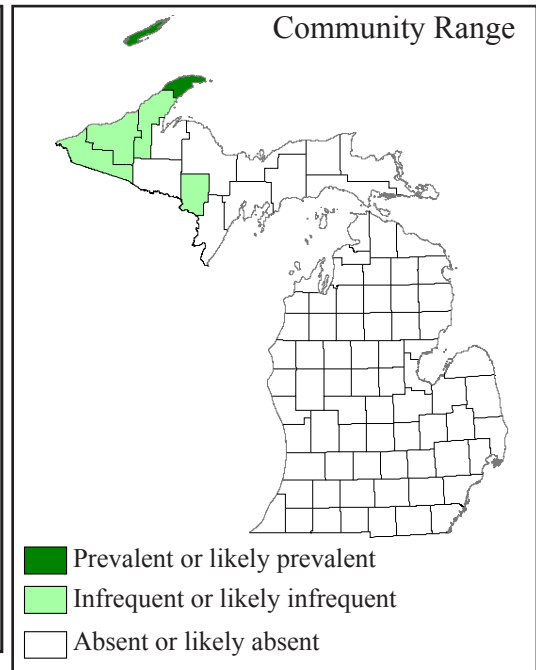




Photo by Michael A. Kost



Overview: Volcanic bedrock glade is a savanna or open forested community that occurs where there are exposures of basaltic bedrock and conglomerates composed of volcanic rocks. The characteristically sparse vegetation has scattered shrubs or shrub thickets and a partial turf of herbs, grasses, sedges, mosses, and lichens growing beneath a canopy of scattered open-grown trees. The community occurs in the western Upper Peninsula on Isle Royale and the Keweenaw Peninsula, extending southwest from Keweenaw County into Houghton, Ontonagon, and Gogebic Counties. Volcanic bedrock glade supports plant species with both alpine and arctic distributions (Given and Soper 1981).

