

## Abstract

*Cirsium pitcheri*, an endangered plant found only in specialized dune conditions, serves as an exemplar of environment-vegetation interactions. We investigated these interactions by focusing on variables that might affect the survival and growth of *C. pitcheri* on Mt. Baldy in P.J. Hoffmaster State Park, Michigan. Our objectives were to document plant characteristics and investigate the optimal conditions for plant growth. Using GPS units and ArcGIS visualization, we mapped the locations of the plants and dune sub-environments. Measurements of leaf length, plant health, evidence of herbivory, slope angle, and aspect were recorded for each located plant. In addition, vegetation density and diversity were measured and recorded in each dune sub-environment. Study results showed *C. pitcheri* was abundant in several dune sub-environments, including windward and leeward dune slopes, as well as deflation areas of blowouts; a majority were found on south-facing slopes. No significant relationship was found between slope angle and maximum leaf length or plant health, but results did show a majority of individuals growing on slopes of less than the angle of repose. This research offers a means to better understand the interactions of *C. pitcheri* with its dune environment and could assist restoration efforts by suggesting dune locations where *C. pitcheri* would most likely thrive.

## Introduction

*Cirsium pitcheri* (figure 1) is an endangered plant found only in specialized dune conditions and serves as an exemplar of environment-vegetation interactions [1]. This species is threatened by human activity, habitat loss, herbivory and climate change [2]. Previous research has identified various factors influencing the plant's growth, including sand burial [3] and light availability [4]. This study attempts to identify additional dune characteristics and variables that influence the location and growth of *C. pitcheri* on a large Great Lake dune.

Study objectives were to:

1. Document individual *C. pitcheri* characteristics in several dune environments.
2. Collect data on variables that affect *C. pitcheri*.
3. Examine data for patterns which show the optimal conditions for the growth of *C. pitcheri*.



Figure 1. Adult *C. pitcheri* surrounded by dune grass, sand and leaf litter.

## Study Area

The study took place on Mt. Baldy in Hoffmaster State Park, along the eastern shore of Lake Michigan (figure 2). At this site, we chose two large study areas that could be divided into dune sub-environments based on their characteristics.

