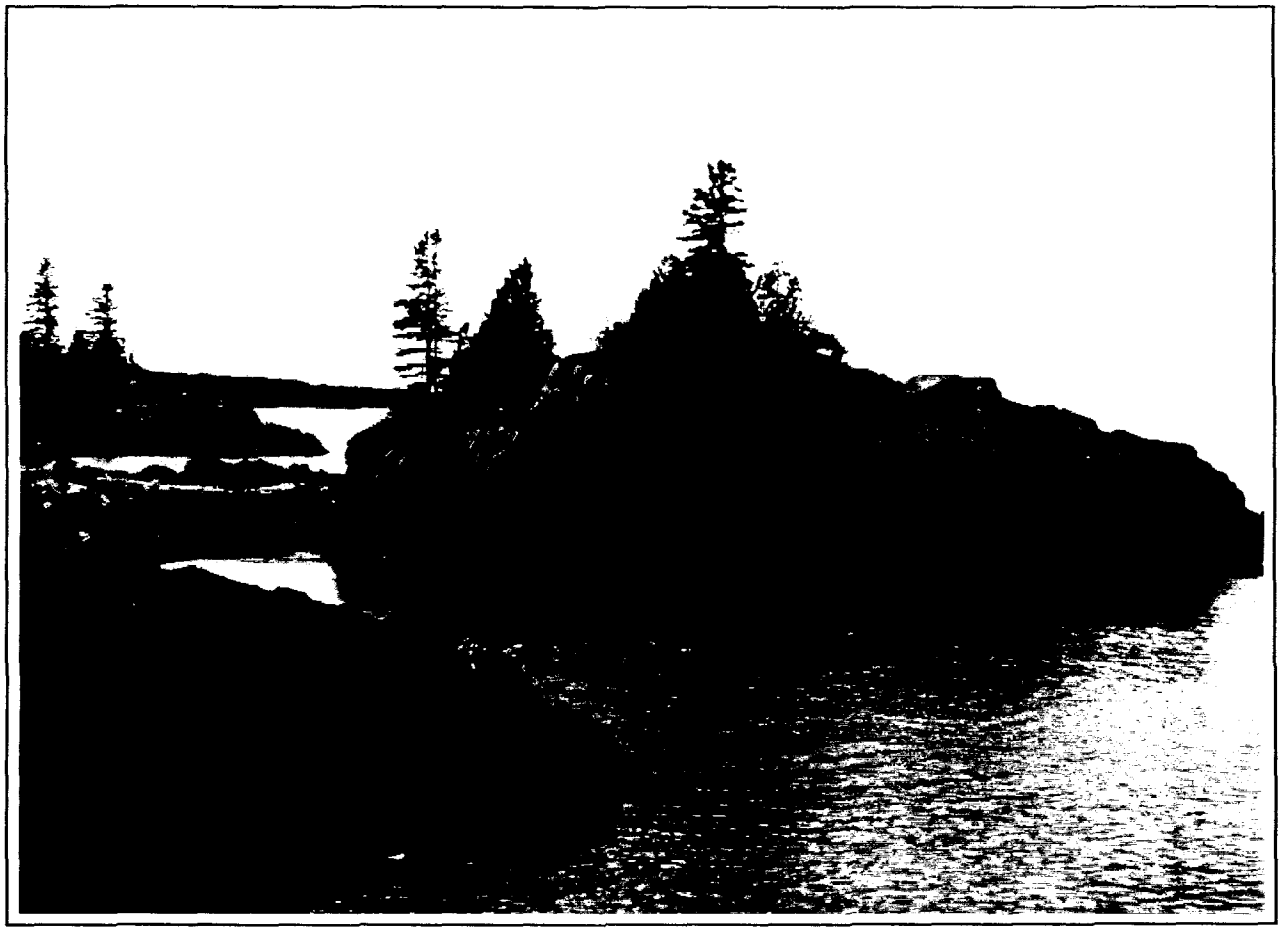
Bedrock Shoreline Surveys of the Keweenaw Peninsula and Drummond Island in Michigan's Upper Peninsula



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ABSTRACT

Bedrock is exposed along large portions of the shoreline of the Great Lakes, especially in the Upper Peninsula, where it supports significant biological diversity and provides incomparable scenic beauty. Increasingly the large portions of the Great Lakes shoreline are becoming inaccessible to the public as a result of residential development. In this study we inventoried portions of the coastal bedrock, both in response to extreme development pressure and because of the significant biological diversity that characterizes much of the coastal bedrock. This report summarizes the results of 1994 inventories along the Lake Superior shoreline of the Keweenaw Peninsula and the Lake Huron shoreline of Drummond Island.

Differences in bedrock result in strikingly different shorelines with equally distinctive floras and faunas. In this survey, we have concentrated on the bedrock of the Keweenaw Peninsula, with surveys of the volcanic bedrock (Portage Lake Volcanics, Copper Harbor Conglomerate), Freda Sandstone, and Nonesuch Shale, and the Silurian- and Ordovician-aged dolomite of Drummond Island. Basic characteristics of these bedrock types are described within the report.

While most of our sampling was conducted in one natural community, **bedrock beach**, sampling was also conducted on **bedrock glade**, **cobble beach**, and **bedrock cliffs**. The greatest diversity of rare plants occurs on bedrock beach, but bedrock glade also contains many rare plant species. Diversity was much lower on cobble beach and bedrock cliffs. It is expected that faunal diversity will be highest on bedrock beach and glade.

The entire shorelines of both the Keweenaw Peninsula and Drummond Island were photo-interpreted in preparation for the field surveys. Aerial reconnaissance was conducted to further evaluate sites and to photograph portions of the shoreline. Sampling of the vegetation of bedrock beach sites followed to collect data for the improvement of MNFI's community classification. Surveys of rare species were also conducted, with intensive inventory of rare plants on both the Keweenaw Peninsula and Drummond Island, and preliminary inventory of insects on Drummond Island.

The surveys resulted in the discovery of many new sites for both rare plants and high quality bedrock beach. Several new bedrock glades were discovered, which added to our understanding of this under-studied plant community. Identification of insect specimens from the surveys is ongoing.

The surveys demonstrated the urgency for conservation action on the bedrock shoreline of the Keweenaw Peninsula. Portions of four high-priority sites have been platted by the owner, Lake Superior Land Company, within the last two years, including Sevenmile Point, Silver Island, Devil's Washtub and Horseshoe Harbor. **Sevenmile Point, Devil's Washtub, and portions of Horseshoe Harbor are the highest priority sites for conservation action.** The southeastern end of the Keweenaw Peninsula is now much more accessible than in the past because of recent road improvements by Lake Superior Land Company, signaling that residential development is also likely in the near future for portions of five other survey sites: High Rock North, Keweenaw Point, Keystone Bay, Fish Cove, and Bete Grise-Bear Bluff. All of these are large, intact sites that could be pursued as state or federal wilderness areas. Several other Keweenaw sites have intact shorelines with some residential development and multiple ownerships. These are important sites, but do not require immediate pursuit. They include Dans Point, Norland Trust, and Agate Harbor-Lake Glazon. A significant site on the Freda Sandstone cliffs is Portage Lake Ship Canal West.

Of the several high quality bedrock shoreline sites on Drummond Island, acquisition is already complete or being pursued by either The Nature Conservancy or the Michigan Nature Association. Two important acquisitions being pursued are Chippewa Point and Grand Marais Lake at the northern end of Maxton Plains. Other important sites for future acquisition on the south shore of the island include Huron Bay and Seamans Point, but these are under less imminent threat than Keweenaw Peninsula sites.

Pursuit of ecologically significant Great Lakes coastal tracts should be among the highest priorities of conservation organizations within the Great Lakes region. Immediate pursuit of rapidly disappearing, high quality coastal tracts is critical.

Acknowledgments

We would like to thank the Coastal Zone Management Program of the Land and Water Management Division, Michigan Department of Natural Resources, and The Nature Conservancy for providing funding for this study. Special thanks go to Theodore J. Bornhorst, professor of geology at Michigan Technological University, who invited D. Albert to attend the field trip of the Keweenaw Peninsula which was part of the 40th annual meeting of the Institute on Lake Superior Geology. He also provided access to both published and manuscript maps of the bedrock exposures of Ontonagon, Houghton, and Keweenaw Counties; these maps proved invaluable for this study. Dr. Allan M. Johnson of Michigan Tech also provided invaluable references on the paleozoic bedrock of Drummond Island. Dr. Ted Cline of Photair provided equally invaluable assistance by flying, photographing, and videographing the shoreline of the Keweenaw Peninsula. Carol Reschke, whose Master's thesis describes the vegetation of the conglomerate shoreline of the Keweenaw Peninsula, assisted us with the sampling of vegetation on the Keweenaw, providing us with many insights. We also enjoyed the hospitality of her family's cottage during our fieldwork. Thanks also go to Kathy Schneider of the New York Heritage Program, for allowing Carol Reschke to work in Michigan; hopefully her flexibility will prove to be of benefit to both programs. Dennis Sotala provided us with information on best routes to survey sites, and provided us with a history of past survey work on parts of the peninsula. Several entomologists provided identifications of insects, including G. M. Fauske of North Dakota State University for Lepidoptera and Orthoptera, K.G.A. Hamilton of Agriculture Canada for the Cicadellidae in part, P.K. Lago of the University of Mississippi for the Scarabaeidae, D.A. Rider of North Dakota State University for the Pentatomidae, E.G. Riley of Texas A&M University for the Chrysomelidae, M.D. Schwartz of Agriculture Canada for the Miridae, D.F. Schweitzer of the Eastern Regional office of The Nature Conservancy for the *Papaipema*, and S.W. Wilson of Central Missouri State University for the Fulgoroidea.

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INTRODUCTION

Bedrock is exposed along large portions of the shoreline of the Great Lakes, especially in the Upper Peninsula. Rugged bedrock shoreline provides some of the most beautiful views of the Great Lakes. Recreational activities along the coast are many, but increasingly the shores of the Great Lakes are being locked up from public access by private residential development. In this study we inventoried portions of the coastal bedrock, both in response to extreme development pressure and because of the significant biological diversity that characterizes much of the coastal bedrock. This report summarizes the results of 1994 inventories along the Lake Superior shoreline of the Keweenaw Peninsula and the Lake Huron and Potagannissing Bay shoreline of Drummond Island.

Plates 1-5 illustrate the major bedrock types sampled during this study and also include several of the special plants associated with basaltic and dolomitic bedrock. Photos are also included in the site summary for many of the significant survey sites.

BEDROCK TYPES

Differences in bedrock result in strikingly different shorelines with equally distinctive floras and faunas. For this reason, bedrock surveys concentrated on sections of shoreline with distinctively different bedrock types. In this, the first year of a three-year survey, we have concentrated on the bedrock of the Keweenaw Peninsula, with surveys of the volcanic bedrock and portions of the Freda Sandstone and Nonesuch Shale, and the dolomite of Drummond Island. Basic characteristics of these bedrock types are described below.

Bedrock of the Keweenaw Peninsula.

The bedrock of the Keweenaw Peninsula, as all of the western Upper Peninsula, consists of older Precambrian bedrock of the Canadian Shield. The bedrock of the Keweenaw Peninsula was deposited during the Late Precambrian, a period of extensive surface volcanic activity. The Keweenaw Peninsula is on the margin of the Lake Superior segment of the Midcontinent rift system, which extends northeasterly from Kansas to Lake Superior and then southeasterly through lower Michigan (Figure 1, from Bornhorst and Rose 1994). The rift beneath Lake Superior is filled with thick deposits of volcanic rock, on which were deposited thick layers of clastic sedimentary rocks.

The mass of the thick Keweenawan rocks, which reach 25 km in thickness, caused the Lake Superior Syncline to sag farther, forming a structural basin which Lake Superior now occupies. The layers of basalt and interbedded conglomerates and other sediments tilted as the syncline sagged; these layers now dip downward toward the northwest at an average angle of about 40 degrees from horizontal. The Keweenawan rock consists of about 400 distinct lava flows or "traps" with 20 to 30 interbedded conglomerate and sandstone layers (Dorr and Eschman 1984). Above these lavas are the thick **Outer Conglomerate** (**Copper Harbor Conglomerate**), and above the conglomerate, the **Nonesuch Shale** and **Freda Sandstone**.

The thick volcanic rocks in the rift include about 10 km of Portage Lake Volcanics (Figure 2). The **Portage Lake Volcanics** of the Keweenaw Peninsula erupted on land over a 2 to 3 million year period, about 1095 million years ago. The thick lava flows of the Portage Lake Volcanics are basaltic type lava that were deposited from vents toward the southeast (Dorr and Eschman 1984). The Portage Lake Volcanics consists of more than 200 basaltic lava flows with total exposed thickness of 2500 to 5200 m on the Keweenaw Peninsula (Bornhorst and Rose 1994). The lava beds appear to have originated from fissures and cracks in the surface of the downwarped area of the Lake Superior Syncline (now the center of Lake Superior), and then flowed outward toward the margins of the basin. Interbedded with the lava beds are thin layers of conglomerate, consisting of pebbles and cobbles deposited from the margins of the basin by streams (White 1960).

Thick deposits of rift-filling clastic sedimentary rocks overlie the volcanic rocks (Figure 1). These sedimentary rocks were deposited during a period of reduced volcanic activity, during which

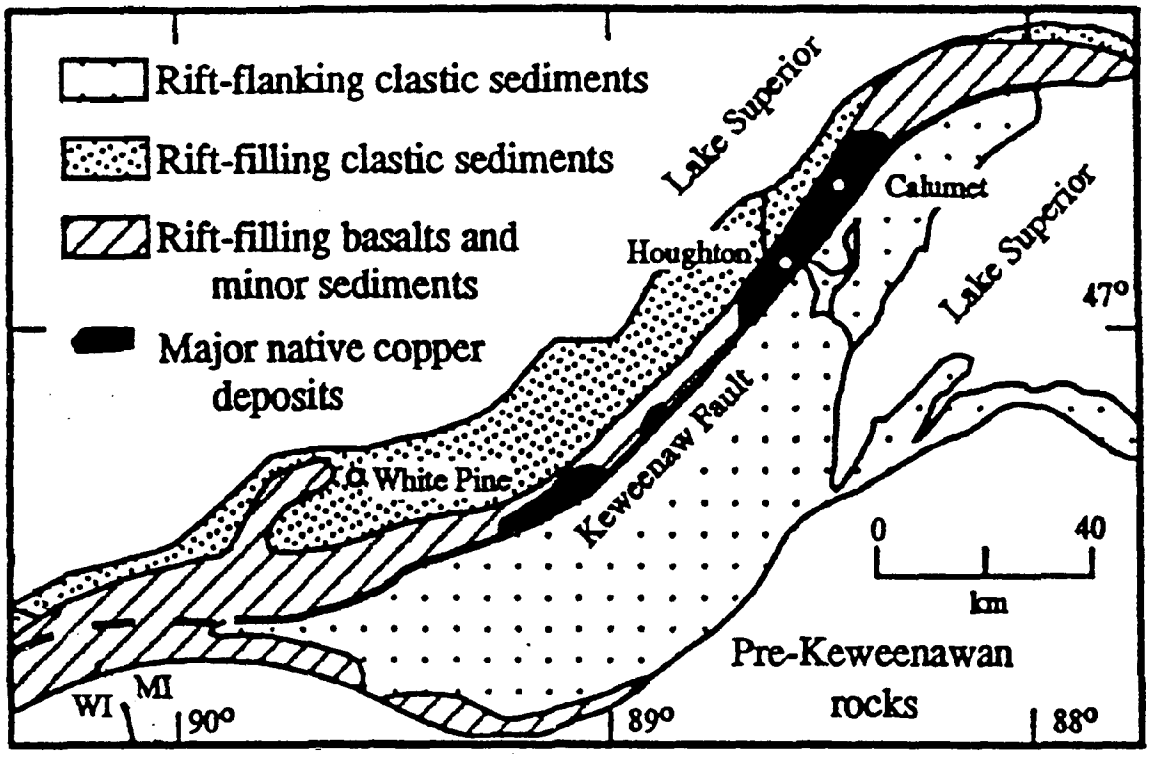


Figure 1. Bedrock history of the Keweenaw Peninsula (from Bornhorst and Rose 1994).

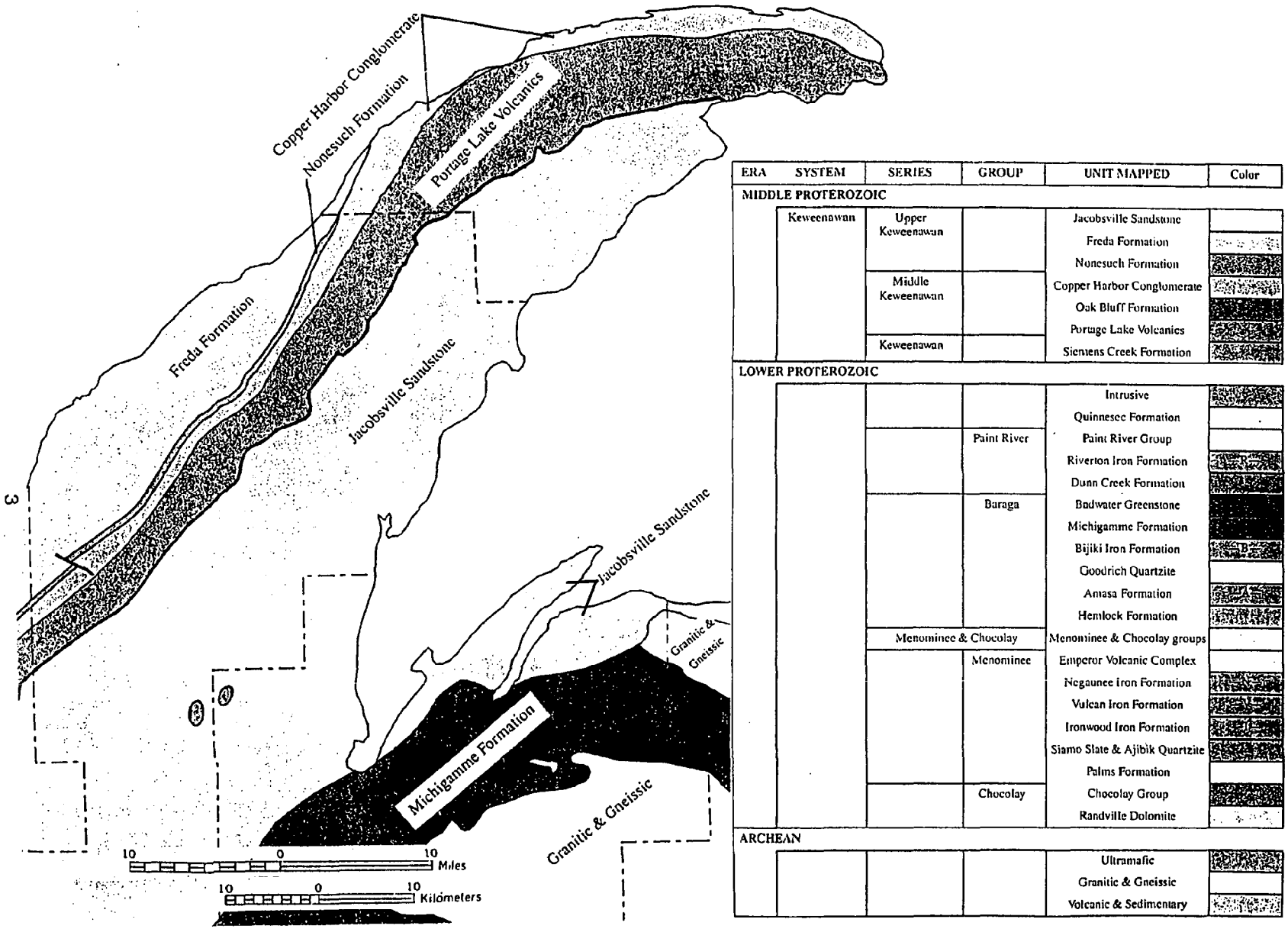


Figure 2. Bedrock of the Keweenaw Peninsula (from Reed and Daniels 1987).

the rift basin continued to subside. Up to 8 km of clastic sedimentary rocks occur beneath Lake Superior, with maximum exposure of 6 km on the Keweenaw Peninsula and other nearby portions of Michigan's Upper Peninsula along Lake Superior.

The distinctive clastic bedrocks exposed on the Keweenaw Peninsula include, in order of deposition, the red-colored conglomerates of the Copper Harbor Conglomerate, the thin gray to black Nonesuch Shale, the fine red-colored Freda Sandstone, and the red-colored **Jacobsville Sandstone** (Figure 2). The first three are rift-filling sedimentary rocks, whereas the Jacobsville Sandstone is from a later rift-flanking sedimentary period, and is restricted to the southeastern shore of the Keweenaw Peninsula. The sediments were eroded from the highlands in the southeast, into the rift to the northwest.

The more erosion-resistant basalts and conglomerates in the middle part of the Keweenawan Series form the long, high, central plateau of the Keweenaw Peninsula. The **Copper Harbor Conglomerate**, which also includes lava flows, forms the broad bedrock shoreline of the north half of the Keweenaw Peninsula, from west of Eagle River to near High Rock Bay at the far eastern point of the peninsula, whereas the **Portage Lake Volcanics**, consisting primarily of dense basaltic lavas, forms the narrower bedrock of the southern shoreline of the Keweenaw, east from Lac La Belle to High Rock Bay.

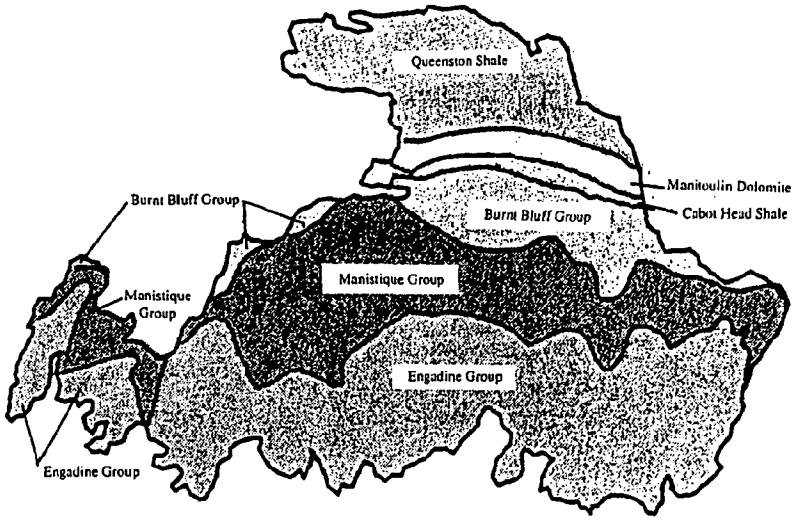
Nonesuch Shale is limited primarily to small exposures along the shoreline between Eagle Harbor and the Portage Shipping Channel. Nonesuch Shale is a succession of siltstones, shales, carbonate laminates, and sandstones (Bornhorst and Rose 1994). Three assemblages are recognized, a marginal lacustrine assemblage consisting of a sandflat-mudflat complex, a lacustrine assemblage that ranged from oxic in shallow areas to anoxic in deeper areas, and a lacustrine to fluvial assemblage. The maximum thickness is 215 m, but on the Lake Superior shoreline of the Keweenaw Peninsula, exposures are generally quite thin and localized. These exposures are subject to too much wave action to support a distinctive plant community. Most of the exposures viewed during this survey were surrounded by pebble and cobble beach and supported almost no plants.

Freda Sandstone forms low cliffs from south of the Portage Shipping Channel to a few miles southwest of the small copper mining town of Freda. These cliffs reach to 60 feet in height, with smooth sculpted surfaces of fine, oxidized red and reduced blue-green sandstone. The Freda Sandstone is a cyclic succession of iron red sandstone, siltstone, and mudstone overlying and grading into Nonesuch Shale (Bornhorst and Rose 1994). Primarily fluvial in origin, Freda Sandstone deposits are over 3700 m thick.

Basaltic lavas (basalt) consist of relatively heavy, dark, finely crystalline rock rich in iron-bearing minerals. Basalt's fine texture is the result of rapid cooling. The basalts occur in subaerial lava flow averaging 10 to 20 m in thickness, but range from 1 to 450 m thick (Paces 1988, White 1960, referenced in Bornhorst and Rose 1994). At the surface of the lava flows, cooling occurred quickly and bubbles of enclosed gas were entrapped, forming small cavities called *vesicles*. *Vesicular lava* or *vesicular basalt* are the terms applied to rocks in which cavities are numerous. The rocks in which these cavities are later filled with secondary minerals such as calcite or copper are termed *amygdaloidal basalt* or *lava*. The hydrothermal fluids that flow through the vesicular lavas and between the lava flows introduce a wide variety of secondary minerals.

Locally felsic domes of reddish **rhyolite** occur within the Portage Lake Volcanics along the southeastern shore of the Keweenaw Peninsula, midway between Keweenaw Point at the east end of the peninsula, and Lac La Belle to the west. Rhyolite is a fine-grained, light-colored (reddish) rock low in iron and magnesium-bearing minerals. There are only three exposures of rhyolite along the shoreline, Fish Cove Knob, Fish Cove Dike less than a kilometer to the west, and Bare Hill 5 to 6 kilometers farther west. These rhyolite exposures are highly resistant to erosion and typically form a steep, rugged shoreline (Bornhorst and Rose 1994).

Our biological exploration in 1994, which did not include faunal surveys, was restricted to the Portage Lake Volcanics, Copper Harbor Conglomerate, Nonesuch Shale, and Freda Sandstone. No large, vegetated exposures of Nonesuch Shale were found.



