First-Year Research in Earth Sciences: Dunes

# Interactions Between Dune Trails and *Cirsium Pitcheri* Habitat

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**ABSTRACT**

This study looks closely at the conditions of a threatened species habitat when it exists among unmanaged dune trails. A fourteen-acre plot of land on the eastern coast of Lake Michigan was recently purchased for conversion from private land into a dune preserve. This property includes hummocky foredunes, blowouts, and two stabilized parabolic dunes, and it serves as critical habitat for the threatened species *Cirsium pitcheri* (Pitcher's Thistle). To determine the condition of the habitat, a study was done to locate all specimens, gauge the condition of the population, and explore the effects of anthropogenic disturbance. GPS mapping was used to create an inventory of all specimen locations and all observed trails through the property. Measurements were taken of each plant to gauge the age of the population and the GPS results were assembled in a map to observe the density. Our results showed 206 *C. pitcheri* specimens, most of which appeared to range from three to six years of age. Spatial analysis of the GPS data showed two distinct groupings of plants along with numerous unmanaged trails. The largest trail, which divided the two groups of plants, extended from the low point between two large parabolic dunes out to the beach. We observed that the heavy use of this trail combined with an extension of the stabilized portion of the dunes produced unfavorable conditions for *C. pitcheri*. With these results we were able to provide the new property owners with important information regarding critical habitat of *C. pitcheri.*

**INTRODUCTION**

The dunes of Lake Michigan are known by many to be fantastic spots for recreation; however they also serve as a unique habitat for both flora and fauna. One species that depends on this habitat is *Cirsium pitcheri*, commonly known as Pitcher's Thistle, which is a federally-listed threatened species. *C. pitcheri*, like most dune vegetation, is vulnerable to trampling resulting from unmanaged trails. This study investigates a coastal dune site on the eastern coast of Lake Michigan to determine the condition of a population of *C. pitcheri* and its interactions with unmanaged trails.

Having previous knowledge of the existence of *C. pitcheri* along with several unmanaged trails in the study area, information was needed to assess the two and look for relationships between them. Our study objectives were to:

1) Map all *C. pitcheri* and unmanaged trails,

2) Assess condition of *C. pitcheri* populations, and
3) Compare human disturbance with specimen locations.

The data and observations we gathered will contribute to the body of knowledge concerning *C. pitcheri* and will also assist the new owners of our study site with developing an effective management plan.

**BACKGROUND**

Conservation of dune sites is important not only for the protection of coastal landforms and natural beauty but for the protection of rare plant species such as *Cirsium Pitcheri*, commonly known as Pitcher's Thistle. *C. pitcheri* was listed as threatened by the United States Fish & Wildlife service in 1988 and remains on that list to this day (USFWS 2013). In Canada, *C. pitcheri* is considered a "Schedule 1" endangered species under the Species at Risk Act (Environment Canada 2012). Because of the relatively small habitat, opportunities to protect existing *C. pitcheri* populations are important.

*C. pitcheri* is a monocarpic perennial, meaning it lives more than two years and flowers only once (Hamze and Jolls 2000). Mature plants will develop flowering stems (figure 1) that bolt in May (Hamze and Jolls 2000). The plant dies after seed dispersal, usually after five to eight years of growth (Girdler and Radtke 2006). It is endemic to shoreline dunes of the western Great Lakes (Hamze and Jolls 2000), being found only in Illinois, Indiana, Michigan, Wisconsin, and Ontario (Gauthier *et al.* 2010). These locations have longshore currents and climatic patterns that form shoreline dunes which provide open sand (Hamze and Jolls 2000). This open sand environment includes sand movement which is an unstable surface condition that *C. pitcheri* has adapted to (Gauthier *et al*. 2010).

*C. Pitcheri* populations have shown to be vulnerable to genetic changes (Gauthier *et al.* 2010). One of these genetic changes is inbreeding in which inputs of genetic material from neighboring populations are absent, lowering genetic diversity (Gauther *et al*. 2010). This factor reduces the strength of the genetics of an isolated population, lowering its ability to survive in the long-term (Gauthier *et al*. 2010).