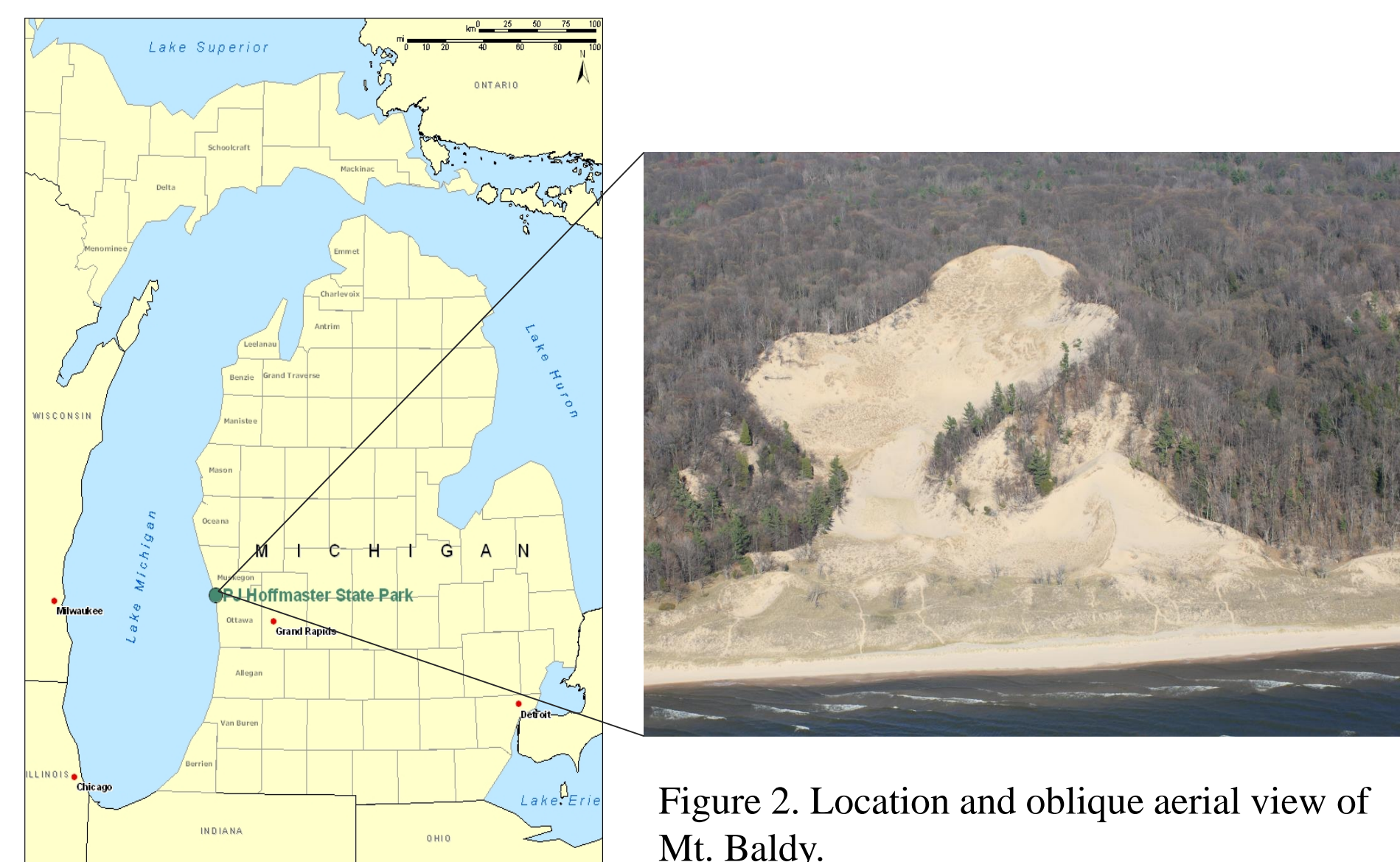


Figure 2. Location and oblique aerial view of Mt. Baldy.

## Methods

Characteristics of individual *C. pitcheri*, the dunes and the surrounding vegetation were measured and analyzed to compare patterns in plant health and location (table 1).

Table 1. Variables and associated methods

Individual Plant Characteristics	Dune Characteristics	Surrounding Vegetation Characteristics
<ul style="list-style-type: none"> <li>• Location (GPS)</li> <li>• Number of leaves</li> <li>• Maximum leaf length (cm)</li> <li>• Is the plant shaded?</li> <li>• Location on dune (description)</li> <li>• Evidence of damage by herbivores</li> <li>• Health rank</li> <li>• Age class</li> </ul>	<ul style="list-style-type: none"> <li>• Slope angle at each plant location (degrees)</li> <li>• Aspect at each plant location (degrees and direction)</li> <li>• Location of trails</li> </ul>	<ul style="list-style-type: none"> <li>• Vegetation density in sub-areas (using quadrat)</li> <li>• Vegetation diversity in sub-areas (using quadrat)</li> </ul>

## Results

131 *C. pitcheri* individuals were mapped (figure 3) and are abundant in several dune sub-environments, including windward and leeward dune slopes.