ERA	SYSTEM	SERIES	GROUP	UNIT MAPPED	Color
PALEOZOIC					
	Devonian			Berea Sandstone	
				Bedford Shale	
				Berea Sandstone & Bedford Shale	
				Ellsworth Shale	
		Chautauquan		Antrim Shale	
		Erian	Traverse	Traverse Group	
				Bell Shale	
				Dundee Limestone	
		Ulsterian	Detroit River	Detroit River Group	
				Sylvania Sandstone	
				Mackinac Breccia	
				Bois Blanc Formation	
				Garden Island Formation	
	Silurian	Cayugan	Bass Islands	Bass Islands Group	
			Salina	Salina Group	
				Saint Ignace Dolomite	
				Point aux Chenes Shale	
		Niagaran	Engadine	Engadine Group	
			Manistique	Manistique Group	
			Burnt Bluff	Burnt Bluff Group	
		Alexandrian	Cataract	Cabot Head Shale	
				Manitoulin Dolomite	
	Ordovician	Cincinnatian	Richmond	Queenston Shale	
				Big Hill Dolomite	
				Stonington Formation	
				Utica Shale Member	
				Collingwood Shale Member	
		Mohawkian	Trenton	*Trenton Group*	
			Black River	Black River Group	
			Prairie du Chien	Prairie du Chien Group	
	Cambrian	*St. Croixan*	*Lake Superior*	*Trempealeau Formation*	
				Munising Formation	
				Inferred Contact	
				Fault	

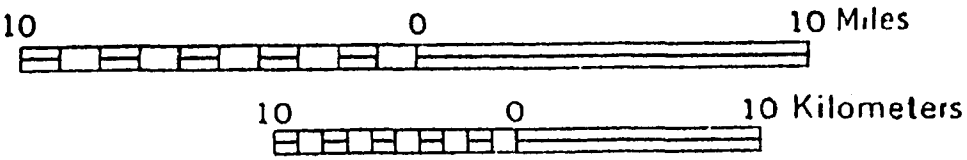


Figure 3. Bedrock of Drummond Island (modified from Reed and Daniels [1987]).

Bedrock of Drummond Island.

The surface bedrock deposits of Drummond Island are from the Ordovician and Silurian Periods (Figure 3, from Reed and Daniels, 1987), during which marine waters covered the MichiganBasin. The Michigan Basin includes all of the Lower Peninsula and the eastern half of the Upper Peninsula of Michigan. The Ordovician and Silurian Periods were characterized by extensive, shallow seas. The Ordovician bedrock of the Upper Peninsula of Michigan consisted of a broad range of sedimentary bedrock, including nearshore deposits of sandstone and shale and marine deposits of limestone and dolomite (Dorr and Eschman 1984). During the Silurian Period, the waters covering much of the state were deep enough that only chemical precipitates were deposited in much of the basin. At the shallower margins of the basin reefs formed. Extensive reefs formed during the Middle Silurian; these reefs form the resistant Niagaran escarpment along the northern shore of Lake Michigan and Lake Huron, of which Drummond Island is part.

Most of Drummond Island consists of Silurian dolomite (Recent geological terminology uses the term **dolostone** to describe the rock, reserving the term dolomite for the mineral.), but older Ordovician bedrock, the **Queenston Shale of the Richmond Group**, is exposed in the northern quarter of the island.

Although the Ordovician bedrock in the north is considered part of the Queenston Shale, all of the exposures consist of dolomite or limestone. Ehlers (1973), who extensively studied the Paleozoic bedrock of the Upper Peninsula, clarifies that although the type location of Queenston Shale in Ontario consists of thick deposits of red shale, rocks deposited during the same time period on Drummond Island are dolomite. At the north end of the island, shelves of bedrock, which appear to be sandy limestone or dolomite, extend out into the North Channel. Along the north shore there are also low cliffs of coral-rich dolomite, which forms blocky, cobble beach where it has been eroded by storm waves. Ehlers describes sandy dolomites with silicified corals, bryozoa, brachiopods, and other marine organisms from south of Raynolds Point. Similar dolomite cliffs and cobble beack of angular dolomitic rock fragments occur near Poe Point, about 3 miles to the northwest.

On Drummond Island the Silurian bedrock consists of a narrow band of Alexandrian Series (Early Silurian) bedrock in the north, with a broad band of Niagaran Series dolomites forming the southern two-thirds of the island (Figure 3). The Niagaran Series in Michigan consists almost entirely of limestone and dolomite; there is almost no shale or other bedrock types included (Ehlers 1973). The thickness of the Niagaran beds is between 820 and 936 feet to the west near St. Ignace. The Niagaran bedrock has a very gentle dip of 40 to 60 feet per mile toward the southern peninsula of Michigan, the center of the Michigan Basin.

The Niagaran Series is well represented on Drummond Island. An escarpment of the **Manistique and Burnt Bluff strata** of the Niagaran Series crosses Drummond Island from Drummond village to Marble Head and **Engadine dolomite** forms a pavement which is exposed along long sections of the south shore of Drummond Island. Engadine dolomite is extensively mined on the west end of Drummond Island. On Huron Bay, low shelves of dolomite form the shoreline, but elsewhere along the south shore, exposures of bedrock are generally quite flat. Weathering has left a pocked surface on the exposed dolomite along the shore. A veneer of locally derived dolomite cobbles of varying thickness occurs along large stretches of the shoreline.

The dolomite of Drummond Island is not uniform in character. Some of it consists of massive, fossil-rich reef formation, while other rock is thinly-bedded, with few or no fossils. Ehlers (1973) credits the rarity of fossils to shallow conditions, possibly with frequent exposures of the bottom to air. He also comments that deep water reefs, also common in northern Michigan, can be low in faunal diversity.

Surveys of plant communities and plants were conducted along the south shore of Drummond Island on Engadine dolomite, and on dolomitic portions of the Queenston Shale formation at the northern end of the island. Insect surveys were conducted on Maxton Plains, at the north end of Drummond Island, at four sites along the south shore of Drummond Island, and at Dudley Bay on the mainland I (Appendix IV).

VEGETATION

Natural Communities of the Keweenaw Peninsula.

Bedrock Beach. The most complete study of the vegetation of the bedrock beaches of the Keweenaw Peninsula was conducted on the Copper Harbor Conglomerate between Agate Harbor and Copper Harbor by Reschke (1985). Reschke found that there were several factors that determined the vegetation of the bedrock shoreline. Distance from the lake had the strongest correlation with species composition. Wave action and ice scour were strongest near the lakeshore, greatly reducing the diversity of plant species present. Farther above the lake, there were other distinct vegetation zones with greater floristic diversity. Reschke identified four floral assemblages: (1) low-wet rocks, (2) intermediate-moist rocks, (3) intermediate-dry rocks, and (4) high-dry rocks. Two additional assemblages were observed in the field but not adequately sampled to be identified in analyses; these are protected low-wet crevices and perched meadow assemblages.

The low-wet assemblage is found close to the lake, where there is a high proportion of bare rock. This assemblage has the largest proportion of mosses, a low proportion of lichens, and a low proportion of herbs, which are restricted to narrow crevices in the rock. The lichens and mosses found on the low-wet rocks appear to be adapted to these conditions, and are much more common here than on higher-drier bedrock.

The intermediate-moist assemblage is best characterized by a larger proportion of herbs and a slightly higher proportion of woody taxa. There is decrease in cover and frequency of lichens, especially crustose, loose foliose, and fruticose lichens.

The intermediate-dry assemblage is characterized by high proportions of crustose and appressed lichens, which cover from 50 to 90 percent of the rock surface. The lichen assemblage is similar to that of the high-dry rock assemblage, but contains few loose foliose and fruticose lichens. Mosses and vascular plants are not distinctive in this assemblage.

The high-dry assemblage is rich in species. Lichens form a nearly continuous cover on the rocks, with high diversity of all lichen types, with more loose foliose and fruticose lichens than in any other assemblage. Bryophytes, herbs, and woody plants are all well represented within this assemblage.

The assemblage of species found at the edges of seasonal rock-pools (perched meadows) is dominated by tuft-forming grasses and sedges, but can also contain other herbs and woody plants found in the other shoreline assemblages.

One of the most important points made by Reschke (1985) was the importance of lichens and bryophytes on the bedrock shore. In Reschke's data set, there were 53 lichens, 28 bryophytes (mosses and liverworts), and 45 vascular plant species. Based on frequency there were 56% lichens, 22% bryophytes, and 22% vascular plant species.

No in-depth studies had been conducted on the bedrock shoreline of the Portage Lake Volcanics, which are dominant along the shoreline between High Rock Point at the east end of the Keweenaw Peninsula, and the town of Bete Grise, located about fifteen miles to the southwest. A large rhyolite knob is located along the shoreline within this stretch of Portage Lake Volcanics.

Bedrock Glade. Another natural community that occurs between the open bedrock beach and the forests found farther inland is the bedrock glade. The bedrock glade consists of open, thin-soiled plant communities dominated by scattered, open-grown trees, scattered shrubs or shrub thickets, and a partial turf of grasses and sedges. There are typically exposed areas of bedrock within the glades. There have been no detailed studies of the glades on the Keweenaw Peninsula, and sampling of the glades was limited in the first year of this study. As the study progressed, it became evident that the glade was a characteristic zone of the shoreline vegetation, especially on the Copper Harbor Conglomerate. Previously glades and balds had been described only from the high, exposed ridges, as on Brockway Mountain. Glades were also encountered on the rhyolite of the Portage Lake

Volcanics. At present, insufficient data has been collected to adequately describe and compare the glades.

Cobble Beach. Cobble beaches occupy a large portion of the shoreline between bedrock exposures. On the north side of the Keweenaw Peninsula, cobble beaches occupy only a small percentage of the shoreline, whereas at the eastern and southeastern end of the peninsula, where the basalts of the Portage Lake Volcanics are exposed, cobble beach is much more prevalent than bedrock beach in many areas. There is typically no vegetation on the steep cobble beaches, so little time will be spent discussing the beaches in this study. It should be noted, however, that the agates and beautifully polished lava pebbles of these cobble beaches (for which the Keweenaw Peninsula is famous) can stop even the most determined botanical explorers dead in their tracks.

Cliff. Freda Sandstone occurs almost exclusively as steep cliffs along the shoreline. These cliffs were some of the most visually appealing coastal features visited, but they are very low in botanical diversity. At some sites it will be worth pursuing further botanical, and possibly insect and mollusc surveys, of the cedar swamps and seeps at the summit of the cliffs.

Natural Communities of Drummond Island.

All of the natural communities described for the Keweenaw Peninsula also occur on the bedrock shoreline of Drummond Island. These include bedrock beach, bedrock glade, cobble beach, and cliff. No major studies have been done in Michigan on these natural communities along dolomite shorelines. The results of this study of these natural communities on dolomite will be briefly discussed in the Summary Section of this report. A more complete discussion will occur in 1996 following completion of inventory of remaining dolomite shoreline in Michigan.

INSECT SURVEYS

Bedrock and cobble shorelines of the Great Lakes contain many important, significant, and endemic plant species. These plants have the potential to support unique assemblages of invertebrates, especially habitat-restricted specialists. Little is known about the insect fauna of alvar regions and even less is known about alvar insects in Michigan. The only published paper is a study of grasshopper communities of limestone glades in Missouri (Bergmann 1983). In addition to our study, there are two ongoing research projects in Michigan dealing with insects of alvar regions (S. Stephenson, pers. comm.; K. Hamilton, pers. comm.). A primary goal of this study is to qualitatively describe the insect community for distinct vegetative associations on a variety of bedrock types.

Plate 1. Copper Harbor Conglomerate.

Plate 1a. West of Horseshoe Harbor, Keweenaw Co. The Copper Harbor Conglomerate, which also includes thin lava flows, forms the broad bedrock shoreline of the north half of the Keweenaw Peninsula, from Eagle Harbor in the west to near High Rock Bay at the far eastern point of the peninsula. Beds of the conglomerate tilt steeply toward the Northwest into Lake Superior at an average angle of about 40 degrees from horizontal. Less resistant beds of lava and conglomerate were eroded by glacial ice and wave action, leaving many small islands of more resistant conglomerate trending parallel to the shoreline.

Plate 1b. Copper Harbor Conglomerate. A close-up of the conglomerate shows pebbles and cobbles in a matrix of sand, cemented by both calcium carbonate (white) and iron oxide. The clasts of the conglomerate consist primarily of rhyolite, but also includes basalt, lava, sandstone, and shale. The numerous cracks and depressions of the conglomerate provide habitat for plant species adapted to the stressful conditions of the bedrock shoreline of Lake Superior.

Plate 1c. Vegetation of the Copper Harbor Conglomerate. The typical vegetation zones of the conglomerate are seen, beginning with bare rock in the wave splash zone along the lake. Usually 3-6 feet above the lake lichens, mosses, and occasionally herbaceous plants begin to occupy protected crevices and depressions. These plants must tolerate storm waves, abrasion by ice, and desiccation. Lichens are typically crustose or closely-appressed foliose. Higher above the lake, where the bedrock is still exposed to some storms and ice abrasion, loose foliose and fruticose lichens (the light areas in the foreground) become more numerous, as do herbs. Scattered shrubs and trees also appear in protected crevices; these have krummholz or flagged form resulting from ice abrasion. In the background, beyond the extent of annual ice accumulation, mature trees can be seen.

Plate 1d. Pebble and cobble beaches occupy the embayments between many of the bedrock points. The cobbles are largely derived from the local Copper Harbor Conglomerate and include volcanic clasts along with sandstone and shale. Rhyolite is often the dominant rock-type in the conglomerate.

Plate 1e. Krummholz on Copper Harbor Conglomerate, Porter's Island. This 10-inch diameter northern white-cedar, located about 60 feet inland behind a narrow protective island, is only 2 to 3 feet tall; trees seldom survive to become larger than 2 to 3 inches in diameter because of the destructive ice abrasion. The sturdy roots of this cedar are anchored in a wide crack, which have provided some protection from ice abrasion.

Plate 1.

a

b

c

d

e

Plate 2. Rare plant species characteristic of the Copper Harbor Conglomerate and Portage Lake Volcanics.

Plate 2a. Narrow spikes of white flowered alpine bistort (*Polygonum viviparum*, state threatened) growing among moist mosses on amygdaloid lava of the Portage Lake Volcanics near Keweenaw Point. The plant has also been found growing beneath alder at Horseshoe Harbor and is much more common on the north shore of Lake Superior and on Isle Royale. The arrow points to a bulblet, a form of vegetative reproduction.

Plate 2b. Pale Indian paintbrush (*Castilleja septentrionalis*, state threatened) is typically found growing in moist seeps near the upper edge of the open bedrock. The plant is occasionally found growing among shrubs farther inland, where the bedrock is covered with an almost complete turf of sedges and grasses.

Plate 2c. Pearlwort (*Sagina nodosa*, state threatened) growing in a crack in lava bedrock; it also grows on conglomerate.

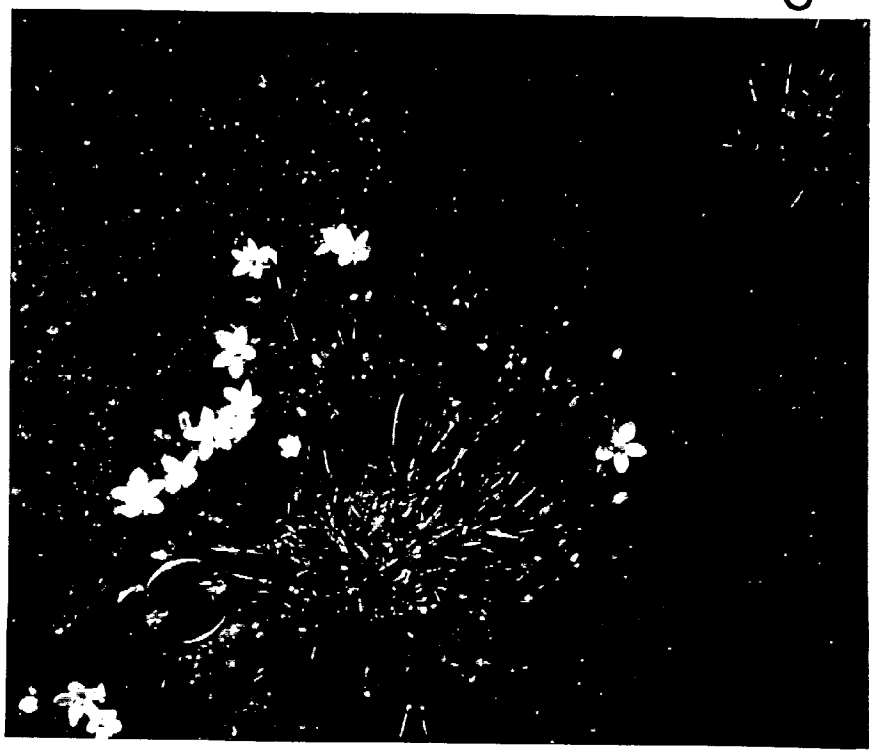
Plate 2d. Calypso (*Calypso bulbosa*, state threatened). This plant is characteristic of the open conifer forests near the shoreline, rather than the open bedrock. It has been found in large colonies on Isle Royale, but is otherwise typically found as scattered plants. It is also found growing in open conifer forests on limestone and dolomite, as on Drummond Island.

Plate 2.

a

b

c



d

Plate 3. Basaltic lavas of the Keweenaw Peninsula.

Plate 3a. Closeup of basalt (Sevenmile Point). Basaltic lavas consist of relatively heavy, dark, finely crystalline rock rich in iron-bearing minerals. Basalt's fine texture is the result of rapid cooling. Note veins of intrusive bedrock. The Portage Lake Volcanics, consisting primarily of dense basaltic lavas such as these, form the narrower bedrock along the southern shoreline of the Keweenaw, east from Lac La Belle to High Rock Bay.

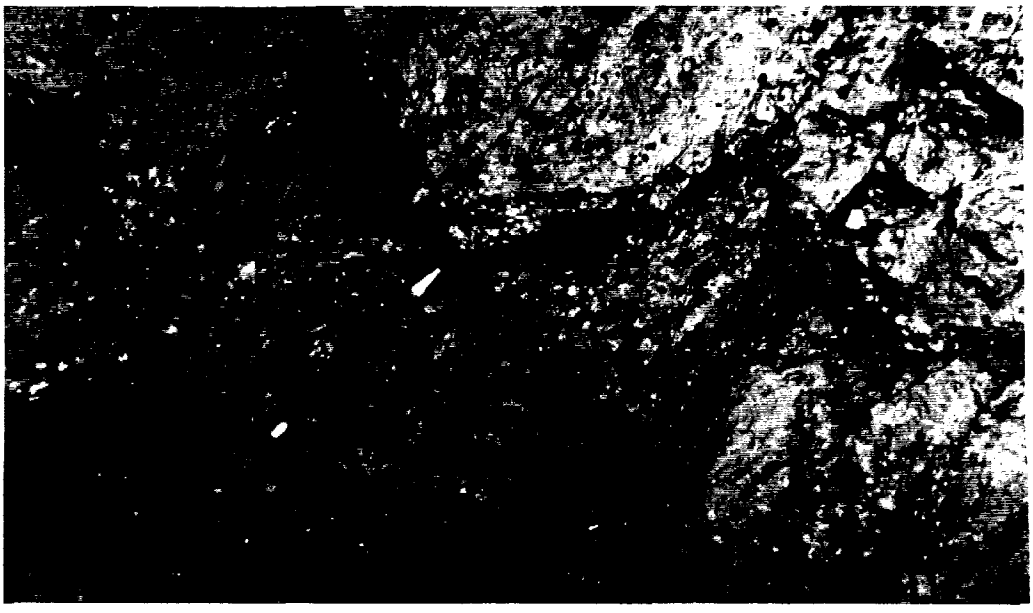
Plate 3b. Basalt surrounded by cobble beach at Sevenmile Point. Plant colonization on the basalt is generally poor for two reasons; there are few cracks for plants to establish in and the bedrock exposures are generally smaller and lower, resulting in extreme ice abrasion and wave activity. At Sevenmile Point, there are a few small wetlands occupying shallow pools in the bedrock.

Plate 3c. *Vesicular lava* or *vesicular basalt* are the terms applied to the lavas that cooled most quickly, entrapping bubbles of gas. In cases where these cavities are later filled with minerals such as calcite or copper, the resulting rocks are termed *amygdaloidal basalt* or *lava*. In this basalt, the reddish mineral in the cavities is largely laumontite. Vesicular lavas (basalts) often contain enough open cavities and cracks to support plants.

Plate 3.

a

b



c

Plate 4. Rhyolite and Freda Sandstone of the Keweenaw Peninsula.

Plate 4a. Fish Cove Knob is a rugged intrusive body of rhyolite near the south eastern end of the Keweenaw Peninsula. Rhyolite is a fine-grained, light-colored (reddish) rock low in iron and magnesium-bearing minerals. There are only three exposures of rhyolite along the shoreline: Fish Cove Knob, Fish Cove Dike less than a mile to the west, and Bare Hill 3 to 4 miles farther west. Both Fish Cove Knob and Fish Cove Dike form steep, rugged shoreline. Wave action appears to be exceptionally severe along this shoreline. Open glades dominated by conifers grow several meters above the lake, as seen in this photo.

Plate 4b. Detail of the rhyolitic bedrock at Fish Cove. The rugged cliff face contains few large cracks or crevices occupied by plants, except for crustose lichens at the tops of the cliffs.

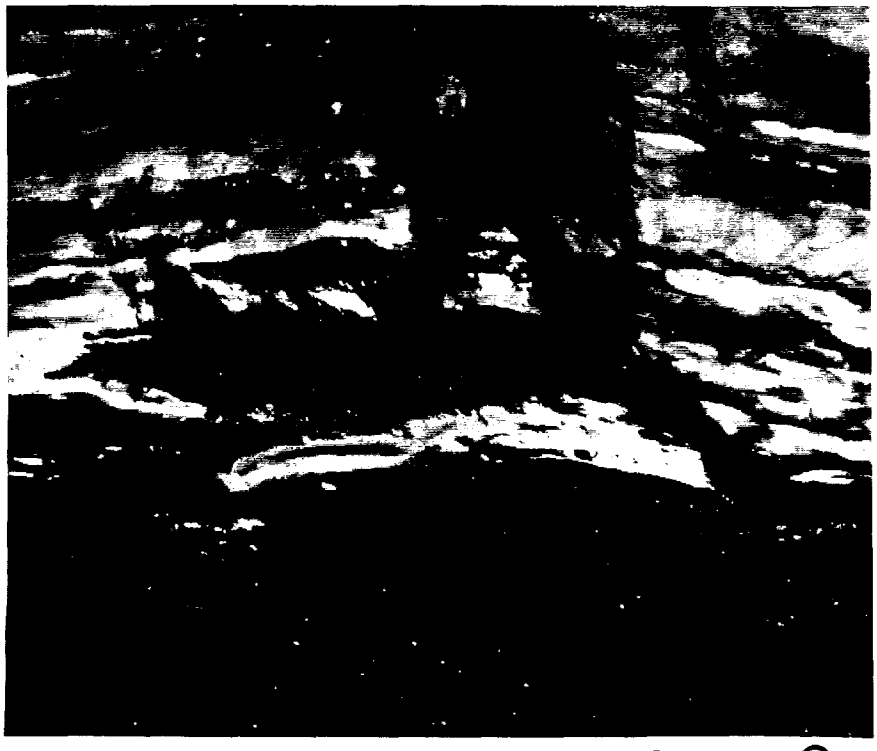
Plate 4c. Close-up of Freda Sandstone. Freda Sandstone ranges in texture from very fine sandstone to siltstone. The red portions of the stone are oxidized, whereas the gray areas are reduced. Dark stamp sands from the mines at Redridge and Freda cover the flat shelf of sandstone at the base of the cliff.

Plate 4d. Wave-cut cliffs of Freda Sandstone. Less than a half mile south of the western end of the Portage River Shipping Channel are several miles of shoreline cliffs, 20 to 40 feet high. Near the town of Redridge, farther to the south, the cliffs are up to 60 feet high. South of the town of Freda the cliffs continue for several miles, but become much lower. Few plants are found growing on the faces of the cliffs, probably because of both intense wave and ice action.

Plate 4.

a

b



c

d

Plate 5. Engadine Dolomite of Drummond Island and associated rare plants.

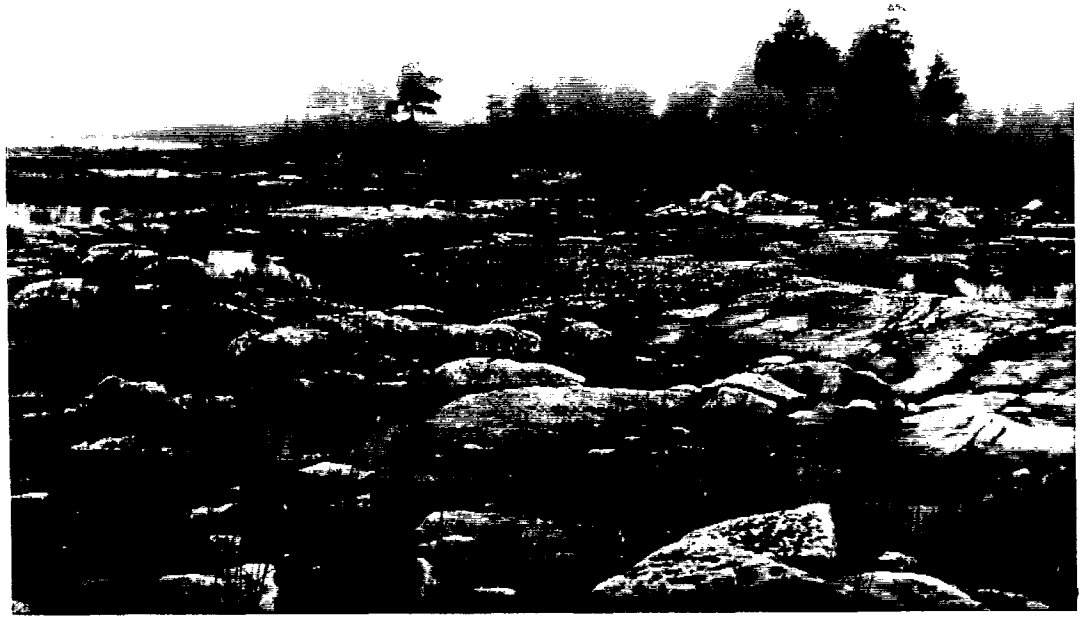
Plate 5a. Engadine Dolomite west of Bass Cove, Drummond Island. The dolomite formed in reefs within a shallow sea. The dip of the bedrock is very gentle, 40 to 60 feet per mile (approximately 1 percent slope) toward the south. There is a broad expanse of bedrock along the shoreline that supports little or no plants, the results of both severe wave action and ice abrasion. Vegetation within the wave splash or ice abrasion zones is often restricted to cracks or crevices in the bedrock. Shrubs and trees dominate the landscape farther inland, where storm waves are infrequent and abrasion by ice is minimal or absent.

