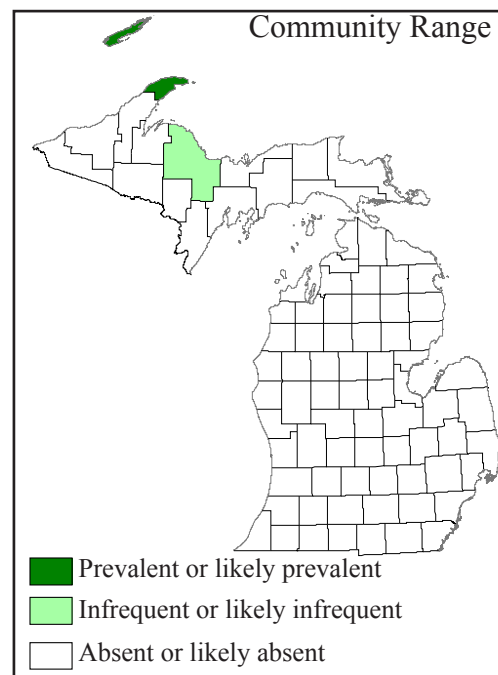




Photo by Michael A. Kost



**Overview:** Volcanic bedrock lakeshore, a sparsely vegetated community, is dominated by mosses and lichen, with only scattered coverage of vascular plants. This Great Lakes coastal plant community, which has been defined broadly to include all types of volcanic bedrock, including basalt, conglomerate composed of volcanic rock, and rhyolite, is located primarily along the Lake Superior shoreline on the Keweenaw Peninsula and Isle Royale.

**Global/State Rank:** G4G5/S3

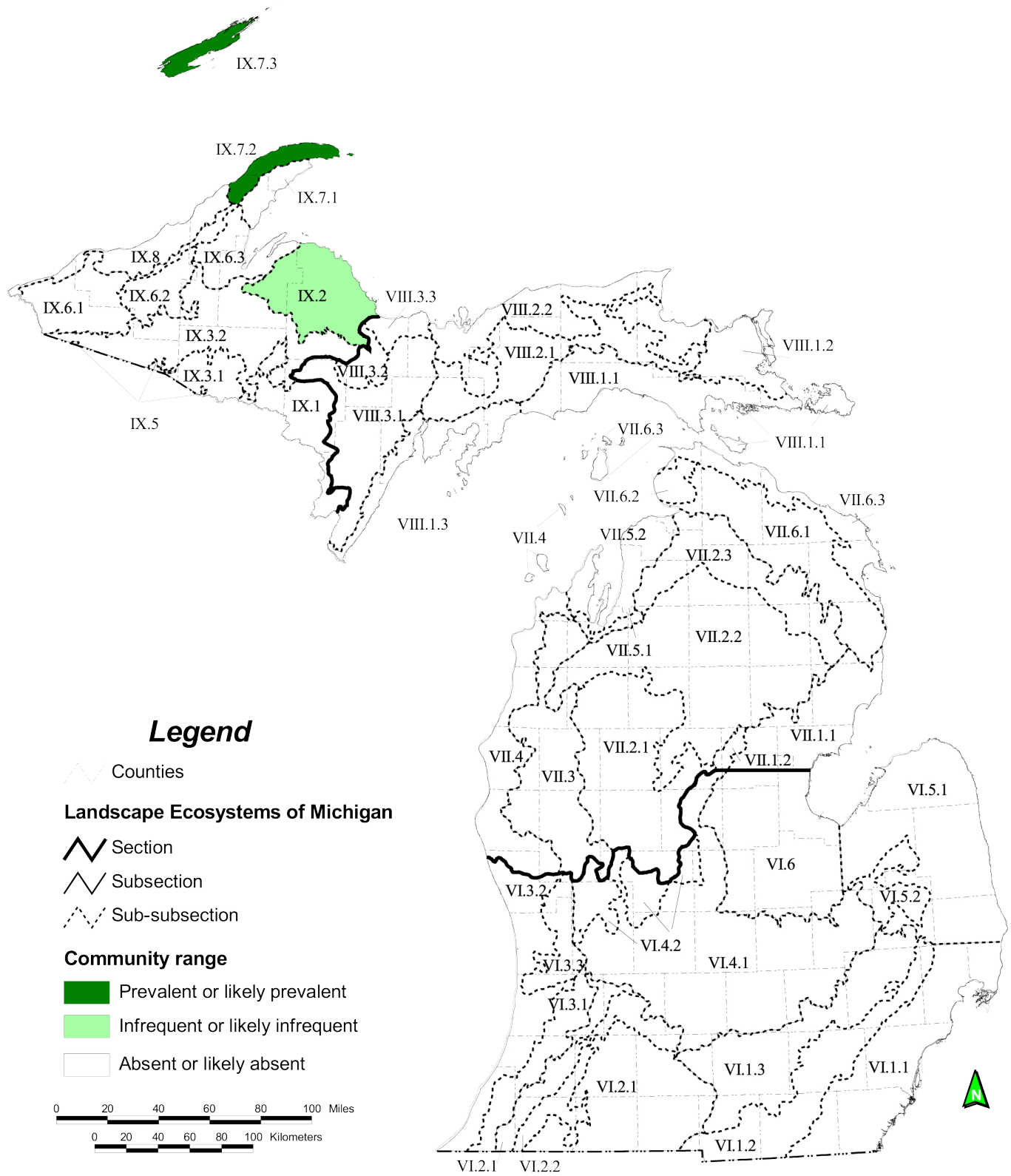
**Range:** Volcanic bedrock lakeshore occurs where volcanic rock is exposed along the Lake Superior shoreline, including Isle Royale and the Keweenaw Peninsula in Michigan, as well as along the shoreline in Ontario and Minnesota. In Ontario, the arctic-alpine flora is relatively rare along the Great Lakes shoreline, but it is much more extensive several hundred kilometers to the north in the Hudson Bay Lowlands (Oldham 2006). Ontario sites on Lake Superior include Pukaskwa National Park, Sleeping Giant Provincial Park east of Thunder Bay, the Slate Islands, Lake Superior Provincial Park, Lake Superior National Marine Conservation Area, and Michipicoten Island Provincial Park (Bakowsky 1998, 2002; Oldham 2006). In Minnesota, coastal volcanic bedrock occurs on the mainland and on Susie Island and other nearby small islands (Bakowsky 1998, Oldham 2006).

