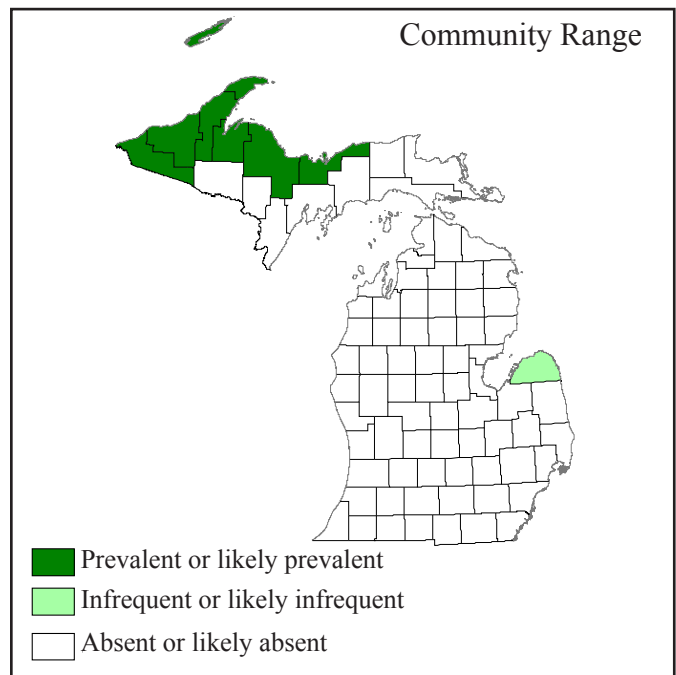




Photo by Joshua G. Cohen



Overview: Sandstone lakeshore cliff occurs where vertical or near-vertical exposures of bedrock are located along the Great Lakes shoreline. These cliffs are characterized by sparse coverage of vascular plants, lichens, mosses, and liverworts. While the majority of the community's distribution is in the central and western Upper Peninsula along Lake Superior, it also occurs along a short stretch of shore along Lake Huron in the thumb region. Sandstone lakeshore cliffs, ranging from 6 to 200 feet (2 to 65 m) high, are characterized by high site moisture due to the proximity of the Great Lakes. The cliffs form a stressed, unstable environment because of severe waves, wind, and winter ice.