Assessing the condition of *C. pitcheri* populations is done in various ways. Measurements to the nearest centimeter of the length of the longest leaf can be used as a significant predictor of the condition of the overall *C. pitcheri* population (Girdler and Radtke

Figure 1: Flowering *C. pitcher* (Source:  Whitsett 2011)

2006). A higher number of large plants indicates favorable growing conditions and healthy populations. Various methods exist for analyzing spatial patterns, such as mapping point data in ArcGIS.

Vegetation on dunes, particularly *C. pitcheri* populations, can be negatively affected by anthropogenic disturbance. Human influences that negatively affect vegetation on dunes come primarily from trampling. Studies have been conducted that show even low levels of trampling can decrease the ability of plants to survive, and steady traffic prevents natural replacement (Carlson and Godfrey 2006). Rickard *et al*. (1994) found that damage to vegetation from pedestrian traffic is manifested as decreased mean height and percentage of vegetation cover. Without vegetation cover the dune surface is more vulnerable to erosion via aeolian activity which can lead to larger areas of bare sand and unsuitable habitat (Rickard *et al.* 1994).

## STUDY AREA

Our study area is a newly acquired plot of land located on the eastern shore of Lake Michigan in Muskegon County, Michigan (figure 2). This fourteen-acre plot was purchased by

