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Ecology of Eastern prickly pear cactus (Opuntia humifusa) in Oak Openings Preserve, northwestern Ohio

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ECOLOGY OF EASTERN PRICKLY PEAR CACTUS (*OPUNTIA HUMIFUSA*) IN OAK OPENINGS PRESERVE, NORTHWESTERN OHIO

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ABSTRACT

Opuntia humifusa (eastern prickly pear cactus) is listed as potentially threatened in Ohio, and we examined the characteristics of *O. humifusa* sites in Oak Openings Preserve in northwestern Ohio's Oak Openings region in an attempt to provide data that may help protect this species. *Opuntia humifusa* occurrences were associated with loose sands of the xeric Udipsamment Ottokee and Oakville soil series on sites that had been cleared before the 1940s during failed agricultural attempts. Shading by encroaching canopy trees is a threat to several *O. humifusa* populations in Oak Openings Preserve, and treatments that reduce canopy cover at these sites may help sustain this species and increase the proportion of flowering individuals. Because the patchy distribution of *O. humifusa* makes the species susceptible to local extinctions, the acquisition of sites by conservation organizations containing *O. humifusa* or providing suitable habitat is consistent with the perpetuation of this rare species in the Oak Openings region. Sandy sites previously disturbed by agricultural clearing, sand mining, or other soil disturbances should not be overlooked for their potential to provide *O. humifusa* habitat in this region.

INTRODUCTION

Opuntia humifusa (Raf.) Raf. (eastern prickly pear cactus) has a patchy but wide distribution in the eastern United States and southeastern Canada, ranging from Massachusetts through Wisconsin to southern Florida (Benson 1982). In the Great Lakes region, *O. humifusa* occurs in 10 counties in western lower Michigan (Voss 1985), southern Ontario including Point Pelee National Park (Reznicek 1982), four northern Ohio counties near Lake Erie and 12 southern Ohio counties (Cooperrider 1995), northern Indiana and Illinois near the southern tip of Lake Michigan (Swink & Wilhelm 1994), and scattered localities in southern Wisconsin (Benson 1982).

Habitats of *Opuntia humifusa* in the Great Lakes region, based on herbarium records and published descriptions, vary widely (Noelle & Blackwell 1972). For example, Reznicek (1982) described two *O. humifusa* sites inland from Lake Erie in southern Ontario as low, south- and west-facing sandy ridges. In the Chicago region, *O. humifusa* occurs in *Quercus* savannas, old cemeteries on sandy soils that have been periodically mowed, and human-made limestone bar-

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rens (Swink & Wilhelm 1994). Kellerman (1901) reported that *O. humifusa* was common in open *Quercus* woods near Sandusky in northern Ohio, and this species also occurred in sand plains (Jennings 1908) and open fields (Moseley 1899) in the same region.

Opuntia humifusa is listed as potentially threatened in Ohio (Ohio Division of Natural Areas and Preserves 2000). Regions supporting *O. humifusa* are widely disjunct in Ohio, and suitable habitats within these regions are patchy, making *O. humifusa* prone to local extinctions (Noelle & Blackwell 1972; Cooperrider 1995). Nonetheless, there are few detailed studies of the habitats and ecology of this species in the Great Lakes region and in the eastern United States in general. To help fill this gap in our knowledge in Ohio, made more serious by the potentially threatened status of *O. humifusa*, we studied *O. humifusa* habitats in Oak Openings Preserve in northwestern Ohio. The objective of this study was to document the environmental, plant community, and historical land-use characteristics of *O. humifusa* sites in Oak Openings Preserve in an attempt to provide data that may help protect this species.

METHODS

Study Species

Nomenclatural history of *Opuntia humifusa* is convoluted (Noelle & Blackwell 1972). Gleason & Cronquist (1991) report that this species has been referred to as *O. calcicola*, *O. compressa*, *O. opuntia*, *O. pollardii*, *O. rafinesquei*, and *O. vulgaris*. Morphological characteristics of *O. humifusa* vary widely across its range, but authors in many regions have concluded that *O. humifusa* is a single species without varieties (Hanks & Fairbrothers 1969b; Voss 1985). This species often grows in clumps, and is typically 7.5–10 cm tall (Benson 1982). Flowering occurs in June and July (Cooperrider 1995), with yellow, showy flowers (Figure 1). Reproduction occurs both by seed and by the detachment of partial or full pads from a parent plant—these fragments readily root on soil surfaces (Voss 1985). *Opuntia humifusa* is a perennial and overwinters in its vegetative form, but no information was found in the literature as to the potential length of its life span. *Opuntia humifusa* often colonizes open, sandy, disturbed areas, and the species may be reduced or eliminated by shading during succession (Wallace & Fairbrothers 1987).