Plate 5b. Shoreline of Engadine Dolomite at Bass Cove, Drummond Island. Near the shoreline where ice scour and wave action are intense, vegetation is restricted to the cracks in the pavement. Along the south shore of Drummond Island, these cracks are often dominated by two rare sedges, *Carex scirpoidea* (state threatened) and *C. richardsonii* (state special concern). The dolomite surface is pocked by small dissolution cavities. In the background, where active ice scour or wave action is minimal, is a shrub zone, with an open forest of conifers beyond.

Plate 5c. Butterwort (*Pinguicula vulgaris*, state special concern) is locally common in pools on dolomite bedrock and marly coastal sediments. This plant is also locally common at the edges of pools on Copper Harbor Conglomerate on the Keweenaw Peninsula. It is the only rare plant observed on the Freda Sandstone, where it was localized on seepy cliffs. The pH of all of these bedrock types, dolomite, volcanic conglomerates, and the Freda Sandstone is roughly circumneutral.

Plate 5d. Hill's thistle (*Cirsium hillii*, C2 federal candidate, state special concern) is found growing in the open shrub and open conifer forest (glade) near the shoreline of Drummond Island. As this photograph demonstrates, a thin, but almost continuous turf often covers the limestone or dolomite bedrock beneath the conifer forest.

Plate 5.



a

b

c

d

METHODS

BEDROCK CLASSIFICATION AND MAPPING

Bedrock classification was based on existing geological studies. For the Keweenaw Peninsula, these include 7.5 minute geological maps published by USGS for portions of the Lake Superior shoreline, and also maps from Bornhorst and Rose (1994) and Reed and Daniels (1987). For Drummond Island, these include publications by Ehlers (1973), Ehlers and Kesling (1957), and Reed and Daniels (1987). At the northern end on Drummond Island, Reed and Daniels' (1987) treatment of the late Ordovician and early Silurian Periods was used.

PHOTO INTERPRETATION

The entire shorelines of both the Keweenaw Peninsula and Drummond Island were photo interpreted, using black-and-white and color aerial photography available from the Michigan DNR, Land and Water Management Division. Photos of both areas were available at the scale of 1"=500' or 1"= approximately 780', excellent scales for mapping coastal bedrock. The width of bedrock shoreline was determined from these detailed aerial photos. Although bedrock shoreline could be easily mapped, cliffs were more difficult to recognize and were verified with a reconnaissance flight.

AERIAL RECONNAISSANCE

Aerial reconnaissance was planned for early summer, but equipment problems resulted in delayed surveys, which were finally conducted in early autumn. Field work demonstrated that photo interpretation had been adequate for most survey sites, and that the flights were most useful to interpret areas where cliffs were suspected. The flights also provided excellent oblique photographs to document the extent and quality of the sites. Oblique photos provide a more ecologically interpretable view of the shoreline landscape than does vertical photography. Flights need to be well-planned to get optimal photos of cliff sites. Cliffs in shadow are difficult to photograph! Videography allows complete coverage of the shoreline, and may be effective for demonstrating the level of shoreline development.

VEGETATION SAMPLING

Intensive sampling was initiated on the Keweenaw Peninsula. Sampling was conducted from late June to late September along transects perpendicular to the shoreline, beginning at the shoreline and continuing into the forest zone. A transect was drawn, showing the slope, type of bedrock, moisture conditions, and approximate coverage value for physiognomic classes of vegetation. Random samples were then taken for each zone of vegetation, using a half meter by half meter sampling frame. Cover class values were recorded for each plant species encountered and ecological variables were described within the sampling frame. Point sampling was done for the overstory of the forest or glade zone, and the presence of shrub and herb species was recorded. One 5m x 5m plot was sampled to describe the bedrock bald at Fish Point.

This sampling approach did not prove effective for the dolomite shoreline of Drummond Island, as many species were not encountered in the sampling frames, thus underestimating floristic diversity, or requiring too much sampling time. Sampling was modified; a meter tape was extended perpendicular to the shoreline and each vegetation zone was identified. A ten-meter wide section of each zone was then sampled, and the presence and rough abundance value for each vascular plant species was noted. Point sampling was conducted in the forest or glade, and presence was recorded for shrubs and herbs that were encountered.

The data collected during the 1994 field season will undergo preliminary analysis prior to the 1995 field season, in an attempt to determine the most appropriate approach for future sampling. A 1995 alvar project may allow us to do more intensive sampling of the alvar and bedrock beach on Drummond Island.

INSECT SURVEY METHODS

Field work was conducted during August and September 1994 at nine sites in Mackinac and Chippewa Counties, Michigan (Appendix IV). Highest quality areas were selected for preliminary work. Results will be used to focus additional work in 1995. Insects were collected with aerial and sweep nets. Light trapping, a method used to document the occurrence of nocturnal insects, was utilized at two sites. Approximately half of the time at each site was spent making a general collection of species present, while the remainder of the time was spent focusing on state listed species including *Prosapia ignipectus* (Homoptera: Cercopidae), *Papaipema aweme* (Lepidoptera: Noctuidae), and *Phyciodes batesii* (Lepidoptera: Nymphalidae). The target groups included Odonata (dragonflies and damselflies), Orthoptera (grasshoppers and katydids), and Homoptera (leafhoppers, spittlebugs, planthoppers, and treehoppers), because these groups contain many habitat-restricted species.

Species that could be identified in the field were recorded and released. Species that required further study for accurate identification were collected and prepared following standard insect collection techniques. Insects were identified to genus or species using published references, or were sent to experts. The experts we consulted were G.M. Fauske (North Dakota State University, for the Lepidoptera and Orthoptera); K.G.A. Hamilton (Agriculture Canada, for the Cicadellidae in part); P.K. Lago (University of Mississippi, for the Scarabaeidae); D.A. Rider (North Dakota State University, for the Pentatomidae); E.G. Riley (Texas A&M University, for the Chrysomelidae); M.D. Schwartz (Agriculture Canada, for the Miridae); D.F. Schweitzer (Eastern Regional office of The Nature Conservancy, for the *Papaipema*); and S.W. Wilson (Central Missouri State University, for the Fulgoroidea).

RESULTS OF 1994 FIELD SEASON

SUMMARIES OF KEWEENAW PENINSULA BEDROCK SURVEY SITES

The bedrock portions of the Keweenaw Peninsula have been divided into several major sites (Figure 4). These proposed sites were delineated on the basis of bedrock type, recognizable natural boundaries, changes in ownership or management pattern along the shore, or historic site boundaries. More detailed maps of each site are shown in Appendix I; each map is referenced by both the **site name** and the **ordinal number** proceeding it in the following brief site descriptions. Information is provided on each of these sites in a summary table (Table 1). The summary table includes site name and number, location (Township and Range), bedrock types along the shoreline, geological classification of the bedrock (from Reed and Daniels 1987), the number of special plants, land ownership, length and rank of bedrock beach, width of bedrock, length and height of cliffs, length of cobble beach, and acres and rank of bedrock glade. Special plant occurrences are summarized in Table 2. No special animals were noted during shoreline surveys.

1. Rockhouse Point-Graveraet River.

No field survey was conducted at this site; this site is scheduled for a 1995 field survey. The site was identified on the basis of existing geological maps and confirmed by a late season reconnaissance flight. Cliffs and low bedrock outcrops were almost continuous for several miles, but were quite low, probably less than 20 feet high. There are no homes along this stretch of coast, however, the forests on the adjacent uplands have all been recently logged.

2. Freda-Redridge.

The cliffs, 30 to 60 feet high, are the highest Freda Sandstone exposures in the state, and are similar to those of Plates 4c and 4d. These cliffs, although low in plant diversity, are quite beautiful, with a pattern of bluish-gray and red on their wave-sculpted face.

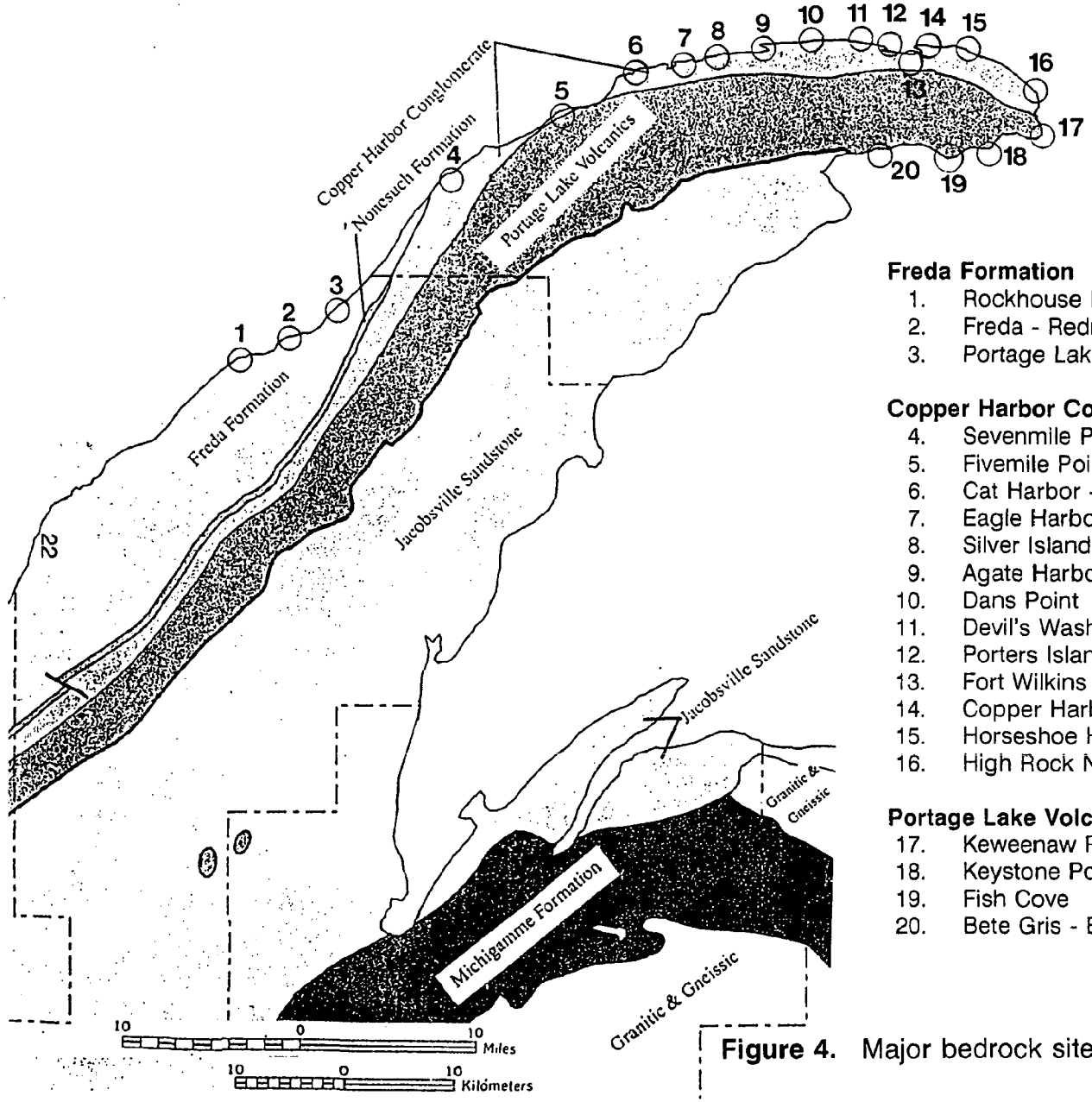
The summit of the cliffs is dominated by northern hardwood forests. Based on surveys at the Portage Lake Shipping Canal site, it is unlikely that many rare plants will be encountered along the cliffs; the steep cliffs provide little habitat for plants. Scattered homes have been built at the summit of the cliffs between Freda and Beacon Hill and house construction is beginning east of Beacon Hill.

Only partial surveys were conducted for this site; a small area of cliffs on the east edge of Freda was surveyed, as was an area just west of Redridge. Steep cliffs made access to this site difficult, requiring further survey by wading or canoeing the coast when weather conditions permit.

3. Portage Lake Ship Canal West.

Although the cliffs are only 20 to 40 feet high, they are the most ecologically intact area of Freda Sandstone (see Plates 4c and 4e). There are almost no houses on the two mile stretch of cliffs, and the seepage-rich slopes above the cliffs are dominated by old-growth cedar swamp. Second-growth northern hardwoods forest dominates the broad upland ridge above the cliffs; much of the logging is quite recent. The only special plant found was butterwort (*Pinguicula vulgaris*), which was quite localized on the moist, upper edge of the cliffs. Some portions of the cliffs are loose shale splitting along bedding planes, while others are compact and highly-sculpted. At the base of the cliffs is a broad shelf, typically covered by two to four feet of water, thus allowing several miles of shoreline to be surveyed by wading. A veneer of stamp sand, carried by currents from the mining operations at Freda and Redridge, covers the base of this shelf, adding to the striking beauty of the shoreline.

Further surveys for rare plants should concentrate on the cedar swamps above the cliffs, and would probably be best conducted in late spring and early summer. These surveys would likely be productive, but will be quite time-consuming, as seepages and deep organic soils are characteristic of the steeply-sloped conifer swamps, as are numerous areas of large, wind-thrown northern white-cedar.



Freda Formation

1. Rockhouse Point - Graveraet River
2. Freda - Redridge
3. Portage Lake - Ship Canal West

Copper Harbor Conglomerate

4. Sevenmile Point
5. Fivemile Point - Eagle River
6. Cat Harbor - Eagle Harbor
7. Eagle Harbor - Grand Marais Harbor
8. Silver Island: Grand Marais Harbor - Bailey Creek
9. Agate Harbor: Esrey Park - Lake Glazon
10. Dans Point
11. Devil's Washtub
12. Porters Island
13. Fort Wilkins State Park
14. Copper Harbor Lighthouse - Norland Trust
15. Horseshoe Harbor
16. High Rock North

Portage Lake Volcanics

17. Keweenaw Point: High Rock Bay - Keystone Bay
18. Keystone Point
19. Fish Cove
20. Bete Gris - Bear Bluff

Figure 4. Major bedrock sites on the Keweenaw Peninsula.

Table 1-A
Summary Data for Keweenaw Peninsula Bedrock Sites

Keweenaw Peninsula Bedrock Site[a]	Site Data					
	Township/ Range	Bedrock[b] Type	Bedrock Classification	# of T & E Plants	Ownership[c]	Level of Development[d]
1. Rockhouse Point - Graveraet River	T54-55N R36W	sandstone, siltstone	Freda Formation	--	P(C)	U
2. Freda - Redridge	T55N R35-36W			--	P(S)	M
3. Portage Lake Ship Canal West	T56N R34-35W			1	P(L)	U
4. Sevenmile Point	T57N R32-33W	VB, B	Copper Harbor Conglomerate	0	P(C)	U, P
5. Fivemile Point - Eagle River	T58N R32W	C, VB, B		6	P(C), P(S)	M-H
6. Cat Harbor - Eagle Harbor	T58-59N R30-31W	VB, B		11	P(S)	M-H
7. Eagle Harbor - Grand Marais Harbor	T59N R30W	VB, B		12	P(S)	M
8. Silver Is.: Grand Marais Harbor-Bailey Cr.	T59N R30W	VB, B		8	P(S), P(L)	L-M
9. Agate Harbor: Esrey Park-Lake Glazon	T59N R29-30W	C		9	P(S)	M-H
10. Dans Point	T59N R29W	C		4	P(S), MNA, MI	U-M
11. Devil's Washtub	T59N R28-29W	C		5	P(C)	U, P
12. Porters Island	T59N R28W	C, VB		1	MI	U
13. Fort Wilkins State Park	T59N R28W	C, VB, B		5	MI	U-M
14. Copper Harbor Lighthouse-Norland Trust	T59N R28W	C		4	P(L), MI	M
15. Horseshoe Harbor	T59N R27-28W	C		8	TNC, P(C,L)	U, P
16. High Rock North	T58-59N R27W	C, VB, B		7	P(L,S), MI	U
17. Keweenaw Pt.: High Rock-Keystone Bays	T58N R27W	VB, B	Portage Lake Volcanics	5	P(L,C), MI	U
18. Keystone Point	T58N R27-28W	VB, B		2	P(L,C)	U
19. Fish Cove	T58N R28W	VB, B, R		6	P(C), MNA	U
20. Bete Grise - Bear Bluff	T58N R28-29W	VB, B		6	P(C,L), MNA	U

Table 1-A (cont.)
Summary Data for Keweenaw Peninsula Bedrock Sites

[a]For site maps see Appendix I.

[b]Bedrock codes are as follows:

VB = vesicular basalt;
B = basalt;
C = conglomerate;
R = rhyolite.

[c]Ownership is listed in order of acreage owned. Ownership codes are as follows:

MI	State of Michigan;
US	Federal;
TNC	The Nature Conservancy;
MNA	*Michigan Nature Association;*
P(C)	Private, corporate;
P(L)	Private, large tracts;
P(S)	Private, small tracts.

[d]Development codes are as follows:

U = undeveloped or sparse;
P = platted for development;
M = moderate development;
H = heavy development.

Table 1-B
Summary Data for Keweenaw Peninsula Bedrock Sites

Keweenaw Peninsula Bedrock Site	Site Data					
	Bedrock Beach Length (mi)/Rank	Bedrock Width (ft)	Bedrock Cliffs		Cobble Beach Length (mi)	Bedrock Glade (acres)/Rank
			Length (mi)	Height (ft)		
1. Rockhouse Pt. - Graveraet River	--	--	3.5	<30	--	--
2. Freda - Redridge	--	--	1.5-2.0	30-60	--	--
3. Portage Lake Ship Canal West	--	--	2.0	20-40	--	--
4. Sevenmile Point	0.5/B	30-45	--	--	0.5	--
5. Fivemile Point - Eagle River	1.5/BC	30-60	--	--	--	--
6. Cat Harbor - Eagle Harbor	1.5+/BC	30-60	--	--	0.8+	--
7. Eagle Harbor - Grand Marais Harbor	1.5/BC	20-150	--	--	<0.5	--
8. Silver Is.: Gr. Marais Harbor-Bailey Cr.	3.0+/B	10-240	--	--	<0.5	40/B
9. Agate Harbor: Esrey Park-Lake Glazon	3.5+/BC	60-240	--	--	<0.5	100/BC
10. Dans Point	2.5/A	80-180	--	--	<0.5	240/AB
11. Devil's Washtub	1.5/A	30-150	--	--	<0.25	200/A
12. Porters Island	0.4/AB	30-120	--	--	0.5-0.75	--
13. Fort Wilkins State Park	1.0/BC	30-90	--	--	0.6-0.7	--
14. Copper Harbor Lighthouse-Norland Trust	1.2/B	60-120	--	--	<0.25	--
15. Horseshoe Harbor	4.0/A	30-120	--	--	0.8	200/AD
16. High Rock North	0.7/B	30-60	--	--	2.2-2.5	--
17. Keweenaw Pt.: High Rock-Keystone Bays	1.0+/B	10-40	--	--	2.5-3.0	--
18. Keystone Point	1.0+/B	20-60	--	--	0.5	--
19. Fish Cove	1.4+/A	10-150	--	--	0.4-0.6	80/AB
20. Bete Grise - Bear Bluff	2.8+/A	10-60	0.5	>50	1.0-1.2	--

Table 2
Rare Plant Species Occurrences on Keweenaw Bedrock Sites

Species	Site Number[a]																				
	Freda Sandstone			Copper Harbor Conglomerate													Portage Lake Volcanics				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19[b]	19[c]	20
Allium schoenoprasum						●	●														
Arnica cordiformis										●	●		●			●					
Aster modestus						●															
Braya humilis													●								
Calamagrostis lacustris						●															
C. stricta							●														
Calypso bulbosa					●		●		●					●	●				●		
Carex media								●													
C. rossii								●											●		●
C. pallescens								●	●												●
C. scirpoidea					●																
Castilleja septentrionalis					●			●	●	●	●		●	●	●	●	●		●		
Ceanothus sanguineus							●		●												
Clematis occidentalis						●															
Crataegus douglasii					●										●						●
Cypripedium arietinum							●		●												
Danthonia intermedia						●			●			●									
Draba arabisans								●													

Table 2 (cont.)
Rare Plant Species Occurrences on Keweenaw Bedrock Sites

Species	Site Number[a]																				
	Freda Sandstone			Copper Harbor Conglomerate													Portage Lake Volcanics				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19[b]	19[c]	20
Drosera anglica							●														
Dryopteris expansa																					●
Elymus glaucus									●							●					
Empetrum nigrum							●														
Listera auriculata					●												●				
Parnassia palustris						●															
Phleum alpinum																					●
Pinguicula vulgaris			●		●	●			●	●	●			●	●						
Polygonum viviparum															●		●				
Potentilla pensylvanica							●														
Pterospera andromedea						●	●	●					●								
Sagina nodosa						●	●	●			●				●	●					
Senecio indecorus							●									●					
Solidago decumbens						●															
Stellaria longipes															●	●			●		
Trisetum spicatum						●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
Vaccinium cespitosum																	●	●	●		

Table 2 (cont.)
Rare Plant Species Occurrences on Keweenaw Bedrock Sites

[a]Keweenaw site names are as follows:

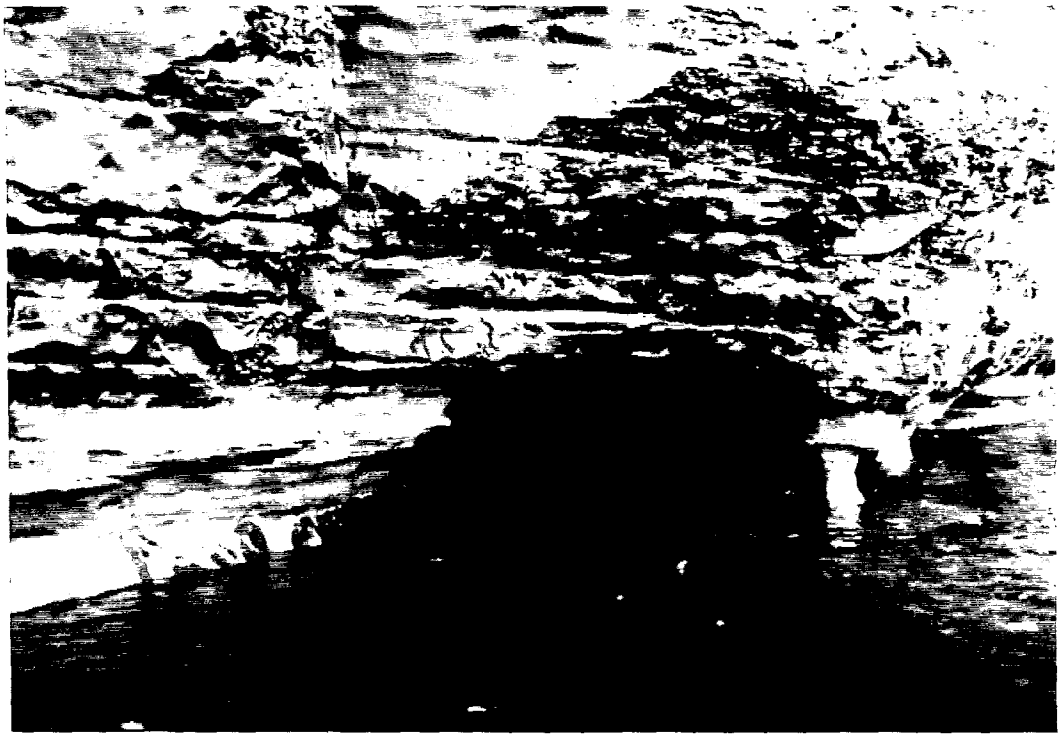
Freda Formation
1. Rockhouse Point - Graveraet River
2. Freda - Redridge
3. Portage Lake Ship Canal West

Copper Harbor Conglomerate
4. Sevenmile Point
5. Fivemile Point - Eagle River
6. Cat Harbor - Eagle Harbor
7. Eagle Harbor - Grand Marais Harbor
8. Silver Island: Grand Marais Harbor - Bailey Creek
9. Agate Harbor: Esrey Park - Lake Glazon
10. Dans Point
11. Devil's Washtub
12. Porters Island
13. Fort Wilkins State Park
14. Copper Harbor Lighthouse - Norland Trust
15. Horseshoe Harbor
16. High Rock North

Portage Lake Volcanics
17. Keweenaw Point: High Rock Bay - Keystone Bay
18. Keystone Point
19. Fish Cove
20. Bete Grise - Bear Bluff

[b]Site 19 (Fish Cove), species occurrences on lava.

[c]Site 19 (Fish Cove), species occurrences on rhyolite.



Portage Lake Shipping Canal West: Cliffs of Freda Sandstone.

The combination of restricted exposure of this bedrock type, high scenic value, and ecological intactness of the adjacent cedar swamp, make this a site worthy of acquisition or protection through conservation easement. This should be an easily accomplished project, as there are few ownerships and the owner of the largest properties has already expressed an interest in protecting the shoreline.