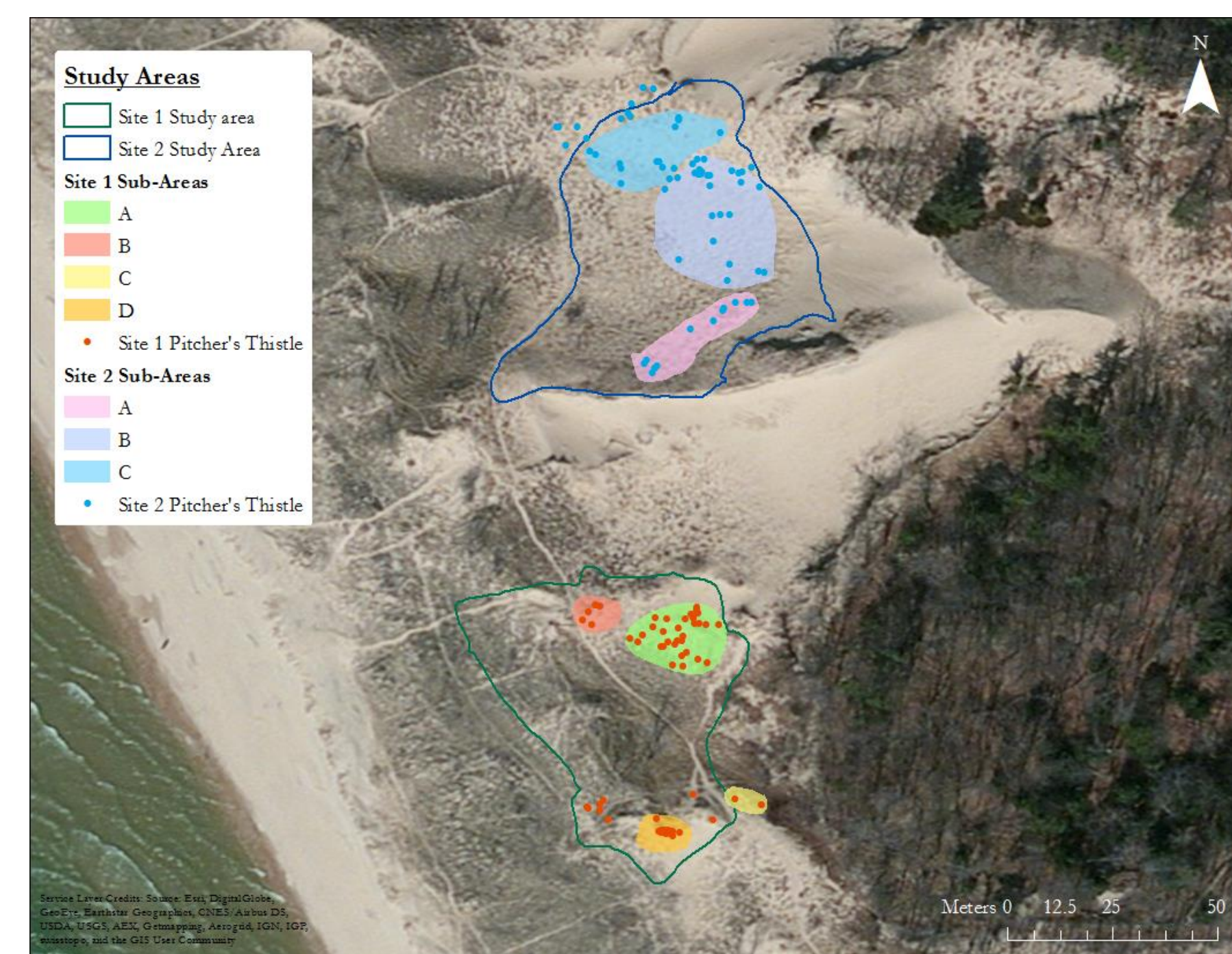


Figure 3. Location of *C. pitcheri* and study areas.

The majority of *C. pitcheri* individuals are in the seedling or small juvenile age class (figure 4). The mean and median distance between *C. pitcheri* individuals are 1.5m and 1.2m, respectively.

