2 mi. linear	common or better / 100-500
5	<50 acres / < ½ mi. linear	less than common / <100

Source: Michigan Natural Features Inventory

Appendix D. Explanation of Protection Status Rank

1 Landowner/manager has been interviewed or notified of specific element occurrence(s) on the tract.

2 Voluntary protection:
- a. Landowner/manager has voluntarily agreed to protect element occurrence(s). The agreement is nonbinding and may be in the form of a registration, cooperative agreement, or use agreement, etc. A use agreement may include an official designation by a corporate owner for conservation purposes.
- b. Property is publicly owned and the land manager has agreed to protect element occurrence(s) of species that are not Federally or State listed.

3
- a. Bequest: Landowner has promised to will the tract to a conservation entity, public or private.
- b. Right of first refusal: Landowner has granted right of first refusal to a conservation entity, public or private.
- c. Property is publicly owned and the local administrative unit has agreed to protect element occurrence(s) as specified in the area management plan (but this low level designation can be revoked with no hearings or other consultation).

4 Landowner has signed a legally binding lease, license or management agreement with a conservation entity to protect the element occurrence(s)

5
- a. Landowner has conveyed an undivided interest in the property to a conservation entity.
- b. Unrestricted life estate: Landowner has granted a remainder interest to a conservation entity without conveying management control over the life estate.

6
- a. Property is publicly owned and has been designated by the managing agency for conservation administration (e.g. a Federal Research Natural Area) and the land manager is aware of element occurrences.
- b. Property is Federally owned and the land manager is aware of element occurrence(s) of a Federally listed species.
- c. Landowner has conveyed an undivided interest in the property, willed the remainder (though this can be revoked), and granted management control over the life estate all to a conservation entity.

7 Less than fee acquisition: A conservation entity controls the element occurrences through a perpetual legally binding agreement such as:
- a. an easement
- a. retained rights (in the deed-out)
- a. reverter interest (in the deed-out)
- d. remainder interest (cannot be revoked) with landowner retaining a restricted life estate.

8 Fee title: A conservation entity holds all rights, manages the property for conservation, and has been notified of element occurrence(s).

9 Dedication or trust investiture: All rights to destroy/degrade the element occurrence(s) have been relinquished through dedication into a legally established nature preserve system or conservation trust.

0 No known landowner contact

U Undetermined whether landowner has been contacted

? Protection status uncertain

Source: Michigan Natural Features Inventory

Appendix E. Federal and Michigan laws related to the protection of *Cirsium pitcheri* and its habitat.

The October 7, 1988 amendments to the Endangered Species Act enhanced protection for Federally listed endangered plants. The amendments expanded Federal jurisdiction from Federal lands only to all lands, providing there is a knowing violation of State law (see Section 9 (a)(2)(B)). However, such protection was not afforded threatened plants, (see Section 9 (a)(2)(E)).

Other laws, such as the expansion of the Coastal Barrier Resources System into the Great Lakes under the Coastal Barrier Improvement Act of 1990 may provide pre-development consultation opportunities to screen out potentially harmful impacts to coastal processes that would disturb *C. pitcheri* sites. Another Federal law that could encourage such proactive work is The Coastal Wetlands Planning Protection and Restoration Act of 1990. Although much of this law focuses on coastal wetland issues in Louisiana, Great Lakes coastal wetland (e.g. interdunal wetland) ecosystems could benefit through the coastal wetland conservation grant program. The Great Lakes Fish and Wildlife Restoration Act of 1990 is a law with the potential to benefit *C. pitcheri*. After appropriation, monies could become available for habitat acquisition which could protect the coastal processes upon which Pitcher's thistle habitat depends.

Federal Laws

Endangered Species Act of 1973. 16 U.S.C.1531-1544; P.L. 93-205, as amended. Regulations in Part 50 CFR Part 17.

Federal Water Pollution Control Act of 1948. 33 U.S.C. 1251-1376; P.L. 845, as amended.

Federal Water Pollution Control Act Amendments of 1972. P.L. 92-500, as amended.

Clean Water Act of 1977. P.L. 95-217. Regulations at 33 CFR Parts 320-330.

National Environmental Policy Act of 1969. 42 U.S.C. 4321-4347; P. L. 91-190 as amended by P. L. 94-83, 1975.

Michigan Laws

Part 301, Inland Lakes and Streams Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.30101 to 324.30113

Appendix E (cont.) Federal and Michigan laws related to the protection of *Cirsium pitcheri* and its habitat.

Part 303, Wetland Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.30301 to 324.30323.

Part 323, Shorelands Protection and Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.32501 to 324.32515.

Part 351, Wilderness and Natural Areas, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.35101 to 324.35111.