Study Area

Oak Openings Preserve is managed by the Toledo Area Metroparks and is located in Lucas County, northwestern Ohio (Figure 2). The preserve consists of a 1496-ha mosaic of wet prairies, open fields, conifer plantations, *Quercus* savannas, woodlands, and forests. Soils are sandy and are derived from beach dunes deposited during the Pleistocene at the western shoreline of Lake Warren, a glacial lake now partially occupied by Lake Erie (Moseley 1928). Presettlement vegetation in this region, based on 1821 land survey records, consisted of 51% *Quercus velutina* (black oak) and *Quercus alba* (white oak) savanna or barrens (< 43 trees ha^{-1}), 23% *Quercus* woodland (> 43 trees ha^{-1}), and 27% treeless wet prairie (Brewer & Vankat 2001). Restoration of these native ecosystems is ongoing and is a high priority in Oak Openings Preserve (Abella et al. 2001).

Data Collection

The Toledo Metroparks maintains a continuously updated database of rare plant locations in Oak Openings Preserve based on formal botanical surveys and observations throughout the preserve. *Opuntia humifusa* occurs at eight known sites in Oak Openings Preserve, and because of the unique and distinctive appearance of *O. humifusa* these sites likely represent all or nearly all extant populations of this species in Oak Openings Preserve. We sampled each of these sites in May, July, and August 2002.

At each site, we counted the number of *Opuntia humifusa* individuals and clumps. Distin-

FIGURE 1. Aerial view of *Opuntia humifusa* flowering in Oak Openings Preserve, northwestern Ohio. (Photo courtesy of R.G. Jacksy, Toledo Area Metroparks).

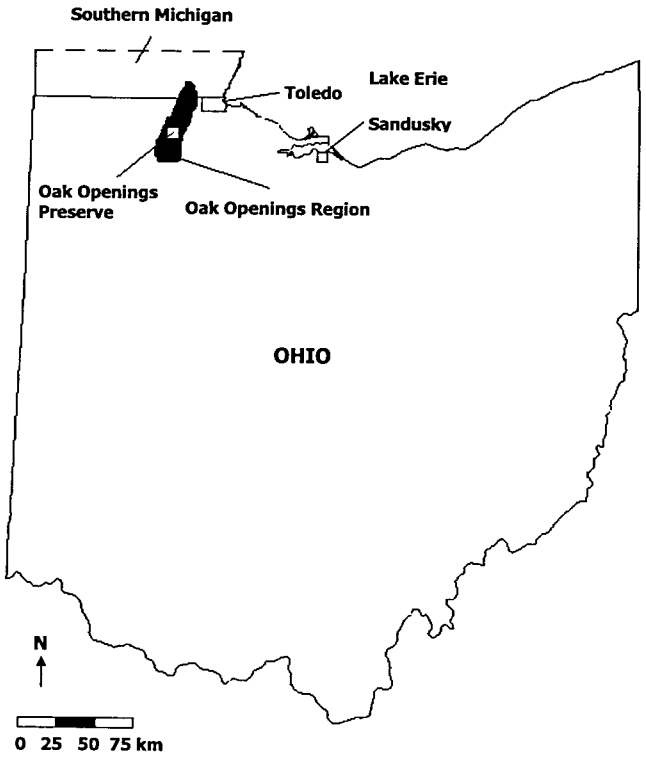

FIGURE 2. Location of Oak Openings Preserve, Lucas County, northwestern Ohio (41°33′N, 83°51′W).

guishing individual *O. humifusa* is difficult because multiple pads can arise from the same root system (Ohio Division of Natural Areas and Preserves 2000). We defined and counted individual *O. humifusa* as a pad growing more than 30 cm from surrounding pads, and a clump as a cluster of *O. humifusa* individuals growing more than 1.5 m from surrounding clumps or individuals. We sampled the soils at each site to a depth of 130 cm using a bucket auger to confirm the soil series mapped for the site in the soil survey (Stone et al. 1980). The two series on which *O. humifusa* occurred, Ottokee and Oakville, are distinguished based on the presence (Ottokee) or absence (Oakville) of mottling within a depth of 100 cm (Stone et al. 1980). We determined Oi horizon thickness to the nearest cm around *O. humifusa* clumps using a ruler. Landforms at each site were described following descriptions in the soil survey (Stone et al. 1980). We measured canopy cover at each site using a densitometer (Geographic Resource Solutions, Arcata, CA) based on estimates to the nearest 5% cover. We also recorded the relative abundances of other plant species at each site, and potential threats to *O. humifusa* such as exotic species or shading. Plant nomenclature follows Voss (1972, 1985, 1996).