In Michigan, the most extensive areas occur on Isle Royale, where there are over 150 miles (240 km) of bedrock shoreline, including several nearby smaller islands, such as Washington, Thompson, Amygdaloid, Conglomerate, Long, and Caribou islands. On the Keweenaw Peninsula, volcanic bedrock lakeshore extends along more than 40 miles (60 km) of shoreline, including Manitou Island east of the mainland. Volcanic bedrock lakeshore is prevalent in Subsections IX.7.2 (Calumet) and IX.7.3 (Isle Royale) and occurs locally within Subsection IX.2 (Michigamme Highland) (Albert 1995; Albert et al. 1997a, 1997b, 2008).

**Rank Justification:** Volcanic bedrock lakeshore has been extensively sampled in Michigan as part of a survey and classification of bedrock shorelines along the entire Michigan Great Lakes shoreline (Albert et al. 1994, Albert et al. 1997a and 1997b). Additional survey of the plant communities growing on the bedrock of Isle Royale were conducted in the late 1990s (The Nature Conservancy 1999), and the equivalent plant communities in Minnesota and Ontario are considered rare, and as a result, have been the attention of rare species and plant community surveys (The Nature Conservancy 1988, Bakowsky 1998, 2002, Oldham 2006).

**Physiographic Context:** Resulting from the flow of air masses across Lake Superior, the shoreline of Lake Superior on the Keweenaw Peninsula and Isle Royale is





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





characterized by a relatively long, cool growing season that averages 134 days (Albert et al. 1986). Even though the growing season may be longer due to the influence of Lake Superior, conditions along the shoreline are harsh, with frequent fog, desiccating winds, ice storms, and ice scour during winter storms (personal observations).

Bedrock of the Keweenaw Peninsula and Isle Royale was deposited during the Late Precambrian (1,100 to 1,000 million years ago), a period of extensive surface volcanic activity (Dorr and Eschman 1970, Bornhorst and Rose 1994, LaBerge 1994, Lillie 2005, Reed and Daniels 1987). The basaltic lavas flowed out through long fissures, covering the landscape with thick deposits of lava called flood basalt (Huber 1983). Similar volcanic deposits are found in other continental rifts, including those of the Basin and Range in the western U.S. and those of east Africa (Lillie 2005). The Keweenaw rock, up to 15.5 miles thick, sagged to form a structural basin that is now occupied by Lake Superior (Dorr and Eschman 1970). The structural sag caused volcanic rock of the Keweenaw Peninsula to tilt steeply downward to the north toward the center of the Lake Superior basin. The volcanic rock of Isle Royale's south shoreline tilted steeply south toward central Lake Superior. The south shore of the Keweenaw Peninsula and the north shore of Isle Royale form steep cliffs.

