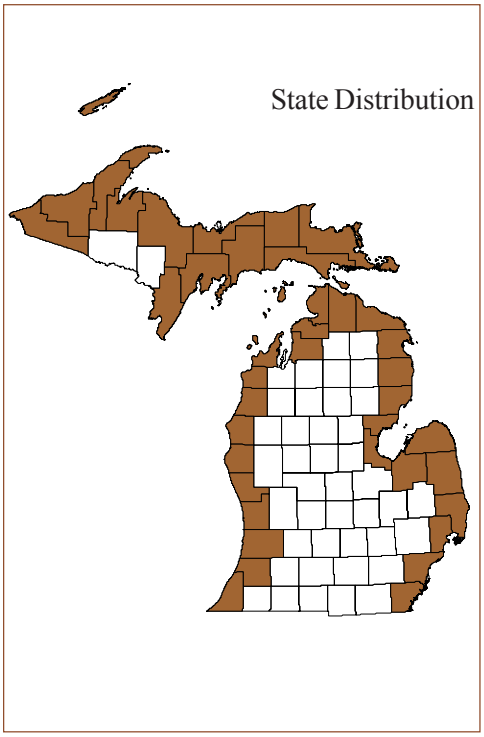
Sand and Gravel Beach — Community Abstract

Photo by Gary A. Reese



Overview: Sand and gravel beaches occur along the shorelines of the Great Lakes and on some of Michigan's larger freshwater lakes, where the energy from waves and ice abrasion are adequate to maintain an open beach. Because of the high levels of disturbance, these beaches are typically quite open, with only scattered vegetation.

Global and State Rank: G3?/S3

Common Names: Sand and gravel beach. In some other Great Lakes states, sand and gravel beaches on inland lakes have been separated into different classes. Sand grains range from 0.05-2.0 mm in diameter (Soil Survey Staff 1975), while gravel ranges from 2.0-76.0 mm in diameter (Buol et al. 1980). In the United Kingdom, gravel beaches are called shingle and include particles ranging from 2.0-200.0 mm (Packham and Willis 1997).

Range: Sand and gravel beach is associated with the entire shoreline of the Great Lakes, except those areas with bedrock beach, cobble shore, cliff, or exposed bluffs extending into the lake. In some areas of gently sloping bedrock beach, sand and gravel beach has developed over bedrock. Sand and gravel beaches also characterize the shoreline of large inland lakes throughout the glaciated northeastern U.S. and Canada, and less frequently in other unglaciated parts of the U.S. and Canada. In Michigan, inland lakes that are large enough to develop sand and gravel beach include Houghton, Higgins, Hubbard, Black, Burt, Mullet, Douglas, Gogebic, Elk, Torch, Charlevoix, Manistique, and probably several smaller lakes. No systematic surveys of sand and gravel beach have been done on either inland lakes or Great Lakes shorelines.

Rank Justification: While few sites have been surveyed for sand and gravel beach, in Michigan there are at least 73 beach sites associated with coastal Great Lakes sand dunes, and many more beaches associated with Great Lakes coastal bluffs and inland lakes. Sand and gravel beach is known from all of the Great Lakes states and Ontario (Faber-Langendoen 2001, NatureServe 2006). Currently 6 beaches have been documented in Michigan, while an additional 14 have been documented in Wisconsin, Illinois, and Ohio. Because of the narrow, linear configuration of most beaches, the average acreage of a beach in Michigan is less than 20 acres (8 hectares), with lengths of shoreline ranging from 1 to 2 miles (1.6 to 3.2 km).

Landscape Context: Sand and gravel beaches occur along the shorelines of the Great Lakes and on some of Michigan's larger freshwater lakes; lakes must be large enough that waves and ice abrasion maintain an open beach. Many of Michigan's larger glacial lakes are more than a mile across, and thus large enough to form

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narrow sand or gravel beaches. Large lakes of glacial origin are common throughout Canada, the Great Lakes region, and northeastern states on a variety of glacial landforms. Natural communities occurring adjacent to sand and gravel beach include open dunes, wooded dune and swale complexes, interdunal wetlands, bedrock lakeshores, lakeshore cliffs, and cobble shores.

Photo by Joshua G. Cohen

Sand and gravel beach frequently occurs lakeward of open dune systems.

