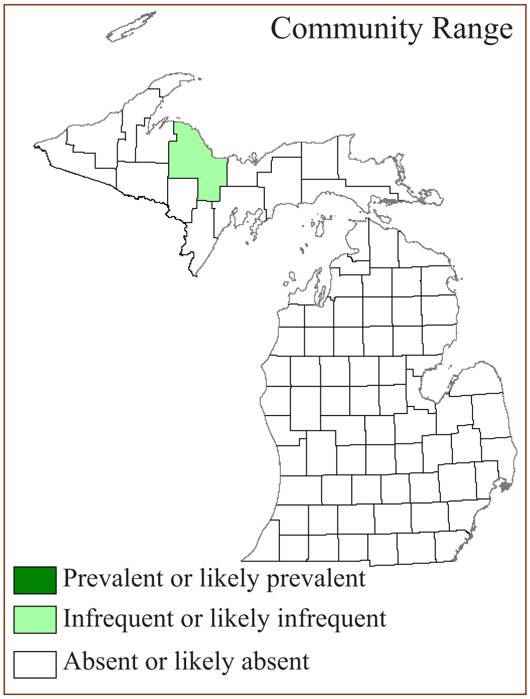
Granite Bedrock Lakeshore — Community Abstract

Photo by Joshua G. Cohen



Global and State Rank: G4G5/S2

Overview: This natural community occurs along the Lake Superior shoreline as small knobs of sparsely-vegetated granitic and metamorphic bedrock, typically between longer expanses of steep sandstone cliffs. Mosses and lichens dominate, with a few herbs, shrubs, tree saplings, and stunted trees restricted to areas above the strong influence of waves and ice scour. Tree cover increases with distance from shore.

Range: Coastal Great Lakes areas where granitic continental shield rocks are exposed include Michigan and the Canadian province of Ontario. Probably the most extensive area occurs along the north and east shores of Georgian Bay in Ontario, where granitic rock forms roughly 80 miles (140 km) of shoreline (Chapman and Putnam 1984, Catling and Brownell 1999), but other areas occur along Ontario's Lake Superior shoreline as well, as seen at Pukaskwa National Park and Neys and Lake Superior Provincial Parks. The continental shield in the upper Great Lakes region is among the oldest parts of the North American continent, formed during the Archean Eon 2.5 to 3.8 billion years ago (Dorr and Eschman 1970, Reed and Daniels 1987, LaBerge 1994, Lillie 2005). These igneous and metamorphic rocks, formed at high pressure and temperature several miles beneath the earth's surface, are exposed due to billions of years of weathering and erosion, including the most recent period of glacial erosion. In Michigan, the granitic and gneissic bedrock is restricted to scattered headlands (erosion-resistant knobs extending into the lake) along a twelve mile stretch of the Lake Superior shoreline between the city of Marquette and the Huron Mountains Club, as well as the Huron Islands. The headlands along the mainland shore include Sugarloaf Mountain (Wetmore Landing), Partridge Bay, Thoney Point, Saux Head Hill, and Granite Point. The Huron Islands form the westernmost exposure of granitic bedrock along the southern shore of Lake Superior, forty miles northwest of Marquette and about six miles east of Point Abbaye. Included within the category of granitic bedrock lakeshore is a small outcrop of quartzite that extends into Lake Superior approximately two miles southeast of the city of Marquette, near Harvey. All of the granite bedrock shoreline sites are in Subsection IX.2, Michigamme Highland (Albert 1995).

Rank Justification: Within Michigan there are nine documented occurrences of granite bedrock lakeshore. All nine sites have been inventoried, with total area of approximately 140 acres (56 hectares). The plant community is also known from the Lake Superior and Georgian Bay shorelines of Ontario, but no inventories document the extent of the community.