Boreal forest typically borders volcanic bedrock lakeshore along its upland margin. Dry-mesic northern forest, mesic northern forest, or volcanic bedrock glade also occasionally occur adjacent to volcanic bedrock lakeshore, as does northern shrub thicket where streams flow through the community. Volcanic bedrock lakeshore is interspersed by areas of volcanic lakeshore cliff, volcanic cobble shore, and sand and gravel beach along the shoreline (Kost et al. 2007, MNFI 2009).

Little soil development occurs on either volcanic conglomerates or massive, fine-grained basalts. Plants are able to establish only in cracks, joints, vesicles, and depressions in the bedrock, where small amounts of organic matter accumulate. Cracks, joints, and depressions are much abundant on the volcanic conglomerate, but still provide relatively few places for soil development. Freshly broken rock surfaces are mildly alkaline (Kost et al. 2007).



Photo by Joshua G. Cohen

Constant wave action scours the lower margin of volcanic bedrock lakeshore.

**Natural Processes:** Extreme conditions characterize all parts of this plant community. Storm waves regularly scour the rock near the water's edge, and during the winter, ice scours and abrades the rock even more violently. Freezing rain and mist coat both the rock and vegetation, and in combination with high winds, result in dwarf shrubs and stunted trees along the shore. Fog occurs on an almost daily basis, allowing plants more characteristic of cooler northern or high elevation habitats to survive beyond their normal range. Along the upland margin of volcanic bedrock lakeshore, lightning strikes result in occasional tree mortality and fires (Josh Cohen, personal communication) and wind storms result in blowdown of shallowly rooted trees.



Photo by Joshua G. Cohen

Volcanic bedrock lakeshore adjacent to recently burned boreal forest along Keweenaw Point.







Volcanic bedrock lakeshores along Lake Superior composed of basalt (above) and conglomerate (below) bedrock are both highly resistant to weathering and also influenced by storm waves and ice scour. As a result, these shorelines are characterized by little soil development and sparse vegetation. Photos by Joshua G. Cohen.





**Vegetation Description:** This community occurs on gentle to steeply sloping rock outcrops along Lake Superior. This community occurs between the open water of the lake up to the forest, glade, or wetland edge (The Nature Conservancy 1999). Several vegetation zones are often apparent. Wave action and ice scour are strongest near the lakeshore, producing a ‘wave-washed zone,’ that is almost devoid of vegetation except for scattered tufts of mosses and lichen (Albert et al. 1997a and 1997b). With greater distance above the lake, plant cover increases, with lichens predominating. On the high, dry rocks, a diversity of lichens forms a nearly continuous cover, while mosses, liverworts, herbs, and woody plants are also well represented. Herbs and woody plants are largely restricted to narrow cracks and joints in the rock, where there is limited soil development and greater moisture retention. Narrow, perched meadows of tufted grasses and sedges are found along the edges of seasonal rock pools.



Photo by Joshua G. Cohen

Seasonal rock pools and driftwood are important structural attributes of volcanic bedrock lakeshore.

The plants covering the greatest percentage of the lakeshores are mosses and lichen, with only scattered coverage of vascular plants. Mosses and lichens, which often attain greater than 50% cover (Reschke 1985), are able to establish and survive close to the lake, while vascular plants are generally above the zone of active storm waves and ice scour. Reschke, in her detailed study of the shoreline of the Keweenaw Peninsula, noted four zones along the exposed bedrock shore. Closest to the water was a low-wet rock assemblage dominated by mosses and also containing low levels of crustose and gelatinous lichens, along with low levels of vascular plants in narrow crevices. Slightly upslope,

the second layer of intermediate-moist rocks has the highest proportion of herbs (26%), and a slightly larger percent of woody plants, with a decrease in frequency and cover of crustose and loose foliose and fruticose lichens. The third zone, the intermediate-dry rocks contains high proportions of crustose (40%) and closely-appressed (20%) lichens, which can cover up to 90% of the rock surface. The highest zone, or high-dry rocks, is the most diverse, with up to 28 species. Sixty nine percent of these species are lichens, including crustose, closely-appressed, and loose foliose and fruticose lichens. Overall, Reschke (1985) found that among the commonest lifeforms, 53 were lichen, 45 vascular plant, and 28 moss. In terms of relative frequency, 56% were lichen, 21% mosses, 16% herbaceous dicots, 4% graminoids, 2% woody dicots, and less than 1% liverworts.