Global/State Rank: GU/S2

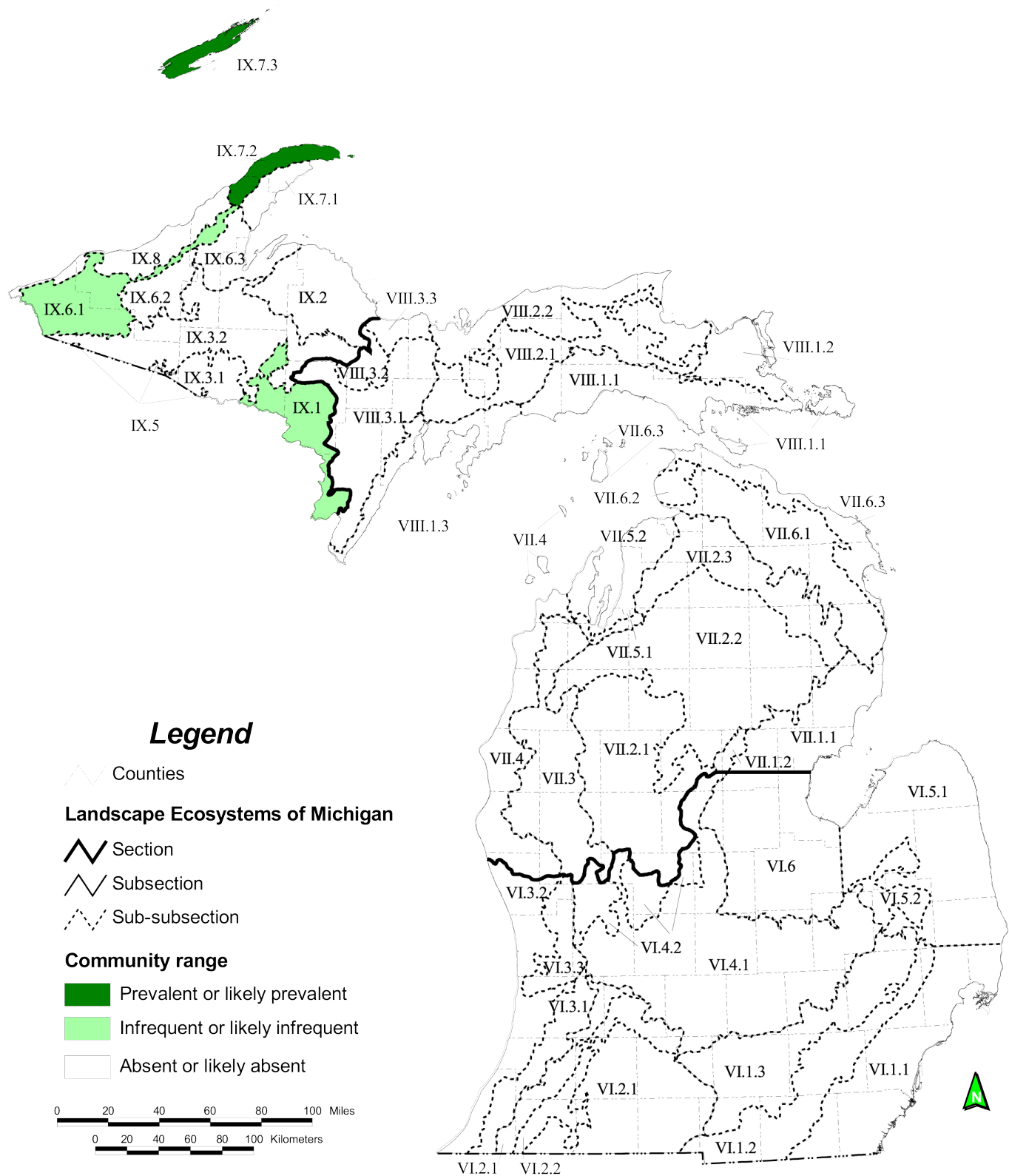
Range: This community occurs where volcanic rock is exposed near the Lake Superior shoreline, including Isle Royale and the Keweenaw Peninsula in Michigan, as well as along the shoreline in Ontario and Minnesota. In Ontario, Oldham (2006) identifies sites where the arctic-alpine flora occurs along the Great Lakes shoreline, and it is assumed that volcanic bedrock glade occurs here as well, just inland from the more open volcanic bedrock lakeshore. Ontario sites near Lake Superior that may support volcanic bedrock glade 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 (based on reports by Bakowsky 1998, 2002; Oldham 2006). In Minnesota, coastal volcanic bedrock occurs on the mainland and on Susie Island and other nearby small islands (The Nature Conservancy of Minnesota 1988), and volcanic bedrock glade is assumed to also be present. In Michigan, volcanic bedrock glade is prevalent in Subsections IX.7.2 (Calumet) and IX.7.3 (Isle Royale) and is locally common in Sub-subsection IX.6.1 (Gogebic-Penokee Iron Range) (Albert 1995, Albert et al. 2008, MNFI 2009).

Rank Justification: Volcanic bedrock glades were 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 natural community surveys (TNC 1988, Bakowsky 1998, 2002, Oldham 2006).

Physiographic Context: Bedrock of the Keweenaw Peninsula and Isle Royale was formed from 1,100 to 1,000 million years ago, during the Late Precambrian, a period characterized by extensive surface volcanic activity (Dorr and Eschman 1970, Reed and Daniels