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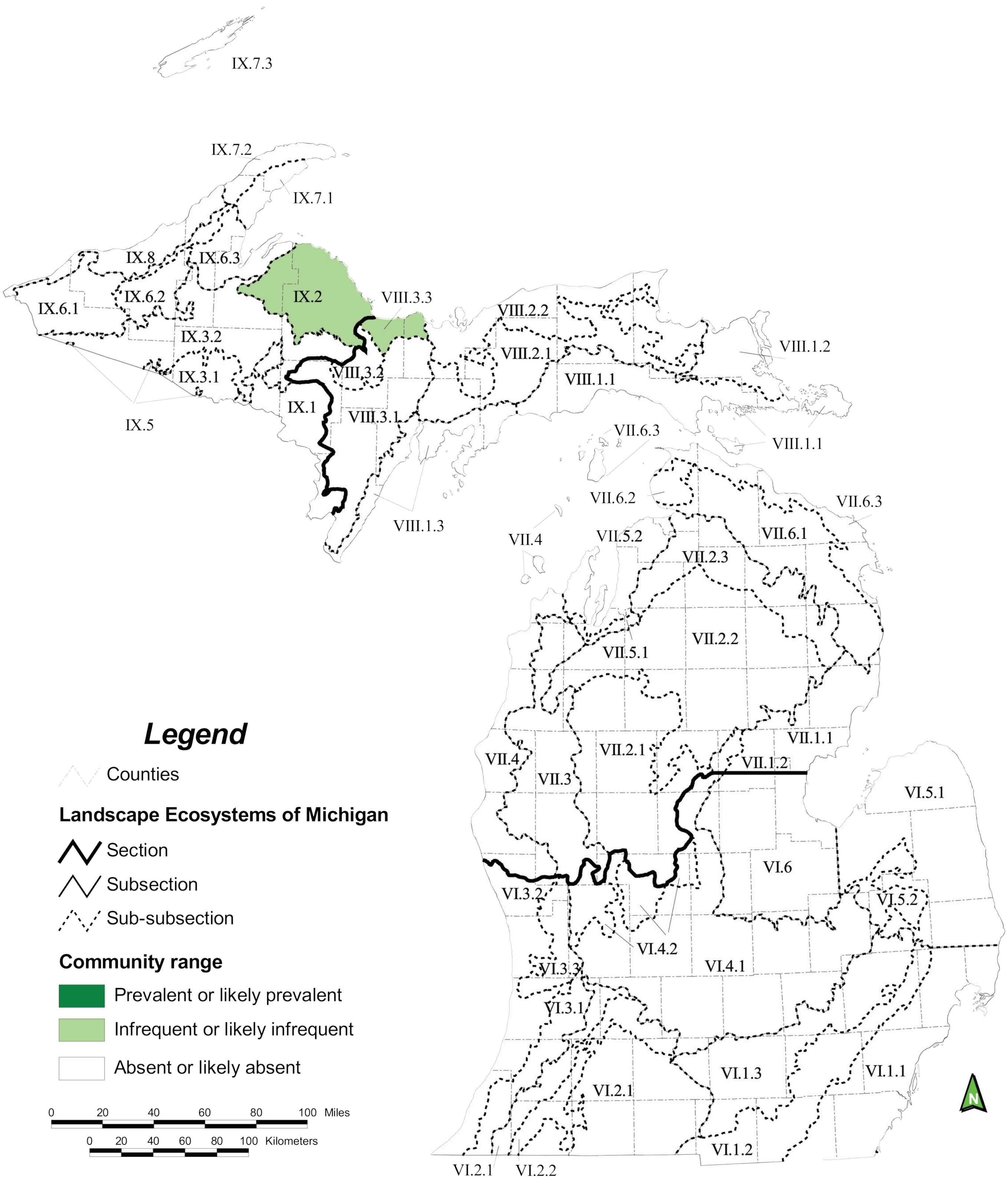


Ecoregional map of Michigan (Albert 1995) depicting distribution of granite bedrock lakeshore (Albert et al. 2008)

Landscape Context: Due to its northern latitude, granite bedrock lakeshore experiences a relatively short growing season of approximately 100 days (Albert et al. 1986). Regularly occurring fog along Lake Superior reduces moisture stress below that seen on more inland bedrock knobs.

A broad range of igneous and metamorphic rock, including gneiss, schist, granite, and quartzite, are often loosely referred to as 'granite.' The granitic rock along the Lake Superior shoreline near Marquette is among the oldest rock in the state, with some of the coastal bedrock exposures approximately 2.3 billion years old. In this area, small exposed knobs of older granitic bedrock are typically surrounded by long expanses of younger, more recently formed sandstone cliffs. Quartzite bedrock east of Marquette was developed from quartz-rich sandstone, when the sandstone was deeply buried and the resulting high temperatures fused the quartz grains together to form an extremely hard quartzite that is highly resistant to weathering (Dorr and Eschman 1970).

