Environmental Assessment of a *Cirsium pitcheri* Restored Population on the Coast of Lake Michigan

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Abstract

Ecological restoration poses a greater challenge when rare plants depend on specific environmental conditions. Endemic to the Great Lakes region, *Cirsium pitcheri* is a federally-threatened, monocarpic thistle species. As such, restoration efforts to maintain and re-establish populations may be essential to the survival of these native plants. This study compared the characteristics of *C. pitcheri* in a second-generation artificially-restored population and a natural population in order to assess management possibilities. During the fall of 2015, we mapped the two populations, recorded physical plant characteristics and measured surface characteristics of the surrounding environments. Plant height, width, health, sand slope angle, and sand pH were compared among both populations. Herbivory, animal impacts and proximate human activity were observed in each study area. The greater density of *C. pitcheri* was recorded in the artificially-restored population. This group also displayed a greater average plant height, health rating, and soil pH than the naturally-occurring population. Results suggest that well-selected environmental locations for *C. pitcheri* regeneration have the potential to be effective management strategies to restore populations and keep them healthy into future generations.

Introduction

Prior research on the viability of *Cirsium pitcheri*, a threatened dune plant, has indicated relationships between dune elevation, surface soil pH, and bare sand area as crucial to *C. pitcheri* health [2]. As such, understanding these variables proves essential to regeneration efforts. Our study evaluated and compared two populations: a second-generation restored population and a natural population.

The objectives of this study were to:

1) record the physical characteristics of native and restored *C. pitcheri* populations
2) identify environmental factors that influence the success of *C. pitcheri*
3) evaluate the effectiveness of greenhouse-raised and strategically- placed juvenile *C. pitcheri* as a restoration effort.

Study Area

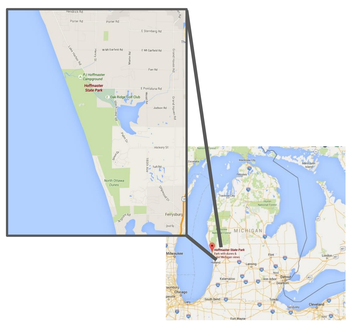

Figure 1: Study area in Michigan

Our study took place in Hoffmaster State Park on the eastern shore of Lake Michigan (Figure 1). Two populations were studied:

1) a restored population of individuals planted as juveniles in the early 2000s, now in their second generation, and
2) a naturally-occurring population of individuals.

Methods

In fall of 2015, we completed various tasks to analyze population and environmental characteristics within the two 15 m by 11 m plots of *C. pitcheri.* Each individual's physical characteristics were assessed, and environmental characteristics were gathered from five randomly-selected areas (Table 1).

Table 1: Methods used to assess C. pitcheri *populations and their surrounding environment.*

Variable	Procedure
Location	Measured and marked boundaries of study site with GPS Mapped each plant within the study plot with GPS
Plant characteristics	Measured plant height, rosette width, and leaf width Recorded number of leaves per plant Assessed plant health on a scale of 1-5
Environmental characteristics	Measured sand slope angle using a Brunton compass Identified sand pH
Proximity to impacts	Mapped nearby human trails and location of visible animal impacts

Results

In the restored population, 66 *C. pitcheri* individuals were identified with an average plant density of .40 plants per m². In the natural population, a total of 48 plants were identified with an average plant density of .29 plants per m². Population size-class distributions of the two populations show both were dominated by juveniles (Figures 2 and 3).