4. Sevenmile Point.

The rugged shoreline south of Sevenmile Point, part of the Lake Shore Traps (resistant basaltic lava flows), is one of the most scenic stretches of undeveloped shoreline remaining on the Keweenaw Peninsula, but it is almost devoid of vegetation on the bedrock shore. No special plants were found on this shoreline. The fine-grained basalt and vesicular basalt that characterize this shoreline do not rise far above Lake Superior, and therefore offer few protected sites for plant establishment. A few of the larger bedrock exposures support localized turfs of sedge and grass, with clumps of small balsam fir and white spruce. Locally, depressions in the basalt contain shallow pools bordered by sedges, rushes, and other aquatic plants.

Between the bedrock exposures are broad expanses of steeply-sloping cobble beach, some of the most popular agate beaches on the Keweenaw Peninsula. Behind these steep-sloped beaches is second-growth forest of white spruce and balsam fir, and east of this narrow upland forest are Mud Lake and Seven Mile Creek. Limited inventory was conducted within these wetlands; the northern portion was a shrubby wet meadow. There is justification for further study of this large wetland complex.

The entire tract is owned by the Lake Superior Land Company, which has recently built a new road from the north to Sevenmile Point. Lake Superior Land has platted both the sandy embayment north of Sevenmile Point and the gravel shoreline south of Sevenmile Point. Based on field surveys, acquisition is recommended for the gravel beach south of Sevenmile Point, as well as the bedrock

portions of Sevenmile Point, located in T57N R33W Section 1 and N2 of Section 12, and T57N R32W W2 of Section 6, with some acquisition of the sandy shoreline in the E2 of Section 6 for buffer.

Sevenmile Point: Rugged Lake Shore Traps surrounded by cobble beach.

5. Fivemile Point-Eagle River.

South of Eagle River, Copper Harbor Conglomerate forms a narrow bedrock beach for more than a mile, but farther south the shoreline is mostly sand dune, with isolated exposures of bedrock west of Silver Creek, and a broad exposure of Copper Harbor Conglomerate at Fivemile Point. A thin lava flow occurs within the Copper Harbor Conglomerate at Fivemile Point. All of the special plants are found on the narrow strip of conglomerate just south of Eagle River, where the bedrock is only 30 to 60 feet wide. Special plants found on the shoreline included pale Indian paintbrush (*Castilleja septentrionalis*), butterwort (*Pinguicula vulgaris*), and bulrush sedge (*Carex scirpoidea*) (Table 2).

Shoreline development is almost complete between Eagle River and Fivemile Point, with the exception of the bedrock section of the shoreline in Section 24, which is owned by Lake Superior Land Company. This section of shoreline is relatively low priority for acquisition, because of heavy development and because the shoreline is narrow and short (1 mile), compared with other exposures of Copper Harbor Conglomerate.

6. Cat Harbor-Eagle Harbor.

The Lake Shore Traps, resistant basaltic lava flows, are exposed between Cat and Eagle Harbors. The exposed bedrock shoreline is relatively narrow, typically between thirty and sixty feet wide, but it supports occurrences of wild chives (*Allium schoenoprasum*), wild oat-grass (*Danthonia intermedia*), pearlwort (*Sagina nodosa*), reclining goldenrod (*Solidago decumbens*), and downy oat-grass (*Trisetum spicatum*). Six other special plants are known from this stretch of coastline, making this one of the sites richest in rare plant species, but most are wetland plants found in the large wetlands south of the shoreline (Table 2).

There are regularly spaced residences along the entire shoreline between Cat and Eagle Harbors, greatly limiting the potential for effective shoreline conservation, unless it were pursued through a registry program. The wetland south of M26, called "The Marshes", appears to have been degraded by hydrologic changes resulting from the highway. The status of the special plants of this wetland is not known; a search for these species in the late 1980s was not successful.

7. Eagle Harbor-Grand Marais Harbor.

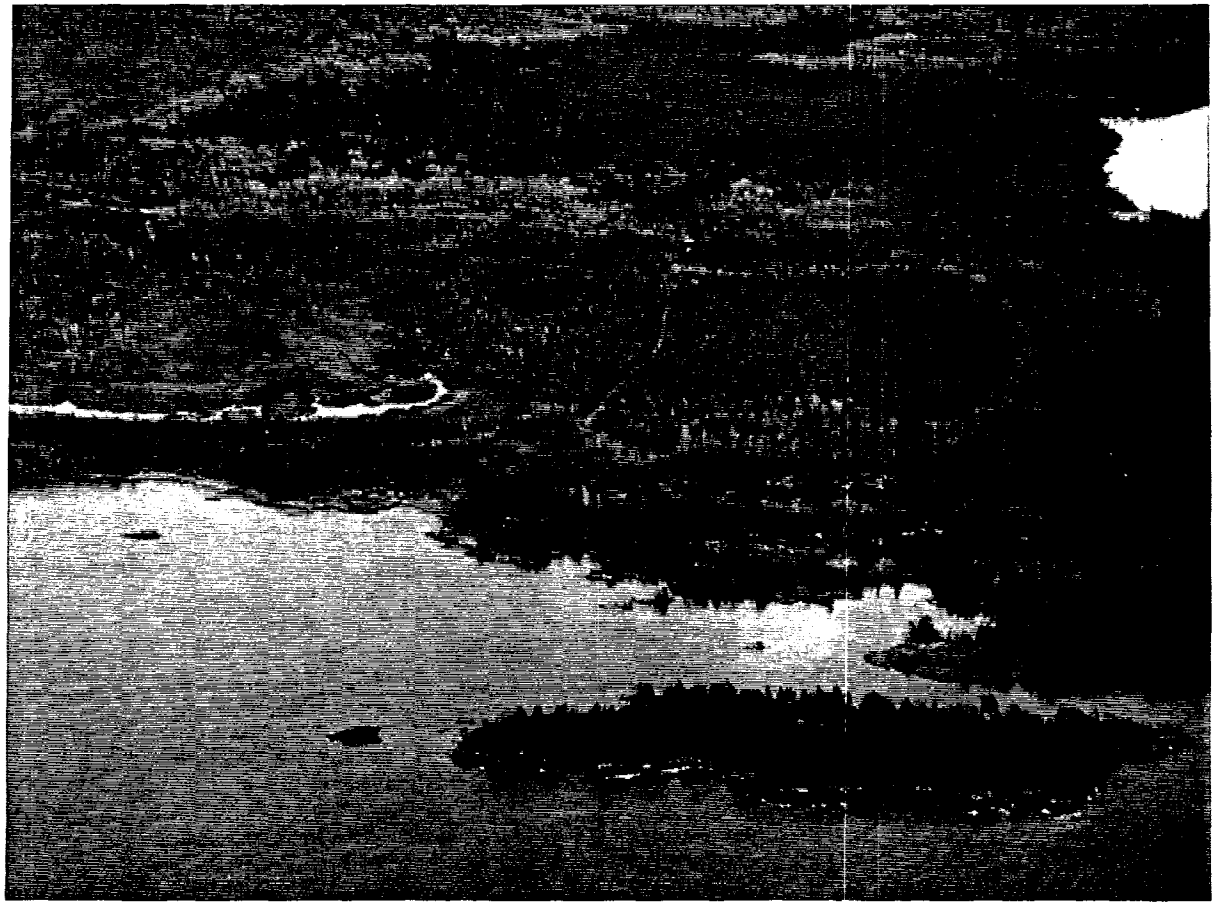
The mile and a half of shoreline between Eagle and Grand Marais Harbors is a thirty to sixty foot wide exposure of resistant basaltic lava flows (the Lake Shore Traps), with maximum bedrock exposures of 150 feet. This stretch of shoreline supports the largest number of special plants recorded on the Keweenaw Peninsula, reflecting the presence of both diverse bedrock and wetland habitat (Table 2). Many of the special plants are northern wetland species found in the large wetland to the south, known locally as "Cedar Swamp".

Potential for effective bedrock shoreline conservation is limited, as houses are scattered along the entire mile and a half of shoreline. At both the eastern and western ends of the expanse houses are farther apart, possibly allowing for some shoreline protection through a registry program.

8. Silver Island: Grand Marais Harbor-Bailey Creek.

Much of the bedrock shoreline, which consists of resistant basaltic lava flows (the Lake Shore Traps), is very narrow, but west of the Silver River exposures are up to 240 feet wide, and open bedrock glade extends another 300 feet in from the shoreline. West of the Silver River mouth there are several islands formed of resistant traprock; the largest, Silver Island, is almost a quarter mile long. There are eight special plants known from this section of shoreline, primarily species characteristic of the bedrock shore, but also including species of the bedrock glade and conifer forests (Table 2). Special plants of the shoreline are known from both the islands and mainland.

This site is ranked B because of both the large number of special plants and the relatively large area of undeveloped shoreline. The Lake Superior Land Company property north of Lake Bailey has been recently platted and several homes are under construction in the western three quarters of Section 34. The eastern quarter of Section 34 and the western half of Section 35 have also been platted, but there has been little development of this subdivision. Conservation action on this site should probably concentrate on these undeveloped portions of Section 34 and 35, including Silver Island.



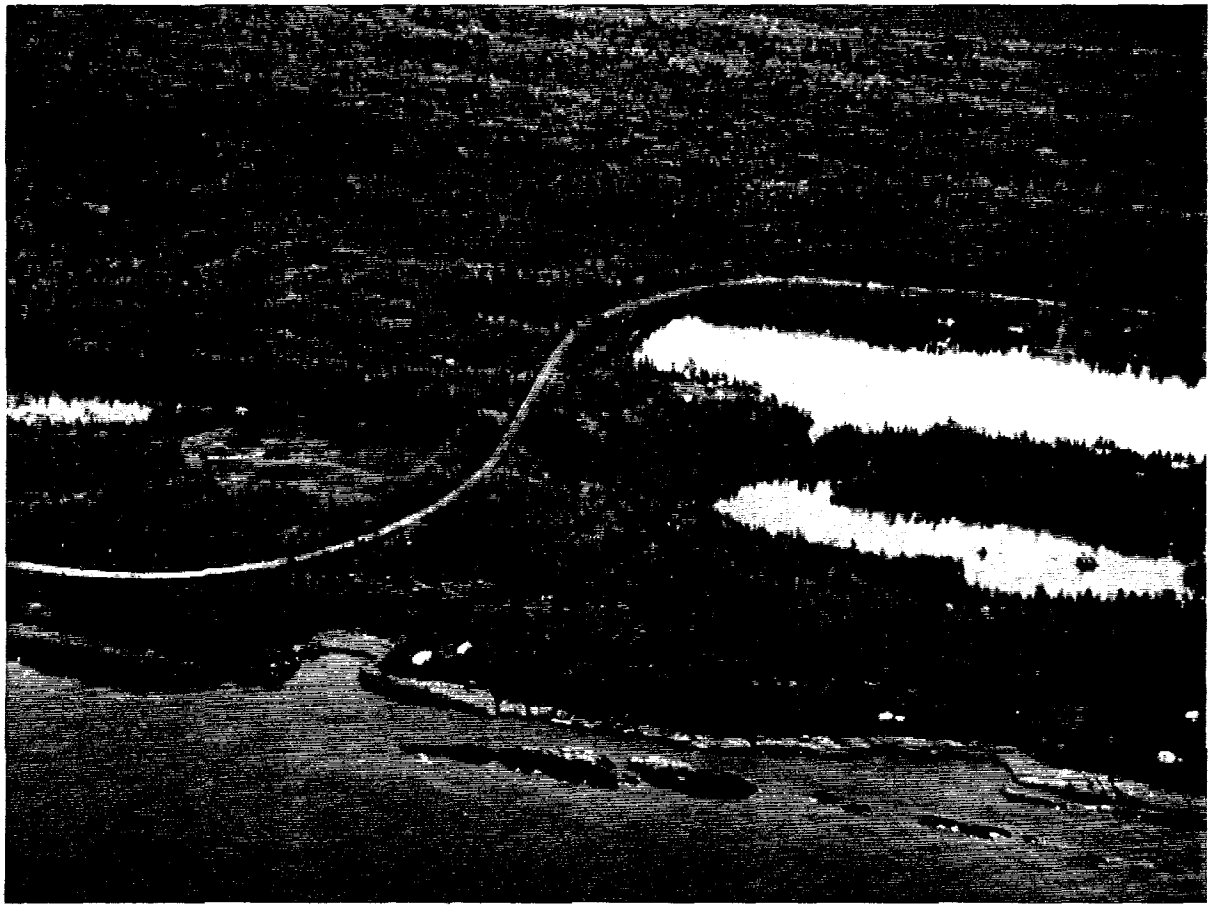
Silver Island: Broad bedrock shoreline and bedrock glade west of the Silver River.

9. Agate Harbor: Esrey Park-Lake Glazon.

The northern peninsula at Agate Harbor and the Lake Superior shoreline north of Lake Glazon consist of one of the broadest exposures of Copper Harbor Conglomerate on the Keweenaw Peninsula, reaching 250 feet in width and regularly greater than eighty feet wide. The southern peninsula, between North and South Bay, and the south shoreline consist of much narrower exposures of basaltic lava flows (the Lake Shore Traps). A broad zone of open bedrock glade, dominated by white pine, red pine, balsam fir, red oak, and several species of shrub occurs just inland from the open bedrock shoreline on much of the Copper Harbor Conglomerate. Our understanding of glade on the Keweenaw is incomplete; the glade appears to be an integral part of the shoreline ecosystem, stretching along much of the shoreline on the Copper Harbor Conglomerate. The nine special plants of this section of shoreline are found growing on both the bedrock shoreline and glade (Table 2).

The combination of both high quality bedrock shoreline and glade should make this an important site for shoreline conservation, but this task will be difficult because of the large number of residences located on the peninsulas. Most of these houses are located within the glade, right at the edge of the bedrock shoreline. Most of the owners value the beauty of the shoreline, and many know of the rare plants found on the shore, possibly allowing for the development of a successful registry program. Education of landowners will probably be needed to get protection or ecologically

sensitive management of the glade. Between the harbor and Lake Glazon shoreline development has been much less continuous on the north side of M-26. Pursuit of acquisition and conservation easements between here and Dans Point is desirable. Large portions of the glade appear to be intact on both sides of M-26 and should be considered in any management plan.



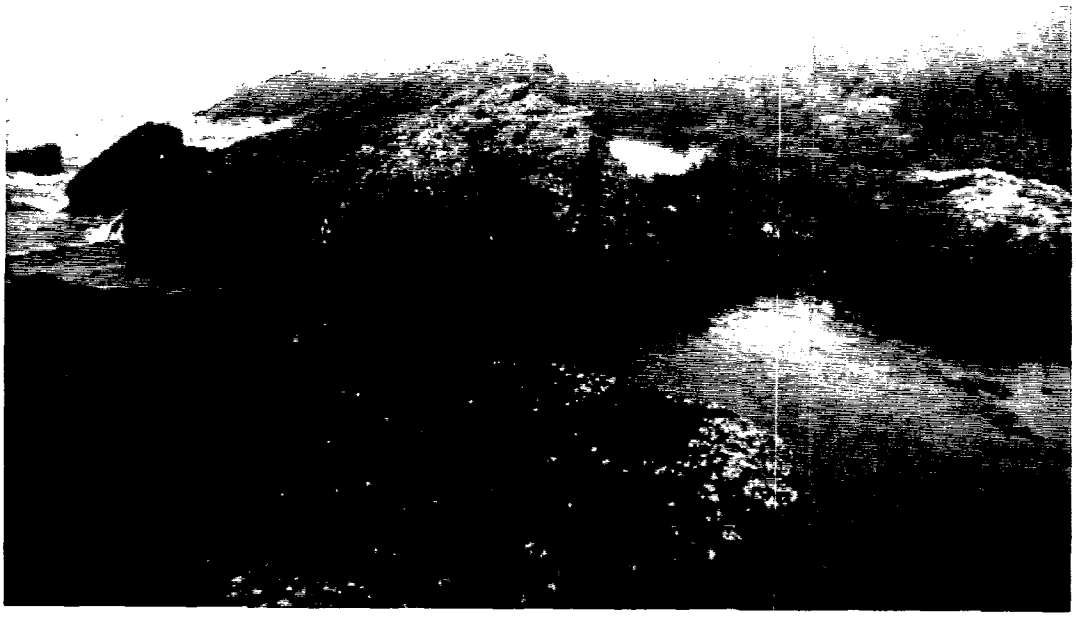
Agate Harbor: Broad bedrock shoreline and glade characterize the Copper Harbor Conglomerate between Agate Harbor and Lake Glazon. The inner bays have a narrow, basalt shoreline.

10. Dans Point.

This three mile stretch of Copper Harbor Conglomerate, located between Lake Glazon in the west and the point where M26 leaves the shoreline in the east, contains broad expanses of both bedrock shoreline and open bedrock glade. Numerous small islands of resistant bedrock parallel the shoreline, creating one of the most rugged and beautiful stretches of conglomerate on the peninsula. The site is visited by geologists because of its excellent exposures of algal tromatolites. Only four special plants are known from the site; three are typical of the shoreline, whereas the fourth, heart-leaved arnica (*Arnica cordiformis*), is characteristic of the glade (Table 2). In the past, much less biological inventory was done in the glades; renewed study of these extensive glades, which are almost three miles in length, may be highly productive for rare plants, insects, and molluscs.

There is tremendous opportunity for conservation work in this section of shoreline. At present the Michigan Nature Association owns two narrow, six-acre tracts at Dans Point. Although there are

several residences south of the road, there are very few north of the road along the beach. Several homes and undeveloped parcels were on the market during 1994 field surveys. Pursuit of these parcels and conservation easements could provide the opportunity to develop a meaningful preserve that would be easily accessible to the public.



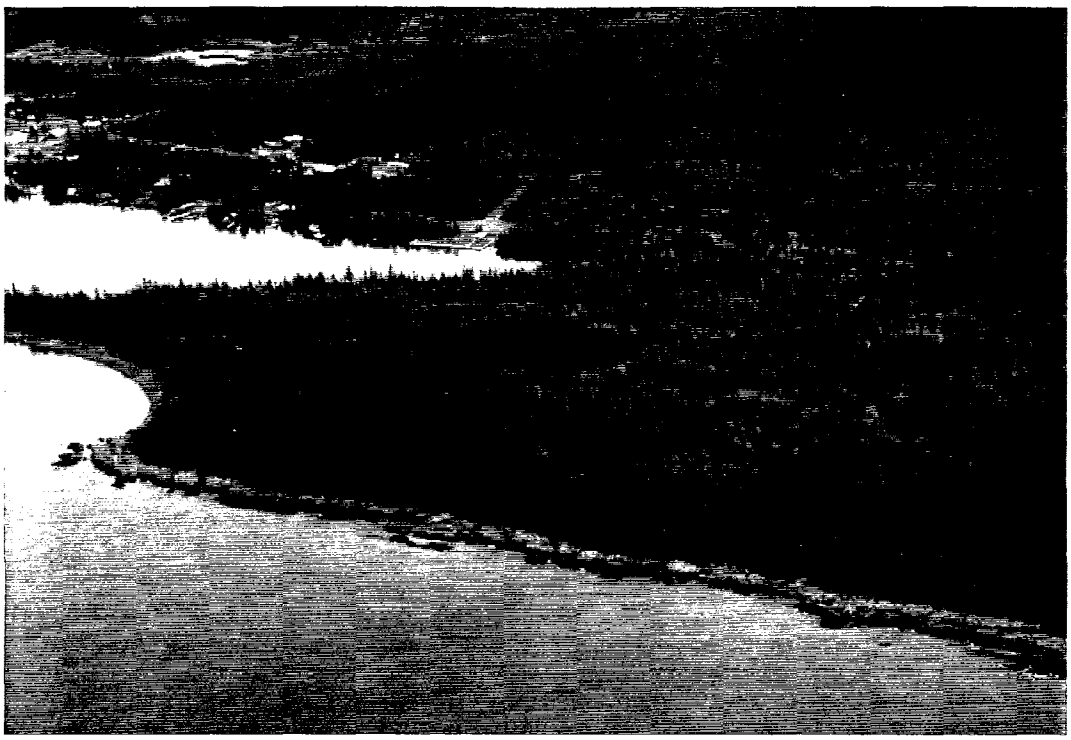
Dans Point: Resistant bedrock forms numerous small islands just off shore. The site contains many shallow pools, some of which support butterwort (*Pinguicula vulgaris*).

11. Devil's Washtub.

West of Copper Harbor, there is a mile and a half of bedrock shoreline that is separated from highway M-26 by nearly a half mile. This stretch of broad bedrock shoreline has long been known as Devil's Washtub because of a large pool in the bedrock that is connected to Lake Superior. The beach of Copper Harbor Conglomerate is up to 150 feet wide and contains many pools and small off-shore islands. A broad glade dominated by white pine, red pine, and shrubs parallels the shoreline. Seepages flow from the forest and glade onto the bedrock, creating abundant habitat for pale Indian paintbrush (*Castilleja septentrionalis*) and butterwort.

Four special plants are known from the bedrock shoreline and one, heart-leaved arnica (*Arnica cordiformis*), is known from the glade (Table 2). Insect surveys are recommended for the glade.

This A-ranked site is a priority site for acquisition, as it is well buffered from the highway, supports both high-quality bedrock beach and glade, and presently has been only minimally developed, having a single home at the west end of the tract. Most of the site is owned by Lake Superior Land Company, which platted the land for development in 1994. The site is used by local residents and visitors for hiking, with access from the Copper Harbor marina, which can be seen in the center of the accompanying aerial photo of the site.



Devil's Washtub: A broad bedrock beach with many pools and small off-shore islands characterizes this site. The town of Copper Harbor can be seen in the background.

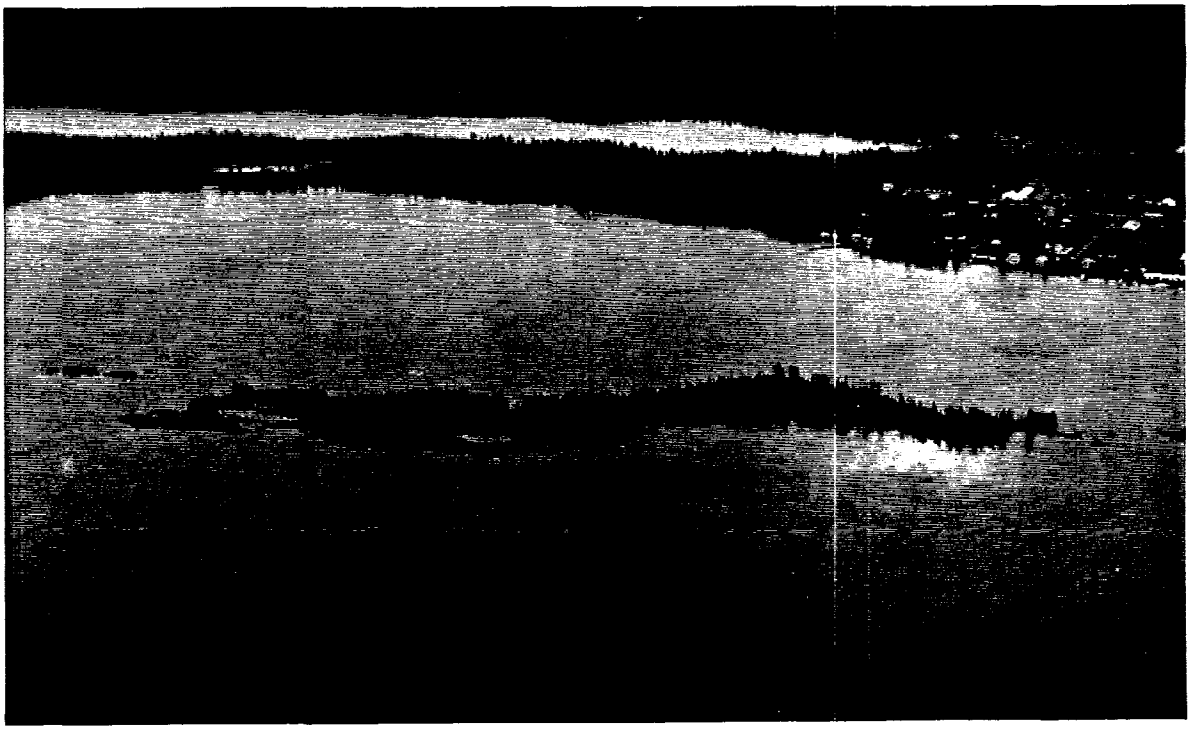
Devil's Washtub: Crustose lichens cover the broad bedrock beach above the wave-splash zone. Farther inland, open-grown white pine and red pine dominate the glade.

12. Porters Island.

This half-mile long island, which provides protection to Copper Harbor from storms out of the north, is part of Fort Wilkins State Park. The northern shoreline is basaltic lava at the west end, with conglomerate to the east; almost the entire south shore is cobble. There are several small islands off the east end of Porters Island. The island supports conifer-dominated forest for its entire length.

The bedrock beach of the island is of excellent quality, as is the conifer forest. There is also a small area of shrubby glade at the southeast end of the island. Only one rare plant, wild oat-grass (*Danthonia intermedia*), is known from the island, and no further species were found during the 1994 field surveys (Table 2). The flora on the bedrock was similar to that seen on other areas of Copper Harbor Conglomerate; a broad zone of crustose and fruticose lichens covered the drier rock above the wave splash zone, with scattered herbaceous plants, shrubs, and small trees. One of the largest and most picturesque northern white-cedars able to survive the severe ice-scour of the Keweenaw coast was seen growing in a crack in the conglomerate (Plate 1e).

A portable dock and an improved trail have been proposed by the park to allow better access to the island. This proposal would also allow tour boats to bring park visitors to the island, much as tours are provided to the Copper Harbor Lighthouse. Based on the small size of the island and the sensitivity of the lichen cover to foot traffic, it is not recommended that regular boat tours visit the island. The present levels of visitation resulting from canoe and motor boat access to the cobbly south shoreline have not caused apparent destruction to the vegetation of either the forest or the bedrock shoreline, in strong contrast with the degraded condition of the bedrock shoreline surrounding the lighthouse, which has resulted from heavy visitation.