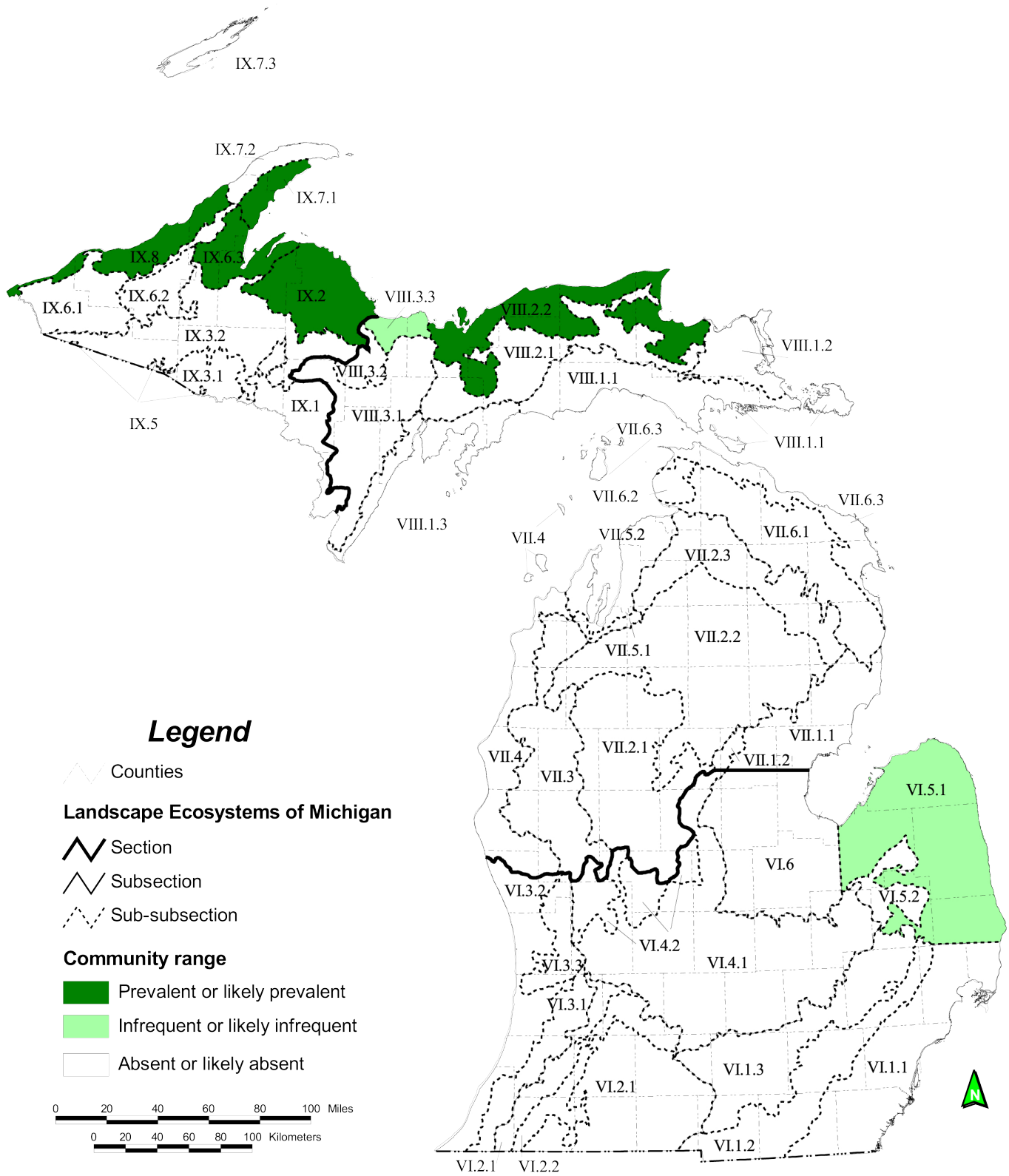
Global/State Rank: G3/S2

Range: This community is found along the northern Great Lakes shorelines of the United States and Canada. The primary substrate is Precambrian sandstone, formed approximately 1 billion years ago, and exposed along the southern shoreline of Lake Superior in Michigan and Wisconsin. In Michigan, sandstone cliffs occur primarily along the shores of Lake Superior as part of the Copper Harbor Conglomerate, Jacobsville Sandstone, and Nonesuch and Freda Formations (Dorr and Eschman 1970, Reed and Daniels 1987, Bornhorst and Rose 1994, LaBerge 1994), stretching from the Wisconsin-Michigan boundary in the west to east of Munising in Pictured Rocks National Lakeshore. Precambrian age sandstone cliffs are also common along

the adjacent Wisconsin shoreline of Lake Superior, on the Bayfield Peninsula and Apostle Islands National Lakeshore, where cliffs of the Orienta, Devils Island, and Chequamenon formations are exposed along several of the islands (Nuhfer and Dalles 1987, Judziewicz and Koch 1993). There is also a half mile stretch of sandstone cliff composed of Marshall Sandstone along the southern Lake Huron shoreline at Point Aux Barques (Dorr and Eschman 1970). In Michigan, sandstone cliffs occur in Subsections or Sub-subsections VI.5.1 (Sandusky Lake Plain), VIII.2.2 (Grand Marais Sandy End Moraine and Outwash), VIII.3.3 (Deerton), IX.2 (Michigamme Highland), IX.6.3 (Baraga), IX.7.1 (Gay), and in both Michigan and Wisconsin, IX.8 (Lake Superior Plain) (Albert 1995, Albert et al. 2008).