Photo by Joshua G. Cohen

Granitic bedrock along Lake Superior is highly resistent to weathering and also influenced by storm waves and ice scour. As a result, these shorelines are characterized by little soil development.

Because the granitic rocks along the coast are highly polished and extremely resistant to weathering, very little soil development takes place. Storm waves and ice scour also regularly remove developing soils. Freshly broken rock surfaces are circumneutral to mildly alkaline in pH, but the surface of weathered granite is acid. Some organic soil development takes place in cracks, under low shrubs, or in pools. Vascular plants are typically limited to these shallow cracks, exfoliation depressions (depressions resulting from weathering), and pool edges where moisture and available nutrients are concentrated.

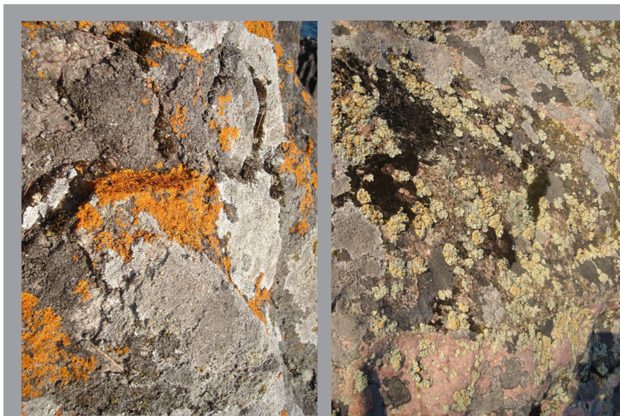
Granite bedrock lakeshores occur as relatively small exposures, from 0.25 to 1.25 miles (0.4 to 2.1 km) in length and typically about 120 feet (30 m) wide. The entire bedrock feature typically extends further inland, and grades into granite bedrock glade farther from the lake. Adjacent natural communities include sandstone cliff, granite bedrock glade, dry-mesic northern forest, and mesic northern forest (Kost et al. 2007).

Natural Processes: The conditions on these coastal knobs are extremely severe, accounting for the open character of the vegetation. Upon deglaciation 10,000 years ago, bare rock was exposed, followed by continued erosion by lake waves and strong winds. Granite weathers to coarse-textured sand and gravel, and wind and rain wash most of the finer sediments into Lake Superior. Soils develop locally in exfoliation depressions, as the combination of summer heat and winter freezing and thawing create depressions in the rock that hold both water and coarse gravelly soil (Quarterman et al. 1993, Shure 1999). Exfoliation depressions are very important for the establishment of vegetation in the southern United States, as rock weathering in the south produces smooth bedrock knobs with few places for vegetation to establish. In northern Michigan, exfoliation depressions may be less important, as the coastal granite bedrock along Lake Superior often contains numerous, blocky depressions and fractures, which formed by the freezing of glacial ice to underlying bedrock during Pleistocene glaciation. Intense freeze-thaw cycles, abundant winter rain and snow, and freezing fog help produce irregular fissures and depressions where plant roots can anchor and find regular moisture during the growing season. Intense heat from forest fires also causes granite to crack and exfoliate, resulting in irregular surfaces where plants can establish (Lynden Gerdes, personal observation in Boundary Waters Canoe Area, northern Minnesota). In shallow depressions, the stressful combination of saturated conditions during the early growing season and drought during summer is responsible for the relatively depauperate flora and slow establishment and growth of shrubs and trees. Poor soil development combined with exposure to strong winds off Lake Superior result in additional water stress for vegetation during the summer months, although moisture stress is reduced by frequent coastal fog. The processes of wind-induced desiccation and coastal fog affect woody plants and perennials with evergreen leaves throughout much of the year. Lightning strikes result in occasional tree mortality and fires. Wind storms maintain the open vegetation structure, causing blowdown of shallowly rooted trees. Both fire and windthrow are confined to the upland margin or 'shrub zone' of granite bedrock lakeshore.

