Restoring Diversity

Strategies for Reintroduction of Endangered Plants

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vegetation across the uplands. No current threats to the translocated populations from activities on adjacent lands have been identified.

Funding

The original collection and propagation of Apalachicola rosemary was supported by Bok Tower Gardens and CPC. CPC transported the plants to the site with TNC financial support. All further support for this reintroduction has been from TNC's International and Florida offices. The Florida Program continues this support (using intern and volunteer assistance). No accounting of funds or time spent on this project has been maintained. TNC is committed to managing this preserve and monitoring these populations in perpetuity as part of our other management and monitoring activities on site.

Partnerships

- CPC
- Bok Tower Gardens
- TNC and several TNC volunteers

Policy and Regulatory Context of Reintroduction

The U.S. Fish and Wildlife Service completed the recovery plan for *C. glabra* in 1994.

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CASE STUDY 5

Pitcher's Thistle (*Cirsium pitcheri*) Reintroduction

Marlin Bowles and Jeanette McBride

Taxon

Cirsium pitcheri; Pitcher's thistle

Endangerment Status and Date of Listing

Cirsium pitcheri was determined to be federally threatened in 1988; it is state threatened in Illinois, Indiana, and Michigan and endangered in Wisconsin (Harrison 1988).

Natural Distribution and Ecology of Taxon

Pitcher's thistle (*Cirsium pitcheri*) is endemic to dune systems of the western Great Lakes shoreline (Figure CS5-1). This thistle requires 70 percent open sand, which restricts its habitat to sand dunes where wind-generated disturbance processes maintain successional vegetation and open sand (McEachern 1992). Because of the dynamics of this habitat, metapopulations are required for persistence of *C. pitcheri*, allowing it to survive local population extinctions by colonizing new habitat from other populations (McEachern, Bowles, and Pavlovic 1994).

Cirsium pitcheri is a striking species. The stems and leaves of both juveniles and adults are wooly white and deeply pinnatifid, with larger spines between the lobes of the distal leaf margins' spines; flowering stems reach 1 meter and flowering heads are cream to light pink in color (Pavlovic et al 1993). Like many early-successional plants, *Cirsium pitcheri* is a monocarpic