Natural Processes: Most beach studies have been conducted on ocean beaches. While the energy levels are typically less in magnitude, the physical processes for Great Lakes and inland lake beaches are similar to those associated with oceans. Extensive studies have been conducted on the energy dynamics of waves and shoreline sediments (Komar 1976, Ritter 1979), but studies of beach vegetation are much less common. Sand beaches require a certain degree of protection to allow for sand and gravel accumulation; no beach development occurs in the most erosive environment of the headlands (Ritter 1979, Dorr and Eschman 1984). The size of beach sediment is determined both by the energy levels of the shoreline, which can change seasonally or even daily, and the source of sediment. Beaches tend to accumulate sand during less windy spring and summer periods, and lose sand through erosion during strong fall and winter storms (Mackey and Liebenthal 2005). The annual movement of coastal sands was documented in the nearshore zone along Lakes Erie, Michigan, and Huron (Mackey and Liebenthal 2005). In the glaciated landscapes of the Great Lakes, varying mixes of gravel and sand occur in the till and outwash deposits that are eroded by wave activity along the shore of large lakes. Gravel movement along the shoreline is generated completely by wave or ice movement, while sand can also be moved by wind after its deposition on the beach, often leading to dune development farther inland. Gravel beaches are also more stable than sand beaches because the gravel's permeability prevents the backwash of waves from eroding the beach away (Packham and Willis 1997).

Photo by Michael A. Kost

The colorful sand and gravel beaches of the Keweenaw Peninsula are derived from volcanic bedrock and often grade into volcanic cobble shore.

By definition, vegetation cover is only partial on sand and gravel beaches. The openness of beach vegetation is the result of the unstable sediment conditions caused by wind, waves, and winter ice. While many species of plants are able to establish on sand or gravel beaches, the extreme conditions of desiccation and erosion allow few species to reach maturity and set seed. Severity of desiccation increases as particle size increases, but on many gravel beaches vegetation can establish because finer particles of sand are trapped among the gravel (Packham and Willis 1997). On sand beaches, successful vegetation establishment causes an increase in surface roughness, slowing both the wind and movement of sand, and resulting in the accumulation of sand in the form of coastal dunes (Olson 1958, Dorr and Eschman 1984, Albert 2006). On most beaches there is accumulation of debris, often of natural origin. Uprooted trees accumulate on some beaches, fostering localized sand accretion and often vegetation establishment. Finer organic material also builds up seasonally on beaches, and can include leaves, eroded graminoid vegetation from adjacent shorelines, plant seeds, algae

from bays or agricultural runoff, and dead lake or wetland organisms such as insects or fish. These aggregations can be large, greatly increasing the nutrient availability and changing the sediment characteristics of the beach, although these changes are often temporary. Insects, birds, and other fauna feed intensively on dead and decomposing organic material, and dense plant beds often develop on the organic deposits as well. Storm waves and winter ice prevent permanent vegetation establishment and soil development. Several invasive plant species are able to establish in the dynamic, erosive habitat of the beach, especially those that produce either abundant seed or extensive rhizomes. Vegetation cover increases with distance from the water's edge due to decreasing levels of erosive wind and water energy. Because water levels fluctuate annually on many lakes, vegetation cover can increase during periods of low water. Sand beaches regularly migrate with changing water levels and shoreline configuration. It is not uncommon for beaches to migrate across wetlands, burying peat or wetland soils (Thompson and Sorenson 2005). Such beaches also have unstable sediments that typically preclude establishment of permanent vegetation. Soils are usually poorly developed and confined to spaces between gravel due to the dynamic, unstable environment of the beach.

Vegetation Description: Among the detailed coastal studies that have examined the sand beach on the Great Lakes were early studies of sand dunes along Lake Michigan (Cowles 1899). Sand and gravel beach is characterized by both a low diversity of plant species and low levels of plant cover. Short-term establishment of tree seedlings such as *Acer saccharinum* (silver maple), *Acer rubrum* (red maple), *Acer negundo* (boxelder), *Ulmus americana* (American elm), and *Populus deltoides* (cottonwood) is a commonly observed phenomena. While seedlings establish easily in the open beach habitat, wave action and seasonal flooding results in high mortality rates, and trees seldom reach maturity. Willows (*Salix* spp.) are one of the most successful groups of shrubs along lakeshores, largely because of their extensive rooting systems. Annuals are common on the beach, utilizing short-lived microhabitats. Rhizome-producing perennial herbs and shrubs establish farther from the shoreline, often initiating sand accumulation and conversion of beach to dune. Because of the high energy conditions of the lower beach, mosses and lichens are not a common component of the flora, but both mosses, such as *Dicranum scoparium*, and crustose lichens can establish on the more stable upper gravel beach (Packham and Willis 1997). Vegetation coverage values on gravel beaches are typically even lower than on sand beaches, as the energy levels that create gravel beaches are generally higher than those of sand beaches, and moisture availability is reduced by the large particle size of the substrate. Shrubs such as *Salix* spp. (willows), *Alnus rugosa* (speckled alder), *Physocarpus opulifolius* (ninebark), and *Rosa acicularis* (wild rose) are most characteristic of gravel beaches, and these are concentrated along the upland margin of the beach. *Lathyrus japonicus* (beach pea) was the most common herbaceous plant growing on the gravel beaches of Lake Superior in Minnesota (Minnesota Department of Natural Resources Ecological Land Classification Program 2003).

