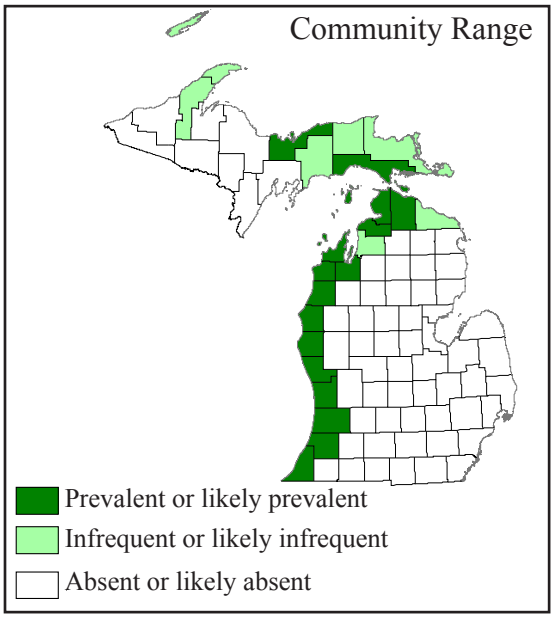
# Open Dunes — Community Abstract

Photo by Addrienne L. Bozic




**Global and state rank**: G3/S3

**Common names**: Great Lakes beachgrass dune. Other communities of the dunes include Great Lakes dune pine forest, Great Lakes pine barrens, Great Lakes juniper dune shrubland.

**Range**: Open dunes are biologically distinct geological features associated with the Laurentian Great Lakes and other large inland lakes, as well as the shorelines of many oceans and seas. Those along the Laurentian Great Lakes are distinguished from other coastal dunes by a distinctive Great Lakes flora and fauna, although some plant species are shared with dunes of the Pacific Northwest (Wiedemann 1984). Great Lakes open dunes occur in Illinois, Indiana, Michigan, New York, Pennsylvania, Wisconsin, and in the Canadian province of Ontario. Small, isolated dune areas also occur on the shores of Lake Champlain in Vermont (Thompson and Sorenson 2000).

**Rank justification**: There are approximately 275,000 acres of sand dune along Michigan's Great Lakes shoreline, including areas of Lakes Superior, Michigan, and Huron. Other major areas of sand dune are located at Long Point, Ontario; Presque Isle, Pennsylvania; and on Lake Erie along the eastern end of Lake Ontario in New York.

Currently, there are over 40 occurrences for open dunes in Michigan. The foredune of many **wooded dune and swale complexes** support the same plant species typically found on open dunes.