Rank Justification: There are over 15 miles (24 km) of cliff in the Porcupine Mountains, 6 miles (10 km) near Point Abbaye, 7 miles (11 km) in the Huron Mountain Club, and over 18 miles (29 km) at the Pictured Rocks National Lakeshore and Grand Island. In all, about 80 miles (128 km) of sandstone lakeshore cliff occur along Michigan's Lake Superior shore, and another 0.5 miles of cliff composed of Marshall Sandstone occurs at Pointe Aux Barque on southern Lake Huron (Albert et al. 1997a and 1997b, Kost et al. 2007). Expanses of sandstone cliffs are also common along the adjacent Wisconsin shoreline of Lake Superior, along the Bayfield Peninsula and on several islands within Apostle Islands National Lakeshore, including Cat, Devils,





Ecoregional map of Michigan (Albert 1995) depicting distribution of sandstone lakeshore cliff (Albert et al. 2008)



Eagle, Ironwood, Madeline, Manitou, North Twin, Oak, Otter, Outer, Sand, and Stockton Islands (Nuhfer and Dalles 1987, Judziewicz and Koch 1993).

Landscape Context: The growing season ranges from less than 100 days in the Michigamme Highland to more than 130 days in the Keweenaw, but extreme wind and ice along the Lake Superior shore create extremely harsh conditions for plant growth (Albert et al. 1986). Regularly occurring fog along Lake Superior reduces moisture stress to levels below that which occurs on more inland cliffs. Cliffs range from 6 to 200 ft (2 to 65 m) high, with the highest cliffs at the Pictured Rocks National Lakeshore (Albert et al. 1997a and 1997b). Similar sandstone cliffs occur along the Wisconsin shoreline of Lake Superior. In Michigan, sandstone lakeshore cliff is typically bordered along its inland margin by boreal forest, dry-mesic northern forest, mesic northern forest, and occasionally by hardwood-conifer swamp (Kost et al. 2007). Along the shoreline, sandstone lakeshore cliffs are interspersed with areas of sandstone bedrock lakeshore, sandstone cobble shore, volcanic lakeshore cliff, volcanic bedrock lakeshore, volcanic cobble shore, granite bedrock lakeshore, and sand and gravel beach.



Photo by Joshua G. Cohen

Sandstone lakeshore cliff is often backed by boreal forest with sandstone talus at the cliff base.

Sandstone lakeshore cliffs occur as several-mile long exposures at Pictured Rocks National Lakeshore, the Huron Mountains, and Porcupine Mountains State Park. While these are the three largest sites, at least ten other sites range from 1 to 6 miles (2 to 10 km) in length.

Natural Processes: The vertical structure of cliffs results in constant erosion and restricts soil development to upper cliff edge, ledges, crevices, and the base of the cliff where organic matter and sandy particles can accumulate (Judziewicz and Koch 1993, Albert et al 1997a and 1997b). Desiccating conditions that limit plant growth are the result of thin soils and direct exposure to wind, ice, and sun. However, cliff aspect and local seepages result in a variability of site moisture conditions, with north- and east-facing cliffs typically moister than south- and west-facing cliffs because of reduced wind and reduced direct exposure to the sun. Groundwater seepages along the cliff face and surface flow across the cliff during rain events or snow melt provide moisture locally on cliff faces. Fog also occurs regularly on the coast, fostering the growth of moss and lichen. Trees commonly blow down along the tops and bases of cliffs due to strong lake winds and shallow soils, providing localized areas for soil accumulation. Sandstone cliff faces break free regularly, forming blocky talus at the base of many of the sandstone cliffs and exposing fresh, bare rock substrates. Cliff faces are also scoured by ice and waves, further increasing rates of erosion.