Small pools occur where blocks of stone were plucked from the rock by glacial ice or loosened by freeze-thaw cycles and later removed by storm waves. Rock pools are recognized as common features in several studies of granite knobs (Quarterman et al. 1993, Catling and Brownell 1999, Shure 1999). In the southern U. S., these pools and moist depressions in the rock are viewed as important for the initial establishment of vegetation. Moist depressions undergo a successional progression that can take a thousand years, beginning with initial colonization of bare rock by lichens and mosses (Quarterman et al. 1993, Shure 1999). Annual herbs gradually replace the mosses, followed by a mix of annual herbs and lichens, then a mix of annuals and perennials, and finally a mix of herbs, shrubs, and trees. It is assumed that the northern Michigan and Ontario granite knobs undergo a similar succession, although different plant species are involved and moister conditions along the Great Lakes may result in more rapid succession. Along Lake Superior, some larger rock pools remain flooded throughout the year and only support vegetation along their margins.

Photo by Joshua G. Cohen Photo by Dennis A. Albert

Sparse vegetation along granite bedrock lakeshore is concentrated in cracks (left) and along the margins of rock pools (right)



Photos by Joshua G. Cohen

A colorful array of lichens and mosses are often the only vegetation occurring on the granitic bedrock.

Vegetation Description: The plant community consists of distinct zones with different dominants. Just above the water is a zone of several meters where storm waves and winter ice regularly scour the rock of vegetation, except in scattered protective cracks. Above this high-energy zone is a spray zone where the moisture is adequate to support lichens and mosses, with herbs and shrubs occupying only protective cracks or depressions with additional moisture. Lichens are conspicuous on rock bare of other vegetation. The importance of crustose and foliose lichens in early succession on bare granite rock has also been noted elsewhere, including Texas (Whitehouse 1933), the southeastern U.S. (Quaterman et al. 1993, Shure 1999), and southern Ontario (Catling and Brownell 1999). While lichens and mosses are among the first plants to establish on bare rock, their appearance does not necessarily result in the accumulation of soil needed for the establishment of vascular plants, as wind and rain may result in erosion of rock fragments dissolved by organic acids and exfoliation of the rock surface may result in lichen or moss dieback (Quarterman et al. 1993). Farther above Lake Superior, where wave action and ice scour are minimal, soils gradually develop in cracks and depressions in the rock and are able to support a greater diversity of herbs, shrubs, and trees.

Characteristic Plants: Many of the herbs, shrubs, and trees found on granite bedrock lakeshore also occur on basalt and volcanic conglomerate bedrock lakeshores, but the diverse flora of arctic-subalpine species characteristic of the volcanic rock are typically absent on granite (Soper and Maycock 1962, Given and Soper 1981, Albert et al. 1997). Common vascular species (80% or greater occurrence) of the open granitic lakeshore include ticklegrass (*Agrostis hyemalis*), harebell (*Campanula rotundifolia*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia cespitosa*), and blueberry (*Vaccinium angustifolium)*. Other characteristic plants include paper birch (*Betula papyrifera*), three-toothed cinquefoil (*Potentilla tridentata*), yarrow (*Achillea millefolium*), fireweed (*Epilobium angustifolium*), and grass-leaved goldenrod (*Euthamia graminifolia*). Farther from the lakeshore, shrubs, tree saplings, and stunted trees become relatively common on rounded slopes and summits of the granitic knobs. Shrubs and trees include mountain-ash (*Sorbus decora*), mountain alder (*Alnus crispa*), bearberry (*Arctostaphylos uva-ursi*), bush honeysuckle (*Diervilla lonicera*), common juniper (*Juniperus communis*), leatherleaf (*Chamaedaphne calyculata*), ninebark (*Physocarpus opulifolius*), white pine (*Pinus strobus*), quaking aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), northern white-cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), and jack pine (*Pinus banksiana*). Low moist cliffs and vertical faces of boulders are dominated by ferns, including fragile fern (*Cystopteris fragilis*), rusty woodsia (*Woodsia ilvensis*), and common polypody (*Polypodium virginianum*). Lichens are equally common on the vertical cliff and boulder faces. Pools in the rock commonly support several herbaceous plants along their edges, including blue-joint grass (*Calamagrostis canadensis*), hair grass (*Deschampsia cespitosa*), bog lobelia (*Lobelia kalmii*), and wool-grass (*Scirpus cyperinus*) (Albert et al. 1997).