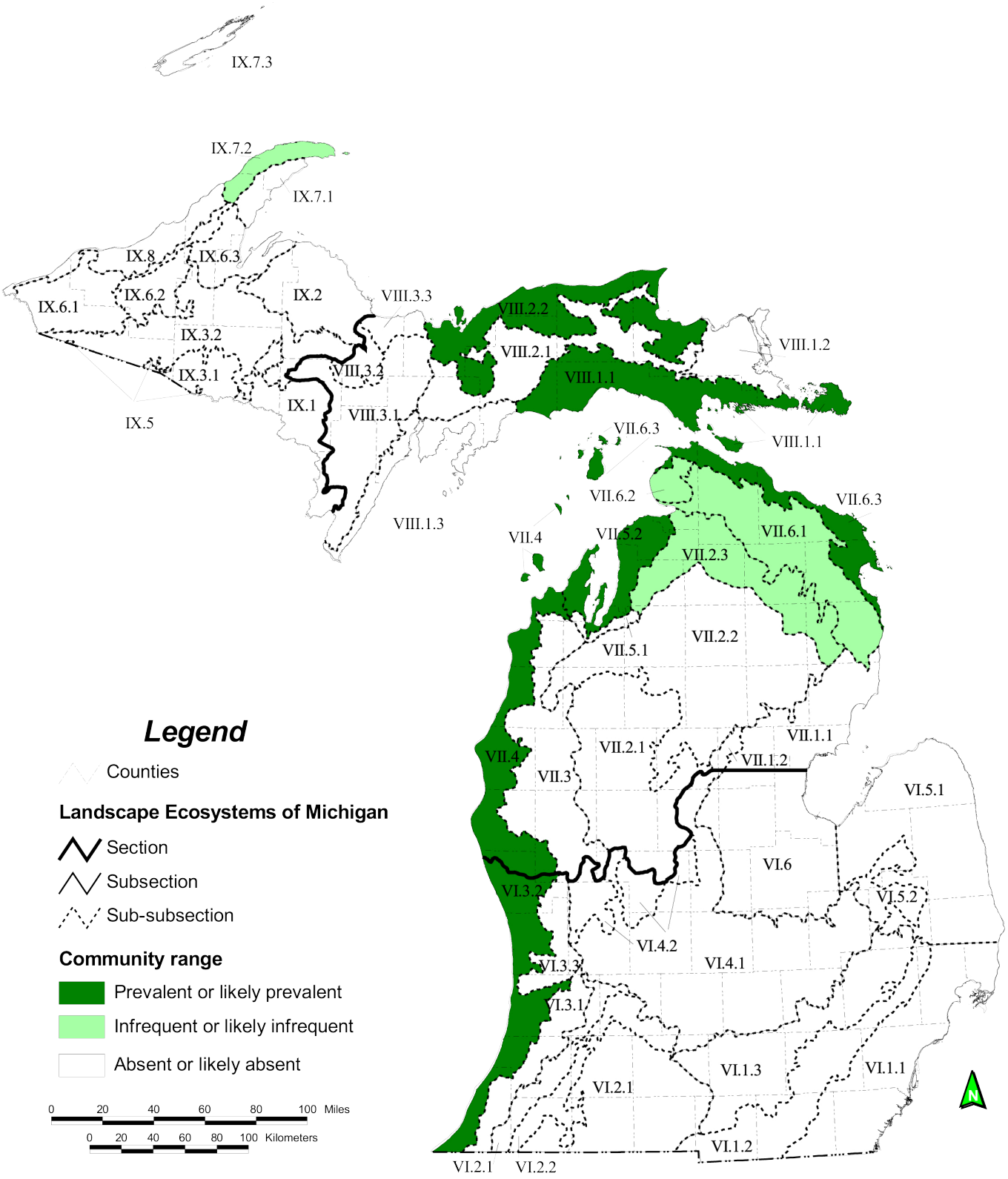
While most dune areas remain intact, degradation has occurred on many dunes as the result of residential and road development, sand mining, golf course development, and recreational use by off-road vehicles (Boven et al. 1988). Logging has altered the forested portions of many dunes, generally reducing the amount of upland conifer dominance. Many non-native plants are introduced as a result of residential development (Leege 1997, Comer and Albert 1991, 1993). These non-natives are a major source of degradation, disrupting normal dune migration, causing dune stabilization, and often replacing native plant species.

**Landscape context**: Great Lakes dunes are relatively young, as the Great Lakes were occupied by ice until approximately 16,000 years ago. The dune sands are derived from glacial sediments, including lacustrine and outwash sands and sandy tills (Dorr and Eschman 1970). Most of our larger dune complexes are associated with the Lake Nipissing stage of the Great Lakes, when water levels were 25 to 30 feet higher than present day lake levels (Dorr and Eschman 1970). These higher lake levels resulted in greater amounts of coastal erosion and dune formation. There are also numerous dune features further inland, often associated with glacial Lake Algonquin water levels, from about 12,000 years ago. Most of these older dunes are completely forested and are not represented in our database of open dunes.

**Natural processes**: A combination of water erosion and wind deposition resulted in the formation of Great Lakes coastal dunes. The sand source for the coastal dunes was glacial sediment that was eroded by streams and by waves eroding bluffs along the Great Lakes shoreline. These sediments were then moved along the Great Lakes shoreline by near-shore currents, and then deposited along the shoreline by wave action. Strong winds then carried the sands inland, creating dunes.

Elaborate classifications of dune types have been developed (Tague 1947, Calver 1947, Buckler 1979, Kelly 1962, Bird 1969). Open dunes includes the full range of dune types found in Michigan, including foredunes, parallel dunes, perched dunes, blow outs, and barrier dunes.

**Michigan Natural Features Inventory**
P.O. Box 30444 - Lansing, MI 48909-7944
Phone: 517-373-1552




Ecoregional map of Michigan (Albert 1995) depicting distribution of open dunes (Albert et al. 2008)

**Michigan Natural Features Inventory**
P.O. Box 30444 - Lansing, MI 48909-7944
Phone: 517-373-1552

Several major dune types are briefly described in the following paragraphs. **Parabolic dunes** are U-shaped, with the bottom of the U inland. Parabolic dunes typically form when stable, forested dunes are destabilized, and they often occur as series of overlapping dune ridges. These are common along the eastern shore of Lake Michigan. Areas of open, destabilized dune are called **blowouts**. While blowouts can occur because of human activities, the original surveyor's notes (Comer et al. 1995) indicated that blowouts were widespread along the coast, probably largely the result of wind storms and lightning strikes.