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



1987, Bornhorst and Rose 1994, LaBerge 1994, Lillie 2005). Basaltic lavas flowed out through long fissures in the earth's surface, covering the land with thick lava deposits called flood basalt (Huber 1983). Similar volcanic deposits formed in other continental rifts, such as the Basin and Range in the western U.S. and east Africa (Lillie 2005). The Keweenaw rock deposits were up to 15.5 miles thick, and their huge mass caused them to sag and form a structural basin, now occupied by Lake Superior (Dorr and Eschman 1970). The sagging caused the volcanic rock of the Keweenaw Peninsula to tilt steeply downward to the north toward the center of the Lake Superior. The volcanic rock of Isle Royale's south shore tilted steeply south toward the center of Lake Superior. The contrasting south shore of the Keweenaw Peninsula and north shore of Isle Royale form steep cliffs. Basalt and conglomerate bedrock tilt about 40 degrees from horizontal, creating a landscape where vegetation cover is often sparse and unstable. Volcanic bedrock glades typically occupy exposed bedrock knobs, which may include areas of steep to stair-stepped slopes and short cliffs. The community is found both inland and adjacent to the Lake Superior shoreline. The forest types adjacent to volcanic bedrock glade are typically dry-mesic northern forest or mesic northern forest and along the Lake Superior shoreline, boreal forest. In addition to boreal forest, coastal volcanic bedrock glade is associated with volcanic bedrock lakeshore, volcanic cobble shore, volcanic lakeshore cliff, and sand and gravel beach (Kost et al. 2007, MNFI 2009).



Photo by Joshua G. Cohen

Volcanic bedrock glade with stair-stepped topography.

Continental glacial ice sheets covered the landscape until about 10,000 years ago, leaving large areas of bedrock devoid of soil. Large areas remain devoid of soil, supporting only lichens and mosses. Locally, thin organic soil has developed in pockets and cracks within the volcanic rock. The prevalent rock formations on both Isle Royale and the Keweenaw Peninsula are Precambrian-age Copper Harbor Conglomerates and Portage Lake Volcanics, formed from vast sheets of flowing lava interbedded with thin layers of conglomerate (Dorr and Eschman 1970, Bornhorst and Rose 1994). The conglomerate is formed from both pebbles and cobbles, reflecting different stream velocities. Basalt, the predominant bedrock of the glades, ranges from medium acid to mildly alkaline in pH.

Natural Processes: Erosion, windthrow, desiccation, and fire are all important natural processes influencing volcanic bedrock glade communities. Erosion of the surface rock results in accumulation of loose rocks (talus) at the base of slopes. The combination of thin soils and strong winds off Lake Superior results in numerous windthrown trees. Vegetation is especially prone to desiccation due to thin soils, cold winter temperatures, steady winds, and summer droughts. Rain on sloping bedrock outcrops quickly runs off to lower elevations, further contributing to dry conditions and removing accumulated plant debris that could otherwise initiate soil formation. Glades are subject to both lightning and human-caused fires. Super-canopy white pines and red pines are prime targets for lightning-strikes during Lake Superior storms. The susceptibility of these glades and adjacent forests to fire was demonstrated by lightning fires that struck during the dry summer of 2007 and burned large areas at the north end of the Keweenaw Peninsula (Joshua Cohen, personal communication). Some of the glades on Isle Royale have known fire history (The Nature Conservancy 1999). Crown fires likely occur within volcanic bedrock glades, especially where conifers have branches that extend to the ground, a trait characteristic of both jack pine and red pine on low-productivity bedrock sites. Glades are focal points for contemporary and historic human gathering due to open structure and elevated position above Lake Superior. Such gatherings continue to foster escaped campfires.





Photo by Joshua G. Cohen

Fire is an important component of the natural disturbance regime of volcanic bedrock glades.

Vegetation Description: On the Keweenaw Peninsula, vegetation cover ranges from nearly absent on exposed outcrops of basalt or conglomerate to dense where soil has accumulated on talus or in joints and depressions (Albert et al. 1997a and 1997b). The overstory is dominated by white pine (*Pinus strobus*), red pine (*P. resinosa*), jack pine (*P. banksiana*), paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), mountain-ash (*Sorbus decora*), and red oak (*Quercus rubra*). The same trees dominate on Isle Royale, with coverages ranging from 5 to 60 percent (Nature Conservancy 1999). On Isle Royale, the canopy is kept open by moose browsing, as moose heavily browses both balsam fir and mountain-ash. Paper birch – white spruce glade or woodland also occurs on steep talus slopes.