There is little soil development on the cliffs except for shallow organic soil development along the narrow cliff summit and ledges, in crevices in the cliff face, and at the base of the cliff where sand particles, along with decaying roots and plant debris accumulate. Vascular plants are limited to these shallow cracks and crevasses in the cliff face, and to depressions at the summit of the cliff. The breakdown of sandstone and plant matter results in an acidic, sandy, organic-rich soil, although some sandstones are more calcareous, especially those of the Nonesuch Formation in Michigan and Devil's Island and Orienta Formations in Wisconsin (Judziewicz and Koch 1993, Albert et al 1997a and 1997b).

Vegetation Description: On the face of the cliff, near the water, there is a zone where storm waves and winter ice scour the rock of vegetation, except for in narrow, protected cracks in the rock. This bare zone can extend quite high, and storm waves regularly reach the tops of high sections of lakeshore cliff. While mosses, lichens, and liverworts can be common on the exposed cliff face, vascular plants cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), ledges, crevices in the cliff face, and along the cliff base, if a ledge of talus, cobble, sand,





Non-vascular flora, lichens, mosses, and liverworts, are often common along the exposed cliff face while vascular plants are typically sparse and restricted to crevices and ledges. Photos by Joshua G. Cohen.



or bedrock is present between the cliff and the open water (Judziewicz and Koch 1993, Albert et al 1997a and 1997b). However, the coarse talus blocks at the base of many Jacobsville sandstone cliffs supports little or no vegetation (Albert et al 1997a and 1997b). Mosses, lichens, and liverworts are dominant in groundwater seepage areas along the cliff face, where streams pass over the cliff face, and where cliff faces overhang the water. On calcareous sandstone cliffs, these seepages contain calciphiles like Kalm's lobelia (*Lobelia kalmii*), butterwort (*Pinguicula vulgaris*), and bird's-eye primula (*Primula mistassinica*).

A forest of northern white-cedar occurs along the edge of Pointe Aux Barques, and its face is dominated by mosses and lichens. Michigan's sandstone lakeshore cliffs share species with volcanic, limestone, sandstone, and granite bedrock lakeshore, as well as limestone glade, limestone cliff, limestone bedrock glade, limestone cobble shore, and coastal fen (Kost et al. 2007)

Characteristic Plants: Common herbaceous species associated with sandstone lakeshore cliff include fragile fern (*Cystopteris fragilis*), northern beech fern (*Thelypteris phegopteris*), lady fern (*Athyrium filix-femina*), spinulose woodfern (*Dryopteris carthusiana*), tufted hair grass (*Deschampsia cespitosa*), yarrow (*Achillea millefolium*), fireweed (*Epilobium angustifolium*), wild strawberry (*Fragaria virginiana*), three-toothed cinquefoil (*Potentilla tridentata*), harebell (*Campanula rotundifolia*), Kalm's lobelia, common horsetail (*Equisetum arvense*), grass-leaved goldenrod (*Euthamia graminifolia*), hairy hawkweed (*Hieracium gronovii*), marsh violet (*Viola cucullata*), beach pea (*Lathyrus palustris*), jewelweed (*Impatiens capensis*), northern bugleweed (*Lycopus uniflorus*), and two invasive plants, pearlwort (*Sagina procumbens*) and Canada bluegrass (*Poa compressa*). Common shrubs include ninebark (*Physocarpus opulifolius*), dwarf raspberry (*Rubus pubescens*), wild red raspberry (*R. strigosus*), mountain alder (*Alnus crispa*), red-osier dogwood (*Cornus stolonifera*), bush honeysuckle (*Diervilla lonicera*), sand cherry (*Prunus pumila*), black cherry (*P. serotina*), choke cherry (*P. virginiana*), serviceberries (*Amelanchier* spp.), and willows (*Salix* spp.). In Wisconsin's Apostle Islands, common willows included Bebb's willow (*Salix bebbiana*), pussy willow (*S. discolor*), prairie willow (*S. humilis*), satiny willow (*S. pellita*, state special concern), and tea-leaved willow