Elevations of sites were obtained from a U.S. Geological Survey topographic map (Whitehouse quadrangle, 1964). To evaluate past land uses of the sites, we obtained 1939 aerial photographs (1:240,000 scale) of Oak Openings Preserve from the Natural Resources Conservation Service (Maumee, OH).

RESULTS

Characteristics of the eight *Opuntia humifusa* sites in Oak Openings Preserve are summarized in Table 1 and are described individually in the following sections. Numbers after each site name in the following sections correspond to the site's number in Table 1.

Reed Plantation (1)—Associates of *Opuntia humifusa* at this site include *Rubus flagellaris* (northern dewberry), *Fragaria virginiana* (wild strawberry), *Lepidium campestre* (field peppergrass), *Rumex acetosella* (sheep sorrel), *Antennaria* spp., occasional *Asclepias tuberosa* (butterfly-weed), and seedlings of *Acer rubrum* (red maple), *Prunus serotina* (black cherry), *Quercus velutina*, and *Sassafras albidum* (sassafras). Canopies consist of ca. 20-cm diameter *Quercus velutina*, *Quercus palustris* (pin oak), *Pinus strobus* (eastern white pine), and *Pinus banksiana* (jack pine). The site consists of an opening adjacent to the south of a *Pinus banksiana* plantation and north of an *Acer rubrum*-dominated forest on a different soil series (Tedrow, a moist series [Stone et al. 1980]). Few *O. humifusa* at this site flowered, and threats to this population appear to be shading by an encroaching canopy of *Quercus* and *Pinus*, smothering by leaf litter, and the presence of an invasive shrub *Elaeagnus umbellata* (autumn olive).

Yucca Meadow (2)—This site has been restored to *Quercus* savanna by the thinning of *Quercus velutina* and the removal of *Acer rubrum*. *Pinus resinosa* (red

TABLE 1. Summary of characteristics of *Opuntia humifusa* sites in Oak Openings Preserve, northwestern Ohio

Site	1	2	3	4	5	6	7	8
No. *Opuntia* clumps	20	18	1	2	9	15	2	5
No. *Opuntia* individuals	69	61	13	3	28	79	10	32
Size *Opuntia* area (m^2)[1]	6000	2400	100	50	400	1000	100	100
Landform type	Dune knoll	Dune knoll	Dune knoll	Dune ridge	Dune knoll	Dune knoll	Beach ridge	Beach ridge
Elevation (m)	215	217	216	219	215	215	215	215
Soil series[2]	Ottokee	Oakville	Oakville	Oakville	Oakville	Ottokee	Oakville	Ottokee
Oi horizon	Patchy[3]	Absent	Patchy	Absent	Patchy	Absent	Absent	Patchy
Canopy cover (%)[4]	50	<5	<5	0	50	50	0	0
1939 land use	Agriculture	Agriculture	Agriculture	Sand dune	Agriculture	Agriculture	Agriculture	Agriculture

[1] Size of area containing *Opuntia* including area between clumps.
[2] Ottokee and Oakville series classified as mixed, mesic Aquic and Typic Udipsamments (Stone et al. 1980).
[3] Patchy = ranges from absent to a maximum of 4 cm thick across site.
[4] Average of site or point-sample above *Opuntia* for small-sized sites.

pine) plantations are adjacent to this site to the west, and the rest of the site is surrounded by closed-canopy *Quercus* forest. *Andropogon scoparius* (little bluestem), *Krigia virginica* (dwarf-dandelion), *Lupinus perennis* (wild lupine), *Rubus flagellaris*, *Lespedeza capitata* (bush clover), *Fragaria virginiana*, *Asclepias tuberosa*, and occasional *Yucca filamentosa* (yucca) dominate this site. Encroachment by the exotic *Elaeagnus umbellata* is a possible threat to this population of *Opuntia humifusa*.