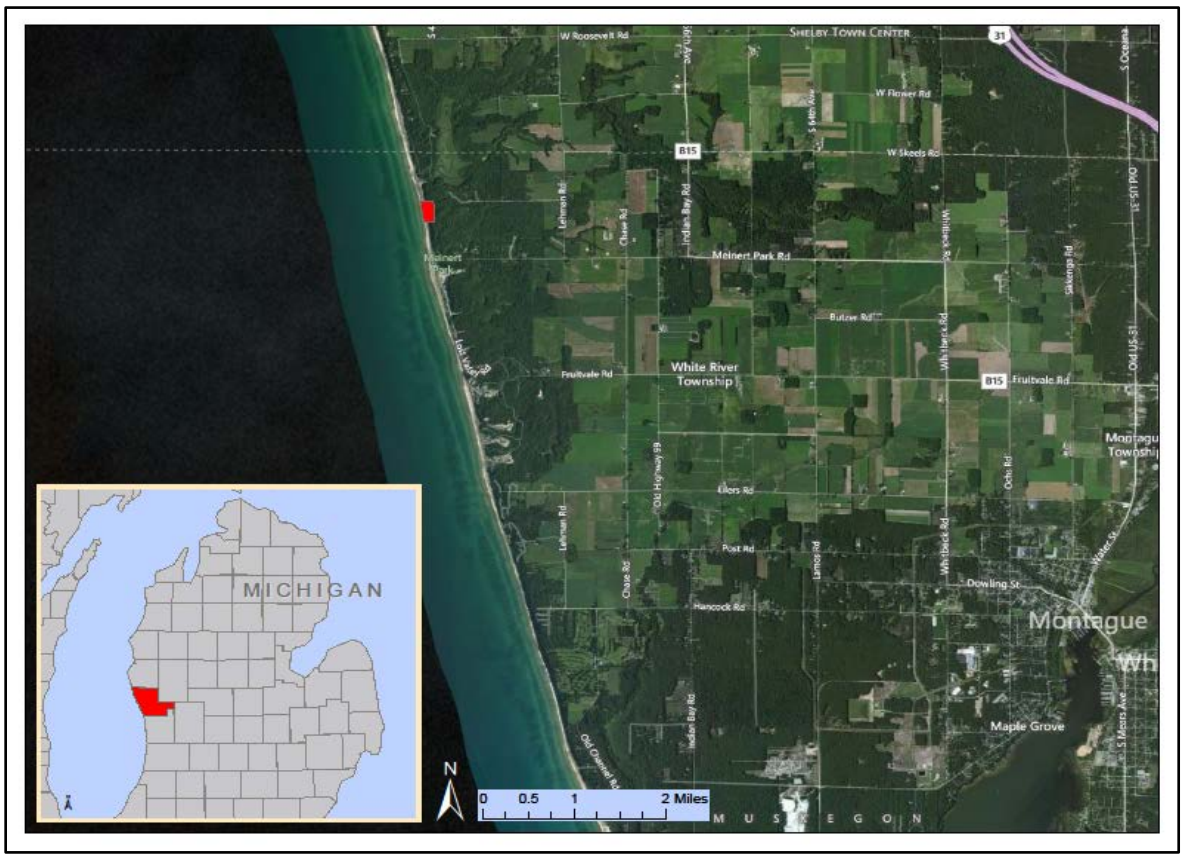


Figure 2: Study site location on Lake Michigan

the Land Conservancy of West Michigan for conversion from private ownership into a dune preserve. Features of this study area include approximately 275 meters of beachfront backed by hummocky foredunes, an established dune ridge with blowouts, and two large, stabilized parabolic dunes. A network of unmanaged trails are scattered throughout the lower foredune area and extend up to the crest of the parabolic dunes. Nearby features include private beachfront cottages bordering the north and south boundaries of the property, and Meinert Park, part of Muskegon County Parks, 0.5 kilometers to the south.

**METHODS**

We collected information about *C. pitcheri* at our site by using GPS Trimble units to take point data at each individual specimen on the site. In addition to GPS locations, we took measurements of the longest leaf of each specimen based on the methods used in Girdler and Radtke (2006) and made a note of the plant's condition according to the categories in Table 1. To ensure no duplicate specimen data was recorded, a flag was placed next to each specimen after data was collected.

To assess the unmanaged trails at our site we walked each individual trail while recording line data with GPS Trimble units. We recorded observations about trail size and where each trail was heading.

To determine the spatial relationships between *C. pitcheri* and the unmanaged trails we assembled the GPS data into a map using ArcGIS software. We looked for patterns of *C. pitcheri* locations and possible relationships in the locations of *C. pitcheri* and the trails.

| ***C. pitcheri* Condition** | **Description** |
|---|---|
| Good | Plant leaves are full, no withering |
| Good/Fair | Plant leaves are full, few signs of withering |
| Fair | Plant leaves less full and/or several signs of withering |
| Fair/Poor | Sparse plant leaves and/or ¼ of plant is withered |
| Poor | Sparse plant leaves and/or ½ of plant is withered |

Table 1: *C. pitcheri* condition categories

**RESULTS**

Our research team visited the study site three times during late October and early November of 2012. Conditions experienced during these visits all included strong autumn winds blowing from the west and cool temperatures.

The study site contains 206 C. pitcheri specimens congregated around the established foredune ridge (figure 3). Data are located in Appendix A. Measurement of leaf lengths