Photo by Joshua G. Cohen

Scattered trees and shrubs occur along the upper margin of volcanic bedrock lakeshore while the wave-washed zone is often devoid of vegetation.



Photo by Joshua G. Cohen







Volcanic bedrock lakeshore is a sparsely vegetated community dominated by mosses and lichens, with a scattered coverage of vascular plants. Herbs and woody plants are largely restricted to narrow cracks and joints in the rock. Photos by Joshua G. Cohen.





On the Keweenaw Peninsula, areas of massive basalt with few cracks or vesicles support a depauperate flora, while on Isle Royale, the flora tends to be more diverse on the massive basalt. Rhyolites, an angular, reddish volcanic rock found locally on the south shore of the Keweenaw Peninsula east of Bete Grise, has a depauperate flora similar to that of massive basalt.

Of the vascular plants present on the bedrock shoreline, almost all represent the arctic-alpine flora (Given and Soper 1981, Slavik and Janke 1987, Thompson and Wells 1974), including two rare mosses, *Pseudoleskea patens* and *Pseudoleskeella tectorum* (Crum and Anderson 1981). Soper and Maycock (1963) and Given and Soper (1981) consider that the habitat of these arctic-alpine plants was maintained by stress and disturbance in the form of cold water temperature (<15° C), high heat loading of rocks, ice scour and freeze and thaw weathering of rock, and wave action. While the minimum temperature correlates well with the largest occurrences of arctic-alpine flora, single occurrences occur further south on Lake Superior, where there are local outcrops of volcanic rock, indicating that rock type is also an important factor.

Limestone cobble shore and limestone bedrock lakeshore share many species with volcanic bedrock lakeshore (Albert et al. 1997a and 1997b). A lesser number of species are shared with granite bedrock lakeshore and sand dunes.

**Characteristic plants:** Herbaceous species, listed in order of common occurrence, include harebell (*Campanula rotundifolia*), wild strawberry (*Fragaria virginiana*), three-toothed cinquefoil (*Potentilla tridentata*), downy oatgrass (*Trisetum spicatum*, state special concern), yarrow (*Achillea millefolium*), hair grass (*Deschampsia cespitosa*), butterwort (*Pinguicula vulgaris*, state special concern), bulrush (*Scirpus cespitosus*), fescue (*Festuca saximontana*), bird's-eye primula (*Primula mistassinica*), and the invasive plant, Canada bluegrass (*Poa compressa*). Other common species include balsam ragwort (*Senecio pauperculus*), grass-leaved goldenrod (*Euthamia graminifolia*), Gillman's goldenrod (*Solidago simplex*), fireweed (*Epilobium angustifolium*), northern bog violet (*Viola nephrophylla*), poverty grass (*Danthonia spicata*), and wormwood (*Artemisia campestris*). Prevalent shrubs include blueberry (*Vaccinium angustifolium*), bog-bilberry (*Vaccinium uliginosum*), bearberry (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), dwarf

raspberry (*Rubus pubescens*), ninebark (*Physocarpus opulifolius*), serviceberries (*Amelanchier* spp.), soapberry (*Shepherdia canadensis*), and bush honeysuckle (*Diervilla lonicera*). Stunted, shrub-sized trees included balsam fir (*Abies balsamea*), northern white-cedar (*Thuja occidentalis*), quaking aspen (*Populus tremuloides*), white pine (*Pinus strobus*), and white spruce (*Picea glauca*). Perched meadows at the edges of seasonal rock pools are dominated by blue joint grass (*Calamagrostis canadensis*), hair grass, downy oatgrass, poverty grass, tufted bulrush (*Scirpus cespitosus*), and sedges (*Carex buxbaumii* and *C. castanea*).



Photo by Joshua G. Cohen

Characteristic vegetation include scattered tufts of grass-leaved goldenrod and hair grass.