Vasvery Homestead (3)—This site is adjacent to a private inholding to the north, a road and a *Pinus strobus* plantation to the west, and a restored *Quercus* savanna to the south and east. Common plants near *Opuntia humifusa* at this site include *Rubus flagellaris*, *Euphorbia corollata* (flowering spurge), *Rhus copallina* (winged sumac), *Lespedeza capitata*, and seedlings of *Quercus velutina*. Two other state-listed plants, *Asclepias amplexicaulis* (blunt-leaf milkweed) and *Prunus pumila* (sand cherry) occur within 100 m of *O. humifusa* at this site. Because of its proximity to a private inholding, the area where *O. humifusa* occurs at this site was not included in restoration treatments that were applied to adjacent areas, and threats to this population of *O. humifusa* include shading by encroaching canopy trees and brush.

Railroad Ridge (4)—Common plants around *Opuntia humifusa* at this site include *Quercus velutina* seedlings, *Carex* spp., *Rubus flagellaris*, *Euphorbia corollata*, *Rumex acetosella*, *Lepidium campestre*, *Asclepias tuberosa*, *Asclepias syriaca* (common milkweed), *Krigia virginica*, *Lespedeza capitata*, *Ambrosia artemisiifolia* (common ragweed), and *Conyza canadensis* (horseweed). This site comprises the highest elevation of all *O. humifusa* sites, and soils consist of loose, shifting sand. A bike trail is located 30 m north of the site, and this trail occupies an old railroad bed present in 1939. The site was an open sandy area in 1939, and is the only *O. humifusa* site not in agriculture at that time (Table 1). Removal of *O. humifusa* by park visitors is a potential threat to *O. humifusa* at this site because of its proximity to the trail, although there was no present evidence that any *O. humifusa* have been recently removed.

Jack Pine Opening (5)—This site consists of an opening within a *Pinus banksiana* plantation. Canopy trees include *Quercus palustris* and *Quercus velutina*, and ground-flora includes *Rubus flagellaris*, *Krigia virginica*, *Rumex acetosella*, *Rhus copallina*, *Yucca filamentosa*, and seedlings of *Quercus velutina*, *Quercus palustris*, and *Sassafras albidum*. Potential threats to this population of *Opuntia humifusa* are shading by encroaching canopy trees and smothering by leaf litter.

Douglas-Fir Border (6)—Adjacent to the east of a *Pseudotsuga menziesii* (Douglas-fir) and *Picea abies* (Norway spruce) plantation, *Opuntia humifusa* on this site occur in an opening surrounded by *Quercus* saplings (Figure 3). Associates of *O. humifusa* include *Pteridium aquilinum* (bracken fern), *Lepidium campestre*, *Andropogon scoparius*, and *Quercus velutina* seedlings. Shading by

FIGURE 3. *Opuntia humifusa* clump (left foreground) in an opening adjacent to a *Pseudotsuga menziesii* and *Picea abies* plantation established in 1950, Oak Openings Preserve, northwestern Ohio. Shading by encroaching canopy trees is a potential threat to *O. humifusa* at this site and several other sites in Oak Openings Preserve. (Photo by S.R. Abella, 11 May 2002).

encroaching *Quercus* saplings and height growth of conifers in the plantation are potential threats to *O. humifusa* at this site.

Girdham Field (7)—This site is 50 m southeast of a *Pinus resinosa* and *Pinus strobus* plantation and is part of a 12-ha meadow with occasional large *Quercus alba* that has been restored from closed-canopy *Quercus* and *Acer rubrum* forest. Other species occurring near *Opuntia humifusa* include *Panicum clandestinum* (deertongue), *Rubus flagellaris*, *Potentilla simplex* (common cinquefoil), *Fragaria virginiana*, and *Rumex acetosella*. There are no apparent threats to this *O. humifusa* population.

White Oak Savanna (8)—A 122-cm diameter open-grown *Quercus alba* occurs within 50 m of the *Opuntia humifusa* clumps at this site that is part of the same meadow as the Girdham Field site (Figure 4). Aerial photographs taken in 1939 indicate this site was cleared for agriculture at that time, but the large *Q. alba* is visible in the photograph and was apparently not removed during agricultural clearing. Common plants around *O. humifusa* at this site include *Rubus flagellaris* and *Ambrosia artemisiifolia*. No imminent threats to *O. humifusa* are apparent at this site.

FIGURE 4. White oak savanna *Opuntia humifusa* site characterized by a 122-cm diameter open-grown *Quercus alba*, Oak Openings Preserve, northwestern Ohio. *Opuntia humifusa* at this site occurs in clumps scattered around the *Q. alba*. (Photo by S.R. Abella, 4 August 2002).