Part 353, Sand Dune Protection and Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.35301 to 324.35326.

Part 365, Endangered Species Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.36501 to 324.36507.

Part 17, Michigan Environmental Protection Act, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.1701 to 324.1706

General Real Estate Powers, SubPart 11, Conservation and Historic Preservation Easement, of Part 21 of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.2140 to 324.2144.

Appendix F. Global and local problems in *Cirsium pitcheri* metapopulation/sub-population management.

GLOBAL SCALE

Query	Resolution
Is landscape large enough to afford needed habitat heterogeneity for multiple sub-populations?	Expand landscape area to incorporate adjacent sites with appropriate local habitat and landscape mosaic characteristics.
Are environmental events correlated across the landscape such that the entire metapopulation is affected and could be extirpated?	Expand landscape area to incorporate tracts where environmental events are uncorrelated with current management areas.
Is immigration or colonization between habitat patches and sub-populations improbable due to spacing distances?	Establish sub-populations in potential habitats lacking Pitcher's thistle, transplant seedlings into suitable habitats between widely separated sub-populations.
Are there barriers that prevent dispersal to suitable habitat patches?	Remove barriers, artificially move animals that play a role in dispersal or propagules between habitat patches. If visitor use is preventing dispersal, establish natural areas for dune species preservation where visitor use is limited. If housing and commercial developments are acting as barriers, purchase land to restore dune systems and Pitcher's thistle populations.
Has the environmental regime that creates mosaic of habitat patches shifted causing a lack of synchrony between habitat and population turnover (e.g. change in sand supply)?	Reestablish altered or lost environmental regime. Remove groins and jetties to restore positive sand flow to dune systems and initiate sand nourishment if necessary.
Has a slow change in landscape-wide deterministic process caused a loss of local populations (e.g. change in groundwater quality)?	Manage landscape-wide deterministic change in environmental conditions.

Appendix F (cont.) Global and local problems in *Cirsium pitcheri* metapopulation/sub-population management.

LOCAL SCALE

Query	Resolution
Is the population so small that random fixation of deleterious alleles and inbreeding depression are causing low seed production?	Transplant seedlings from seeds from nearby sub-populations to increase genetic content and population size.
Is population so small that chance fluctuations in demographic fates will cause local extinction?	Manipulate population growth rate or introduce individuals to increase population size.
Is the habitat too small to allow the population to reach a large size?	Increase the size of the local habitat patch. This could be accomplished by removing litter or by reducing the cover of grasses.
Has there been an environmental event within the habitat that eliminates individual plants (e.g., grazing pressure due to increases in rabbit populations, pre- or post-dispersal seed predators)?	Buffer habitat against local environmental catastrophes. For example, protect plants from herbivory or seed predation, using exclosures of various types or ensure there is suitable early successional habitat. Apply fertilizer or water to adult plants to boost seed size and number.
Are environmental fluctuations so variable that population is likely to decline (e.g., change in microclimate)?	Manipulate local habitat or population to dampen variance caused by the environmental fluctuation.
Is a deterministic process, like succession or recreational use, active in the habitat and eliminating individuals?	Ensure adequate sand supply and promote natural disturbance processes. Educate visitors about their impacts on dune habitats and Pitcher's thistle sub-populations so that catastrophic loss does not occur, increase law enforcement activities in highly used areas.

Appendix G. Peer Review and Public Comment

Development of this recovery plan began several years ago, before the Service issued its July 1, 1994, policy on peer review. A draft recovery plan for *Cirsium pitcheri* (Pitcher's thistle) was made available for public review and comment in 1991. The administrative record for public comment and review on this plan is maintained by the Service Regional Office in Fort Snelling, MN.

Twenty or more reviewers from a wide spectrum of agencies and private individuals received copies of the draft plan, with some reviewers submitting written comments to the U.S. Fish and Wildlife Service. Comments and opinions received are not summarized separately in this plan, but have been considered and incorporated when appropriate into this Recovery Plan.

Comments were received from the following reviewers.

June Dobberpuhl - Wisconsin Department of Natural Resources
Ron Nicotera - Bureau of Endangered Resources, Wisconsin Department of Natural Resources
USFWS - East Lansing Field Office, East Lansing, Michigan
Mr. Biloss, City of Manistee, Michigan
Dr. Edward Voss, University of Michigan Herbarium, Ann Arbor, Michigan
Bob Jones, Landscape Contractor, Glen Arbor, Michigan
Dale Engquist, Indiana Dunes National Lakeshore, NPS
John Gardner, Jr., Covert, Michigan
Marcella DeMauro, Forest Preserve Manager, Will Co., Illinois
David Ewert, The Nature Conservancy - Michigan
Bill Bruckart, USDA

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