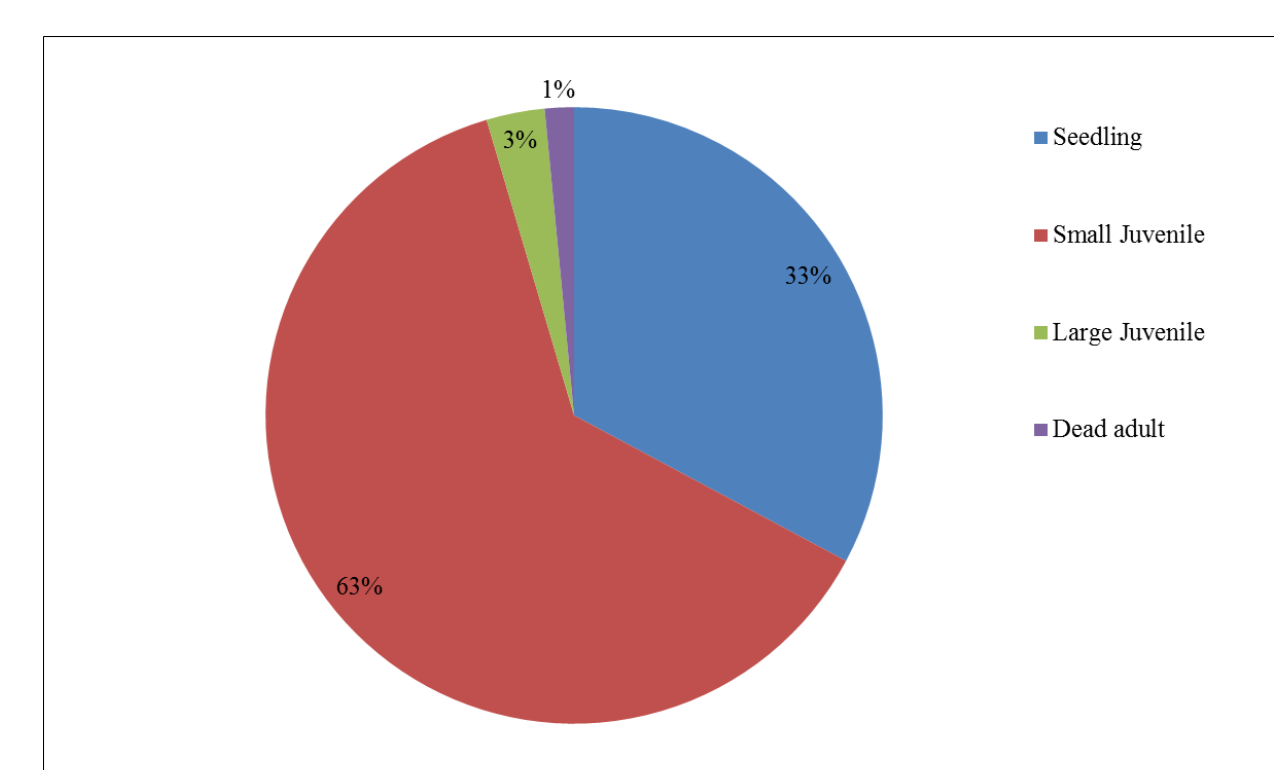


Figure 4. *C. pitcheri* age class distribution.

No statistically significant relationship was found between dune slope angle and *C. pitcheri* plant health, or between slope angle and maximum leaf length of *C. pitcheri* individuals (figure 5).