DISCUSSION

Habitats of Opuntia humifusa

Occurrences of *Opuntia humifusa* in Oak Openings Preserve are associated with the xeric Oakville and Ottokee soil series, occupying the highest elevations in the preserve on dune knolls, dune ridges, and beach ridges. However, only a small areal portion of these series support *O. humifusa*, and many apparently suitable sites were unoccupied by *O. humifusa*. It is unclear what factors constrain the distribution of *O. humifusa* within areas of the Oakville and Ottokee soils. Consistent with a study of *O. humifusa* habitats in New Jersey (Hanks & Fairbrothers 1969a), there does not appear to be a distinct plant community in which *O. humifusa* occurs in Oak Openings Preserve. Plant assemblages associated with *O. humifusa* varied by site, with *Rubus flagellaris* exhibiting the highest constancy (87%) at *O. humifusa* sites. Attempts to locate additional *O. humifusa* populations in Oak Openings Preserve, if they exist, could focus on open areas of loose sand of the Oakville and Ottokee series, areas that have been disturbed by agricultural clearing or other disturbance, and areas supporting other plant species characteristic of dry, open environments.

Seven of eight *Opuntia humifusa* sites in Oak Openings Preserve were in

agriculture in 1939, suggesting *O. humifusa* was present before clearing and the plants or seed survived, or *O. humifusa* did not occur on these sites before clearing and became established sometime after farm abandonment. It is possible that soil disturbances created by agricultural clearing provided a favorable environment for *O. humifusa* colonization. Many of the abandoned farms were converted to *Pinus* plantations in the 1940s and 1950s when land for Oak Openings Preserve was acquired by the Toledo Metroparks (Abella & MacDonald 2002). Because all eight presently known *O. humifusa* sites occur within 100 m of a conifer plantation, it is uncertain if some *O. humifusa* sites were lost by the conversion of abandoned farms to plantations.

Origin and Distribution of Opuntia humifusa

The origin of *Opuntia humifusa* in the Oak Openings region is unclear. In Wood County, 13 km east of the city of Bowling Green and 35 km southeast of Oak Openings Preserve, Moseley (1931) documented an *O. humifusa* occurrence on a site known to have been a long-term Native American campsite. Moseley (1931) also noted that *O. humifusa* occurrences around Sandusky in northern Ohio east of the Oak Openings region were associated with the presence of Native American artifacts. He postulated that Native Americans had introduced *O. humifusa* to northern Ohio because they favored its edible, succulent fruit. In Moseley's classic paper (1928) on the flora of the Oak Openings region based on his botanical surveys in the 1890s and early 1900s, he does not mention *O. humifusa* as occurring in the region. Moseley's routes through Oak Openings are uncertain, and there could be many reasons why he did not document the occurrence of *O. humifusa* if the species did occur in the Oak Openings region at that time. Noelle & Blackwell (1972) reported that the earliest known herbarium record of *O. humifusa* in Ohio other than for the Sandusky region is a collection in 1911 in Adams County in extreme southern Ohio. However, Noelle & Blackwell (1972) asserted that the absence of herbarium records for *O. humifusa* should be interpreted cautiously because of the scattered distribution of *O. humifusa* and the incompleteness of early collection records. The first published documentation of *O. humifusa* in the Oak Openings region appears to be by Easterly (1979) during his rare plant survey. It is uncertain how *O. humifusa* became established in the Oak Openings region and for how long the species has been in this region.

Protection of Opuntia humifusa

Shading has been widely cited to reduce flowering and eventually eliminate *Opuntia humifusa* (Hanks & Fairbrothers 1969a; Reznicek 1982; Wallace & Fairbrothers 1987). Five of eight *O. humifusa* sites in Oak Openings Preserve exhibited encroachment by trees or shrubs, and shading appears to be an imminent threat to these *O. humifusa* populations. Restoration treatments that restore the open *Quercus* savanna vegetation native to *O. humifusa* sites (Abella et al. 2001) would probably alleviate shading threats to *O. humifusa* and increase the proportion of flowering individuals. Continued monitoring of these sites is necessary to ascertain the temporal dynamics of *O. humifusa*. Although the presettlement distribution of *O. humifusa* in Oak Openings Preserve is not known, the

present fragmented nature of the preserve and the localized occurrences of *O. humifusa* suggest that establishing *O. humifusa* on additional sites in Oak Openings Preserve might be desirable. *Opuntia humifusa* can be established by removing pads from existing plants and planting the pads (Voss 1985).