**Parallel dunes** is a term used for the series of dune and swale features along major Great Lakes embayments. We use the term **wooded dune and swale complex** for parallel dune complexes and a separate abstract has been written for this community (Albert and Comer 1999).

**Perched dune** is a term describing wind-blown sand dunes that are perched on top of glacial moraines. Some of Michigan's most famous dunes are perched dunes, including Sleeping Bear Dunes National Lakeshore on Lake Michigan and Grand Sable Banks near Grand Marais (Lake Superior).

Within the dune fields there are often wetlands. Within the wooded dune and swale complexes, both herbaceous and forested wetlands can comprise a major part of the complex. Within other types of dune complexes, wetlands and water bodies range from small, seasonally moist depressions to ponds or lakes.

While wind is the prevalent form of natural disturbance process within the dune fields, fire resulting from lightning strikes probably also occurred, but was likely much less common. Both oaks and pines were common on the dunes, indicating fire was a natural disturbance factor.

**Vegetation description**: Historically, there has been extreme interest in studying the vegetation of the Great Lakes sand dunes, especially those of southern Lake Michigan, where the concepts of plant succession were developed (Cowles 1899, Olson 1958). On the dunes it is possible to follow succession from unvegetated, recently deposited sand along the shoreline to late-successional forests on the oldest, most stable dunes farther inland.

Physical conditions responsible for the vegetation zones on the dunes include distance from the lake, amount of soil development, and available light (Olson 1958, Cowles 1899). Lichter's (1998) recent study of dune and swale complexes at Wilderness State Park in northern Lower Michigan found that, at the Lake Michigan shoreline, young dunes had 1) stronger winds, 2) more sand burial and erosion, 3) higher levels of sunlight, 4) higher rates of evaporation, and 5) lower available nitrogen and phosphorus than older beach ridges further inland, resulting in an open herbaceous-dominated plant community along the shore. Farther inland, with greater protection from sun and wind and with greater soil development, there was succession from open dune, first to grassland, then to shrubs, and finally to forest, with mesic northern hardwood forests increasing in dominance farther from the shoreline.

The foredunes are commonly quite open, harsh habitats, with moving sand, extremely dry conditions, and little organic material for nutrients. Common plants of the foredune include sea rocket (*Cakile edentula*), wormwood (*Artemisia campestris*), Pitcher's thistle (*Cirsium pitcheri,* federally threatened), Lake Huron tansy (*Tanacetum huronense*, state threatened), beach grass (*Ammophila breviligulata*), dune grass (*Calamovilfa longifolia*), autumn willow (*Salix serissima*), dune willow (*S. cordata*), and balsam poplar (*Populus balsamifera*).

As one leaves the foredune, dune grasses and shrubs continue to stabilize the moving sand, although blowouts can form, maintaining open sand quite far inland. Several shrubs, including ground juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), bear berry (*Arctostaphylos uva-ursi*), and sand cherry (*Prunus pumila*), begin to stabilize the moving sand, leading to further accumulation of sand into dune features.

As the dunes stabilize farther from the foredune, forests begin to develop. Typically pines, including jack pine *(Pinus banksiana*), white pine (*P. strobus*), and red pine (*P. resinosa*), are among the first tree species to establish, forming a scattered overstory canopy. Oaks, especially red oak (*Quercus rubra*) and black oak (*Q. velutina*), also establish in the early stages of forest succession. Gradually forest succession leads to development of a mesic hardwood forest, usually dominated by American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), basswood (*Tilia americana*) and other hardwoods. In the more protected, cooler ravines between dunes, northern white cedar (*Thuja occidentalis*) or eastern hemlock (*Tsuga canadensis*) often grow. This succession is by no means one directional; it is very common to see a stand of cedar or northern hardwoods being buried by a newly activated blowout. As the blowout progresses, it sometimes re-exposes "ghost forests" that were buried far in the past.