Common shrubs include bearberry (*Arctostaphylos uva-ursi*), bush honeysuckle (*Diervilla lonicera*), creeping juniper (*Juniperus horizontalis*), common juniper (*J. communis*), trailing arbutus (*Epigaea repens*), wild rose (*Rosa acicularis*), soapberry (*Shepherdia canadensis*), blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), Canada bilberry (*V. membranaceum*), thimbleberry (*Rubus parviflorus*), mountain ash (*Sorbus decora*), and serviceberry (*Amelanchier* spp.). On Isle Royale, steep talus slopes support abundant yew (*Taxus canadensis*) and dwarf raspberry (*Rubus pubescens*), with steep, rocky conditions probably reducing grazing pressure by moose on yew. The shrub layer of volcanic

bedrock glade is quite variable, ranging from sparse to dense, probably because of its fire history and differences in soil development.

Common grasses on volcanic bedrock glade are poverty grass (*Danthonia spicata*), hair grasses (*Deschampsia flexuosa* and *D. cespitosa*), and rough-leaved rice grass (*Oryzopsis asperifolia*). Common forbs include cow-wheat (*Melampyrum lineare*), twinflower (*Linnaea borealis*), harebell (*Campanula rotundifolia*), wild strawberry (*Fragaria virginiana*), yarrow (*Achillea millefolium*), bastard toad-flax (*Comandra umbellata*), red honeysuckle (*Lonicera dioica*), large-leaved aster (*Aster macrophyllus*), and Canada mayflower (*Maianthemum canadensis*). Bracken fern (*Pteridium aquilinum*) can also be common. Isle Royale shares almost all of these herbs with the mainland (Nature Conservancy 1999). Lichens (e.g., *Cladina* spp. and *Usnea* spp.) and mosses (e.g., *Polytrichum* spp.) are typically abundant to locally dominant.

Invasive Plants: Spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.).

Michigan Indicator Species: White pine (*Pinus strobus*), red pine (*P. resinosa*), jack pine (*P. banksiana*), paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), red oak (*Quercus rubra*), bearberry (*Arctostaphylos uva-ursi*), creeping juniper (*Juniperus horizontalis*), common juniper (*J. communis*), trailing arbutus (*Epigaea repens*), wild rose (*Rosa acicularis*), soapberry (*Shepherdia canadensis*), blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), Canada bilberry (*V. membranaceum*), thimbleberry (*Rubus parviflorus*), serviceberries (*Amelanchier* spp.), poverty grass (*Danthonia spicata*), hair grasses (*Deschampsia flexuosa* and *D. cespitosa*), rough-leaved rice grass (*Oryzopsis asperifolia*), cow-wheat (*Melampyrum lineare*), twinflower (*Linnaea borealis*), harebell (*Campanula rotundifolia*), bastard toad-flax (*Comandra umbellata*), large-leaved aster (*Aster macrophyllus*), bracken fern (*Pteridium aquilinum*), lichens (*Cladina* spp. and *Usnea* spp.), and mosses (*Polytrichum* spp.).





Volcanic bedrock glade is an open forested or savanna community found where basaltic bedrock and conglomerates are exposed. The sparse vegetation consists of scattered open-grown trees, scattered shrubs and shrub thickets, and a partial turf of herbs, grasses, sedges, mosses, and lichens. Photos by Joshua G. Cohen.



Other Noteworthy Species: Ants are quite abundant in this dry, thin-soiled environment. Black bears use the habitat, possibly because of the abundance of ants, other insects, and wild fruit.

Rare Animals: Moose (*Alces americanus*, state special concern), large marble (*Euchloe ausonides*, state special concern), peregrine falcon (*Falco peregrinus*, state endangered), and northern blue butterfly (*Lycaeides idas nobokovi*, state threatened).

Rare Plants: Rosy pussytoes (*Antennaria rosea*, presumed extirpated from Michigan), heart-leaved arnica (*Arnica cordiformis*, state endangered), pale Indian paintbrush (*Castilleja septentrionalis*, state threatened), wild lilac (*Ceanothus sanguineus*, state threatened), shortstalk chickweed (*Cerastium brachypodum*, state threatened), Douglas's hawthorne (*Crataegus douglasii*, state special concern), American rock-brake (*Cryptogramma acrostichoides*, state threatened), alpine clubmoss (*Diphasiastrum alpinum*, presumed extirpated from Michigan), blue lettuce (*Lactuca pulchella*, presumed extirpated from Michigan), big-leaf sandwort (*Moehringia macrophylla*, state threatened), Franklin's phacelia (*Phacelia franklinii*, state threatened), and prairie buttercup (*Ranunculus rhomboideus*, state threatened).