Porters Island: Porters Island with the town of Copper Harbor in the right background and Fort Wilkins State Park to the left.

13. Fort Wilkins State Park.

The southern and eastern shoreline of the embayment at Copper Harbor are part of Fort Wilkins State Park. The bedrock shore is relatively steep and narrow basaltic lava, except near the Copper Harbor lighthouse, where the conglomerate beach is broader. Five special plants are known from the shoreline of the park (Table 2). The vegetation along the southern shore does not appear to have been greatly effected by park visitation, but the shrubby vegetation around the lighthouse contains numerous foot trails. There is an informative interpretative trail on the bedrock shoreline around the lighthouse. Rather than build an additional dock and interpretive trail on Porters Island, I would suggest further improvements to this existing trail. Present management at the park is adequate to maintain the vegetation of the remainder of the bedrock shoreline.

14. Copper Harbor Lighthouse-Norland Trust.

The conglomerate bedrock shoreline of this site is similar to that of Horseshoe Harbor to the east, but there are scattered homes along the shoreline of this site, whereas Horseshoe Harbor has no residential development. The bedrock glade of this site has also been degraded with numerous trails and driveways. The bedrock shoreline has not been significantly degraded by residential development and four special plants are found either on the bedrock or in the adjacent conifer forest (Table 2).

A large vein of calcite cuts across the conglomerate about 0.5 miles east of the lighthouse. There are also several small, steeply sloped cobble beaches along the shoreline.

Since the landowners are all part of a neighborhood association, it might be possible to pursue an effective program of landowner contacts or conservation easements. At least one of the landowners is in regular communication with The Nature Conservancy.

15. Horseshoe Harbor.

This section of the Lake Superior shoreline has the largest coastal nature preserve on the Keweenaw Peninsula, The Nature Conservancy's Horseshoe Harbor Preserve, which stretches across one and a half miles of shoreline. The broadest part of this shoreline, approximately 120 feet wide, occurs within the preserve. This broad and scenic section of shoreline has extremely steep, narrow islands and broad cobble beaches. Algal stromatolites are also common on the preserve. The bedrock beach continues to be broad and steep to the west of the preserve, in the western half of Section 35. To the east of the preserve, in Sections 31 and 32 of T59N R27W, the bedrock is not as wide, but it is very steep, and contains the full range vegetation zones typically found on broader expanses of bedrock, including a narrow zone of bedrock glade. Farther east, a narrow beach of lava bedrock alternating with cobble beach becomes more common. Bedrock glade is well expressed at the west end of the tract, throughout Section 35. Little biological survey has been conducted in this large glade and in the large wetlands farther to the south.

Eight special plants are known from the preserve (Table 2). Three new special plants were found in 1994, black hawthorn (*Crataegus douglasii*) in Section 35, and pearlwort (*Sagina nodosa*), and stitchwort (*Stellaria longipes*) in Section 32. Habitat for special plants and animals includes both dry and wet (seepy) bedrock beach, bedrock pools, bedrock glade, and conifer forest.

This is one of the top two sites for further acquisition, with potential for site expansion both to the east and west. Acquisition of tracts owned by Lake Superior Land Company in Section 35 (T59N R28W) and Section 31 (T59N R27W) has been pursued in the past by The Nature Conservancy, but is even more urgent now, as Lake Superior Land Company has recently platted their lands in Section 35. The private lands in Section 32 (T59N R27W) were among the most diverse and beautiful shoreline visited in 1994 (see accompanying photo).

Horseshoe Harbor: All of Section 32 is characterized by steep shoreline of conglomerate bedrock, backed by a narrow bedrock glade dominated by shrubs and conifers.

16. High Rock North.

This three mile section of shoreline consisted largely of cobble beach, with isolated, narrow bedrock exposures of both basalt and conglomerate. Although the bedrock is narrow, seven special plants are known from the shoreline and adjacent conifer forests (Table 2).

There has been no development of this shoreline, but there are over 20 ownership parcels, both small and large, including ownership by Lake Superior Land Company. High Rock Point is owned by the University of Michigan. The combination of no development and several special plants makes this a priority for acquisition, but much less urgent than either Horseshoe Harbor, the Devil's Washtub, or Sevenmile Point.

17. Keweenaw Point: High Rock Bay-Keystone Bay.

This site is similar to High Rock North, consisting largely of broad embayments of cobble beach between narrow bedrock points. The typical bedrock of these points is the basaltic lavas of the Portage Lake Volcanics. Five special plants are known from this section of shoreline (Table 2), but they are restricted to very small populations on restricted bedrock habitat. Alpine bistort (*Polygonum viviparum*), known from only one other mainland site (Horseshoe Harbor), is found locally on seepages north of Keweenaw Point.

This shoreline is remote and undeveloped, providing extensive, intact coastal ecosystems, but only limited rare plant habitat. Inventory for rare fauna has not yet been conducted. It is probably best pursued as part of a State Land Trust or Federal Wilderness project, where remoteness and ecological intactness are important criteria.

18. Keystone Point.

This site is one of the shortest segments of bedrock shoreline, consisting of about a mile of bedrock beach, with another half mile of cobble beach. The shoreline is narrow, often less than 30 feet wide; in many places trees grow to the shoreline edge and there is a 10 to 15 foot high cliff of lava. On such a rugged shoreline, habitat for shoreline plants is restricted. Only one rare shoreline plant species was encountered, downy oat-grass (*Trisetum spicatum*). Another rare species, dwarf bilberry (*Vaccinium cespitosum*), was found as scattered plants along the open shoreline trail. Dwarf bilberry is the host plant for state-threatened northern blue butterfly (*Lycaeides idas nabokovi*).

As with the Keweenaw Point tract discussed above, it is remote and undeveloped. This tract, along with the Keweenaw Point, Bete Grise-Bear Bluff, and portions of the Fish Cove tract could all be part of a large Land Trust or Wilderness project.

19. Fish Cove.

The Fish Cove site includes the only coastal areas of rhyolite in Michigan, as well as long, narrow exposures of basalt. The rhyolite knob, which is less than a quarter mile across, forms steep bedrock escarpments, stacks, and glade (Plates 4a and 4b). There are other glades farther inland, both east and west of the Montreal River. Both the rhyolite and basalt are part of the Portage Lake Volcanics, the dominant bedrock along the southeastern shore of the Keweenaw Peninsula. About one quarter of the two mile long site is cobble beach, which is concentrated west of Fish Point.

Six special plants are known from this section of shoreline (Table 2), making it the richest site for special plants on the southeastern Keweenaw Peninsula bedrock shoreline. Only one species occupies the rhyolite, downy oat-grass (*Trisetum spicatum*). Most remaining species are found on coastal basaltic bedrock, but only occupy small microsites above the wave-impact and ice-scour zones.

Most of the rhyolite knob is within the Michigan Nature Association's (MNA) Gunn Preserve, but the remainder of this site is owned by the Lake Superior Land Company. It is worth pursuing acquisition of the upper and lower falls of the Montreal River and the nearby glades, all located in the eastern half of Section 27 and the southwestern quarter of Section 26.

20. Bete Grise-Bear Bluff.

The shoreline between Bete Grise and Bear Bluff is rugged, narrow basaltic lava, broken by many embayments of cobble. The exposed bedrock shoreline is very narrow, often forming low escarpments, with forest growing to the lake edge. A total of six special plants are known from the shoreline or nearby rocky habitat (Table 2); the narrow shoreline does not provide large areas of habitat for any of these. This is the only coastal site for mountain timothy (*Phleum alpinum*), an alpine grass.

There are large expanses of cliff within a quarter mile of the shore. Rare plants on these cliffs and exposed knobs include small blue-eyed Mary (*Collinsia parviflora*) and expanded woodfern (*Dryopteris expansa*).

Most of the lands along this shoreline are commercial forest lands, owner both by Lake Superior Land or Escanaba Paper Companies. The Michigan Nature Association also owns a 160 acre preserve at Bear Bluff, but this parcel does not include shoreline. Acquisition of this site would probably be best pursued as part of a large State Land Trust or Federal Wilderness project.

SUMMARIES OF DRUMMOND ISLAND BEDROCK SITES

Areas with large amounts of exposed bedrock have been mapped (Figure 5) and the bedrock shoreline and adjacent inland exposures of bedrock on Drummond Island have been divided into several major sites (Figure 6). As on the Keweenaw Peninsula, these proposed sites were delineated on the basis of bedrock type, recognizable natural boundaries, changes in ownership or management pattern along the shore, or on historical site boundaries. More detailed maps of each site are shown in Appendix II; each map is referenced by both the **site name** and the **ordinal number** proceeding it in the following brief site descriptions. Each site is also described in a summary table (Table 3), which includes site name and number, location (Township and Range), bedrock types along the shoreline, geological classification or mapping of the bedrock (from Reed and Daniels 1987), the number of special plants, land ownership, length and rank of bedrock beach, width of bedrock, length and height of cliffs, length of cobble beach, and acres and rank of bedrock glade. Special plant occurrences are summarized in Table 4. No special animals were noted on survey sites.

1. Maxton Plains West.

Maxton Plains is the largest and best known area of limestone and dolomite pavement (alvar) in Michigan. Traditionally the plains have been arbitrarily broken into the West, Middle, and East Maxton Plains. The plains is located on the Queenston Shale Group at the northern end of Drummond Island. Although Queenston Shale consists of thick deposits of red shale farther east in Ontario and New York, only limestone and dolomite bedrock characterize the group on Drummond Island. Whereas the alvar at this site is quite extensive and of high quality, the bedrock shoreline is narrow, disturbed by vehicle traffic, and covered by cobbles in many areas.

Seven special plants are known from the alvar and small inclusions of glade within the alvar (Table 4). Bedrock glade is scattered throughout the alvar, but the occurrences are too small to rank.

Most of the site is owned and managed either by the State of Michigan or The Nature Conservancy. There is a possibility of acquiring some of the small ownerships in Section 32.

2. Chippewa Point.

The Chippewa Point site is the smallest site recognized on Drummond Island, with a short exposure of bedrock beach backed by approximately 50 acres of alvar. No field visit was conducted at the site, but it is expected that most of the species found at Maxton Plains West and Grand Marais Lake to the east will also be found here. On the aerial photos several large cracks can be seen in the dolomite bedrock, and the photo signature of the alvar is similar to that of the nearby alvar sites.

The site has a single owner, who also owns a portion of the Grand Marais Lake bedrock beach and alvar site. Acquisition of this site is a high priority for The Nature Conservancy and the owner has already been contacted.

3. Grand Marais Lake (Maxton Plains North).

This site contains some of the least degraded bedrock shoreline and alvar in the state. The bedrock is exposed along the shores of Grand Marais Lake, and gradually grades into alvar farther from the shoreline. Along the shore, dolomite is exposed, and vegetation occupies the cracks and some of the moist pavement. Spike-rush (*Eleocharis rostellata*) is the common dominant on the moist pavement, and this species is often surrounded by a thin film of precipitated calcium carbonate. Farther inland vegetation cover becomes complete, forming a shallow turf dominated by sedges and grasses. Along the North Channel shoreline to the north, is steep cobble beach; the cobbles are angular, fossil-rich dolomite, probably derived from the cliffs near Poe Point to the east. Bedrock glade occurs near the North Channel shoreline and scattered throughout the alvar. Glade occurrences are too small to rank individually.

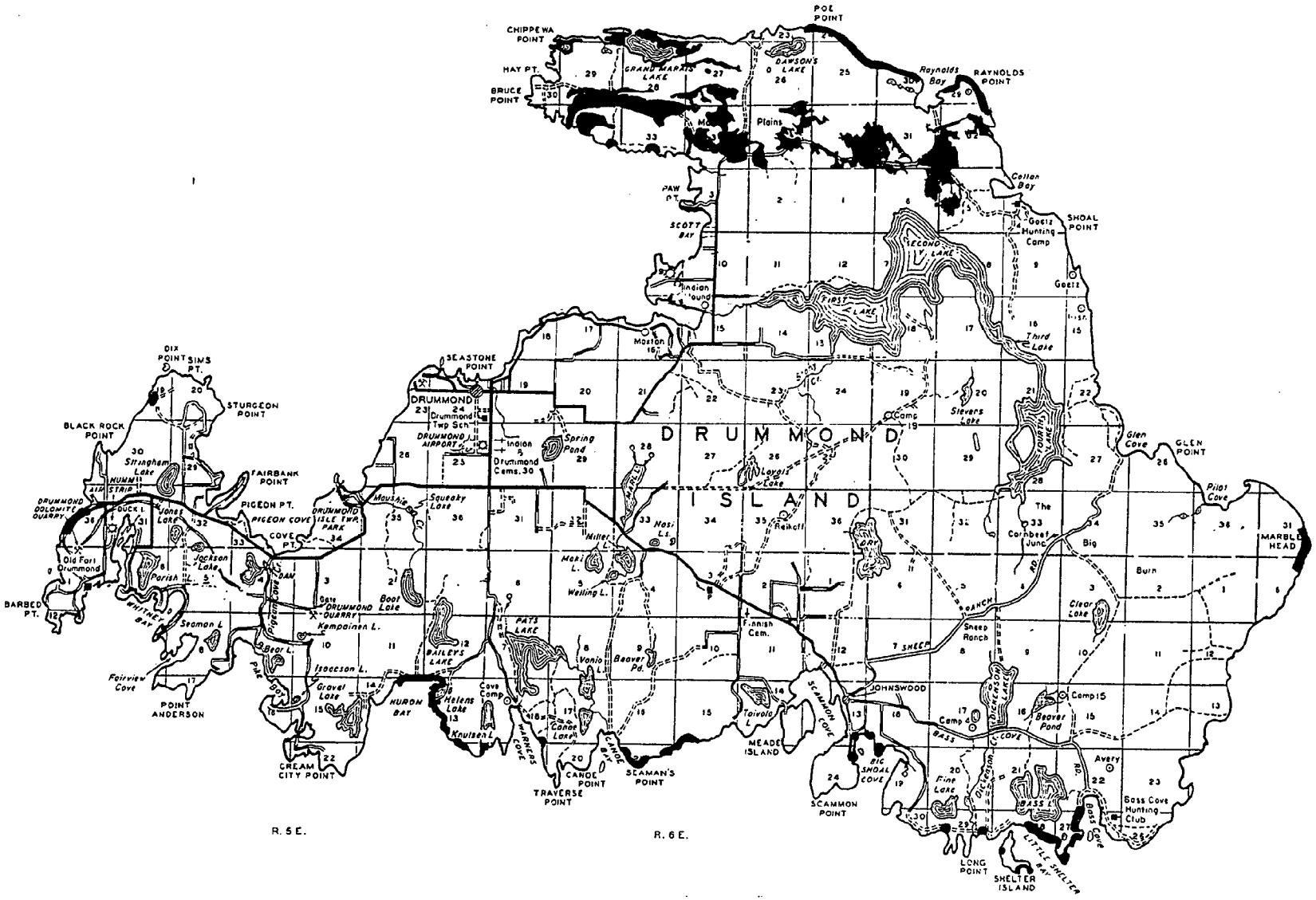


Figure 5. Major areas of bedrock shoreline, exposed dolomite pavement (alvar), or cliffs.

Queenston Shale

1. Maxton Plains West
2. Chippewa Point
3. Grand Marais Lake
4. Poe Point
5. Maxton Plains Middle
6. Raynolds Point
7. Maxton Plains East

Manistique Group (Dolomite)

8. Marble Head

Engadine Group (Dolomite)

9. Bass Cove - Little Shelter Bay
10. Big Shoal Cove
11. Seamans Point
12. Warners Cove
13. Huron Bay

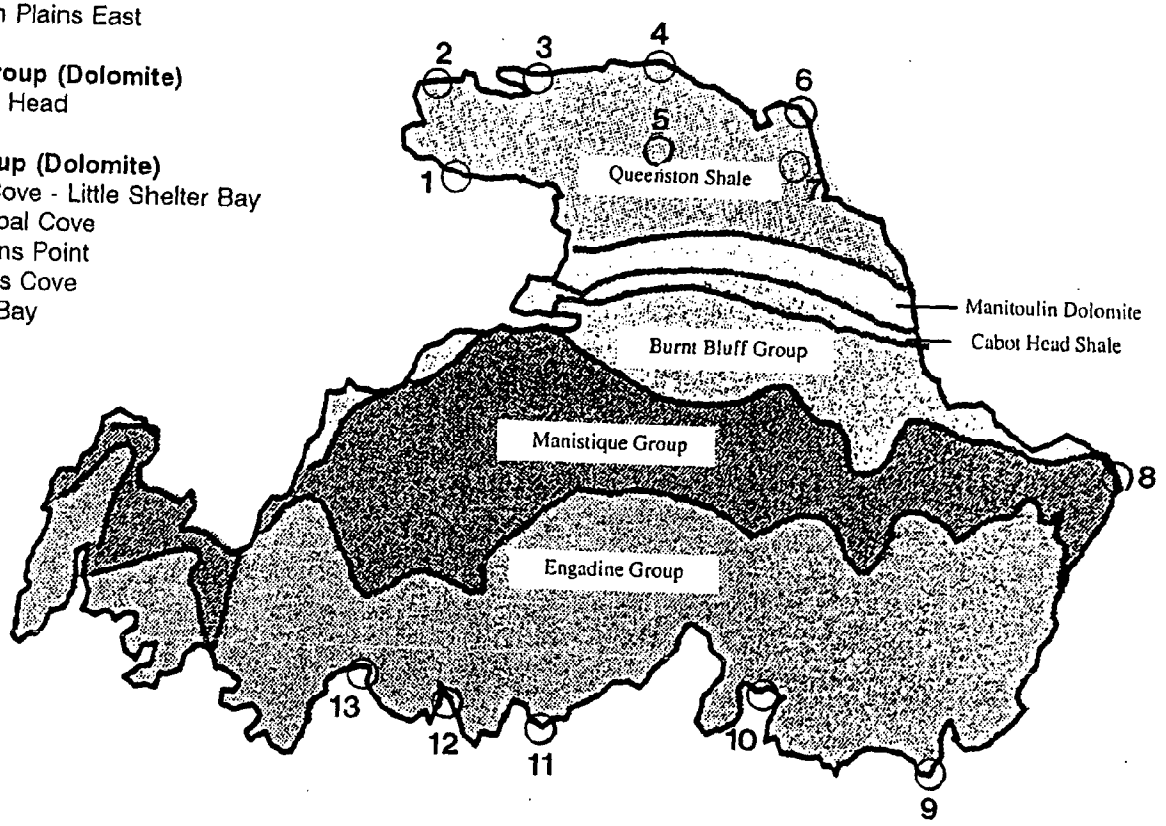


Figure 6. Major bedrock sites on Drummond Island.

Table 3-A
Summary Data for Drummond Island Bedrock Sites

Drummond Island Bedrock Site[a]	Site Data					
	Township/ Range	Bedrock Type	Bedrock Classification	# of T & E Plants	Ownership[b]	Level of Development[c]
1. Maxton Plains West	T43N R6E	Dolomite	Queenston Shale	7	MI, TNC, P(S)	U, M
2. Chippewa Point	T43N R6E	Dolomite		1	P(L)	U
3. Grand Marais Lake	T43N R6E	Dolomite		7	TNC, MI, P(L)	U
4. Poe Pt. - Raynolds Bay	T43N R6-7E	Dolomite		1	TNC, MI, P(L)	U
5. Maxton Plains Middle	T43N R6E	Dolomite		7	MI, P(L)	U
6. Raynolds Point	T43N R7E	Limestone		0	P(L)	U
7. Maxton Plains East	T43N R6-7E	Dolomite		2	MI, P(L)	U
8. Marble Head	T41-42N R8E	Dolomite	Manistique Group	3	MI	U
9. Bass Cove - Little Shelter Bay	T41N R7E	Dolomite	Engadine Group	6	MI, P(L)	U
10. Big Shoal Cove	T41N R6-7E	Dolomite		9	P(S), MNA	U, M
11. Seamans Point	T41N R6E	Dolomite		6	MI, P(L)	U
12. Warners Cove	T41N R6E	Dolomite		2	MI, P(L)	U
13. Huron Bay	T41N R5-6E	Dolomite		10	P(C), MI	U, M

[a]For site maps see Appendix II.

[b]Ownership is listed in order of acreage owned. Ownership codes are as follows:

MI	State of Michigan	P(C)	Private, corporate
US	Federal	P(L)	Private, large tracts
TNC	The Nature Conservancy	P(S)	Private, small tracts
MNA	Michigan Nature Association		

[c]Development codes are as follows: **U** = undeveloped or sparse; **M** = moderate development; **H** = heavy development.

Table 3-B
Summary Data for Drummond Island Bedrock Sites

Drummond Island Bedrock Site	Site Data					
	Bedrock Beach: Length (mi)/Rank	Bedrock Width (ft)	Cliff Length (mi)	Cobble Beach[a] Length (mi)	Alvar: Acres/Rank	Bedrock Glade[b] (acres)
1. Maxton Plains West	0.2/	50-100	--	0.3	600/A	●
2. Chippewa Point	0.1/	50-100	--	0.3	50/	●
3. Grand Marais Lake	1.5/A	200-300	--	1.3	200/A	●
4. Poe Pt. - Raynolds Bay	0.8+/	< 50	> 1.0	2.0	--	--
5. Maxton Plains Middle	--	--	--	0.3	800/A	●
6. Raynolds Point	1.0/	< 50	--	0.4	--	--
7. Maxton Plains East	0.2/	--	--	●	1000/BC	●
8. Marble Head	--	--	0.8	--	--	--
9. Bass Cove - Little Shelter Bay	1.8/A	150-200	--	5.0	--	200/AB
10. Big Shoal Cove	0.8/B	50-100	--	2.0+	--	●
11. Seamans Point	0.8/A	50-150	--	1.0	50/B	●
12. Warners Cove	0.2/C	50-100	--	2.0+	--	●
13. Huron Bay	2.0/A	200-300	--	2.0+	--	●

[a] ● = present, no acreage calculated.

[b] ● = present, no acreage calculated.

Table 4
Rare Plant Species Occurrences on Drummond Island Bedrock Sites

Species	Site Number[a]												
	Queenston Shale							Manistique Group	Engadine Group				
	1	2	3	4	5	6	7	8	9	10	11	12	13
Asplenium ruta-muraria								●					
Astragalus neglectus										●			
Calypso bulbosa	●		●	●	●								●
Carex concinna			●							●			
C. richardsonii					●				●	●	●		●
C. scirpoidea	●		●		●				●	●	●	●	●
Cirsium hillii	●		●						●	●	●	●	●
Cypripedium arietinum										●			
Eleocharis compressa	●		●		●		●		●				
Geum triflorum	●												
Gymnocarpium robertianum								●					●
Iris lacustris										●	●		
Pellaea atropurpurea													●
Piperia unalascensis	●	●	●						●	●	●		●
Poa alpina													●
Pterospora andromedea								●					
Scutellaria parvula					●								●

Table 4 (cont.)
Rare Plant Species Occurrences on Drummond Island Bedrock Sites

Species	Site Number[a]												
	Queenston Shale							Manistique Group	Engadine Group				
	1	2	3	4	5	6	7	8	9	10	11	12	13
Solidago houghtonii											●		
Sporobolus heterolepis	●		●		●		●			●			
Stellaria longipes									●				
Trichostema brachiatum					●								
Trisetum spicatum													●

[a]Drummond Island site names are as follows:

Queenston Shale (primarily Dolomite in Michigan)

1. Maxton Plains West
2. Chippewa Point
3. Grand Marais Lake
4. Poe Point - Raynolds Bay
5. Maxton Plains Middle
6. Raynolds Point
7. Maxton Plains East

Manistique Group (Dolomite)

8. Marble Head

Engadine Group (Dolomite)

9. Bass Cove - Little Shelter Bay
10. Big Shoal Cove
11. Seamans Point
12. Warners Cove
13. Huron Bay

Botanical inventory has been much less intensive than on the Maxton Plains alvar to the south, but seven special plant species have been found (Table 4). A rare moss, *Scorpidium turgescens*, is known from this site. It is likely that small skull-cap (*Scutellaria parvula*) and false pennyroyal (*Trichostema brachiatum*) will also be found.

This site is already partially owned by both the State of Michigan and The Nature Conservancy. The Conservancy is presently pursuing acquisition of the remaining large private parcel west of Grand Marais Lake.

4. Poe Point-Raynolds Bay.

The shoreline of North Channel between Poe Point and Raynolds Bay consists of alternating segments of steep cobble beach and narrow dolomite pavement, which extends another 50 to 100 feet into the bay as a shelf just beneath the water surface. Behind the cobble beach are low, coral-rich dolomite cliffs surrounded both above and below by a dense band of northern white-cedars. Only one special plant, calypso (*Calypso bulbosa*), is known from the base of the cliffs, but the habitat looks appropriate for several special plants, including ram's head lady's-slipper (*Cypripedium arietinum*), Alaska orchid (*Piperia unalascensis*), and several ferns.

Large portions of the shoreline are owned by both the State of Michigan and The Nature Conservancy. Remaining private ownership consists of a single large parcel. Acquisition of this parcel is less important than acquisition of the remaining Grand Marais Lake (Maxton Plains North) parcels.

5. Maxton Plains Middle.

There is no exposed bedrock shoreline south of Maxton Plains Middle; the shoreline consists of a marly cobble beach. This portion of Maxton Plains supports high quality alvar. Small inclusions of bedrock glade occur throughout, but these are too small to map or rank. Seven special plants are known from the alvar (Table 4); most are shared with the Maxton Plains West and Grand Marais Lake sites.

Almost the entire Middle Plains is owned and managed by the State of Michigan, but there are a few small private parcels at the southern edge of the alvar. Acquisition of these parcels should be pursued to limit residential and recreational development of the Maxton Plains.