(*S. planifolia*). Scattered and stunted trees are restricted to ledges and crevices and include paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), northern white-cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), balsam poplar (*Populus balsamifera*), and quaking aspen (*Populus tremuloides*). Trees occurring at the top of the cliff include sugar maple (*Acer saccharum*), paper birch, white spruce, balsam poplar, white pine (*Pinus strobus*), northern white-cedar, and eastern hemlock (*Tsuga canadensis*). At the edges of small pools, which occur along the top of the cliffs, sensitive fern (*Onoclea sensibilis*) and interrupted fern (*Osmunda claytoniana*) are common, as are sweet gale (*Myrica gale*), tufted hairgrass (*Deschampsia cespitosa*), and several sedges (*Carex* spp.).

While most Jacobsville Sandstone sites have blocky talus at the base of the cliffs, talus is typically absent on Freda Sandstone sites. Talus supports almost no vegetation due to frequent inundation and severe storm waves. Cliff faces are largely unvegetated, except within cracks, on ledges, and where seepages or small streams crossing the rock surface. In these moist areas mosses, lichens, and grasses can form thick beds of vegetation. Vegetation of sandstone lakeshore cliffs tends to have greater density and diversity along lower escarpments. Tops of cliffs typically support boreal forest, but can include dry-mesic northern forest, mesic northern forest, and less frequently forested wetland.

The Freda Formation on the Keweenaw Peninsula in Michigan, and the Devil's Island and Orienta Formations in the Apostle Islands are somewhat calcareous, resulting in multiple occurrences of Kalm's lobelia, butterwort (*Pinguicula vulgaris*, state special concern), bird's-eye primrose (*Primula mistassinica*), and downy oatgrass (*Trisetum spicatum*, state special concern) in both Michigan and Wisconsin (Judziewicz and Koch 1993, Albert et al 1997a and 1997b). Other calciphiles, including several sedges (*Carex viridula*, *C. buxbaumii*, *C. diandra*) and bulrush (*Scirpus hudsonianus*), were noted as common on Wisconsin's moist cliffs.

Studies from inland cliffs in central Wisconsin document that there were several mosses that commonly occurred on north facing cliffs (Elliott and Forman 1965). These mosses occupied moist cliff faces, seepages on the cliff face, and crevices where thin soil was beginning to accumulate. Elliott (1967) also found



several moss species growing on the splash zone of sandstone cliffs along Lake Superior, including *Blindia acuta*, *Distichium capillaceum*, and *Oncophorus virens*. Nichols (1933, 1938) also documents several moss species from damp sandstone ledges and cliffs along Lake Superior at the Huron Mountains and Pictured Rocks.

Zonation: The base of almost all lakeshore cliffs is devoid of vegetation due to storm waves and ice scour. Closer to the top of the cliff, mosses, lichens, and liverworts become more common on the open face. Most vascular plants are restricted to narrow cracks in the cliff face. Seepages contain the most diverse mix of bryophytes and vascular plants, while the narrow, open ledge at the top of many cliffs may even support a krummholz of stunted shrubs and trees (Judziewicz and Koch 1993). Where soil accumulates at the top of the cliff, a diversity of forest and wetland types can occur, but the stature of trees is generally small, and uprooted trees are common due to storm winds.

Invasive Plants: Several non-native plants are common on sandstone lakeshore cliffs; Canada bluegrass (*Poa compressa*), lawn prunella (*Prunella vulgaris*), pearlwort (*Sagina procumbens*), common dandelion (*Taraxacum officinale*), spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), sheep sorrel (*Rumex acetosella*), hawkweeds (*Hieracium* spp.), Kentucky bluegrass (*P. pratensis*), and hawkweeds (*Hieracium* spp.).