Photo by Joshua G. Cohen

The 'wave-washed zone' immediately adjacent to the lake is devoid of vegetation due to wave action and ice scour while the 'open, vegetated zone' is dominated by lichens and mosses with herbs and occassional shrubs restricted to bedrock cracks and depressions.

Zonation: Wave action and ice scour close to the lakeshore produce a 'wave-washed zone' that is almost devoid of vegetation except for small tufts of mosses and crustose lichens (Albert et al. 1997). Farther above the lake lies an 'open, vegetated zone,' where the dominant vegetation consists of mosses and lichens, with lichen cover increasing with elevation above the water. Herbs and shrubs are restricted to bedrock cracks in the lower part of this zone, but become more common with increasing elevation above the lake. Above the strong influence of storm waves and ice scour, woody vegetation gradually forms a 'shrub zone' where shrubs and shrub-sized and scattered overstory trees are also able to survive.

Associated Species: Michigan's Great Lakes coastal sites share both native and non-native plant species with granitic bluffs along the lakeshores of Voyageur National Park in northern Minnesota, as well as Quetico Provincial Park (northwest of Lake Superior) and Georgian Bay in Ontario (Catling and Brownell 1999). The Georgian Bay and the northern Michigan sites shared roughly twenty percent of their species. In contrast, Michigan's granitic bedrock shares almost none of the vascular plant species found on the granite outcrops, barrens, or glades of the southeastern U.S. or the Ozarks (Quarterman et al. 1993, Heikens 1999). Endemism is common on the ancient granite rock outcrops of the southern U.S., while the younger granite shorelines of Michigan and Ontario have no known endemic plants – vegetation has occupied these rock shorelines for only ten or twelve thousand years.

Invasive Plants: Surveys of granite bedrock lakeshore found one non-native invasive, Canada bluegrass (*Poa compressa*), growing on 80% of the sites and hawkweeds (*Hieracium* spp.) were found on 60% of sites. Other less common non-natives included ox-eye daisy (*Chrysanthemum leucanthemum*) and timothy (*Phleum pratense*) (Albert et al. 1997).

Michigan Indicator Species: ticklegrass (*Agrostis hyemalis*), harebell (*Campanula rotundifolia*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia cespitosa* and *D. flexuosa*), blueberry (*Vaccinium angustifolium)*, paper birch (*Betula papyrifera*), three-toothed cinquefoil (*Potentilla tridentata*), yarrow (*Achillea millefolium*), fireweed (*Epilobium angustifolium*), bearberry (*Arctostaphylos uva-ursi*), bush honeysuckle (*Diervilla lonicera*), common juniper (*Juniperus communis*), ninebark (*Physocarpus opulifolius*), fragile fern (*Cystopteris fragilis*), rusty woodsia (*Woodsia ilvensis*), polypody (*Polypodium virginianum*), and lichens (Albert et al. 1997).

Other Noteworthy Species: While rare animals were surveyed on the granite bedrock (Albert et al. 1997), general faunal surveys were not conducted in Michigan. Surveys of the Ontario granite barrens indicated that they were quite diverse, supporting 30 mammals, 136 breeding birds, 10 reptiles, 9 amphibians, and 46 butterfly species (Catling and Brownell 1999). In contrast to the relatively high faunal diversity of Ontario's granite knobs, those in the southern U.S. appear to have lower diversity due to extreme summer temperatures; in the south, invertebrates are the most prevalent faunal taxa, and many of these seek shelter in rock crevices, under rock, or in vegetation during the extreme heat of the day, with most feeding occurring nocturnally (Quarterman et al. 1993). Michigan's coastal sites may support a similar level of faunal diversity compared to Ontario's, although reptile and amphibian diversity is likely lower based on regional distribution patterns.

Special Animals: Bald eagles (*Haliaeetus leucocephalus*, state special concern) build nests in tall conifers near the edge of the granitic knobs, while peregrine falcons (*Falco peregrinus*, state endangered) nest on some of the cliff faces that can be found on or near the bedrock knobs.