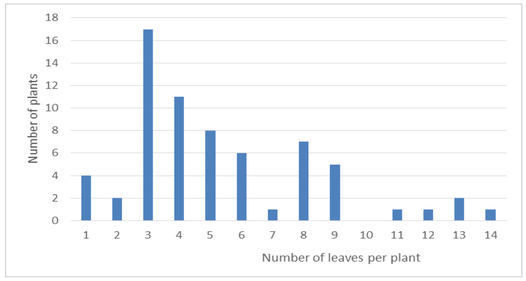

Figure 2: Size-class distribution of restored population

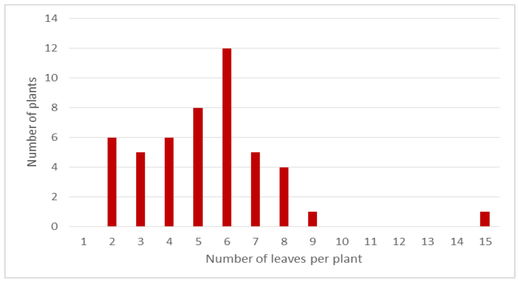

Figure 3: Size-class distribution of natural population

Further differences were observed in the physical and environmental characteristics of both populations (Table 2). The plant height, rosette width, leaf width, health score, and pH were significantly different between the two populations at α=0.05. Health ratings show significantly higher overall health in the restored population (Figure 4). Additionally, individuals were distributed in a slightly clustered distribution across the study sites (Figure 5).

Table 2: Results of C. pitcheri *physical and environmental characteristic survey. T tests were completed and p values reported.*

	HEIGHT	WIDTH	LEAF WIDTH	# OF LEAVES	HEALTH	HERBIVORY	pH	SLOPE ANGLE
RESTORED	11.3	21.2	1.0	5.3	3.5	14%	7.2	15.8
NATURAL	7.3	15.3	2.4	5.3	2.9	8%	6.7	29.8
T TEST	1.56E-05	0.00517	0.000196335	--	0.000528	--	0.006769	--

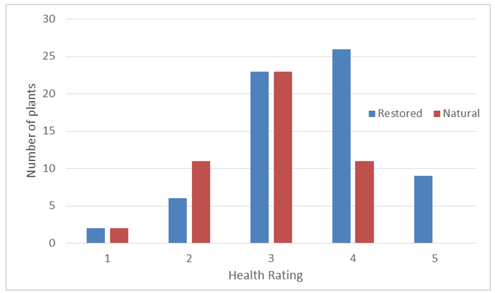

Figure 4: Health rating distribution of populations

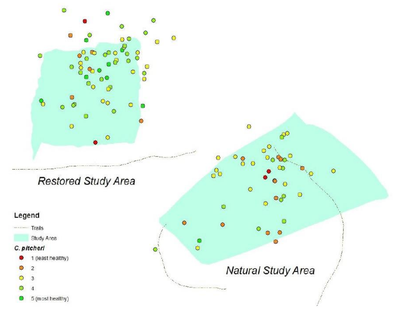

Figure 5: Distribution of individuals by health rating

Discussion

The variation between observed characteristics of *C. pitcheri* individuals from both populations suggest that restored plantings are a potentially effective management method. The comparable number of leaves indicates that the populations are approximately the same age [1], but the increased height, rosette width, and health suggest that the restored population is currently healthier (Figure 6).

However, the smaller average leaf width in the restored population may indicate a lower probability for plant success in the future [1]. The higher pH of the restored population could also be correlated with the higher plant density of that site [2]. Previous studies suggest the increased herbivory may have no effect on total plant density or success [3].

Longer-term monitoring and research on the population is suggested to continue exploring the dynamics and possibilities of restoration for threatened species management.

Figure 6: Example of restored C. pitcheri

Conclusions

The greater *C. pitcheri* height, rosette width, and health rating of individuals located in the restored population suggest that planting strategies for species restoration have been effective so far. Herbivory, pH, and location may also affect juvenile success. Further research of restored populations is warranted to gain a greater understanding of the effectiveness of this management strategies across the Lake Michigan region.

Acknowledgements and References

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[1] D'Ulisse, A., Maun, M. 1996. "Population ecology of *Cirsium pitcheri* on Lake Huron sand dunes: survivorship of plants." *Canadian Journal of Botany* 74: 1701-1707.

[2] Marshall, J. 2014. "Influence of topography, bare sand, and soil pH on the occurrence and distribution of plant species in a lacustrine dune ecosystem." *Journal of the Torrey Botanical Society* 141(1): 29-38.

[3] Stanforth, L., Louda S., and Bevill R. 1997. "Insect herbivory on juveniles of a threatened plant, *Cirsium pitcheri*, in relation to plant size, density and distribution." *Ecoscience* 4(1): 57-66.