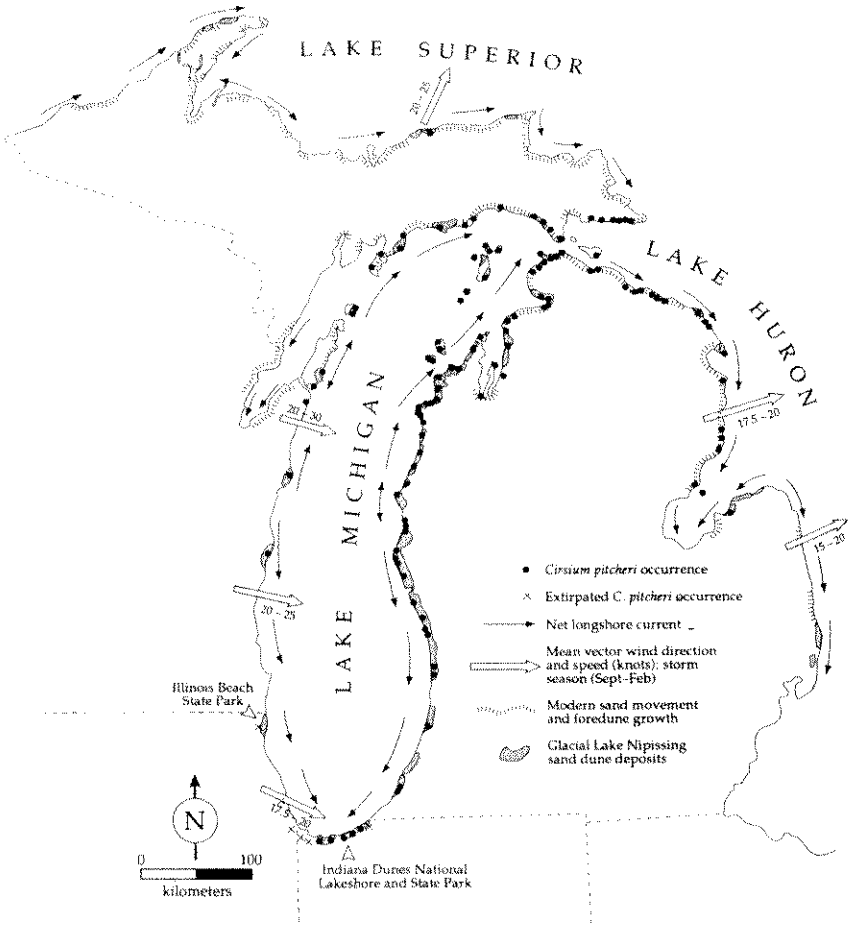

FIGURE CS5-1. Location of *Cirsium pitcheri* populations and habitats in the western Great Lakes and location of Illinois Beach State Park restoration sites (Bowles et al. 1993; McEachern, Bowles, and Pavlovic 1994).

perennial; plants flower after five to eight years and then die, with population maintenance dependent upon reproduction from seeds (Loveless 1984). This reproductive strategy presents a challenge for restoration, requiring establishment of staged cohorts that allow replacement of flowering plants in the population. Transplanting of greenhouse-propagated plants can accelerate cohort development and maturity, but may avoid environmental selection at the seedling stage and determination whether plants can actually complete their life cycle.

Threats to Taxon

Although Pitcher's thistle is adapted to a dynamic habitat, it is susceptible to disturbances that occur out of phase or with higher frequency, severity, or magnitude than natural dune processes (Bowles et al. 1993). For example, disturbances such as recreational impacts that consistently remove seedling cohorts or prevent seed production would lead to population decline (Dobberpuhl and Gibson 1987; McEachern 1992). Impacts such as sand mining, shoreline development, dune and shoreline stabilization, or disruption of shoreline currents that replenish eroded shorelines can eliminate thistle habitat and are now widespread throughout the range of the species (Pavlovic et al. 1993; Bowles et al. 1993). *Cirsium pitcheri* is also subject to potentially damaging seed predation, either in the seed head or after seed dispersal (Loveless 1984; Keddy and Keddy 1984), which can affect levels of seed production and seedling establishment that are critical for population maintenance.

Conditions That Initiated Reintroduction

Because of the narrow, linear Lake Michigan shoreline dune habitat in Illinois, former Pitcher's thistle populations there were probably extremely vulnerable. They apparently disappeared from Illinois shoreline dunes before 1920 due to the combined effects of increasing human activity, lake level fluctuations, collecting, and other chance events (Bowles et al. 1993).

Objectives of Reintroduction

With federal listing and recovery planning, restoration of a Pitcher's thistle metapopulation in Illinois became an important goal to test whether the species could be successfully restored, thereby improving its population status and protecting it from extirpation (Pavlovic et al. 1993). Protection of a large portion of the Illinois shoreline as a state park provided the only remaining Illinois dune system where *Cirsium pitcheri* restoration could be tested (Bowles et al. 1993). Because *C. pitcheri* persists as metapopulations, reintroduction into multiple habitats was required (McEachern et al. 1994).

Description of Reintroduction Sites

Illinois Beach State Park is located 70 kilometers north of Chicago on a low (up to 3 meters of relief), narrow (1.5-kilometer wide) sand deposit that

extends for over 20 kilometers along the Lake Michigan shoreline. The shoreline is dynamic, with sediment transport southward by the longshore current; former beach ridges form a compressed dune field north of the Dead River and a more widely spaced dune ridge and swale system south of the River (Figure CS5-2). In a detailed study, secondary dunes in a protected nature preserve south of the Dead River were found to replicate appropriate habitat for this species and appeared to be free from shoreline erosion and recreational impacts (Bowles 1991; Bowles et al. 1993). This area was recommended to the Illinois Endangered Species Protection Board as an initial site for reintroduction of Pitcher's thistle (Bowles 1991). To meet metapopulation requirements dunefield habitat north of the Dead River was also recommended for reintroduction of this species (McEachern *et al.* 1994).