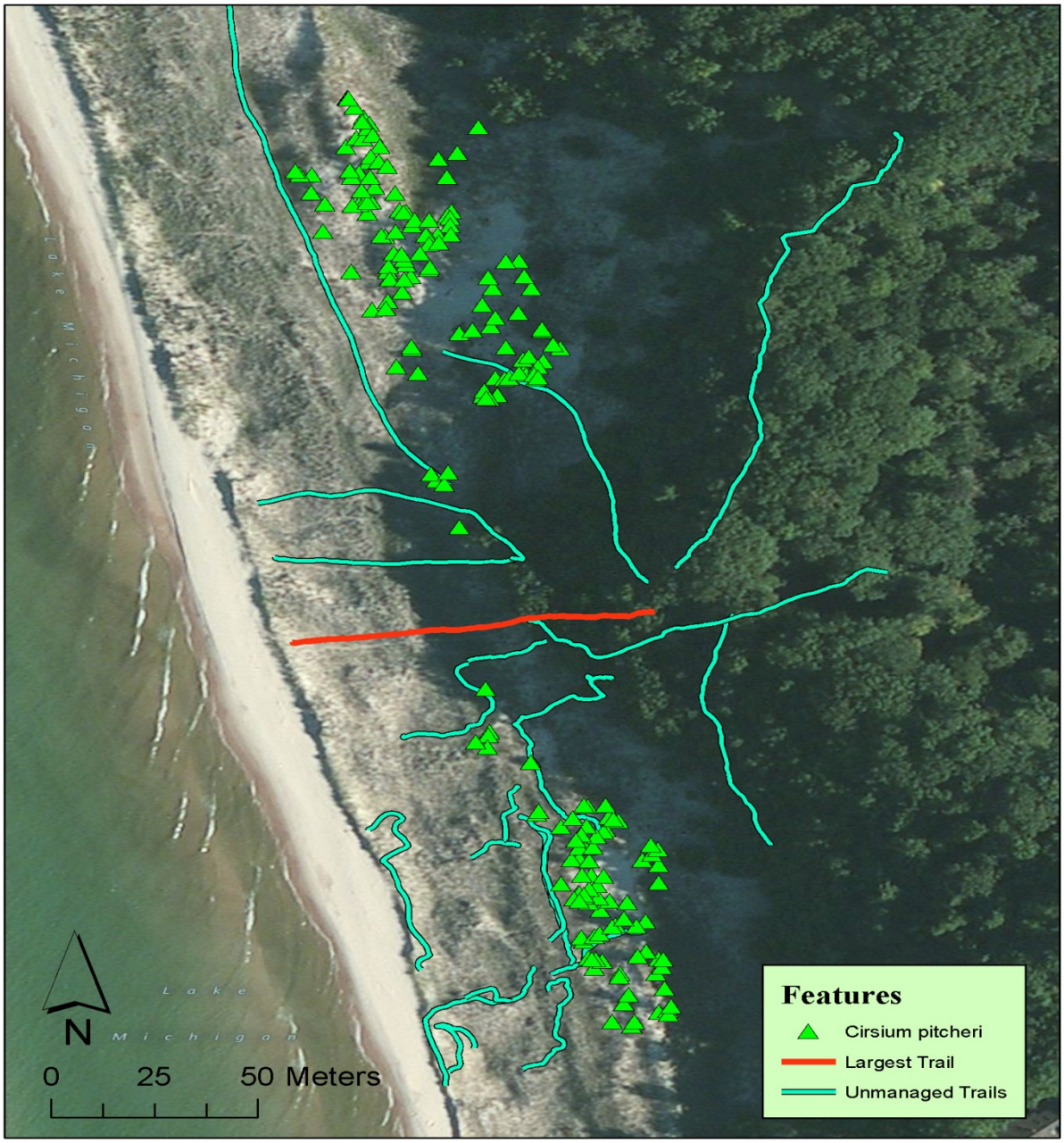


Figure 3: Map of trails and *C. pitcheri*

produced a wide range of plant sizes (figure 4). The smallest specimen was measured at 4 cm while the largest was 51 cm. Overall, 90% of the specimens fell between 10 and 40 cm. There were no flowering plants; however remains of flowering specimens were observed at the site. Observations of the condition of each specimen were positive with 143 observations being 'good' or 'good/fair' (figure 5).