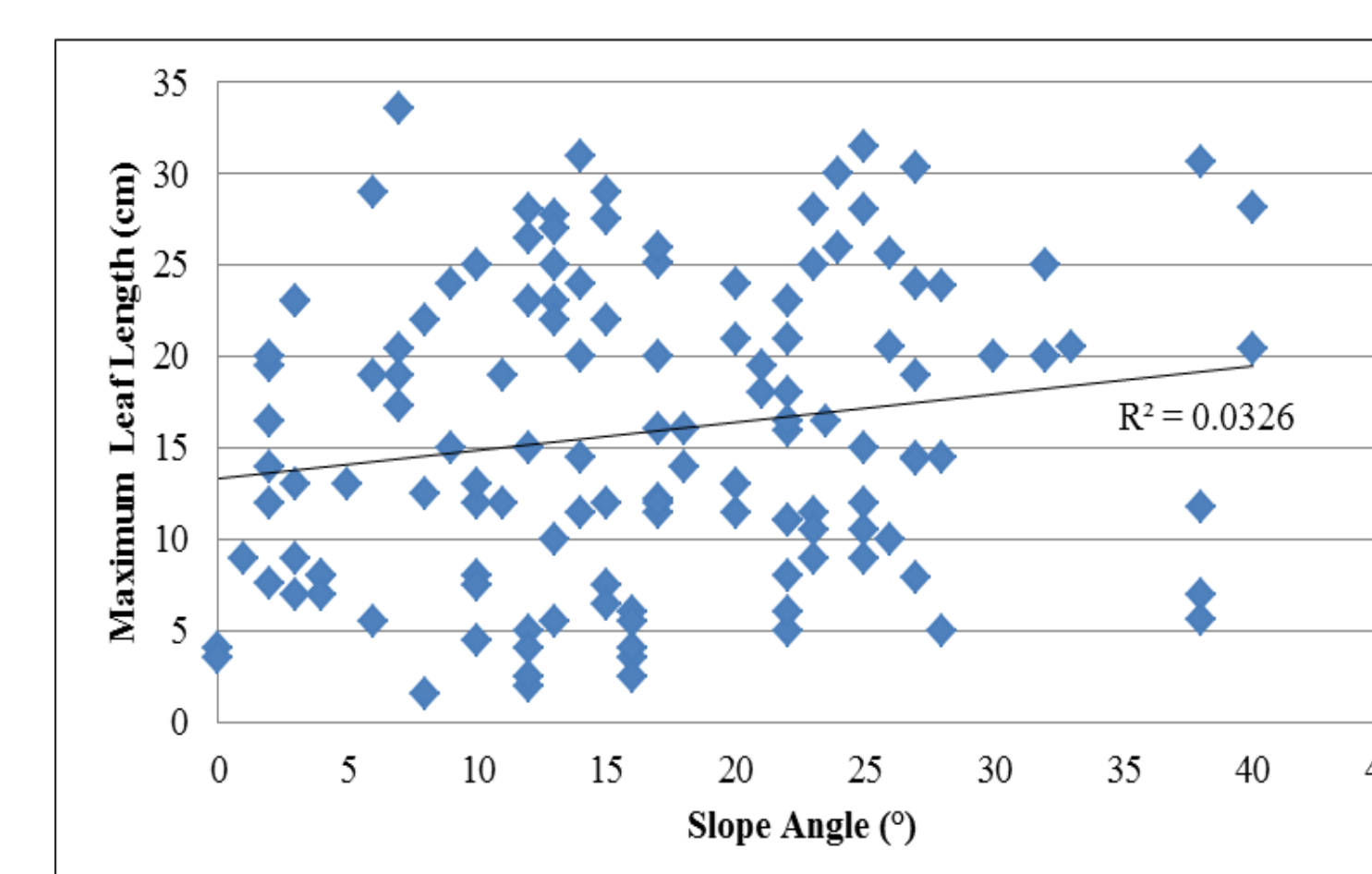


Figure 5. Relationship between dune slope angle and the maximum leaf length of *C. pitcheri* individuals.

The majority (45%) of plants surveyed were found on south-facing slopes (figure 6) with steepness less than 30°.