Description of Reintroduction Project

With approval of the Illinois Department of Natural Resources and the Illinois Nature Preserves Commission, *Cirsium pitcheri* reintroduction to Illinois Beach began in 1991. Propagules for this restoration were derived from seeds collected by permit in 1990 from Indiana and southern Wisconsin. Seed collection in subsequent years also included southern Michigan populations. Seeds were moist stratified and greenhouse propagated the following spring. After hardening, seedlings were outplanted in early August. In 1991, seventy-seven Indiana and Wisconsin *C. pitcheri* seedlings were translocated into secondary dune habitat south of the Dead River. In 1992, a new cohort of eight Indiana seedlings was also introduced (Bowles et al. 1993). In 1993, a third cohort of seventy-nine Indiana, Wisconsin, and southwestern Michigan seedlings was introduced. In addition 853 seeds that had been moist stratified at the Morton Arboretum were planted in early April 1993.

In 1994, twenty-two seedlings were translocated, while 878 seeds were planted within the population south of the Dead River. To begin establishing a metapopulation, seedlings were also planted in dunefield habitat north of the Dead River in 1994. This area receives recreational disturbance, which may help maintain open habitat but might negatively impact thistle seedlings (Dobberpuhl and Gibson 1987), thus allowing an examination of recreational impact on thistles.

In 1992, twenty-five (32.5 percent) of the 1991 cohort had survived, with a higher over-winter mortality rate among Wisconsin plants (Table CS5-1). In 1993, four of the 1992 cohort survived, resulting in a population of over one hundred plants. By 1994, fifty-three of the *C. pitcheri* transplants for 1991, 1992, and 1993 were alive at Illinois Beach, representing 32.3 percent survival. Greatest mortality occurred over the first winter for each cohort and

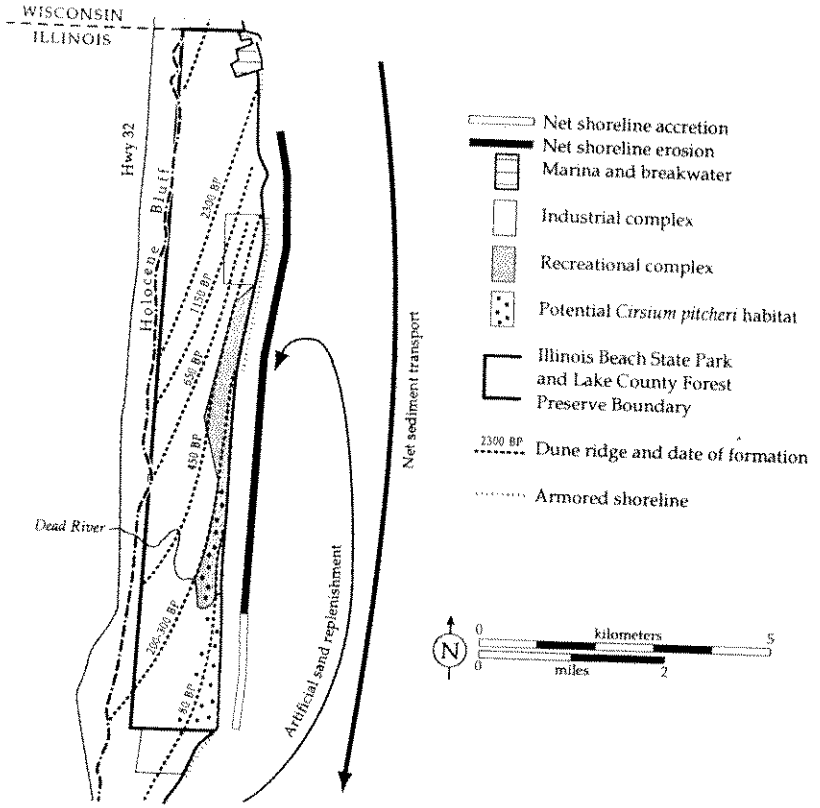

FIGURE CS5-2. Locations of potential *Cirsium pitcheri* habitat in Illinois Beach State Park (Bowles et al. 1993; McEachern, Bowles, and Pavlovic 1994). Populations have been restored in habitat north and south of the Dead River.