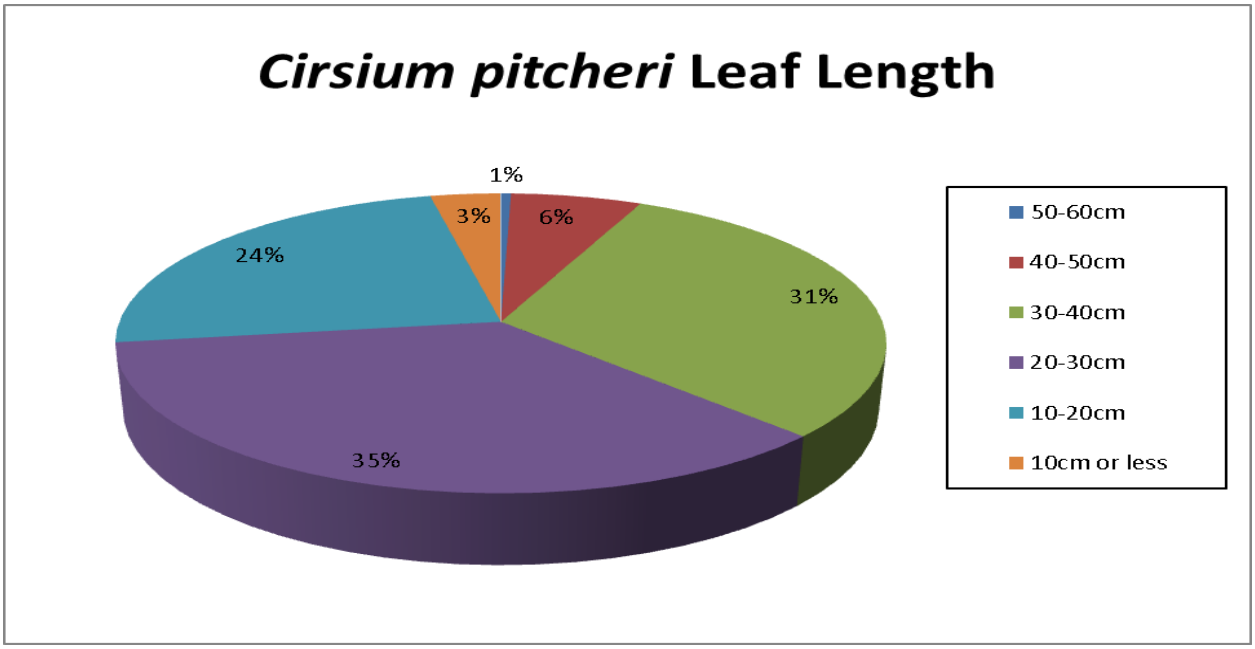


Figure 4: Leaf length measurements

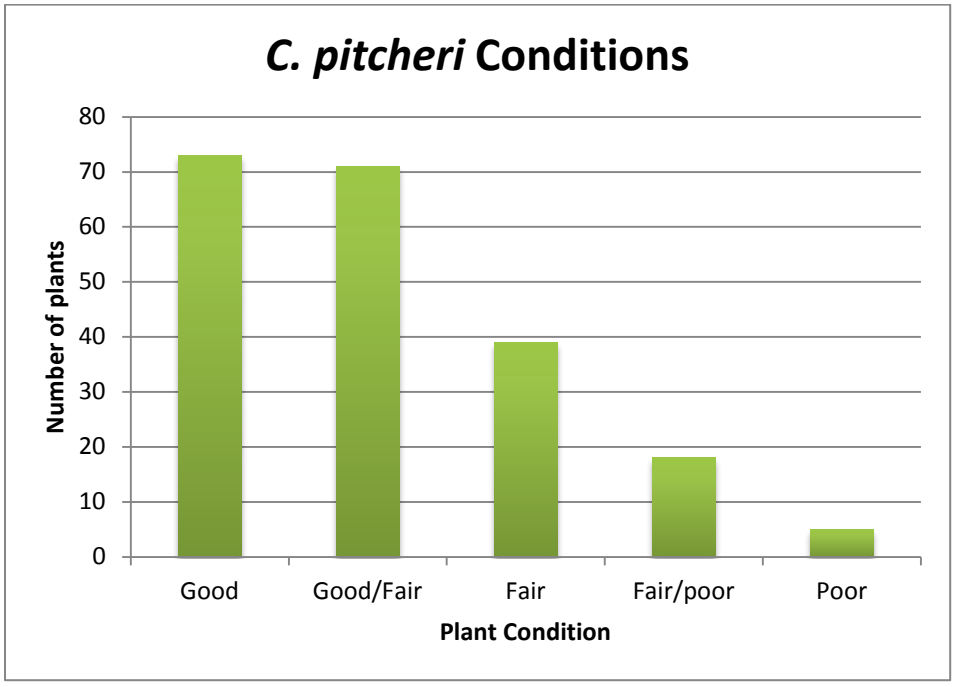


Figure 5: Observations of individual plant conditions

Spread throughout the property are a variety of unmanaged trails leading to points of interest such as blowouts and dune crests. One trail, highlighted in red in figure 2, was observed to be the most prominent (figure 6). This largest trail begins at the beach and extends inland 65 meters to the base of the two parabolic dunes where their arms meet, providing access to trails leading to the dune crests.

The *C. pitcheri* specimens are divided by the main trail into two groups at least 25 meters away from the trail. Other smaller trails that traveled through *C. pitcheri* habitat were usually found to be two meters or more away from the plants except for three instances.