Photo by Joshua G. Cohen

Vegetation on sand and gravel beach is sparse due to wave, wind, and ice action as well as desiccation and

Characteristic Plants: Among the species able to best survive the dynamic beach zone are *Lathyrus japonicus* (beach pea), *Juncus balticus* (Baltic rush), *Potentilla anserina* (silverweed), *Cakile edentula* (sea rocket), *Euphorbia polygonifolia* (seaside spurge), *Corispermum hyssopifolium* (bugseed), *Ammophila breviligulata* (marram grass), *Calamovilfa longifolia* (sand reed grass), *Schoenoplectus pungens* and *S. acutus* (bulrushes), *Salix exigua* (sandbar willow), and *Prunus pumila* (sand cherry). The rare Great Lakes endemics, *Cirsium pitcheri* (Pitcher's thistle) and *Tanacetum huronense* (Lake Huron tansy), occasionally establish on upper sand beaches during low-water periods. Several willows are found growing on the beach, including *Salix discolor* (pussy willow), *S. lucida* (shining willow), *S. bebbiana* (Bebb's willow), *S. eriocephala*, *S. cordata* (sand dune willow), *S. candida* (hoary willow), *S.*

serissima (autumn willow), *S. amygdaloides* (peach leaved willow), *S. myricoides* (blue leaf willow), and *S. petiolaris* (slender willow). Grasses also commonly establish on the beach, including *Poa palustris* (fowl meadow grass), *Bromus pumpellianus* (brome), *B. ciliatus* (fringed brome), *Festuca saximontana* (fescue), *Elymus canadensis* (wild-rye), *Agropyron trachycaulum* (wheatgrass), *Sphenopholis obtusata* (wedgegrass), *Deschampsia cespitosa* and *D. flexuosa* (hairgrasses), *Sporobolus cryptandrus* (dropseed), *Calamagrostis inexpansa* (reed grass), *Agrostis stolonifera* (creeping bent), *A. hyemalis* (ticklegrass), *Spartina pectinata* (cordgrass), *Panicum capillare* (witch grass), and *Schizachyrium scoparium* (little bluestem). Other graminoids of the beach include *Cladium mariscoides* (twig-rush), *Juncus canadensis* and *J. nodosus* (rushes), *Eleocharis elliptica* (spike rush), *Sisyrinchium montanum* (blue-eyed-grass), *Cyperus diandrus*, *C. schweinitzii*, *C. strigosus* (nut-rushes), and *Schoenoplectus pungens* and S. *acutus* (bulrushes). *Smilacina stellata* (Starry false solomon-seal) is a common monocot (Kost et al. 2007).

Zonation: There is typically a zone of open sand or gravel along the water, with only scattered stems of the above mentioned characteristic plants. Above the zone of active waves, marram grass and other grasses, herbs, and shrubs are able to stabilize the sand with their extensive roots and rhizomes, allowing for the accumulation of sand into a beach ridge. Many more plant species can survive in this zone of sand accumulation, including both herbs and shrubs. While trees may establish in this zone, they seldom reach maturity. Stabilization of the beach ridge may eventually result in further sand accumulation and the creation of larger, more permanent sand dunes. On gravel beaches, there is also a lower high-energy zone that supports little or no vegetation, and an upper zone that is exposed less frequently to storms and supports scattered herbs and shrubs.