Succession can also be seen in the swales and interdunal wetlands within the dune complexes. Wetlands near the shoreline have lake-influenced hydrology and the substrate is calcareous sand. Swales can contain twig-rush (*Cladium mariscoides)*, bladderwort (*Utricularia cornuta*), rush (*Juncus balticus*), and sweet gale (*Myrica gale*), with shrubby cinquefoil (*Potentilla fruticosa*), blue joint grass (*Calamagrostis canadensis*), Kalm's lobelia (*Lobelia kalmii*), false asphodel (*Tofieldia glutinosa*), and grass-of-Parnassus (*Parnassia glauca*) along the drier edges. In the Straits of Mackinac area, federally-threatened Houghton's goldenrod (*Solidago houghtonii*) can be found in the swales. Jack pine sometimes grows along with wetland plants.

Farther inland the interdunal wetlands typically support shrub swamps or treed swamps. Swamp dominants typically include northern white cedar, balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), and trembling aspen (*Populus tremuloides*).

**Characteristic vegetation of open foredune**

| Strata | Most abundant |
|---|---|
| Tree canopy | *Populus balsamifera* (balsam poplar) |
| Short shrub | *Salix serissima* (autumn willow), *S. cordata* (dune willow), *S. exigua* (sandbar willow), *Juniperus communis* (ground juniper), *J. horizontalis* (creeping juniper), *Arctostaphylos uva-ursi* (bear berry), *Prunus pumila* (sand cherry), *Hudsonia tomentosa* (beach-heath) |
| Herbaceous | *Cakile edentula* (sea rocket), *Artemisia campestris* (wormwood), *Cirsium pitcheri* (Pitcher's thistle, federally threatened), *Lathyrus japonicus* (beach pea), *Arabis lyrata* (sand cress), *Tanacetum huronense* (Lake Huron tansy, state-threatened), *Asclepias syriaca* (common milkweed), *Lithospermum caroliniense* (hairy puccoon), *Ammophila breviligulata* (beach grass), *Calamovilfa longifolia* (dune grass), *Andropogon scoparius* (little blue stem), *Festuca saximontana* (fescue) |

**Characteristic vegetation of open interdunal swale**

| Strata | Most abundant |
|---|---|
| Tree canopy | |
| Short shrub | *Myrica gale* (sweet gale), *Potentilla fruticosa* (shrubby cinquefoil), *Betula pumila* (bog birch), *Aronia prunifolia* (chokeberry), *Cornus stolonifera* (red osier dogwood) |
| Herbaceous | *Carex lasiocarpa*, *C. oligosperma* (sedges), *Eleocharis acicularis* (spike-rush), *Cladium mariscoides* (twig rush), *Calamagrostis canadensis* (blue joint grass), *Juncus balticus* (rush), *Scirpus cyperinus* (woolgrass), *Thelypteris palustris* (marsh fern), and *Utricularia cornuta* (horned bladderwort) |

**Characteristic vegetation of forested dune**

| Strata | Most abundant |
|---|---|
| Tree canopy | *Pinus banksiana* (jack pine), *P. strobus* (white pine), *P. resinosa* (red pine), *Quercus rubra* (red oak), *Betula papyrifera* (paper birch), *Populus grandidentata* (bigtooth aspen), *Acer rubrum* (red maple), *Abies balsamea* (balsam fir) |
| Short shrub | *Gaylussacia baccata* (black huckleberry), *Vaccinium myrtilloides* (blueberry) |
| Herbaceous | *Pteridium aquilinum* (bracken fern), *Cornus canadensis* (bunchberry), *Gaultheria procumbens* (wintergreen) |

**Michigan indicator species**: *Cakile edentula* (sea rocket), *Artemisia campestris* (wormwood), *Ammophila breviligulata* (beach grass), *Calamovilfa longifolia* (dune reed), *Cirsium pitcheri* (Pitcher's thistle), *Tanacetum huronense* (Lake Huron tansy), *Juniperus horizontalis* (creeping juniper), *Prunus pumila* (sand cherry), *Solidago simplex* (Gillman's goldenrod).

**Other noteworthy species**: Several rare animals are associated with the dunes, including *Charadrius melodus* (piping plover, state endangered), *Trimerotropis huroniana* (Lake Huron locust, state threatened), *Sterna caspia* (Caspian tern, state threatened), *S. herundo* (common tern, state threatened), *Euxoa aurulenta* (dune cutworm, state special concern), and *Dendroica discolor* (prairie warbler, state endangered).