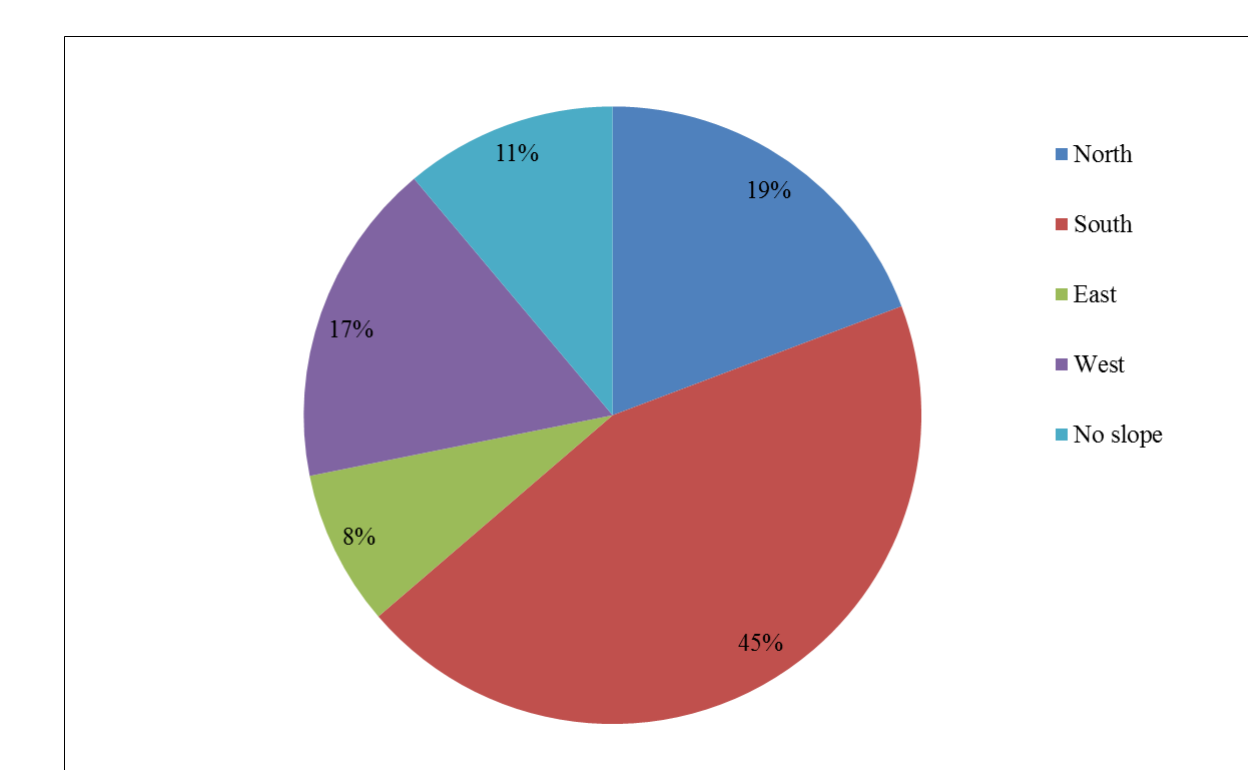


Figure 6. Distribution of *C. pitcheri* individuals by aspect.

## Discussion

The abundance of young *C. pitcheri* (figure 7) indicates that individuals are not reaching older age classes due to negative impacts, or that many individuals in the previous generation successfully flowered and died (figure 7), creating an abundant new generation. The latter is probable, since many dead individuals were observed but not surveyed due to time constraints.

Results suggest *C. pitcheri* grow well on south-facing slopes where light availability is highest. Slope angle appears to have little effect on the health or growth of individuals, suggesting *C. pitcheri* easily adapts to a wide range of slope angles.

The small distances between *C. pitcheri* individuals indicates that the species grows best in clusters.



Figure 7. *C. pitcheri* in the seedling (left) and dead adult (right) age class.

## Conclusions

The *C. pitcheri* populations studied on Mt. Baldy appear healthy with the ability to produce well-sized future generations. Various conditions found at this site seem to promote the growth and survival of the populations, including south-facing slopes. Restoration efforts should seek to plant *C. pitcheri* individuals in clusters on south-facing slopes at angles of less than 30°.

## Acknowledgements and References

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### References:

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