Figure 6: Largest trail connecting to the beach

**DISCUSSION**

The spatial density of specimens along with the leaf length measurements indicates the *C. pitcheri* populations to be currently healthy. Due to the time of year we collected data, we missed the *C. pitcheri* flowering phase, however, remains of flowering individuals indicates that the habitat is able to sustain specimens to maturity.

The two distinct populations of *C. pitcheri* denote some kind of disturbance on the site causing a separation. With the largest trail serving as the bisecting line between the populations it is reasonable to suggest that this trail is negatively affecting the *C. pitcheri*. Carlson and Godfrey (1989) point out that anthropogenic disturbance in the form of trampling can cause vegetation to suffer and create areas of bare sand. In addition to trampling, *C. pitcheri* face a topographic challenge at this site. Where the arms of the parabolic dunes meet there is a forested area that protrudes out onto the foredune ridge (figure 7). Forested areas suggest stabilized conditions, meaning there is not enough sand transport for *C. pitcheri* to flourish. The combination of trampling and the forested intrusion have likely caused two *C. pitcheri* populations to form.

The existence of two populations has potential for decreased longevity. According to Gauthier *et al.* (2010), isolated populations of *C. pitcheri* will experience high levels of inbreeding. Without introduction of seeds from different populations, each population may experience reduced genetic diversity thereby reducing the strength of the population. If a natural connection cannot be established between the two populations, or if further separation is caused by trail activity, management should consider human-induced seed dispersal and plantings.

Figure 7: Forested intrusion on right

While *C. pitcheri* specimens are not found near the largest trail, other trails are in close proximity to some specimens. This factor does not weaken evidence of trampling as a negative influence because these locations are also affected by topography. The trails that come into close contact with *C. pitcheri* specimens are located on dune ridges (figure 8) where the slopes serve to keep people on the trail thereby limiting the trampling to a narrow path.

Figure 8: Trail on a dune ridge

## CONCLUSIONS

This future dune preserve currently contains 206 *C. pitcheri* specimens that are thriving despite anthropogenic disturbance from a network of unmanaged trails. Management efforts that control and direct pedestrian traffic will reduce the disturbance, and, along with seed dispersal and vegetation planting, increase the ability of *C. pitcheri* populations to grow.

## ACKNOWLEDGEMENTS

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**APPENDIX A: *C. Pitcheri* Measurements**

| Plant: | Leaf Length (cm): | Relative Health: | Notes: |
|---|---|---|---|
| 1 | 32 | Fair-poor | |
| 2 | 42 | Good | |
| 3 | 22.5 | Fair-poor | |
| 4 | 28.3 | Good | |
| 5 | 31.8 | Fair | |
| 6 | 40.2 | Fair | 1 Dying leaf, possible insect or parasite damage |
| 7 | 25.6 | Good-fair | 0 |
| 8 | 39.8 | Fair | 1 Dying leaf |
| 9 | 28.9 | Good-fair | |
| 10 | 11.9 | Good-fair | |
| 11 | 39.2 | Good | |
| 12 | 18 | Good | |
| 13 | 46.6 | Fair | Damage, not grazing |
| 14 | 31.9 | Good-fair | |
| 15 | 36.3 | Good-fair | Several dying leaves |
| 16 | 33.2 | Good | Very slight grazing damage |
| 17 | 29.8 | Good | |
| 19 | 15.9 | Good | |
| 20 | 15.2 | Good | |
| 21 | 25 | Good | |
| 22 | 20 | Good-fair | |
| 23 | 29.4 | Fair-poor | |
| 24 | 30.5 | Good | |
| 25 | 33.1 | Good | |
| 26 | 31.9 | Good | |
| 27 | 22.4 | Good-fair | |
| 28 | 32.4 | Good-fair | |
| 28 | 19 | Good-fair | |
| 29 | 22.1 | Fair | |
| 30 | 28.3 | Good | |
| 31 | 23.7 | Good-fair | |
| 32 | 12.4 | Good | |
| 33 | 37.6 | Good | Thin Foliage |
| 34 | 27 | Good | |
| 35 | 38.7 | Fair | |
| 36 | 4 | Good | |
| 37 | 20 | Good | |
| 38 | 28.6 | Good-fair | |