Rare plants associated with the dunes include *Cirsium pitcheri* (Pitcher's thistle, state threatened), *Solidago houghtonii* (Houghton's goldenrod, state threatened), *Tanacetum huronense* (Lake Huron tansy, state threatened), *Botrychium acuminatum* (moonwort, state endangered), *B. campestre*, (dunewort, state threatened), *B. hesperium* (western moonwort, state threatened), *B. spathulatum* (spatulate moonwort, state threatened), and *Orobanche fasciculata* (broomrape, state threatened).

Invasive, non-native plant species include *Gypsophila paniculata* (baby's-breath), *Rumex acetosella* (red sorrel), *Pinus nigra* (black pine), *Centaurea maculosa* (spotted knapweed), *Populus nigra* var. *italica* (Lombardy poplar), *Saponaria officinalis* (bouncing bet), *Melilotus alba* (white sweet clover), *Elaeagnus umbellata* (autumn olive), and within the interdunal wetlands, *Lythrum salicaria* (purple loosestrife) and *Phragmites australis* (reed) (Penskar et al. 1997, Leege 1997).

**Conservation/management**: The Atlas of Critical Dunes (Michigan DNR 1989) identifies sand dune areas within the state that are subject to development restrictions. While residential development of the dunes is not forbidden, it is restricted in the law, limiting much of the development to the forested portions of the dunes, where slopes are not as steep and unstable as on the open dunes. Building structures, building roads, or changing contours on slopes steeper than 33% percent is prohibited.

Control of invasive plants is necessary on dunes to restore natural vegetative patterns of diversity. Manual removal

and limited herbicide treatment have proven effective in controlling exotics and native woody invasives

**Research needs**: Monitoring of exotic plants is needed, as well as the monitoring of the effectiveness of exotic plant management. Long-term effectiveness of sand dune regulations on dune processes also needs to be evaluated. Populations of threatened and endangered species associated with open dunes and wetlands within the dunes also need monitoring.

**Similar communities**: sand and gravel beach, wooded dune and swale complex, interdunal wetland, Great Lakes barrens

**Other classifications**

Michigan Natural Features Inventory (MNFI) presettlement vegetation: open sand dune and wooded dune and swale complex. Numerous other upland and wetland forest and shrub types occur within the open dune complexes.

Michigan Department of Natural Resources (MDNR): sand dune (code = Y), but several other cover types can occur in open dune complexes.

Michigan Resource Information Systems (MIRIS): sand dune, exposed bluff (code = 73), but several other MIRIS cover types can also occur within open dune complexes.

Other: special, detailed dune classifications were developed as part of the MDNR dune-mining monitoring program (Beckler 1979).

The Nature Conservancy National Classification: code = V.A.5.N.c, alliance: *Ammophila breviligulata* – (*Schizachyrium scoparium*) herbaceous vegetation.

**Related abstracts**: piping plover, Lake Huron locust, common tern, Caspian tern, dune cutworm, prairie warbler, Pitcher's thistle, Houghton's goldenrod, Lake Huron tansy, dunewort, fascicled broomrape, interdunal wetland, sand and gravel beach, wooded dune and swale complex.

**Selected references**


Albert, D.A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A working map and classification. Gen. Tech. Rep. NC-178. St. Paul, MN: USDA, Forest Service, North Central Forest Experiment Station, St. Paul, MN. http://nrs.fs.fed.us/pubs/242 (Version 03JUN1998). 250 pp.

Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 174 pp.

Bach, D.P. 1978. Plant communities, habitats, and soil conditions of Grand Sable Dunes, Pictured Rocks National Lakeshore, Michigan. Master's thesis. Michigan Technical University. 180 pp.

Bird, E.C.F. 1969. Coasts. M.I.T. Press, Cambridge, MA. pp. 128-146.

Boven, D.S., M. Campbell, S. Coppo, A.M. Stevens, T. Radenbaugh, D. Torgoff, T. van Derworp. 1988. A Handbook for managing Michigan's endangered private dune lands. Group Master's Project. University of Michigan - School of Natural Resources, Ann Arbor, MI. 217 pp.

Buckler, W.R. 1979. Dune type inventory and barrier dune classification study of Michigan's Lake Michigan shore. Report of Investigation 23. Mich. DNR - Geological Survey Division. 32 pp.