Conservation and Biodiversity Management: Off-road vehicles or excessive foot traffic can easily destroy the thin soils and lichen cover of the glades. Seasonal cabins are common within the glades, resulting in the introduction of fill for septic systems, foundations, and driveways, all increasing habitat for invasive plants. Invasive plants that may threaten diversity and community structure in volcanic bedrock glades include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.).

Monitoring and control efforts to detect and remove invasive species will help maintain the native biodiversity of volcanic bedrock glade and surrounding natural communities. Because thin soils and slow-growing lichen and moss cover are sensitive to anthropogenic disturbance and recover slowly, conservation efforts should focus on preserving the ecological integrity of existing high-quality volcanic

bedrock glades. Open conditions within glades can be maintained by allowing wild fires to move through the community where safety permits. Prescribed fire management should be considered for both bedrock glades and adjacent dry-mesic forests.

Research Needs: Further study of the mosses and lichens of the volcanic bedrock glade is warranted, as documented by the work of Reschke (1985) on the nearby volcanic bedrock lakeshores. She not only documented their floristic importance, but also identified potential rare taxa. There are also opportunities within volcanic bedrock glades for studying 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.

Variation: Recent studies indicate that glades on Isle Royale are more often dominated by white spruce and balsam fir than the Keweenaw Peninsula sites, with quaking aspen dominant on more recently burnt sites, and paper birch and white spruce on steep talus slopes (The Nature Conservancy 1999). There may also be vegetation differences between volcanic bedrock glades that grow on different volcanic bedrock types (basalt, rhyolite, or volcanic conglomerate), as well as differences between sites near the Lake Superior shoreline and farther inland.

Similar Communities: Northern bald, granite bedrock glade, limestone bedrock glade, dry-mesic northern forest, boreal forest, volcanic bedrock lakeshore, and granite bedrock lakeshore. Northern bald is a similar plant community growing on the climatically extreme exposed bedrock at the highest elevations on the Keweenaw Peninsula and stretching southwest into Gogebic County.

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.

II.A.4.N.a. Pinus (Banksiana, Resinosa) Woodland; Pinus banksiana – (Picea mariana, Pinus strobus)/ Vaccinium spp. Rocky Woodland; Jack Pine – (Black Spruce, White Pine)/Blueberry species Rocky Woodland.

II.A.4.N.b. Picea Glauca Woodland; Picea glauca – (Betula papyrifera)/Danthonia spicata Woodland; White Spruce – (Paper Birch)/Poverty Grass Woodland.

II.A.4.N.b. Picea Glauca Woodland; Picea glauca – Abies balsamea Basalt (Conglomerate) Woodland; White Spruce – Balsam Fir Basalt (Conglomerate) Woodland.

II.C.3.N.a. Picea Glauca - Betula Papyrifera Woodland [Provisional]; Betula papyrifera – Picea glauca/Acer spicatum – Alnus viridis/Polypodium vulgare Talus Woodland [Provisional]; White Spruce – Paper Birch/ Mountain Maple – Mountain Alder/Common Polypody Talus Woodland [Provisional (Nature Conservancy 1999)].

III.B.3.N.a. Juniperus communis – (Quercus rubra)/ Juniperus horizontalis – Arctostaphylos uva-ursi Shrubland; Juniperus communis shrubland; Common Juniper – (Red Oak)/Creeping Juniper – Bearberry Shrubland.

Related Abstracts: Peregrine falcon, northern blue butterfly, volcanic bedrock lakeshore, granite bedrock glade, limestone bedrock glade.

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Photo by Joshua G. Cohen

Volcanic bedrock glade, Keweenaw Peninsula, Michigan.



Photo by Joshua G. Cohen

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