| Plant: | Leaf Length (cm): | Relative Health: | Notes: |
|---|---|---|---|
| 39 | 19.9 | Good-fair | |
| 40 | 31.5 | Good | |
| 41 | 19.1 | Fair | |
| 42 | 15 | Fair | |
| 43 | 37.2 | Fair | |
| 44 | 28 | Good-fair | |
| 45 | 29.2 | Good-fair | |
| 46 | 26 | Good | |
| 47 | 15.1 | Good-fair | |
| 48 | 38.2 | Fair | Slight grazing damage |
| 49 | 41.5 | Good-fair | 1 Dying leaf |
| 50 | 28.5 | Good-fair | |
| 51 | 18.2 | Fair | |
| 52 | 35.9 | Fair | |
| 53 | 33.4 | Good-fair | |
| 54 | 51 | Good | |
| 55 | 47 | Fair | Damage, not grazing |
| 56 | 38 | Good | Very slight grazing damage |
| 57 | 39 | Fair-poor | Many dead leaves, no grazing |
| 58 | 14.9 | Good | |
| 59 | 20 | Good-fair | |
| 60 | 23.1 | Poor | |
| 61 | 26.3 | Good | |
| 62 | 40 | Good | |
| 63 | 44.2 | Fair | Small damage, not grazing |
| 64 | 21.2 | Good-fair | |
| 65 | 37 | Good | |
| 66 | 30.5 | Good-fair | |
| 67 | 29 | Fair | |
| 68 | 35.2 | Good-fair | Several dead leaves |
| 69 | 30 | Good | |
| 70 | 39.2 | Fair | 1 Dying leaf |
| 71 | 28.3 | Fair | |
| 72 | 24.1 | Good-fair | |
| 73 | 30 | Good-fair | |
| 74 | 12.1 | Fair | |
| 75 | 8.9 | Good | |
| 76 | 15.1 | Fair-poor | |
| 77 | 36.5 | Good | Very young plant |

| Plant: | Leaf Length (cm): | Relative Health: | Notes: |
|---|---|---|---|
| 78 | 29 | Good-fair | |
| 79 | 41.5 | Fair-poor | Damage: probable grazing, possible trampling |
| 80 | 9.3 | Fair | |
| 81 | 44.5 | Good | Thick Foliage |
| 82 | 48 | Good | |
| 83 | 25.4 | Fair-poor | |
| 84 | 15.2 | Good-fair | |
| 85 | 30 | Good-fair | |
| 86 | 19 | Good | |
| 87 | 22.7 | Good-fair | |
| 88 | 22.5 | Good-fair | |
| 89 | 29 | Good-fair | |
| 90 | 27 | Fair | |
| 91 | 14.8 | Fair | |
| 92 | 16.5 | Good-fair | |
| 93 | 8.7 | Fair-poor | |
| 94 | 32.5 | Fair-poor | |
| 95 | 10.4 | Poor | |
| 96 | 23.6 | Good | |
| 97 | 34 | Good | |
| 98 | 10.3 | Good-fair | |
| 99 | 10.2 | Fair | |
| 100 | 32.5 | Good-fair | Several damaged leaves |
| 101 | 28.5 | Good | |
| 102 | 38 | Good-fair | |
| 103 | 25.5 | Good | |
| 104 | 28.2 | Good-fair | |
| 105 | 28 | Good | |
| 106 | 11.1 | Fair-poor | |
| 107 | 21 | Good | |
| 108 | 23 | Good | |
| 109 | 9.2 | Good-fair | |
| 110 | 27.5 | Good-fair | |
| 111 | 35 | Good | |
| 112 | 14.7 | Good-fair | |
| 113 | 29 | Good | |
| 114 | 13.4 | Fair-poor | |
| 115 | 15.8 | Good-fair | |
| 116 | 14.2 | Good | |