The most prevalent mosses on the Keweenaw Peninsula volcanic lakeshore are *Tortella tortuosa* (71% of quadrats) and the two *Grimmias*, *G. alpicola* and *G. apocarpa* (81% of quadrats) (Reschke 1985). Among the most common lichens listed for Isle Royale are *Xanthoparmelia* spp., *Xanthoria elegans*, and *Rhizocarpon geographicum* (The Nature Conservancy 1999).

**Invasive Plants:** Non-native herbs commonly encountered include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), king-devil (*Hieracium caespitosum*), St. John's-wort (*Hypericum perforatum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), lawn prunella (*Prunella vulgaris*), sheep sorrel (*Rumex acetosella*), garden tansy (*Tanacetum vulgare*), common dandelion (*Taraxacum officinale*), red clover (*Trifolium pretense*), and common mullein (*Verbascum thapsus*).



**Michigan Indicator Species:** harebell (*Campanula rotundifolia*), wild strawberry (*Fragaria virginiana*), three-toothed cinquefoil (*Potentilla tridentata*), downy oatgrass (*Trisetum spicatum*, state special concern), yarrow (*Achillea millefolium*), hair grass (*Deschampsia cespitosa*), butterwort (*Pinguicula vulgaris*, state special concern), bulrush (*Scirpus cespitosus*), fescue (*Festuca saximontana*), bird's-eye primula (*Primula mistassinica*), Gillman's goldenrod (*Solidago simplex*), Canada bluegrass (*Poa compressa*), blueberry (*Vaccinium angustifolium*), bog-bilberry (*Vaccinium uliginosum*), bearberry (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), balsam fir (*Abies balsamea*), northern white-cedar (*Thuja occidentalis*).

**Other Noteworthy Species:** Surveys of volcanic bedrock lakeshore documented twenty species of land snails including two rare species with relict periglacial and arctic affinities, crested vertigo (*Vertigo cristata*, state special concern) and mystery vertigo (*Vertigo paradoxa*, state special concern).

**Rare Animals:** Rare animals include Peregrine falcon (*Falco peregrinus*, state endangered), bald eagle (*Haliaeetus leucocephalus*, state special concern), and the above mentioned land snails, crested vertigo and mystery vertigo.

**Rare Plants:** Rare plant species of the volcanic bedrock lakeshore include wild chives (*Allium schoenoprasum* var. *sibiricum*, state threatened), Rosy pussytoes (*Antennaria rosea*, presumed extirpated from Michigan), heart-leaved arnica (*Arnica cordiformis*, state endangered), low northern rock cress (*Braya humilis*, state threatened), northern reedgrass (*Calamagrostis lacustris*, state threatened), narrow-leaved reedgrass (*Calamagrostis stricta*, state threatened), calypso (*Calypso bulbosa*, state threatened), intermediate sedge (*Carex media*, state threatened), Ross's sedge (*Carex rossii*, state threatened), bulrush sedge (*Carex scirpoidea*, state threatened), pale Indian paintbrush (*Castilleja septentrionalis*, state threatened), American rock-brake (*Cryptogramma acrostichoides*, state threatened), ram's head lady's-slipper (*Cypripedium arietinum*, state special concern), wild oat grass (*Danthonia intermedia*, state special concern), rock whitlow-grass (*Draba arabisans*, state special concern), blue wild-rye (*Elymus glaucus*, state special concern), black crowberry (*Empetrum nigrum*, state threatened), small-flowered wood rush (*Luzula parviflora*, state threatened), mountain timothy

(*Phleum alpinum*, presumed extirpated from Michigan), butterwort (*Pinguicula vulgaris*, state special concern), alpine bluegrass (*Poa alpina*, state threatened), alpine bistort (*Polygonum viviparum*, state threatened), prairie cinquefoil (*Potentilla pensylvanica*, state threatened), pearlwort (*Sagina nodosa*, state threatened), northern ragwort (*Senecio indecorus*, state threatened), downy oat-grass (*Trisetum spicatum*, state special concern), dwarf bilberry (*Vaccinium cespitosum*, state threatened), and squashberry (*Viburnum edule*, state threatened).