6. Raynolds Point.

The shoreline of Raynolds Point and to the southwest is narrow (less than fifty feet wide) dolomite or limestone pavement, which extends as a shallow shelf up to 100 feet into the North Channel. The regular blocks of pavement can be easily seen in the shallow water with aerial photos. A narrow cobble beach occurs along the upper edge of the pavement along the east shore of the point. No surveys for special plants have been conducted along the shoreline. The pavement is narrow and plant communities are probably not well developed because of both wave activity and ice scour. There may also be low cliffs of limestone or dolomite above the pavement, much like portions of the Poe Point-Raynolds Bay shoreline.

This site contains three large private parcels; there is no state or Conservancy ownership. The site should be surveyed in 1995.

7. Maxton Plains East.

Maxton Plains East consists of extensive areas of alvar, with a narrow stretch of exposed bedrock and cobble along the shoreline. Maxton Plains East is the most degraded part of the Maxton Plains, having been intensively grazed by sheep. Only two special plants are known from

this section of the plains (Table 4). Further botanical survey may be justified, but was not conducted in 1994. Some surveys were conducted in 1992, but did not result in any new special plant occurrences.

Much of this alvar site is already owned by the State of Michigan; the remainder is in large privately-owned tracts used as hunt clubs. These private tracts should be considered for acquisition by the state if they become available, but probably do not warrant active pursuit by conservation organizations. The state-owned alvar may become a candidate for restoration in the future, but there have been no alvar restoration projects to date.

8. Marble Head.

The cliffs along the shoreline are well-known features to botanists. These cliffs support three special plants, two of which are ferns (Table 4). The cliffs are part of the Manistique Group, characterized as dolomite. The cliffs are quite remote and are most easily visited by small boat. The upland route is impassible in most vehicles. Based on aerial photo interpretation, it appears that there are several smaller inland escarpments and some areas of bedrock glade that deserve botanical and zoological exploration. An attempt will be made to conduct these surveys during the 1995 field season.

The entire tract is owned and managed by the State of Michigan. Most of Marble Head is forested, either with trembling aspen or northern hardwoods. It is likely that these forest stands will periodically be harvested by the Forest Management Division of the Michigan DNR. For this reason it is important to identify any significant bedrock glades and associated special plant occurrences.

9. Bass Cove-Little Shelter Bay.

This seven-mile stretch of shoreline consists primarily of pristine dolomite pavement along the west shore of Bass Cove and along the east shore of Little Shelter Bay (Plate 5a and 5b); it is one of the highest quality dolomite beaches in the state. Farther to the east, and on much of Shelter Island, cobble shoreline is prevalent. The dolomite pavement is locally 250 feet wide. On Bass Cove, the pavement gradually grades into high-quality bedrock glade, dominated by small northern white-cedar, balsam fir, and tamarack. Only a small portion of the glade was explored, but photo interpretation indicates that the glade was approximately 200 acres in area. The AB rank for the glade is tentative, based only on the small portion of the glade visited in 1994.

Six special plants were found during a mid-summer survey (Table 4); it is likely that additional species would be encountered in a late spring survey of the bedrock beach and glade. Two special sedges, *Carex scirpoidea* and *C. richardsonii*, were widespread on the bedrock shoreline, and two additional species, Hill's thistle (*Cirsium hillii*) and Alaska orchid (*Piperia unalascensis*), were common within the open glade. The other two species were much more localized.

The highest quality bedrock pavement and all of the bedrock glade is located on State of Michigan property. The remaining shoreline on both Drummond Island and Shelter Island is mostly cobble beach under large private ownership. The private ownerships should be pursued for acquisition, either by the state or a conservation organization, but they are less important than the private ownerships at Seamans Point and Huron Bay.

10. Big Shoal Cove.

This is one of the shorter expanses of high quality bedrock beach along the south shore of Drummond Island. There are three distinct sections of dolomite pavement; the largest, in Section 18, has been acquired by the Michigan Nature Association. Although the MNA preserve

is relatively small, it contains nine special plants, making it one of the richest sites on Drummond Island for special plants. Insect surveys were conducted during the summer and early autumn of 1994, but the results of these surveys have not yet been finalized.

Residential development and road building have degraded the remaining dolomite pavement. There are no other tracts on the bay to recommend for acquisition.

11. Seamans Cove.

This site contains four distinct segments of broad, high-quality dolomite pavement separated by cobble beach. There are also 50 acres of alvar (B-ranked), that extends from the shoreline inland for more than a quarter mile. The dolomite pavement averages approximately 100 feet in width. The open pavement gradually grades into a narrow bedrock glade, which contains Hill's thistle (*Cirsium hillii*), dwarf lake iris (*Iris lacustris*), and Alaska orchid (*Piperia unalascensis*). Special plants common on the pavement are the sedges *Carex richardsonii* and *C. scirpoidea*. Houghton's goldenrod (*Solidago houghtonii*) was also found at the site. It is likely that additional special plants will be found if an early plant survey is conducted. Insect surveys were conducted during the summer and early autumn of 1994. Further surveys of insects and snails may also be conducted at this site as part of a newly initiated international alvar survey.

The State of Michigan owns the shoreline in the eastern quarter of Section 21 and the western half of Section 15, where considerable dolomite pavement and the alvar are located. The western three quarters of Section 21 are owned by George and Eleanor Seaman. This ecologically significant parcel should be pursued either for acquisition or conservation easement.

Seamans Point: Broad dolomite pavement at Seamans Point shows typical zonation seen on the southern shore of Drummond Island. The pavement is almost devoid of vegetation in the wave-splash zone. Farther inland, in the ice-scour zone, sedges and other herbaceous vegetation occupy cracks in the pavement. A shrub-dominated zone grades into a narrow zone of open forested glade.

12. Warners Cove.

Warners Cove was previously recognized as a bedrock beach in MNFI's database. Dolomite pavement in the cove is restricted to less than a quarter mile of shoreline, with no known special plants. Most of the embayment is cobble beach. Only two special plants are known from the northern-most part of the bay, Hill's thistle (*Cirsium hillii*) and a sedge (*Carex scirpoidea*). The site is assigned a rank of C on the basis of the low diversity of special plants and the small size of the dolomite pavement. Further late spring and early summer plant surveys might result in additional special plants, but might not justify increasing the rank of the bedrock shoreline.

Large portions of the shoreline are owned by the State of Michigan. Remaining private parcels are large. Acquisition of these parcels is probably lower priority than parcels at both Seamans Point and Huron Bay.

13. Huron Bay.

Huron Bay has the largest expanse of broad dolomite beach on Drummond Island, and probably for the entire state. The site also has more special plants (10 species) than any other site on Drummond Island (Table 4). The dolomite pavement extends as far as 2000 feet inland and averages 200 to 300 feet wide along the eastern side of the bay. The dolomite along portions of the shoreline are much steeper than is typical on Drummond Island (see photo below), but on most of the shoreline the pavement is quite flat, with less than one percent slope.

The special plants of the site include all of the typical special plants of the dolomite shoreline, but also contain glade species and two rare ferns. The only Drummond Island occurrence for downy oat-grass (*Trisetum spicatum*), a special plant characteristic of the conglomerate bedrock of the Keweenaw Peninsula, is found at Huron Bay.

Huron Bay: Whereas most of Huron Bay has flat dolomite pavement similar to that along Seamans Point and Bass Cove, this portion of the shoreline has a relatively steep escarpment, backed by an open conifer-dominated glade. The northern white-cedars have been grazed to 5 or 6 feet above the ground by white-tail deer.

SUMMARY OF VEGETATION SAMPLING ON THE KEWEENAW PENINSULA

Copper Harbor Conglomerate.

The flora and zonation of the conglomerate bedrock beach was described in detail by Reschke (1985). In our study, we could not adequately sample the lichen and bryophyte floras, and instead concentrated on the vascular plant flora. Carol Reschke assisted us with the sampling and familiarized us with many of the more common lichens and bryophytes. The bedrock flora between Agate Harbor and Copper Harbor, as described by Reschke (1985), was similar to that encountered across the entire length of the conglomerate. Appendix III contains the list of species found by Reschke during her 1985 studies.

The general zonation described by Reschke was also consistently present along the entire length of the Copper Harbor Conglomerate. The low-wet zone, where wave action was most severe, always had low diversity and a high percentage of bare rock. The intermediate-dry and -moist zones, where ice scour was still prevalent, was typically dominated by appressed and crustose lichens, with scattered vascular plants. The high-dry rocks, above the level of extreme wave activity and ice scour, had increased cover and diversity. Finally, where there were depressions and pools protected from wave action and ice scour, the pool flora described by Reschke was encountered.

Different bedrock configurations, as depicted by Reschke (1985), result in local differences in floristic composition (Figure 7). In some of the broader shorelines, all of the described vegetation zones may be present. In contrast, on some of the steeper, narrower shoreline cross-sections, only the low-wet, intermediate-moist, and intermediate-dry associations might occur.

During field surveys, numerous new occurrences of special plants were found. Most of the occurrences were of species already known from the conglomerate of the Keweenaw peninsula. Among the most commonly encountered species were pale Indian paintbrush (*Castilleja septentrionalis*), butterwort (*Pinguicula vulgaris*), pearlwort (*Sagina nodosa*), and downy oat-grass (*Trisetum spicatum*). Stitchwort (*Stellaria longipes*) was newly discovered on the conglomerate.

Bedrock glades were encountered along much of the shoreline on conglomerate; this zone was quite variable in width, from only a few feet to more than a thousand feet. Shrubs were common in this zone, including shadbush (*Amelanchier sanguinea*), low shadbush (*A. spicata*), bearberry (*Arctostaphylos uva-ursi*), bush-honeysuckle (*Diervilla lonicera*), juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), twining honeysuckle (*Lonicera dioica*), sweet gale (*Myrica gale*), ninebark (*Physocarpus opulifolius*), sand cherry (*Prunus pumila*), dwarf raspberry (*Rubus pubescens*), buffalo berry (*Shepherdia canadensis*), mountain ash (*Sorbus decora*), snowberry (*Symphoricarpos albus*), and blueberry (*Vaccinium angustifolium*). Common trees included balsam fir (*Abies balsamea*), paper birch (*Betula papyrifera*), jack pine (*Pinus banksiana*), red pine (*Pinus resinosa*), balsam poplar (*Populus balsamifera*), quaking aspen (*Populus tremuloides*), and northern white-cedar (*Thuja occidentalis*).

Portage Lake Volcanics.

The vascular plant flora of the basalt and vesicular basalt of the Portage Lake Volcanics was very similar to that of the Copper Harbor Conglomerate. The major difference was that the basalt shoreline was generally much narrower than the conglomerate shoreline. As a result, there was often no zone of bedrock above the wave-splash zone. The basalts typically had many fewer cracks for plants to root in. Special plants encountered on the basalts include Ross' sedge (*Carex rossii*), pale Indian paintbrush (*Castilleja septentrionalis*), alpine bistort (*Polygonum viviparum*), stitchwort (*Stellaria longipes*), downy oat-grass (*Trisetum spicatum*), and dwarf bilberry (*Vaccinium cespitosum*).

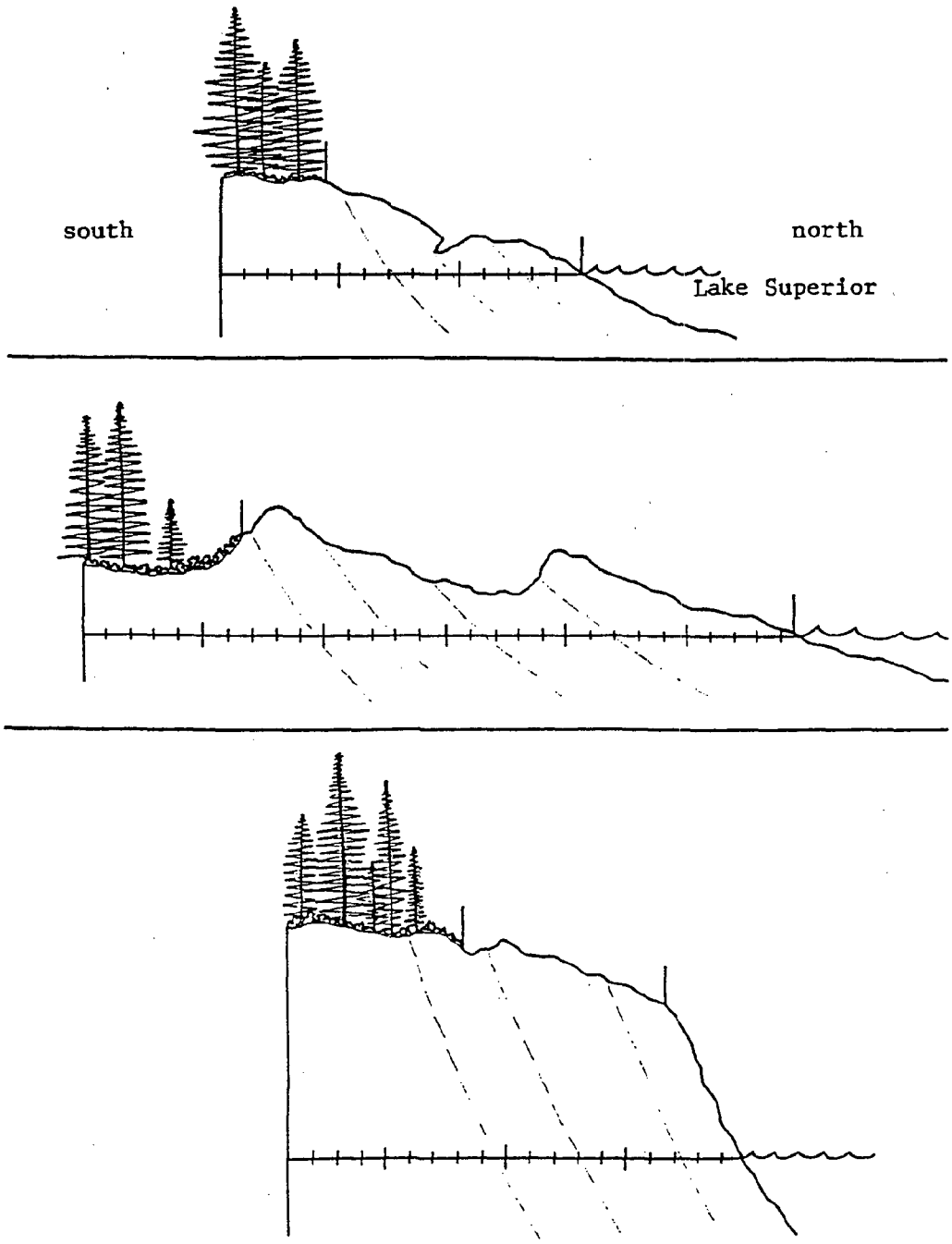


Figure 7. Cross-section diagrams showing the variability in shoreline width and topography from three sample sites. Vertical lines arising from the rock surface indicate the extent of the area sampled. Diagonal dashed lines indicate approximate dip of bedding planes in the conglomerate rock. Horizontal scale indicates distance in meters. Diagram and text from Reschke (1985).

Freda Sandstone.

The vascular plant flora of the Freda Sandstone was quite localized and depauperate, as the entire cliff face appears to be subject to severe wave activity. Further survey of the Freda-Redridge and Rockhouse Point-Graveraet River sites may provide more floristic information. Only one special plant, butterwort (*Pinguicula vulgaris*), was found on the moist, seepy upper cliffs at the Portage Lake Ship Canal West site.

SUMMARY OF VEGETATION SAMPLING ON THE DOLOMITE OF DRUMMOND ISLAND

Sampling of the dolomite beaches of Drummond Island indicate that some of the same zones identified on the conglomerate beaches of Keweenaw Peninsula occur on the dolomite. Although the shoreline is quite flat, with slopes of about 1 degree (as compared to 40 degrees on the Copper Harbor Conglomerate), there is still a distinct wave-splash zone, where there is almost no vegetation, and an ice-scour zone, where vegetation is restricted to cracks in the bedrock. Farther inland, where ice scour is probably less severe, the vegetation in the cracks becomes more diverse, and includes shrubs and small trees. Finally, there was an open glade zone that graded into closed-canopy forest. At Bass Cove, on the south shore of Drummond Island, the wave-splash zone was 2-3 meters wide and had about 1 percent plant cover of mosses and herbs, the ice-scour (and probably storm wave) zone was 15 meters wide and had 10 percent cover of herbs and scattered shrubs in cracks, a third herb-shrub zone above wave and ice action had 40 percent cover of shrubs, herbs, and mosses, and the glade zone had an open canopy of scattered trees with almost 100 percent cover of shrubs, herbs, and mosses.

The vegetation data collected during 1994 has not been completely analyzed, so discussion of the flora will concentrate only on special plants. The most common special plants of the alvar, dolomite shoreline, and glades are, in order of number of occurrences: bulrush sedge (*Carex scirpoidea*) (8), Hill's thistle (*Cirsium hillii*) (7), Alaska orchid (*Piperia unalascensis*) (7), calypso (*Calypso bulbosa*) (5), Richardson's sedge (*Carex richardsonii*) (5), flattened spike-rush (*Eleocharis compressa*) (5), and prairie dropseed (*Sporobolus heterolepis*) (5). *Calypso bulbosa* and *Carex richardsonii* are probably more prevalent than these data suggest, but are most easily recognized in late spring or early summer, before this project was initiated. The most common special plant species on the exposed shoreline were *Carex scirpoidea* and *C. richardsonii*. *Cirsium hillii*, *Piperia unalascensis*, and *Calypso bulbosa* were the most common species in the glades, while *Eleocharis compressa*, and *Sporobolus heterolepis* were most common on the more inland areas of alvar.

COMPARISON OF THE BEDROCK FLORAS OF THE KEWEENAW PENINSULA AND DRUMMOND ISLAND

The special plant occurrences of the shorelines of the Keweenaw Peninsula and Drummond Island were compared. Of the 51 special plant species known from these shorelines, 35 are known from the Keweenaw Peninsula and 22 are known from Drummond Island, with only 6 shared species (12 percent). Of the shared species, only one (*Calypso bulbosa*) has several occurrences on both, with five records from Drummond Island and six from the Keweenaw. Bulrush sedge (*Carex scirpoidea*) is more frequent on Drummond Island (8 vs. 1), and downy oat-grass (*Trisetum spicatum*) is more frequent on the Keweenaw (15 vs. 1). The other shared species, ram's head lady's-slipper (*Cypripedium arietinum*), pine-drops (*Pterospora andromedea*), and stitchwort (*Stellaria longipes*), have four or less occurrences on both the Keweenaw Peninsula and Drummond Island.

The flora of the Keweenaw Peninsula is recognized to have both western (Marquis and Voss 1981) and arctic-alpine phytogeographic affinities (Given and Soper 1981). The alvar and bedrock shoreline of Drummond Island has both arctic and mid-western grassland affinities.

During the spring of 1995, the data from sampling plots will be compared for the Keweenaw Peninsula and Drummond Island. It is expected that there may be more shared common species than rare species, as many of the shrubs and trees are shared.

PRELIMINARY RESULTS OF DRUMMOND ISLAND INSECT SURVEYS

In addition to the species identified by MNFI staff, results were received from G. M. Fauske and D. A. Rider for the Lepidoptera (including the *Papaipema*) and the Pentatomidae. From three orders (Hemiptera, Homoptera, and Lepidoptera), a total of 72 species were recorded from three alvar study areas (Appendix V). Fifty-two species were recorded from the Maxton Plain sites, 31 species from South Drummond Island sites, and 10 species from the Dudley Bay sites. Differences in the number of species at these sites most likely are attributed to sampling intensity. For instance, Dudley Bay was visited twice but on one of those occassions it was overcast and quite cool, which is not optimal insect collecting weather. In addition, nocturnal light-trapping was not conducted at Dudley Bay in 1994. Light-trapping will be conducted there in 1995 so that we can better compare results between sites.

The majority of the species collected are common, wide-ranging insects, however, four genera of leafhoppers (*Flexamia*, *Graminella*, *Laevicephalus*, and *Chlorotettix*) merit special mention. These genera contain species that are very local and restricted to prairie habitats. The leafhopper, *Flexamia delongi*, may have been collected from Maxton Plains and the south shore of Drummond Island; final identification of these specimens has not yet been made. Elsewhere, this species is reported only from high quality prairies and alvar communities in Ontario and northern Illinois, is extremely local in occurrence, and appears to be associated with little bluestem (*Andropogon scoparius*) (Hamilton 1990). When insect identifications are completed, information on listed species will be added to MNFI Biological and Conservation Database and will become available for management and project review activities.

RECOMMENDATIONS

For the 1995 field surveys, it is recommended that insect and mollusc surveys be conducted on the bedrock glades of both Drummond Island and the Keweenaw Peninsula. Surveys for the northern blue butterfly (*Lycaeides idas nabokovi*) are recommended near the Keweenaw shoreline at Keystone Point and Fish Cove, where dwarf bilberry (*Vaccinium cespitosum*) was found.

Recommendations for site protection and acquisition were made within the Summary Section for each site. In this section of the report only brief recommendations will be made, with an attempt to provide an overview of the survey sites. As we conducted our surveys, it was obvious that there is a limited window of opportunity for protecting Great Lakes coastal ecosystems. This window was clearly demonstrated when an outdated topographic map was taken into the field and compared with present conditions. The 1950s map failed to show several miles of coastal roads, which were now completely lined with homes, mostly dating from the 1960s and early 1970s. It was further demonstrated by visits to three Lake Superior sites in Alger County, where over five miles of recently developed sites, with new roads and electrical hook-ups were encountered. On the Keweenaw the story was the same: five recently platted sites, two with over a mile and a half of new roads and electrical hook-ups, the others in the process of being surveyed. **Our window for conservation action along the Great Lakes cannot be measured in years, but rather, in months.**

The greatest urgency for action is on the Keweenaw Peninsula, where Lake Superior Land Company is platting its accessible coastal lands for residential development. Accessible is a relative term, as modern road construction equipment allows for rapid development of sites that appear quite inaccessible. Many of Lake Superior Land Companies' remaining undeveloped lands at the tip of the Keweenaw Peninsula are presently being logged, and the access road is now adequate for 2-wheel drive vehicles. Within a year much of the shoreline along the southeastern tip of the peninsula could be developable.

Probably the most important sites to pursue on the Keweenaw Peninsula are Devil's Washtub, immediately southwest of Copper Harbor, followed by the western edge and center of the Horseshoe Harbor site (W2 of Section 35 and center of Section 31), and Sevenmile Point, with priorities in roughly that order. Sevenmile Point is ecologically significant, with extensive wetlands along its inland margin, and is recreationally and inspirationally very important. The Wescoat parcel within the Horseshoe Bay site is of exceptional quality and should be doggedly pursued. Most of the other sites on the north side of the peninsula contain numerous small ownerships that could be pursued with a more relaxed, long-term program of acquisition and conservation easement.

The southeastern shoreline (including Keweenaw Point, Keystone Point, Fish Cove, and Bete Grise-Bear Bluff) is ecologically significant; it provides expansive wetlands and upland forest for large mammals and northern songbirds, but the size of the project is imposing. Ownership is almost entirely private.

Most of the difficult projects on Drummond Island have already been completed or initiated. Important contacts have already been initiated on Chippewa Point and Grand Marais Lake, extending the Maxton Plains preserve northward. Both Seamans Point and Huron Bay are important projects to pursue, but there does not appear to be extreme urgency on either project. Much of the Huron Point property is owned by Drummond Dolomite, Inc., whose long-term goal for the site is likely mining. This shoreline parcel could provide an opportunity to improve the company's corporate image; it might be a much easier project than first impressions indicate.

Pursuit of ecologically significant Great Lakes coastal tracts should be among the highest priorities of conservation organizations within the Great Lakes region. Immediate pursuit of rapidly disappearing, high quality coastal tracts is critical.