Calver, J.L. 1947. The glacial and post-glacial history of the Platte and Crystal Lake depressions, Benzie County, Michigan. Publication 45, Geological Series 38. Part II. Occ. Papers for 1946 on the Geology of Michigan. Geological Survey Division of Michigan. 70 pp.

Chapman K.A. 1986. Natural community description: open dune. Michigan Natural Features Inventory, Lansing, MI. 2 pp.

Curtis, J.T. 1959. Vegetation of Wisconsin: An Ordination of Plant Communities. Univ. of Wisconsin Press, Madison, WI. 657 pp.

Chrzastowski, M.J. and T.A. Thompson. 1992. Late Wisconsinan and Holocene coastal evolution of the southern shore of Lake Michigan. In, Quaternary Coasts of the Unites States: Marine and Lacustrine Systems. SEPM (Society for Sedimentary Geology) Special Publication No. 48. pp. 398-413.

Comer, P.J. and D.A. Albert. 1991. A Survey of wooded dune and swale complexes in the northern lower and eastern upper peninsulas of Michigan. A report by Michigan Natural Features Inventory to Mich. DNR - Coastal Mgmt. Program. 99 pp.

Comer, P.J. and D.A. Albert. 1993. A Survey of wooded dune and swale complexes in Michigan. A report to Mich. DNR - Land and Water Mgmt. Division, Coastal Zone Mgmt. Program. 159 pp.

Comer, P.J., D.A. Albert, H.A. Wells, B.L. Hart, J.B. Raab, D.L. Price, D.M. Kashian, R.A. Corner, and D.W. Schuen. 1995. Michigan's presettlement vegetation, as interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. digital map.

Cowles, H.C. 1899. The ecological relations of the vegetation on the sand dunes of Lake Michigan. Bot. Gaz. 27:95-117, 167-202, 281-308, 361-396.

Dorr, J.A. and D.F. Eschman. 1970. Geology of Michigan. Univ. of Mich. Press, Ann Arbor, MI. 476 pp.

Kelley, R.W. 1971. Geologic sketch of Michigan sand dunes. Geological Survey Pamphlet No. 5. Mich. DNR. 20 pp.

Photo by Joshua G. Cohen

Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural communities of Michigan: Classification and description. Michigan Natural Features Inventory, Report Number 2007-21, Lansing, MI. 314 pp.

Leege, L. M. 1997. The ecological impact of Austrian pine (*Pinus nigra*) on the sand dunes of Lake Michigan: an introduced species becomes an invader. Dissertation, Michigan State University. 182 pp.

Lichter, J. 1998. Primary succession and forest development on coastal Lake Michigan sand dunes. Ecol. Monograph, 68 (4): pp 487-510.

Michigan DNR. 1989. Atlas of Critical Dunes. Land and Water Management Div. 72 pp.

Olson, J. S. 1958. Rates of succession and soil changes on southern Lake Michigan sand dunes. Bot. Gaz. 119(3): 125-170.

Penskar, M.R., P. J. Higman, J. D. Soule, and L. J. Scrimger. 1997. A survey of the Lake Huron and Lake Michigan coastal zones for Great Lakes endemic plant species. Michigan Natural Features Inventory. 135 pp.

Thompson, E.H., and E.R. Sorenson. 2000. Wetland, Woodland, Wildland: A guide to the natural communities of Vermont. Vermont Department of Wildlife and The Nature Conservancy. University Press of New England, Hanover, NH.

Tague, G. C. 1947. The post-glacial geology of the Grand Marais embayment in Berrien County, Michigan. Publication 45, Geological Series 38. Part I. Occ. Pap. for 1946 on the Geology of Michigan, Geological Survey Div. of Michigan. 82 pp.

Thompson, T. A. 1992. Beach-ridge development and lake-level variation in southern Lake Michigan. Sed. Geol. 80:305-318.

Wiedemann, A. M. 1984. The Ecology of Pacific Northwest Coastal Sand Dunes: A Community Profile. USFWS. FWS/OBS-84/04. 130 pp.

**Abstract citation**

Albert, D.A. 1999. Natural community abstract for open dunes. Michigan Natural Features Inventory, Lansing, MI. 6 pp.

Updated June 2010.



Funding for abstract provided by Michigan Department of Natural Resources - Parks and Recreation Division.

**Michigan Natural Features Inventory**
P.O. Box 30444 - Lansing, MI 48909-7944
Phone: 517-373-1552