Special Plants: Downy oatgrass (*Trisetum spicatum*, state special concern), an arctic-alpine plant, grows on the open bedrock at two of the granitic bedrock lakeshore sites, but in general, the granite shoreline supports few rare plant species. This lack of rare arctic and disjunct western plant species that characterize more base-rich volcanic and limestone bedrock has also been noted on the Canadian shoreline of Lake Superior (Soper and Maycock 1962).

Conservation and Biodiversity Management: The killing of lakeshore vegetation by trampling or off-road vehicle use can accelerate soil loss through wind and rain erosion. After soil has been lost, soil development is slow. Loss of lichen cover, due to off-road vehicle use, intensive hiking, and air pollution, have been documented in the southeastern U.S. (Quarterman et al. 1993, Shure 1999) and on volcanic bedrock of the Keweenaw Peninsula (Albert et al. 1997). While drought resulting from thin soils and temperature extremes are largely responsible for open conditions, wildfires may have been much more important in the past for preventing succession to more closed-canopy forests along the upland margin.

Research Needs: Additional characterization of non-vascular plants and resident fauna is needed. Documenting response of the community to fire will also help inform management efforts. Refinement of the classification of granite bedrock lakeshore demands the survey of sites in nearby Ontario (see below).

Photo by Joshua G. Cohen

Granite bedrock lakeshore occurs on a variety of igneous and metamorphic bedrock including quartzite.

Variation: Because this plant community occurs on a broad range of igneous and metamorphic rock along the Great Lakes shorelines of Michigan and Ontario, including gneiss, schist, granite, and quartzite, it may be possible to identify subtypes of this plant community. However, sampling of all known Michigan sites during the mid-1990s did not provide adequate information to justify further subdivision in Michigan. A more thorough sampling of Ontario coastal granite shorelines along Lake Superior and Georgian Bay, as well as similar inland lake sites along the lakeshores of Voyageur National Park and nearby Quetico Provincial Park, would allow for the better characterization of the floristic variation of this plant community.

Similar Natural Communities: NatureServe (2006) includes this type in its United States National Vegetation Classification as "Granite – Metamorphic Bedrock Great Lakes Shoreline Sparse Vegetation" only documented from Michigan. Granitic bedrock types are also described for parts of Ontario's Lake Superior and Georgian Bay shorelines (Soper and Maycock 1962, Catling and Brownell 1999), and Ontario Heritage lists Granite Bedrock Beach as an ecosite, as well as eight different herb, shrub, or tree dominated granite barren types (National Heritage Information Center 1997). Ontario Heritage provides no description of these granite bedrock types. In Michigan, Ontario, and Minnesota, Volcanic Bedrock Lakeshore has steep shorelines with similar vegetation zonation, but greater vegetation diversity. The arctic-alpine flora so typical of the volcanic bedrock is poorly represented on the granitic bedrock lakeshore. Limestone Bedrock Lakeshore shares some of the plant species of this community, but has much greater plant diversity and forms flat shelves along the shore rather than the steep slopes of granitic rock.

Granite bedrock lakeshore is very similar in terms of floristic composition to granite bedrock glade. In addition to the Upper Peninsula of Michigan, granite bedrock glades are known from inland sites in many states of the northeastern U.S., including New York (Edinger et al. 2002, Reschke 1990), New Hampshire (Sperduto and Nichols 2004), and Vermont (Thompson and Sorenson 2005), as well as in the Ozark Mountains and the Black Hills of South Dakota (Faber-Langendoen 2001, NatureServe 2006). The New York and New England granite sites share many plants with Michigan's granite shoreline. New York also describes shoreline granite outcrop (Edinger et al. 2002), which shares several species with Michigan's granite bedrock lakeshores.

Other Classifications:

Michigan Natural Features Inventory (MNFI) Circa 1800 Vegetation: 74, exposed bedrock.

Michigan Department of Natural Resources (MDNR): K, rock.

Michigan Resource Information Systems (MIRIS): 74, exposed rock.

National Wetland Inventory (NWI): none.

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

VII.A.2.N.a; Open Pavement Sparsely Vegetated Alliance; Granite - Metamorphic Bedrock Great Lakes Shore Sparse Vegetation; Great Lakes Granite - Metamorphic Bedrock Shore

Related Abstracts: Limestone bedrock lakeshore.

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Photo by Joshua G. Cohen

Granite bedrock lakeshore northwest of Marquette occurs adjacent to sandstone lakeshore cliff.

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