**Conservation and Biodiversity Management:** Lichens and mosses are especially sensitive to off-road vehicle and foot traffic. In many stretches of the shoreline this damage is minimal because of the extreme steepness of the shores and the remote location of many of the volcanic bedrock lakeshore occurrences. While herbaceous vegetation is also vulnerable to foot traffic, roots are often protected within cracks in the rock. Soil recovery and plant re-establishment are slow in this harsh environment. Invasive species that threaten diversity and community structure of volcanic bedrock lakeshore include Canada bluegrass, common dandelion, common mullein, garden tansy, Kentucky bluegrass, king-devil, lawn prunella, ox-eye daisy, red clover, sheep sorrel, St. John's-wort, and spotted knapweed. Maintaining a mature, unfragmented forested buffer around volcanic bedrock lakeshores may help limit the local seed source for invasive species distributed by wind or birds. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of volcanic bedrock lakeshore and surrounding natural communities.



Photo by Joshua G. Cohen

Non-native species invasions can be limited by maintaining an unperturbed forested buffer adjacent to volcanic bedrock lakeshore and limiting vehicular access to the shoreline.





**Research Needs:** Further study of the mosses and lichens of the volcanic bedrock lakeshore is warranted, as documented by the work of Reschke (1985), who not only documented their floristic importance, but also identified potential rare taxa. There is opportunity to study the response of plants to disturbance, the impact of non-native species on the native flora, and the long-term effect of global climate change.

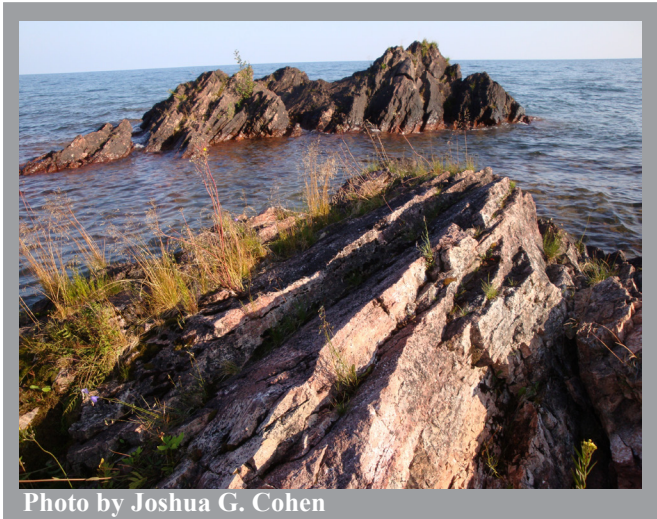


Photo by Joshua G. Cohen

An important research need is to ascertain how global climate change will impact this lakeshore ecosystem.

**Variation:** In earlier versions of the MNFI community classification, the volcanic conglomerate and basalt bedrock lakeshores were treated as separate natural communities because the lakeshore conglomerates of the Keweenaw Peninsula support higher plant species richness and greater vegetative cover than the lakeshore basalts. However, because the basaltic bedrock of Manitou Island at the east end of the Keweenaw Peninsula and on Isle Royale supports a similar and equally diverse vascular flora as the conglomerate of the Keweenaw Peninsula, both of the volcanic bedrock lakeshore types have since been combined into one type, volcanic bedrock lakeshore (see Kost et al. 2007).

Basalt bedrock lakeshores of the Keweenaw Peninsula are characterized by lower plant richness and cover than the basalt bedrock lakeshores of Isle Royale, probably due to the lack of plant habitat in the form of cracks and small cavities in the smooth, fine-grained basaltic rock (Albert et al. 1997a and 1997b). In contrast, the volcanic conglomerates of the Keweenaw Peninsula support many more plant species and higher coverage values than the basalt. Rhyolite bedrock is also low in plant diversity and coverage compared to volcanic conglomerate bedrock.

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

**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 2009): CODE; ALLIANCE; ASSOCIATION; COMMON NAME.

VII.A.2.N.a Open Pavement Sparsely Vegetated Alliance; Great Lakes Basalt (Conglomerate) Bedrock Lakeshore Sparse Vegetation.

**Related Abstracts:** Alpine bistort, alpine bluegrass, calypso, dwarf bilberry, pearlwort, ram's head lady's-slipper, northern ragwort, small-flowered wood rush, squashberry, bald eagle, peregrine falcon, *Vertigo cristata*, *Vertigo paradoxa*, volcanic bedrock glade, limestone bedrock lakeshore, and granite bedrock lakeshore.



Photo by Joshua G. Cohen

Volcanic conglomerate lakeshore, Keweenaw Peninsula.



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Volcanic bedrock lakeshore, Keweenaw Peninsula. Photo by Joshua G. Cohen.