TABLE CS5-1. *Cirsium pitcheri* transplant survival at Illinois Beach. Percent cohort survival is in parentheses.

	1991	1992	1993	1994
1991 cohort	77	25 (32.5)	25 (100)	23* (92)
1992 cohort	—	8	4 (50)	4 (100)
1993 cohort	—	—	79	26 (32.9)
1994 cohort				22
TOTAL	77	33	108	75

*Two plants of the 1991 cohort flowered and died in 1994.

exceeded 60 percent in the two largest cohorts. Subsequent mortality was almost nonexistent. Among the 1991 cohort, survivorship was 92 percent between 1992 and 1994, leaving twenty-three plants alive. No winter mortality occurred among the 1992 cohort during transition to 1994, while 32.9 percent of the 1993 cohort survived the transition to 1994. Thus, we expect about two-thirds over-winter mortality of newly planted cohorts.

Germination of outplanted seeds was extremely low and confounded by seed dormancy (Table CS5-2). Of 853 seeds planted in spring 1993, only eleven (1.3 percent) germinated and became established by 30 July 1993. However, all of these seedlings survived into 1994, when an additional thirty-two previously dormant seeds germinated, thirty of which were from Wisconsin. Of the 878 seeds planted in 1994 only two germinated, but additional seeds may germinate in 1995. Although seed predation by birds and small mammals may have depleted the seed plots, the delayed germination indicates that some seeds survived. Germination among the greenhouse-germinated seeds was 22.1 percent.

In its fourth year, the *Cirsium pitcheri* reintroduction included seventy-three *ex situ*–propagated and translocated juvenile plants and forty-five *in situ*–germinated seedlings and juveniles. High rainfall during 1993 appears to have promoted plant growth, which allowed two plants to flower in 1994. Although insecticide treatment of flowering plants was planned to deter seed predators (Louda 1994), no applications were made. This treatment was apparently unneeded, as fourteen hundred seeds were produced among the two plants. However, the central flowering stem of the largest plant was destroyed by animal herbivory. The small number of flowering plants at Illinois Beach may have failed to attract seed predators, or seed predators may not be present. In comparison, eight flowering Wisconsin plants in a sand bed at the Morton Arboretum also produced fourteen hundred seeds. Seed production in this artificial population was over 20 percent higher in unbagged plants (26.1 percent of all ovules) than bagged plants (4.7 percent of all ovules), apparently due to outcrossing by pollinators. Although seed predation may have been unnoticed, it was apparently not a factor in the different levels of seed production at the arboretum. If animal herbivory continues, it could be a critical factor affecting growth of this small population.

Bioregional Context

Cirsium pitcheri possesses a low level of genetic variation, but it has a negative correlation between genetic similarity and geographic distance between populations (Loveless and Hamrick 1988). We found apparent genetic differences between Indiana and Wisconsin seed sources, with Indiana plants better adapted to habitat at Illinois Beach. A significantly smaller cotyledon

TABLE CS5-2. Seed sources, seed numbers, and germination of *Cirsium pitcheri* seeds introduced to Illinois Beach State Park.

	Wisconsin	Indiana	Michigan	Total
Seeds planted (1993)	648	205	—	853
Germinated (1993)	4	7	—	11
Germinated (1994)	30	2	—	32
Seeds planted (1994)	—	399	479	878
Germinated (1994)	—	0	2	2

size found in Wisconsin seedlings in 1991 (Bowles et al. 1993) was consistent during germination of seeds in 1993, and all Indiana and Michigan seedlings germinated in 1994 had similar cotyledons. Although Indiana plants had greater suvivorship (45 percent) than Wisconsin plants (16.2 percent) in 1992 (Bowles et al. 1993), there was no significant difference in survivorship between the 1992 Wisconsin cohort (36.1 percent) and Indiana cohort (37.9 percent) in 1994. The 1994 Michigan cohort had 16.7 percent survival in 1994.