Associated Species: Sand and gravel beach supports many of the plants found growing on adjacent sand dunes, bluffs, and forests. While many of these plants establish on the beach, the active sediment movement of the sand beach does not allow most to persist.
Invasive Plants: Among the invasive plant species are several grasses, including *Bromus tectorum* (downy chess), *B. inermis* (smooth brome), *Agrostis gigantea* (redtop), *Festuca arundinacea* (tall fescue), *Echinochloa crusgalli* (barnyard grass), *Agropyron repens* (quack grass), *Hordeum jubatum* (squirrel-tail grass), *Phleum pratense* (timothy), and *Setaria viridis* (green foxtail). There is one invasive willow, *Salix fragilis* (crack willow), and several forbs, including *Corispermum hyssopifolium* (bugseed), *Xanthium strumarium* (cocklebur), *Daucus carota* (wild carrot), *Gypsophila paniculata* (baby's-breath), *Silene vulgaris* (bladder campion), *Saponaria officinalis* (bouncing bet), *Sedum acre* (mossy stonecap), *Verbascum thapsus* (common mullein), and *Linaria vulgaris* (butter-and-eggs). Invasives of the gravel beach include *Erucastrum gallicum* (dog mustard) and *Diplotaxis muralis* (wall rocket).

Michigan Indicator Species: Sea rocket, seaside spurge, Baltic rush, silverweed, marram grass, sand reed grass, *Schoenoplectus pungens* and *S. acutus* (bulrushes), sandbar willow, sand cherry, Pitcher's thistle, and Lake Huron tansy.

Other Noteworthy Species: Sand beaches are favorite feeding grounds for shorebirds, such as *Actitis macularia* (spotted sandpiper). Large numbers of aquatic insects, such as *Chironomidae* (midges), live in the sediments and provide important food for migratory songbirds during spring migration (Albert 2006). In the lower, more permanently flooded portion of the sand beach, invertebrates can include midges, *Oligochaetae* (aquatic worms), and *Sphaeriidae* (bivalves) (Goforth and Carmen 2005). Butterflies often gather on the beach for moisture and nutrients during migration. Tiger beetles, including *Cicindela scutellaris*, are common predators on other insects of the beach, and *Coccinellidae* (ladybird beetles) often congregate in beach debris in large numbers during migration. *Pompilidae* (digger wasps) are common in the upper beach zone. Gravel beaches, especially on islands, are used by nesting *Larus* spp. (gulls), *Sterna* spp. (terns), and other waterbirds. Large mammals such as *Odocoileus virginianus* (white-tailed deer), as well as smaller mammals such as *Procyon lotor* (raccoon), *Castor canadensis* (beaver), *Mustela vison* (mink), and *Lutra canadensis* (river otter) can be seen on sand beaches, where they both drink and feed.

Special Animals: Rare birds associated with gravel beach include *Charadrius melodus* (piping plover, state and federally threatened), *Sterna hirundo* (common tern, state threatened), and *Sterna caspia* (Caspian tern, state threatened). Rare reptiles using this habitat include

Emys blandingii (Blanding's turtle, state special concern) and *Elaphe vulpine glovdi* (eastern fox snake, state threatened). *Trimerotropis huroniana* (Lake Huron locust, state threatened) utilize dune habitat adjacent to the open beach.

Special Plants: *Tanacetum huronense* (Lake Huron tansy, state threatened), *Cirsium pitcheri* (Pitcher's thistle, state and federally threatened), *Salix pellita* (satiny willow, state special concern), *Adlumia fungosa* (climbing fumitory, state special concern), *Potentilla paradoxa* (sand cinquefoil, state threatened), *Beckmannia syzigachne* (slough grass, state threatened), *Calamagrostis lacustris* (northern reedgrass, state threatened), and *Elymus mollis* (American dune wild-rye, state special concern) are able to establish on the active upper beach. While few rare plant species establish on the beach, a few grow on more stable habitat immediately adjacent to the open beach. Among these are *Listera auriculata* (auricled twayblade, state special concern), which grows under alder thickets along the Lake Superior shoreline, and *Polygonum viviparum* (alpine bistort, state threatened), found on rocky seepages at the edge of gravel beaches on the Keweenaw-Peninsula shores of Lake Superior. *Iris lacustris* (Dwarf lake iris, state and federally threatened) is occasionally found on the upper beach of northern Lakes Michigan and Huron.

Conservation and Management: Raccoons and unleashed dogs are a major threat to piping plovers, and high levels of human visitation to plover beaches can also result in low breeding success. Off-road vehicles can further destabilize beach areas, especially those areas farther from the shore where vegetation is becoming stabilized. Many parks actively maintain open beach conditions by mechanical grooming, eliminating the natural flora and fauna of the beach. Artificial sand beaches have been created on numerous lakes by trucking in sand, but due to their anthropogenic origin, heavy recreational use, and lack of native vegetation, these should not be considered natural communities.