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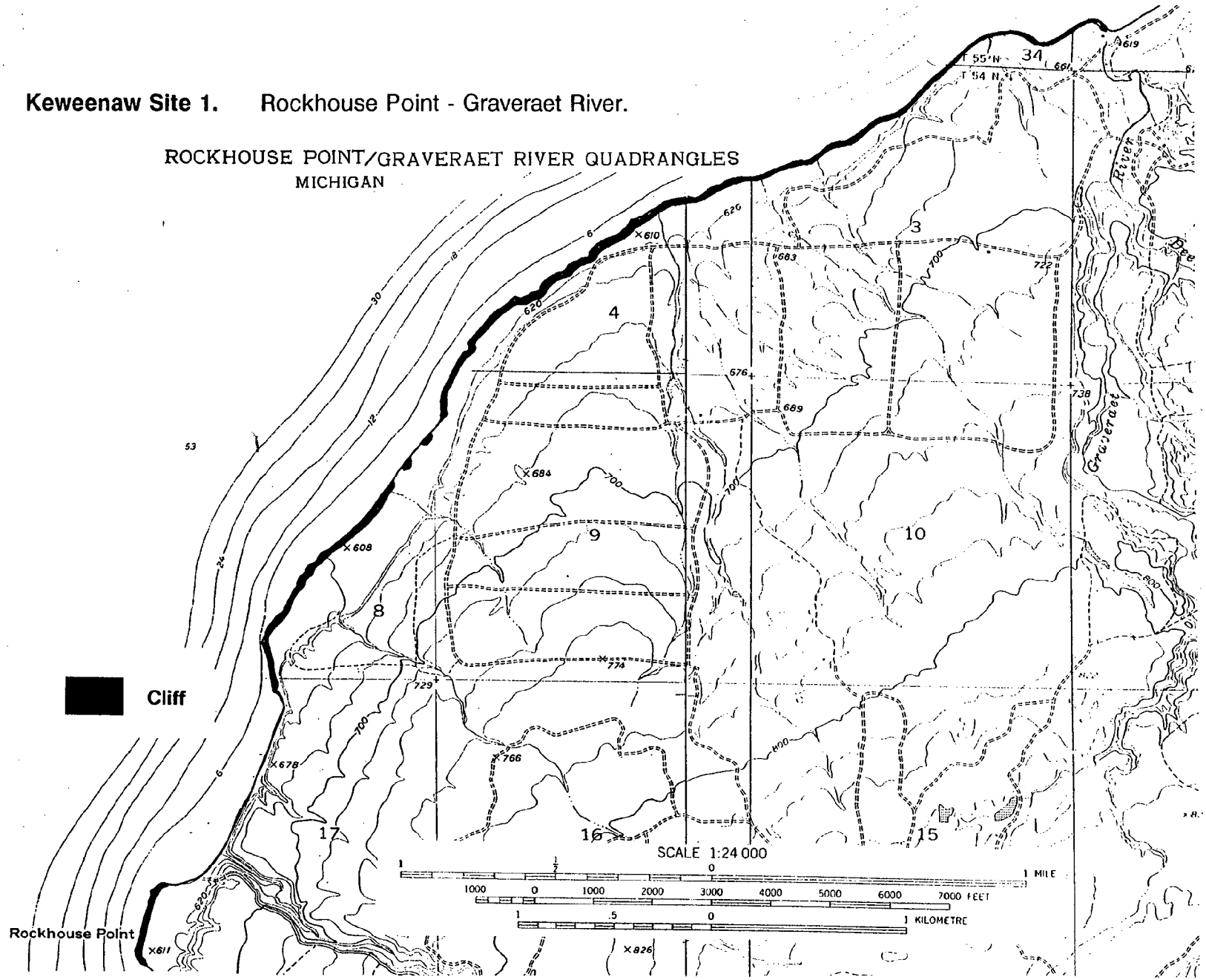
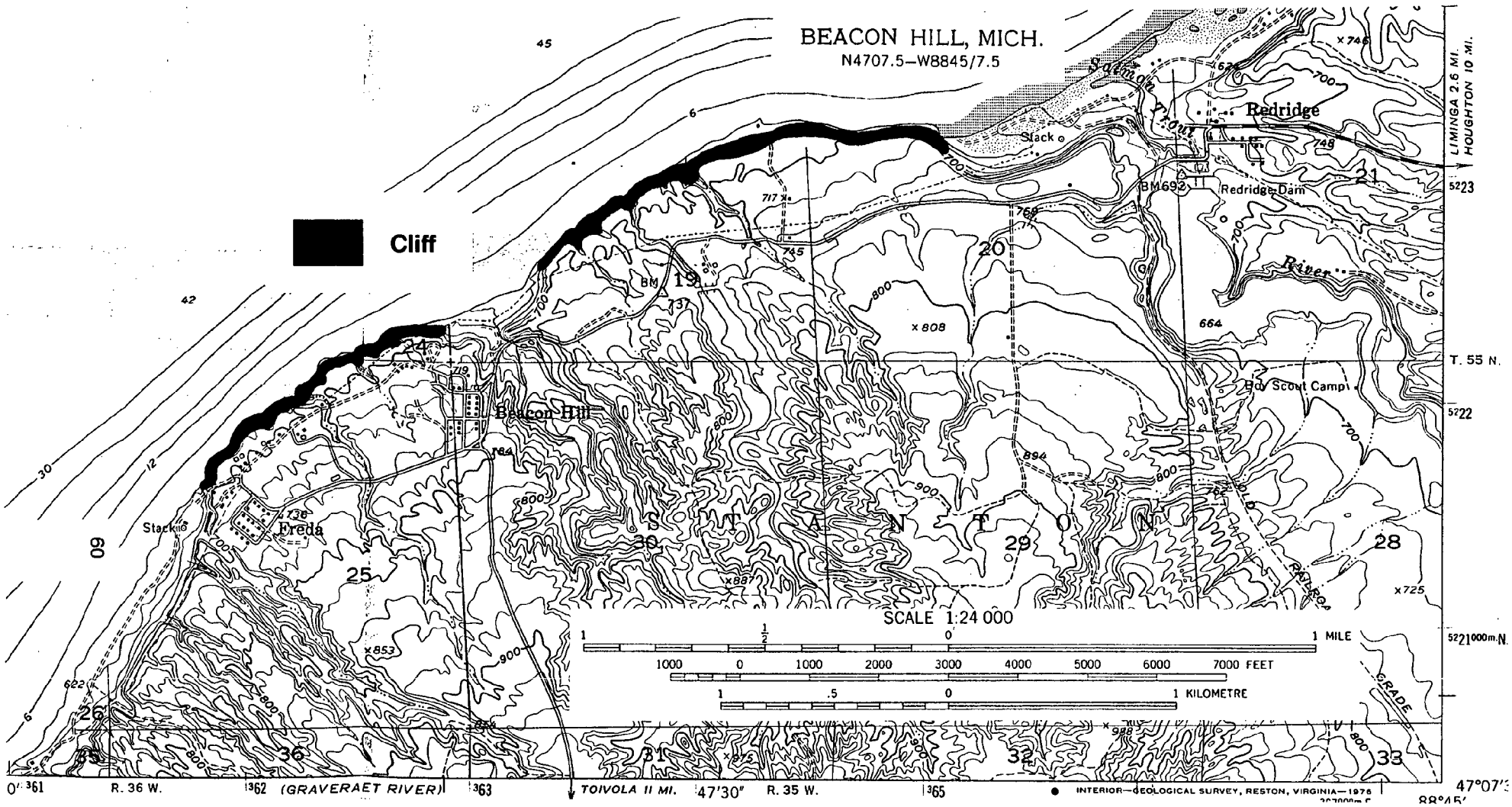
APPENDICES

APPENDIX I

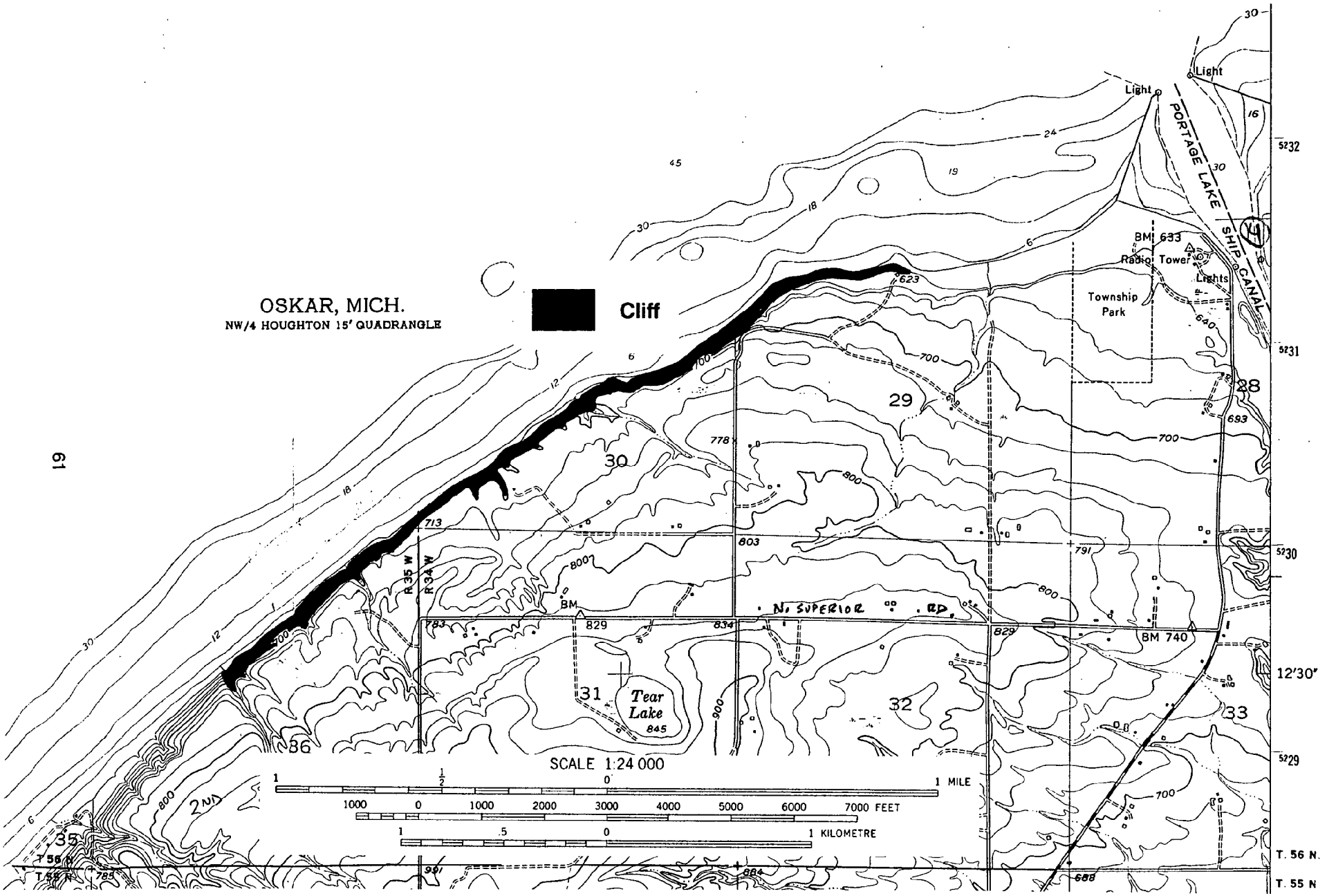
Maps of Keweenaw Peninsula Bedrock Sites

Keweenaw Site 1. Rockhouse Point - Graveraet River.

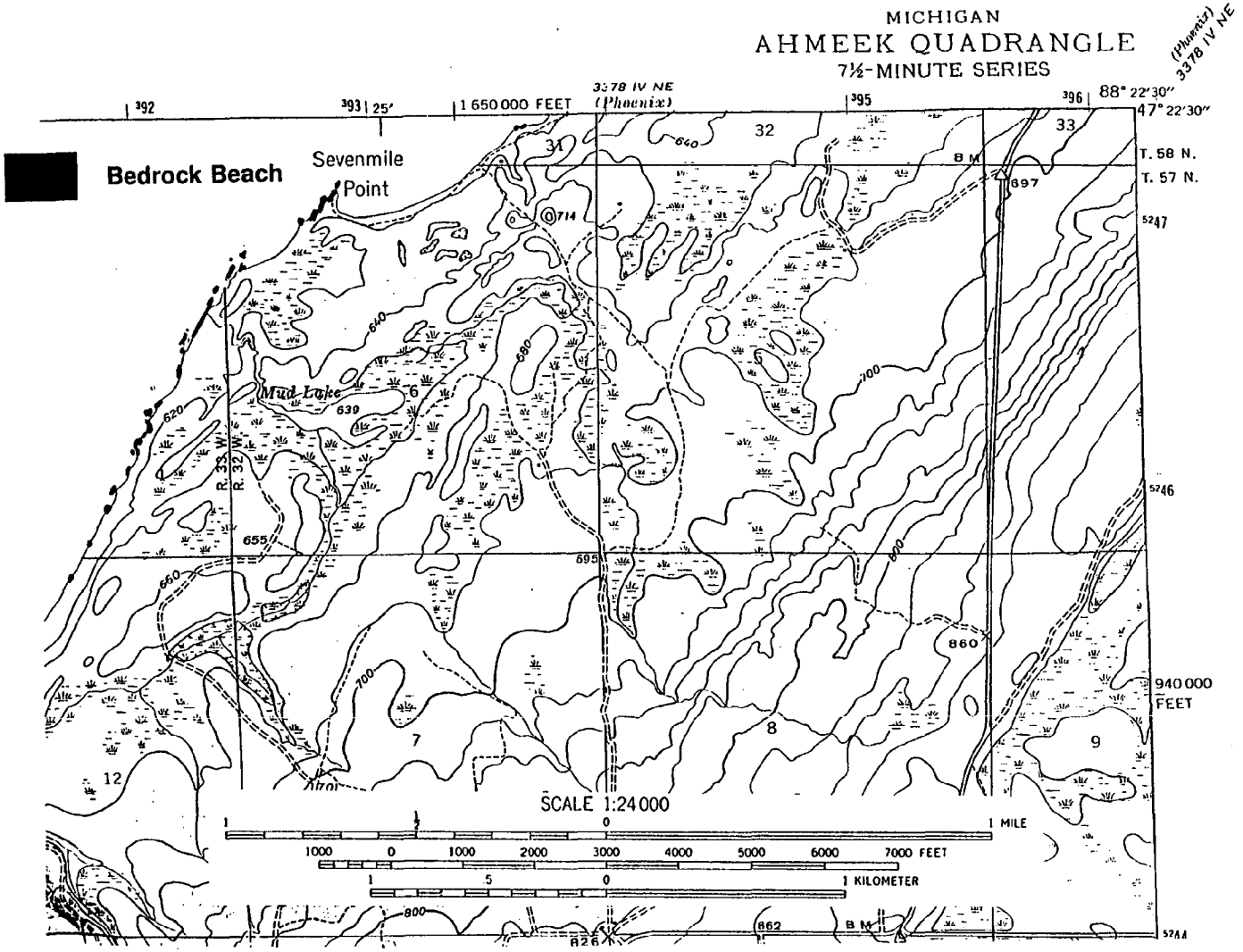




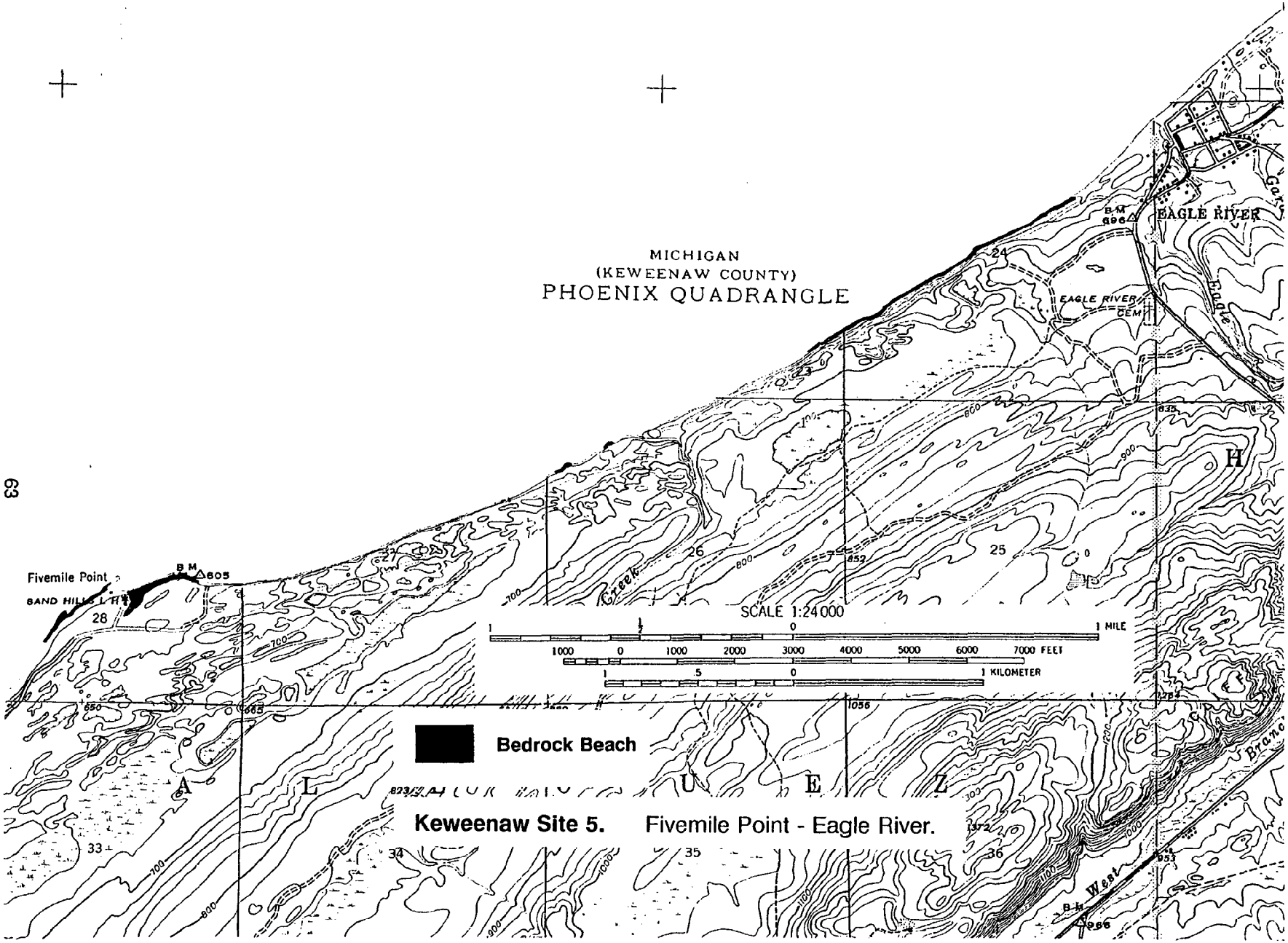
Keweenaw Site 2. Freda - Redridge.



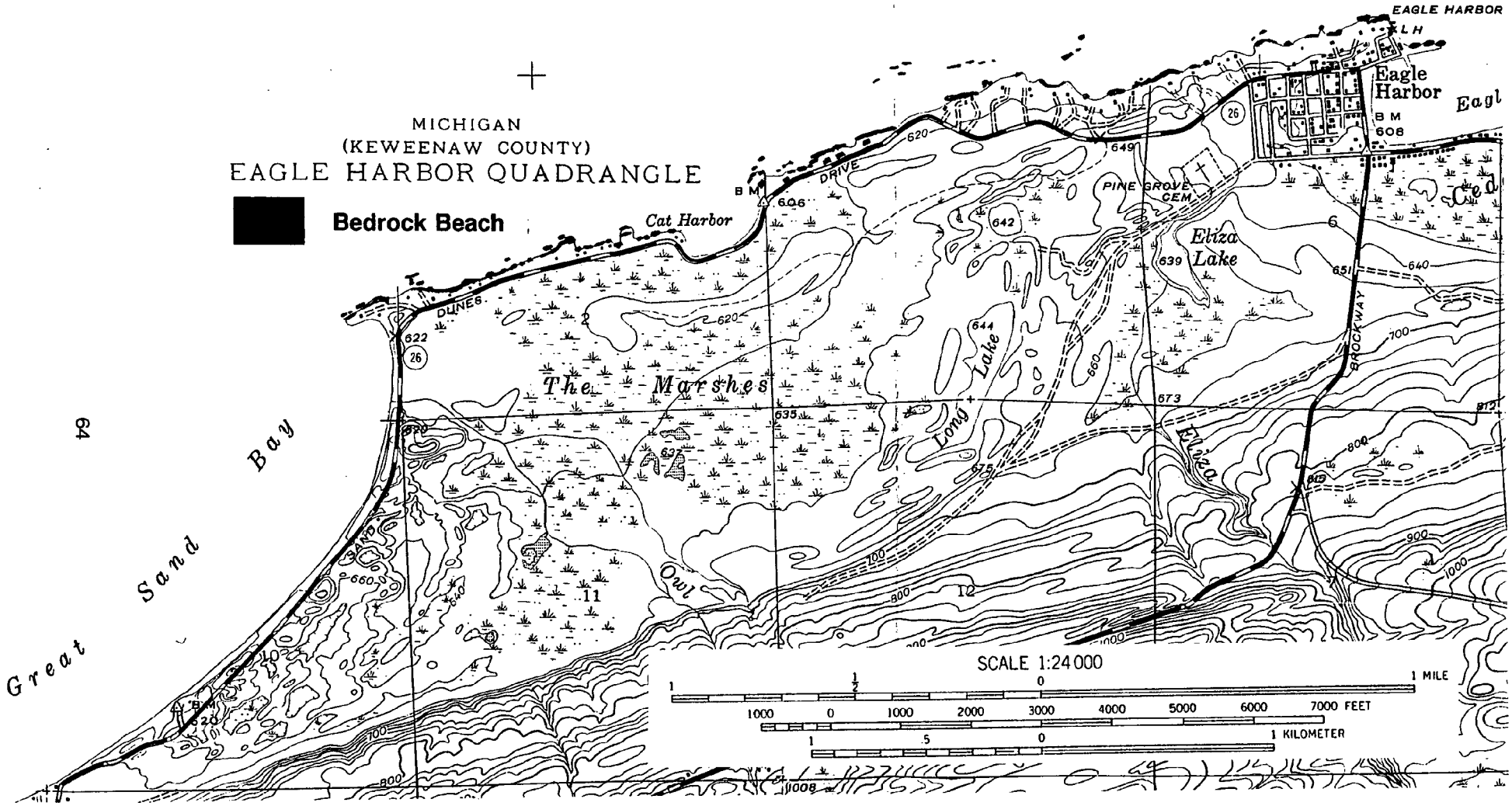
Keweenaw Site 3. Portage Lake Ship Canal West.



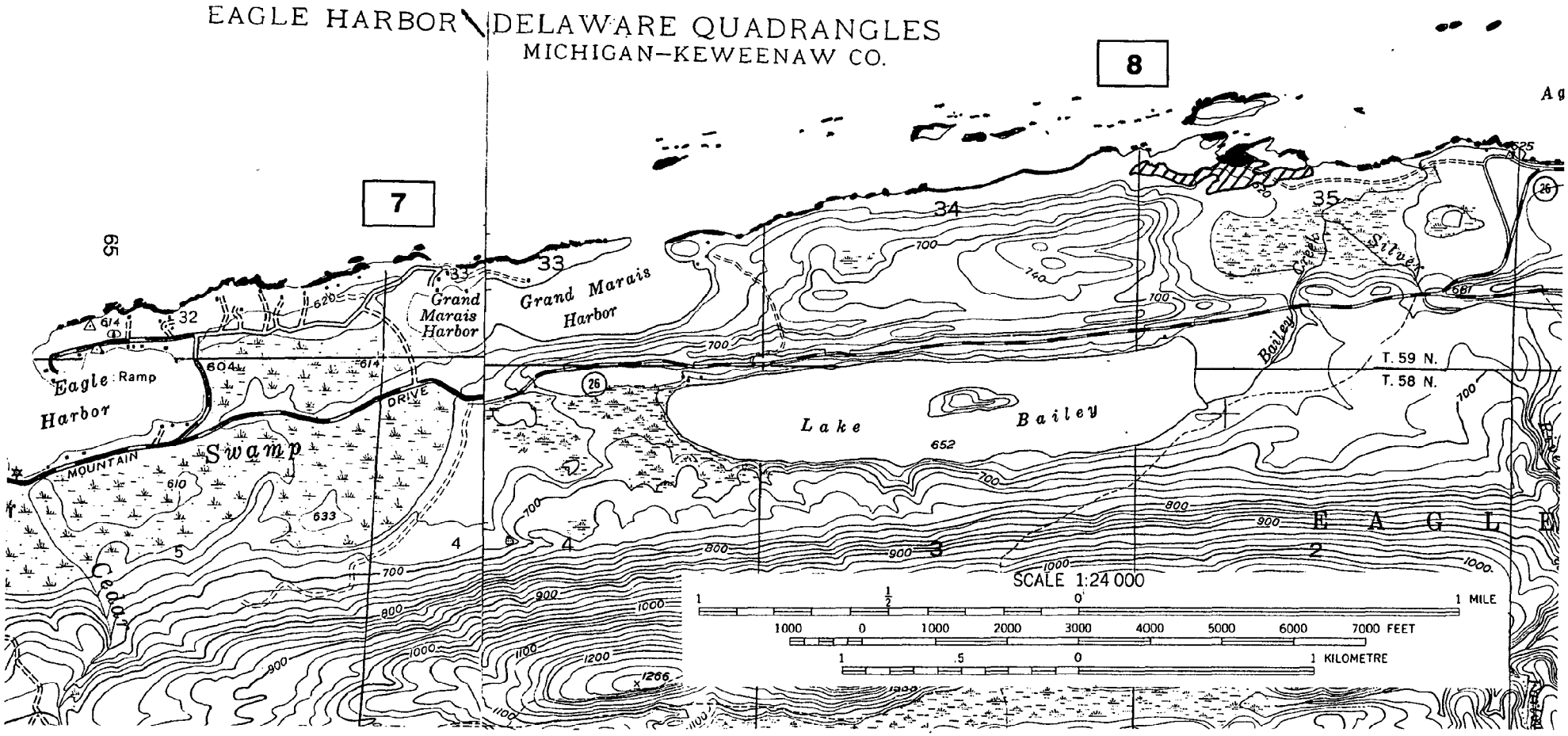
Keweenaw Site 4. Sevenmile Point.



Keweenaw Site 5. Fivemile Point - Eagle River.