Michigan Indicator Species: Yarrow (*Achillea millefolium*), paper birch (*Betula papyrifera*), harebell (*Campanula rotundifolia*), fragile fern (*Cystopteris fragilis*), hair grass (*Deschampsia cespitosa*), fireweed (*Epilobium angustifolium*), common horsetail (*Equisetum arvense*), grass-leaved goldenrod (*Euthamia graminifolia*), wild strawberry (*Fragaria virginiana*), hairy hawkweed (*Hieracium gronovii*), dwarf raspberry (*Rubus pubescens*), and fleshy stitchwort (*Stellaria crassifolia*) (Albert et al. 1997a).

Other Noteworthy Species: Cliffs provide nesting habitat for raptors and common ravens (*Corvus corax*).

Rare Animals: Bald eagles (*Haliaeetus leucocephalus*, state special concern) build nests in tall conifers at the edges of cliffs, and merlin (*Falco columbarius*, state threatened) and peregrine falcon (*Falco peregrinus*, state endangered) nest on some of the cliff faces.

Rare Plants: Crowberry (*Empetrum nigrum*, state threatened), northern ragwort (*Senecio indecorus*, state threatened), dwarf bilberry (*Vaccinium cespitosum*, state threatened), and downy oat-grass (*Trisetum spicatum*, state special concern), all species with arctic-alpine distributions, grow on the narrow ledges at the top of the cliffs. Scabrous black sedge (*Carex atratiformis*, state threatened) and butterwort (*Pinguicula vulgaris*, state special concern) occupy moist, mossy crevices in the upper cliff face.

Conservation and Biodiversity Management: Threats to lakeshore cliffs include shoreline development, logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, and invasive plants. Soil development and plant re-establishment are slow due to the unstable environment, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Maintenance of a mature, unfragmented forested buffer around sandstone lakeshore cliffs may limit the local seed source for invasive species distributed by wind or birds. Among invasive plants threatening biodiversity of sandstone lakeshore cliffs are Canada bluegrass, common dandelion, Kentucky bluegrass, lawn prunella, spotted knapweed, ox-eye daisy, sheep sorrel, hawkweeds, and pearlwort. Monitoring and control efforts to detect and remove invasive species will help maintain the ecological integrity of sandstone lakeshore cliff and surrounding natural communities.

Research Needs: There is need of additional characterization of non-vascular plants and resident fauna. Both Pictured Rocks and Apostle Island National Lakeshores are known to have large lichen floras, with 264 and 324 species respectively (Bennett and Wetmore 2005), many of which likely occupy cliff and rock faces. Analyzing these existing databases would likely provide important information for biodiversity conservation. It is also recognized that cliffs are important habitat for many rare bryophytes (Vitt and Belland 1997). Further data collection is needed for the vascular and non-vascular flora of Lake Huron's cliffs, which could be compared to the more northerly cliffs of Lake Superior.

Variation: The sandstone bedrock along Lake Superior varies significantly in texture and erosion resistance, which influence vegetative composition and structure. Some of the sandstone cliffs grade into much finer siltstone, and there is variation between acid and basic sandstone, which is reflected in floristic differences.



Similar Natural Communities: Volcanic lakeshore cliff, granite lakeshore cliff, limestone lakeshore cliff, granite cliff, limestone cliff, sandstone cliff, volcanic cliff, granite bedrock glade, volcanic bedrock glade, sandstone bedrock lakeshore, and sandstone cobble shore.

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. Nature Serve 2006): CODE; ALLIANCE; ASSOCIATION; COMMON NAME.

VII.A.1.N.a. Sandstone Great Lakes Shore Cliff Sparse Vegetation: Great Lakes Shore Sandstone Cliff.

Related Abstracts: Bald eagle, dwarf bilberry, merlin, northern beech fern, peregrine falcon, northern ragwort, sedge (*Carex atratiformis*).

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Photo by Joshua G. Cohen

Sandstone lakeshore cliff, Baraga County, Michigan.

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Sandstone lakeshore cliff, Houghton County, Michigan.