Because of the potentially threatened status of *O. humifusa* in Ohio, the acquisition of sites by conservation organizations containing *O. humifusa* or providing suitable habitat in the Oak Openings region is consistent with the perpetuation of this rare species in Ohio. Results of this study suggest that sandy sites disturbed by agricultural clearing, sand mining, or other soil disturbances should not be overlooked for their potential to provide *O. humifusa* habitat in the Oak Openings region.

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LITERATURE CITED

Abella, S .R., J. F. Jaeger, D. H. Gehring, R. G. Jacksy, K. S. Menard, & K. A. High. 2001. Restoring historic plant communities in the Oak Openings region of northwest Ohio. Ecological Restoration 19: 155–160.

Abella, S. R., & N. W. MacDonald. 2002. Spatial and temporal patterns of eastern white pine regeneration in a northwestern Ohio oak stand. Michigan Botanist 41: 115–123.

Benson, L. 1982. The cacti of the United States and Canada. Stanford University Press, Stanford, California. 1044 pp.

Brewer, L. G., & J. L. Vankat. 2001. The vegetation of the Oak Openings of northwest Ohio at the time of Euro-American settlement. Map and text. Ohio Biological Survey, Columbus, Ohio.

Cooperrider, T. S. 1995. The *Dicotyledoneae* of Ohio. Part 2. *Linaceae* through *Campanulaceae*. Ohio State University Press, Columbus, Ohio. 656 pp.

Easterly, N. W. 1979. Rare and infrequent plant species in the Oak Openings of northwest Ohio. Ohio Journal of Science 79: 51–58.

Gleason, H. A., & A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. New York Botanical Garden, Bronx, New York. 910 pp.

Hanks, S., & D. E. Fairbrothers. 1969a. Habitats and associations of *Opuntia compressa* (Salisb.) Macbr. in New Jersey. Bulletin of the Torrey Botanical Club 96: 592–596.

Hanks, S. & D. E. Fairbrothers. 1969b. Diversity of populations of *Opuntia compressa* (Salisb.) Macbr. in New Jersey. Bulletin of the Torrey Botanical Club 96: 641–652.

Jennings, O. E. 1908. An ecological classification of the vegetation of Cedar Point. Ohio Naturalist 8: 291–340.

Kellerman, W. A. 1901. Notes on the flora of Sandusky. Ohio Naturalist 1: 82–85.

Moseley, E. L. 1899. Sandusky flora. Ohio Academy of Science, Special Paper Number 1. 167 pp.

Moseley, E. L. 1928. Flora of the Oak Openings. Proceedings of the Ohio Academy of Science, Volume 8, Special Paper Number 20: 79–134.

Moseley, E. L. 1931. Some plants that were probably brought to northern Ohio from the west by Indians. Papers of the Michigan Academy of Science, Arts and Letters 13: 169–172.

Noelle, H. J., & W. H. Blackwell. 1972. The Cactaceae in Ohio. Castanea 37: 119–124.

Ohio Division of Natural Areas and Preserves. 2000. Rare native Ohio plants: 2000–01 status list. Ohio Department of Natural Resources, Columbus, Ohio. 28 pp.

Reznicek, A. A. 1982. The cactus in southwestern Ontario. Ontario Field Biologist 36: 35–38.

Stone, K.L., E.H. McConoughey, G.D. Bottrell, & D.J. Crowner. 1980. Soil Survey of Lucas County, Ohio. U.S. Department of Agriculture, Soil Conservation Service. U.S. Government Printing Office, Washington, D.C. 139 pp.

Swink, F., & G. Wilhelm. 1994. Plants of the Chicago region. Indiana Academy of Science, Indianapolis, Indiana. 921 pp.

Voss, E.G. 1972. Michigan Flora. Part I. Cranbrook Institute of Science, Bloomfield Hills, Michigan. 488 pp.

Voss, E.G. 1985. Michigan Flora. Part II. Cranbrook Institute of Science, Bloomfield Hills, Michigan. 727 pp.

Voss, E.G. 1996. Michigan Flora. Part III. Cranbrook Institute of Science, Bloomfield Hills, Michigan. 622 pp.

Wallace, R. S., & D. E. Fairbrothers. 1987. The New England distribution of *Opuntia humifusa* (Raf.) Raf. Rhodora 89:327–332.