Older cohorts of the Indiana plants have out-performed Wisconsin plants. At the time of planting in 1991, greenhouse plants from both sources had similar numbers of leaves and leaf lengths (Bowles et al. 1993). By 1992, Wisconsin plants were smaller in all aspects of morphology except number of leaves; by 1993, almost all plants from both sources had doubled in size, but Indiana plants were larger and had more leaves (unpublished data). Basal root-crown width appears to be a good indicator of plant growth (McEachern 1992). Only two plants, both from Indiana, had root-crown widths exceeding 1 centimeter in 1993, and these plants flowered in 1994. Population structure, based on root-crown width size-classes in 1994, was also dominated by Indiana plants (Figure CS5-3). Twelve of the Indiana plants had widths exceeding 1 centimeter in 1994, but only one Wisconsin plant was that large. This indicates that the Indiana plants have greater potential to flower or are more expedient in reaching flowering size.

Possible explanations for these potential genetic differences include geographic and ecological factors (Bowles et al. 1993). The Indiana seed source is 70 kilometers closer to Illinois Beach than the Wisconsin seed source, and its more southern habitat may have selected for adaptation to habitat conditions that are similar to Illinois Beach.

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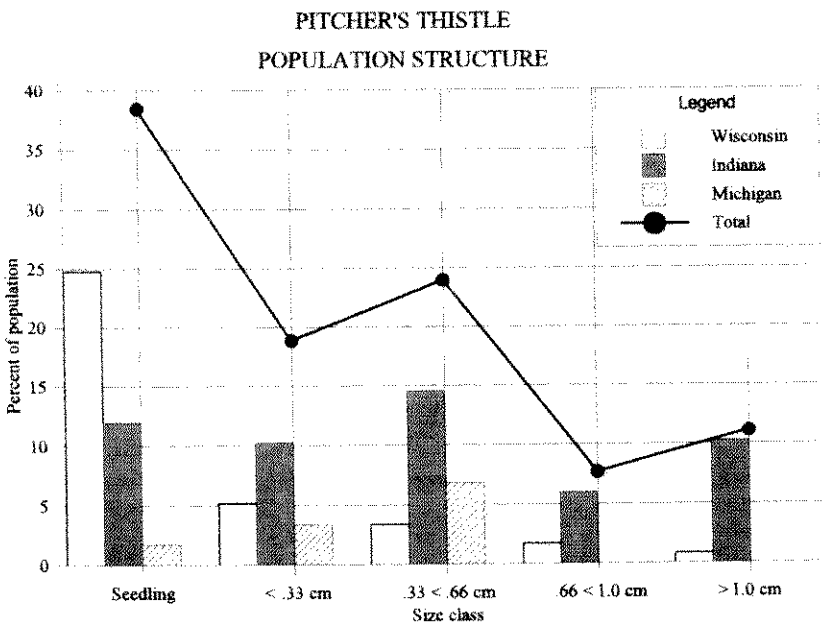

FIGURE CS5-3. Population structure of 118 Pitcher's thistles at Illinois Beach Nature Preserve. Percentage of population is given for each of three seed sources among five size classes. Seedling size class indicates seedlings and one-year-old juveniles derived from on-site germination of seeds. Other size classes are 1994 basal root widths in centimeters of greenhouse-propagated plants translocated to Illinois Beach.

Partnerships

- Illinois Department of Natural Resources (through participation of Randy Heidorn and John Schwegman).
- Illinois Endangered Species Protection Board (through participation of Sue Lauzon).
- Illinois Nature Preserves Commission (through participation of Steve Byers).
- Illinois Beach State Park (through participation of Bob Grosso).
- Lake County Forest Preserve District (through participation of Ken Klick).
- U.S. Fish and Wildlife Service (through participation of Amelia Orton-Palmer).

Policy or Regulatory Context of Reintroduction

There are no direct policy or regulatory effects on the restored population. Because the plants occur within a state park and nature preserve, they are protected by Illinois state park and nature preserve statutes.

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