Research Needs: A systematic survey of sand and gravel beaches is needed across the Great Lakes and the glaciated northeastern U.S. and Canada to improve their description and classification. The dynamics of their plant populations over multiple years would also be a significant contribution to understanding the ecology of beaches. Cluster analysis of plant data could assist in determining whether sand beach and gravel beach should be separated into different natural communities. For understanding the relationship of the flora of gravel beaches, both gravel size and mineral type will need to be components of any study.

Photos by Joshua G. Cohen

Sand and gravel beach occurs in a variety of settings, including adjacent to granite bedrock lakeshore (left) and sandstone lakeshore cliff (right). A systematic survey of sand and gravel beaches across the Great Lakes is needed to enhance the classification and description of different variants.

Similar Communities: In Michigan, open dune, wooded dune and swale complex, bedrock lakeshore, and cobble shore are similar communities and may contain inclusions of sand or gravel beach. Wisconsin and Ohio recognize a Great Lakes beach subtype, while Minnesota lumps within its Lake Superior beach both sand and gravel-cobble subtypes (Faber-Langendoen 2001, Epstein et al. 2002, Minnesota Department of Natural Resources Ecological Land Classification Program 2003, NatureServe 2006). Minnesota also recognizes an inland beach, which includes sand and gravel-cobble subtypes. Wisconsin also has a Great Lakes dune and an inland sand beach type (Epstein et al. 2002). Vermont has a lake sand beach that is found along Lake Champlain, but only one high-quality site is known (Thompson and Sorenson 2005). New York has sand beach, Great Lakes sand dune, maritime beach, maritime dune, and cobble beach (Reschke 1990, Edinger et al. 2002). New Hampshire has a rare inland beach strand community with sand sediment, found only along the shoreline of Ossipee Lake (Sperduto and Nichols 2004). Ontario recognizes several freshwater coastal dune types, including cove, big bay, foreland, baymouth barrier, and tombolo; all of these have sand beaches along the lake edge (Bakowsky 1996).

Other Classifications:

The Nature Conservancy National Vegetation Classification: (Faber-Langendoen 2001, NatureServe 2006): CODE; ALLIANCE; ASSOCIATION; COMMON NAME

V.A.5.N.c; *Ammophila breviligulata* Herbaceous Alliance; *Ammophila breviligulata* - (*Schizachyrium scoparium*) Herbaceous Vegetation; American Beachgrass - (Little Bluestem) Herbaceous Vegetation; Great Lakes Beachgrass Dune.

VII.B.2.N.b: Cobble/Gravel Shore Sparsely Vegetated Alliance; Igneous - Metamorphic Cobble - Gravel Inland Lake Shore Sparse Vegetation; Inland Lake Igneous - Metamorphic Cobble - Gravel Shore

VII.B.2.N.b; Cobble/Gravel Shore Sparsely Vegetated Alliance; Limestone Cobble - Gravel Great Lakes Shore Sparse Vegetation; Great Lakes Limestone Cobble - Gravel Shore

VII.B.2.N.b; Cobble/Gravel Shore Sparsely Vegetated Alliance; Basalt - Diabase Cobble - Gravel Great Lakes Shore Sparse Vegetation; Great Lakes Basalt - Diabase Cobble - Gravel Shore

VII.B.2.N.b; Cobble/Gravel Shore Sparsely Vegetated Alliance; Non-alkaline Cobble - Gravel Great Lakes Shore Sparse Vegetation; Great Lakes Non-alkaline Cobble - Gravel Shore

VII.C.2.N.a; *Cakile edentula* Sparsely Vegetated Alliance; *Cakile edentula* Great Lakes Shore Sparse Vegetation; Sea-rocket Great Lakes Shore Sparse Vegetation; Great Lakes Beach

VII.C.2.N.a; Inland Strand Beach Sparsely Vegetated Alliance; Inland Freshwater Strand Beach Sparse Vegetation; Inland Freshwater Strand Beach

Related Abstracts: American dune wild-rye, dwarf lake iris, Lake Huron tansy, Pitcher's thistle, Lake Huron locust, Blanding's turtle, Caspian tern, common tern, piping plover, limestone cobble shore, limestone bedrock lakeshore, open dunes, wooded dune and swale complex.

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Photo by Joshua G. Cohen

Sand and gravel beach along the Lake Superior shoreline.

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