| Plant: | Leaf Length (cm): | Relative Health: | Notes: |
|---|---|---|---|
| 117 | 13.1 | Fair | |
| 118 | 19.6 | Good-fair | |
| 119 | 23.5 | Good | |
| 120 | 31 | Good | |
| 121 | 19.3 | Fair-poor | |
| 122 | 25 | Good-fair | |
| 123 | 37 | Fair-poor | Several dead leaves |
| 124 | 42 | Fair | Parasite or insect damage |
| 125 | 17 | Good-fair | |
| 126 | 34.1 | Fair | Several dying leaves |
| 127 | 47 | Fair | |
| 128 | 40 | Good | |
| 129 | 23.5 | Fair-poor | |
| 130 | 34.8 | Good-fair | |
| 131 | 41 | Good | |
| 132 | 34.5 | Good | |
| 133 | 12.8 | Good-fair | |
| 134 | 29 | Good | |
| 135 | 31 | Good-fair | |
| 136 | 27 | Good-fair | |
| 137 | 15.2 | Fair | |
| 138 | 33.4 | Fair-poor | More significant parasite or disease damage |
| 139 | 39 | Good-fair | |
| 140 | 37 | Fair | Slight grazing damage |
| 141 | 21.1 | Fair | |
| 142 | 19 | Good-fair | |
| 143 | 25 | Fair | |
| 144 | 39 | Fair | |
| 145 | 19.1 | Good | |
| 146 | 34.7 | Poor | |
| 147 | 22.3 | Good | |
| 148 | 25.4 | Good-fair | |
| 149 | 25.8 | Fair-poor | |
| 150 | 15.2 | Good-fair | |
| 151 | 11.9 | Good-fair | |
| 152 | 23.3 | Good-fair | |
| 153 | 27 | Good | |
| 154 | 33.9 | Fair | Slight parasite or disease damage |
| 155 | 35.1 | Fair | |

| Plant: | Leaf Length (cm): | Relative Health: | Notes: |
|---|---|---|---|
| 156 | 35.6 | Good | |
| 157 | 18.6 | Good-fair | |
| 158 | 10.9 | Good | |
| 159 | 25.2 | Good-fair | |
| 160 | 36.4 | Good | |
| 161 | 22 | Good | |
| 162 | 31.2 | Good | |
| 163 | 29 | Fair | |
| 164 | 33 | Good | |
| 165 | 30.7 | Good-fair | |
| 166 | 22.2 | Good-fair | |
| 167 | 11.5 | Good | |
| 168 | 30.4 | Good | |
| 169 | 35.2 | Good | |
| 170 | 30 | Fair | |
| 171 | 6.2 | Good-fair | |
| 172 | 35.9 | Poor | Majority of leaves are dead |
| 173 | 36 | Good-fair | Several dying leaves |
| 174 | 35.1 | Good | |
| 175 | 10.9 | Good-fair | |
| 176 | 20.6 | Good-fair | |
| 177 | 30.4 | Good-fair | |
| 178 | 35.4 | Good | Young plant |
| 179 | 20.8 | Good-fair | |
| 180 | 35.5 | Fair | Very thin foliage |
| 181 | 35.9 | Good | Very young plant |
| 182 | 15.9 | Good-fair | |
| 183 | 24.6 | Fair | |
| 184 | 13 | Good | |
| 185 | 5.3 | Fair | |
| 186 | 26.9 | Good-fair | |
| 187 | 20.3 | Poor | |
| 188 | 15 | Good-fair | |
| 189 | 20.2 | Good-fair | |
| 190 | 28.6 | Good | |
| 191 | 34.9 | Good | Very young plant |
| 192 | 29.9 | Good-fair | |
| 193 | 44.4 | Good | Thin Foliage |
| 194 | 25.1 | Good | |

| Plant: | Leaf Length (cm): | Relative Health: | Notes: |
|---|---|---|---|
| 195 | 29 | Good | |
| 196 | 16.2 | Fair-poor | |
| 197 | 12.6 | Good-fair | |
| 198 | 24 | Fair-poor | |
| 199 | 32.3 | Good | |
| 200 | 34.8 | Good | |
| 201 | 30.5 | Good | |
| 202 | 13.8 | Good-fair | |
| 203 | 26.6 | Good | |
| 204 | 27 | Fair | |
| 205 | 29 | Good-fair | |
| 206 | 28.1 | Good-fair | |