Keweenaw Site 6. Cat Harbor - Eagle Harbor

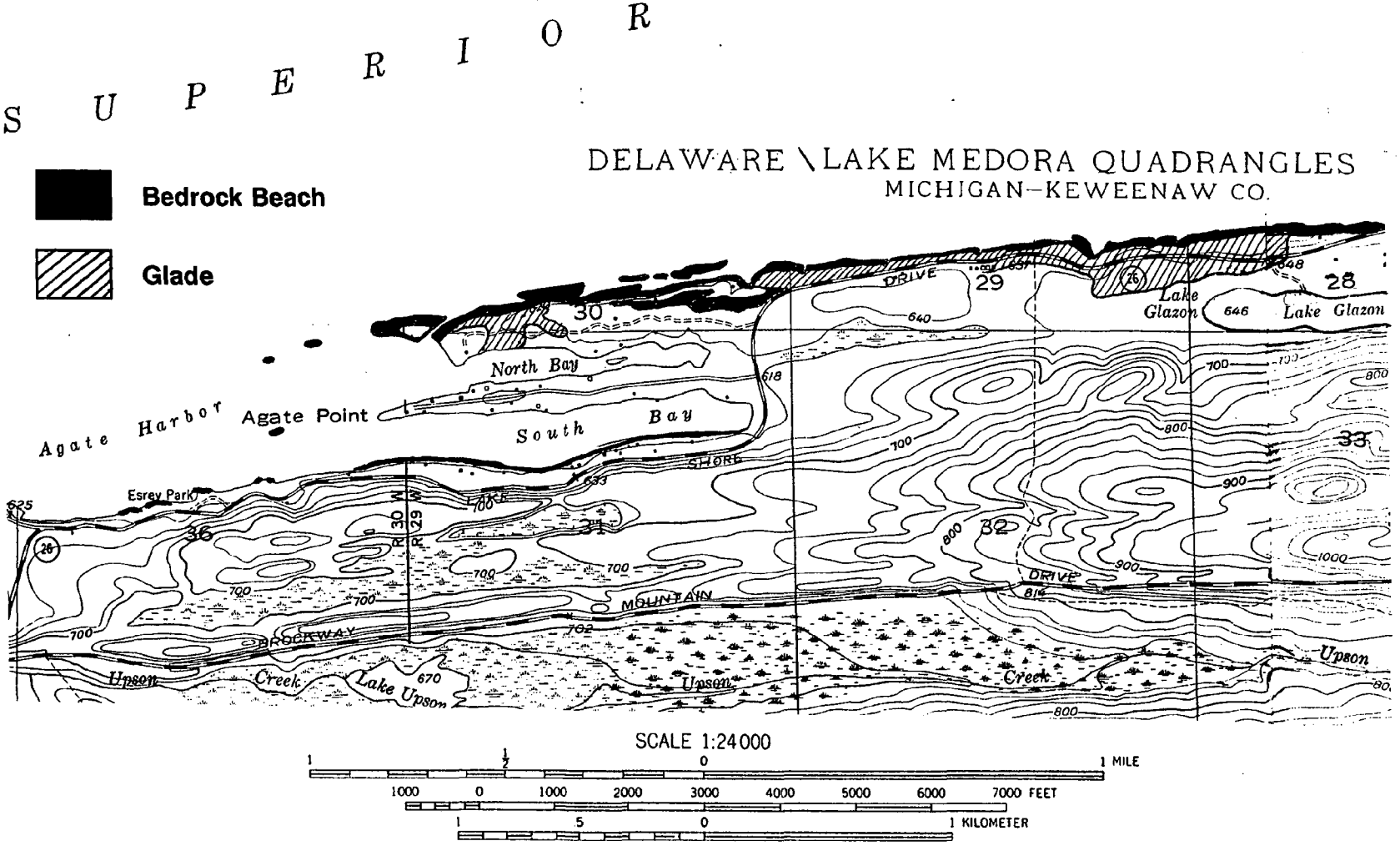


Keweenaw Site 7. Eagle Harbor - Grand Marais Harbor.

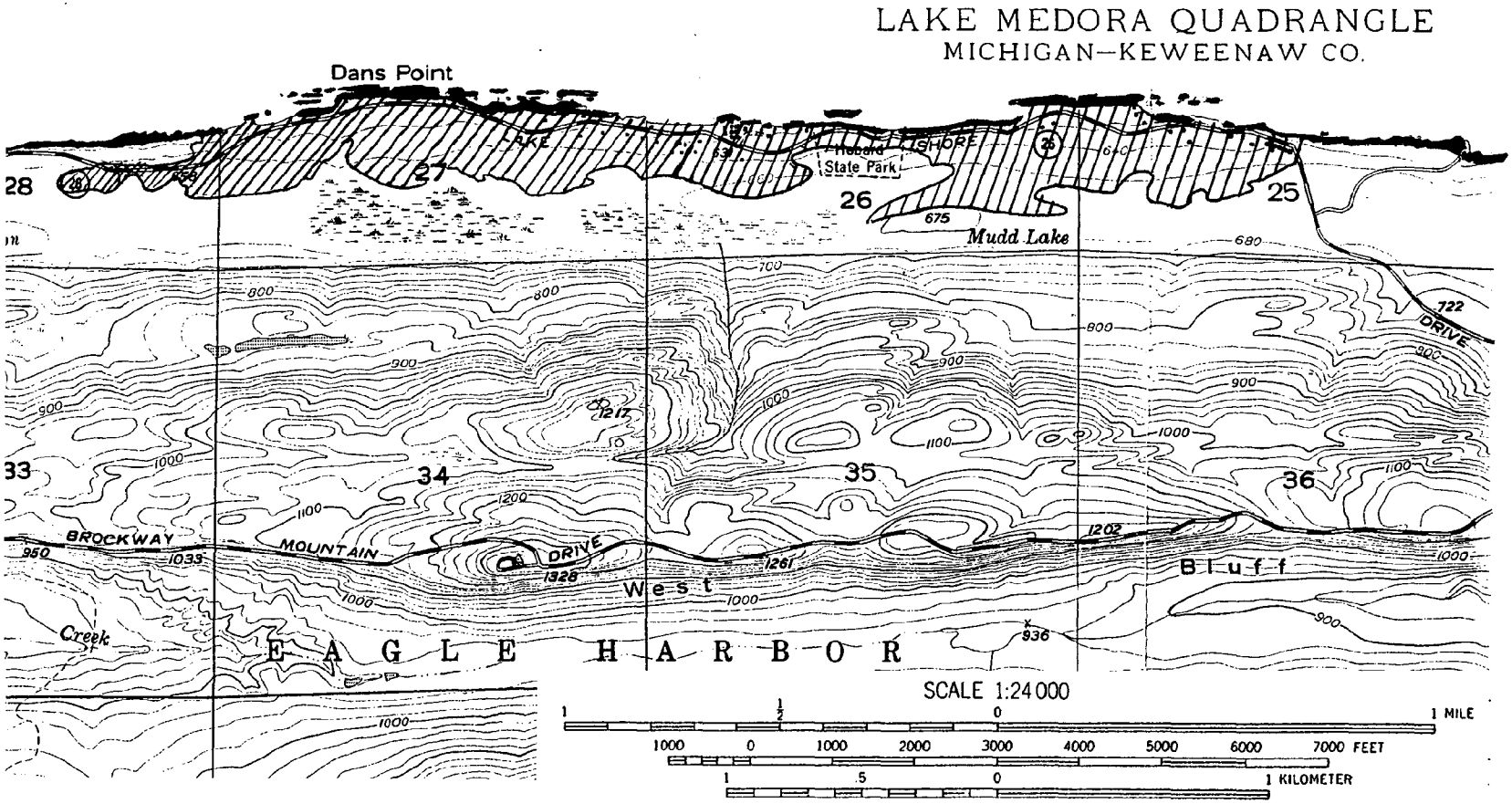
Keweenaw Site 8. Silver Island: Grand Marais Harbor - Bailey Creek.

Bedrock Beach

Glade



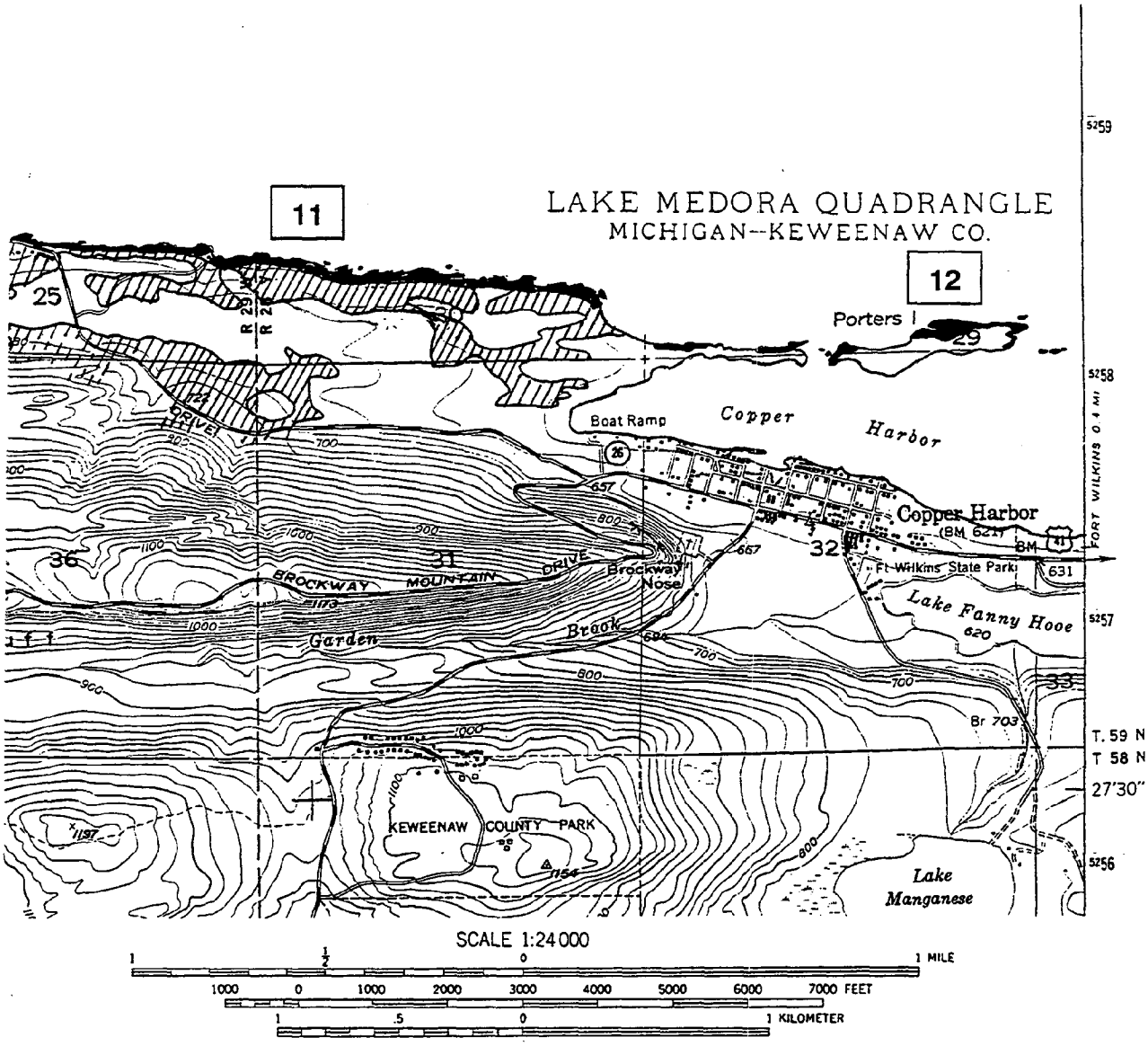
Keweenaw Site 9. Agate Harbor: Esrey Park - Lake Glazon.



Keweenaw Site 10. Dans Point.

Bedrock Beach

Glade

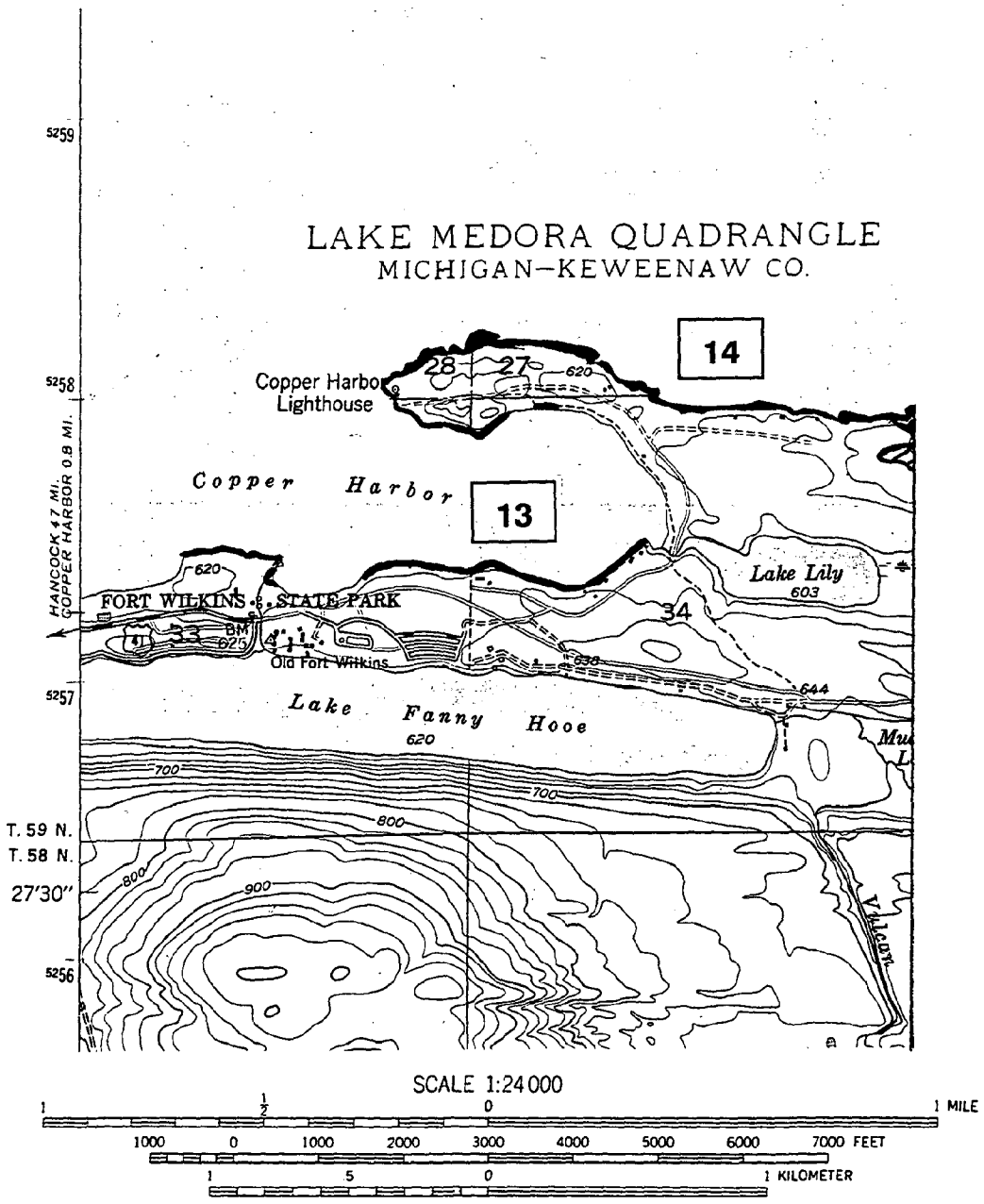


Keweenaw Site 11. Devil's Washtub.

Keweenaw Site 12. Porters Island.

Bedrock Beach

Glade

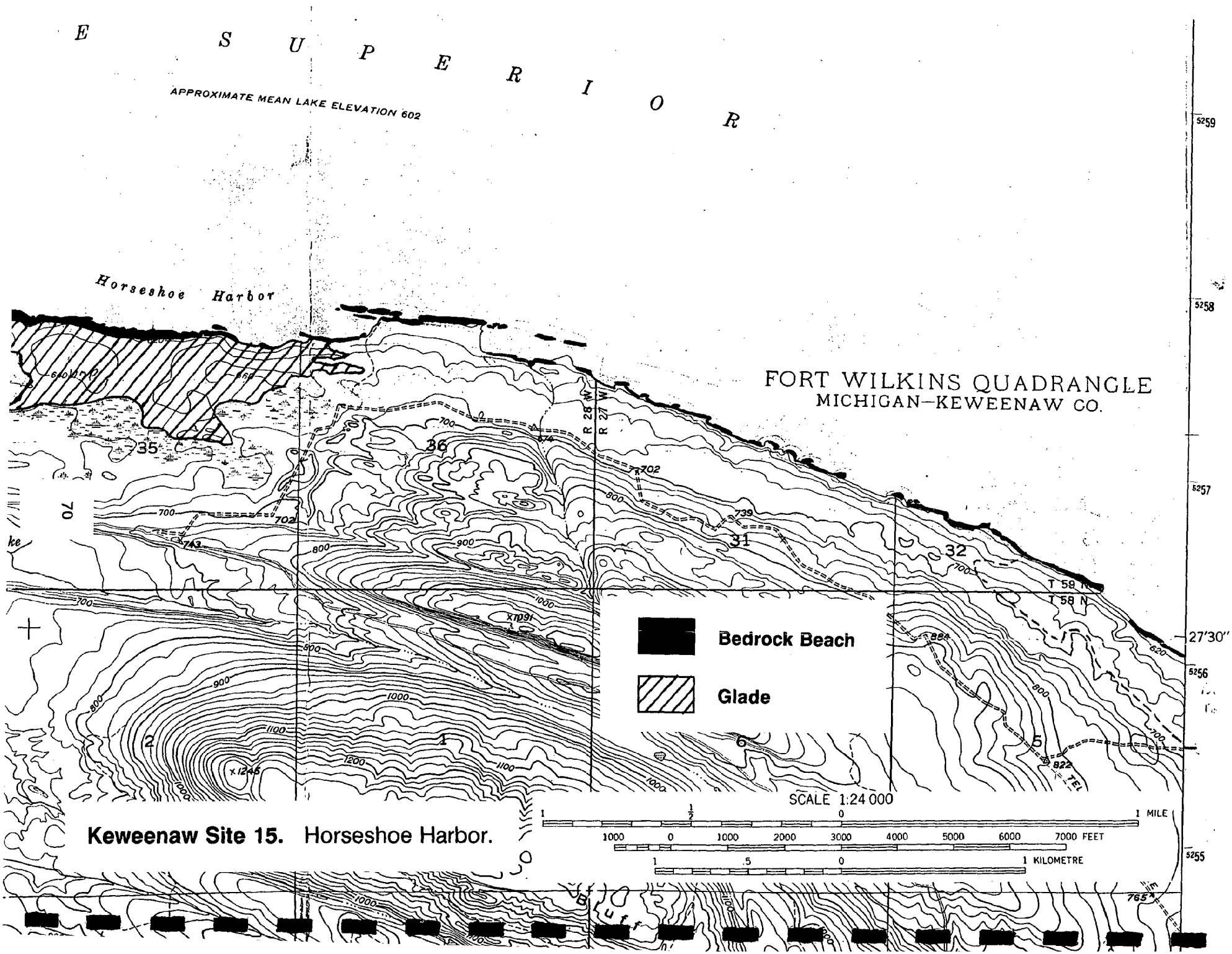


Bedrock Beach

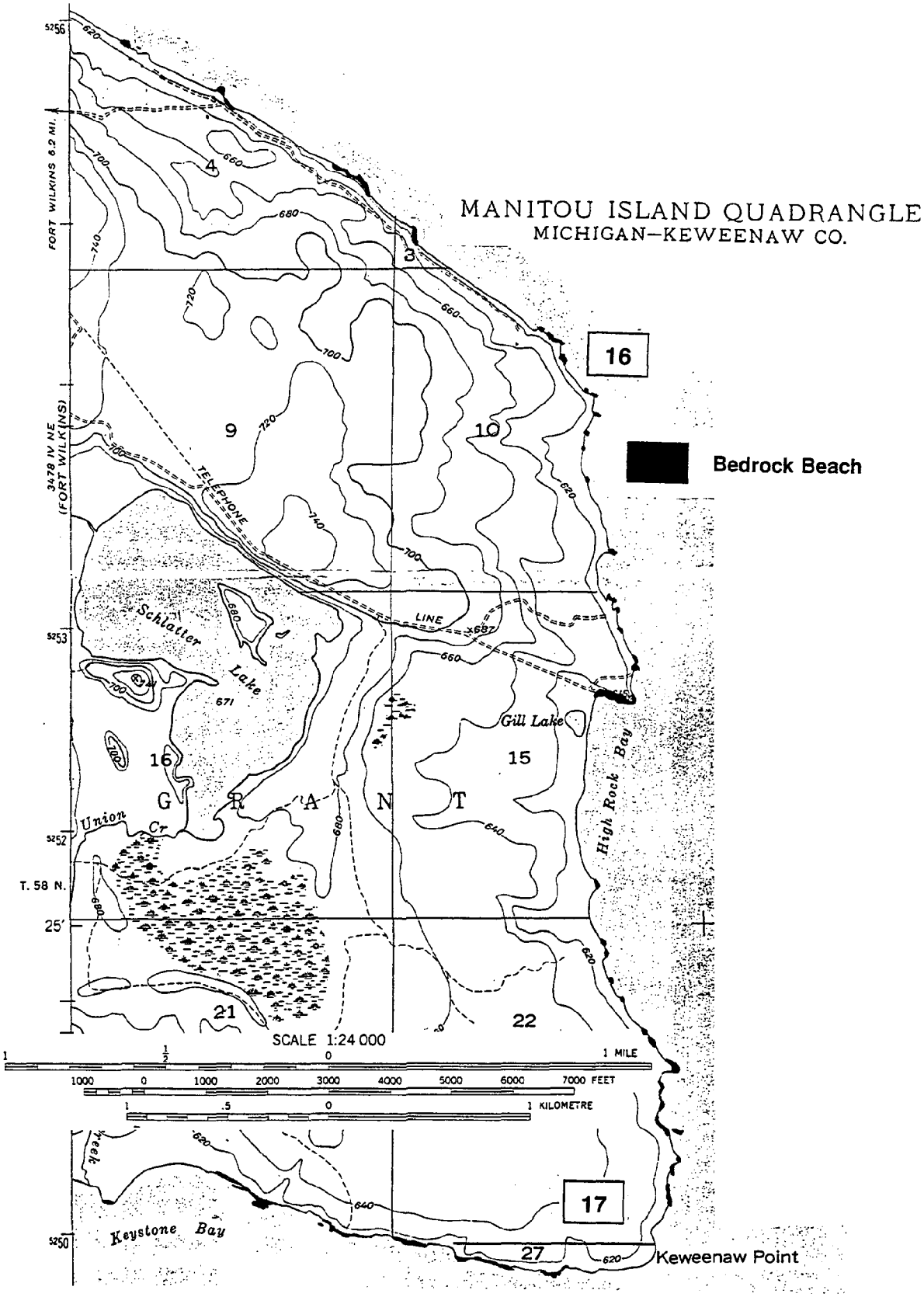
Glade

Keweenaw Site 13. Fort Wilkins State Park.

Keweenaw Site 14. Copper Harbor Lighthouse - Norland Trust.

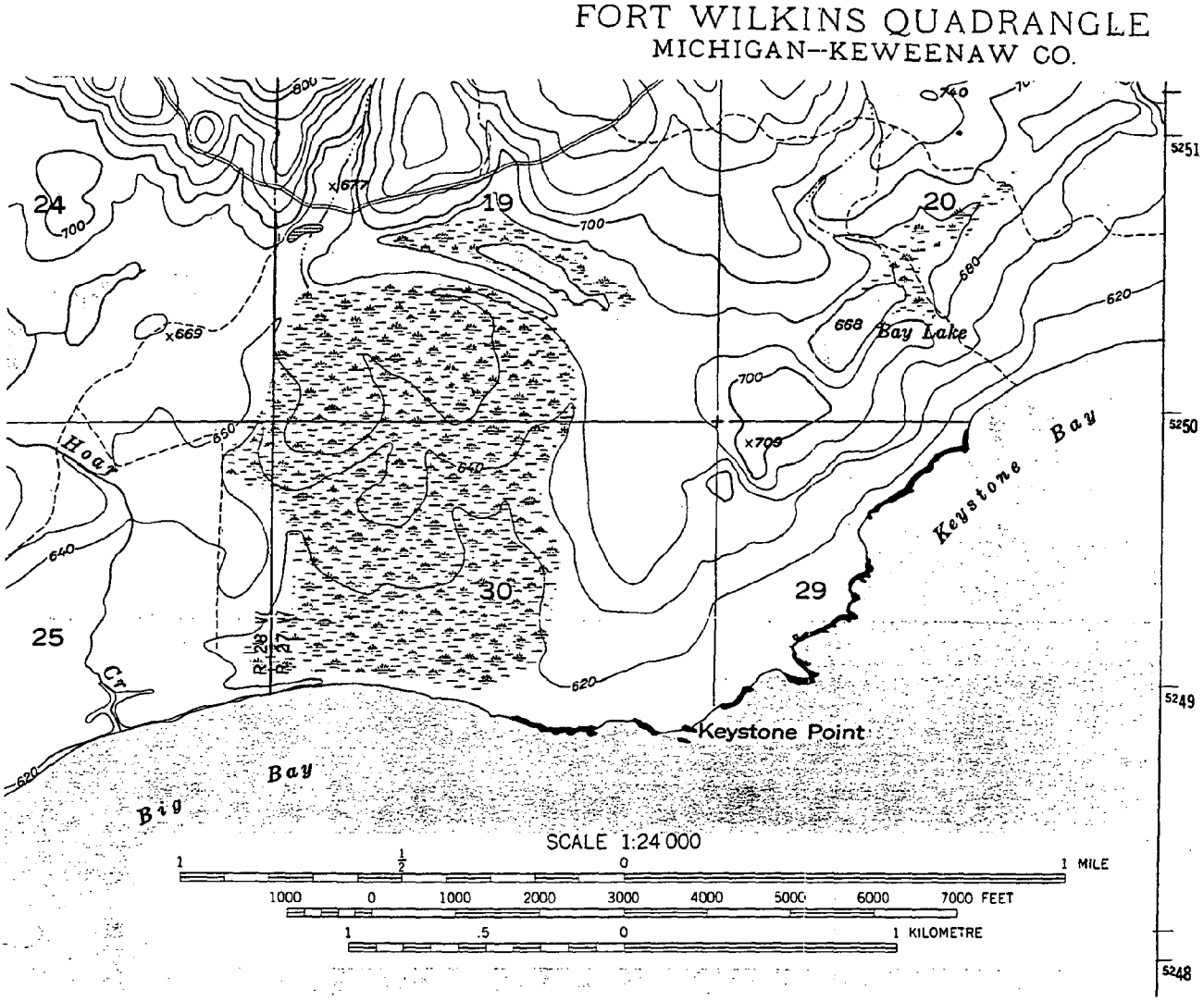


Keweenaw Site 15. Horseshoe Harbor.



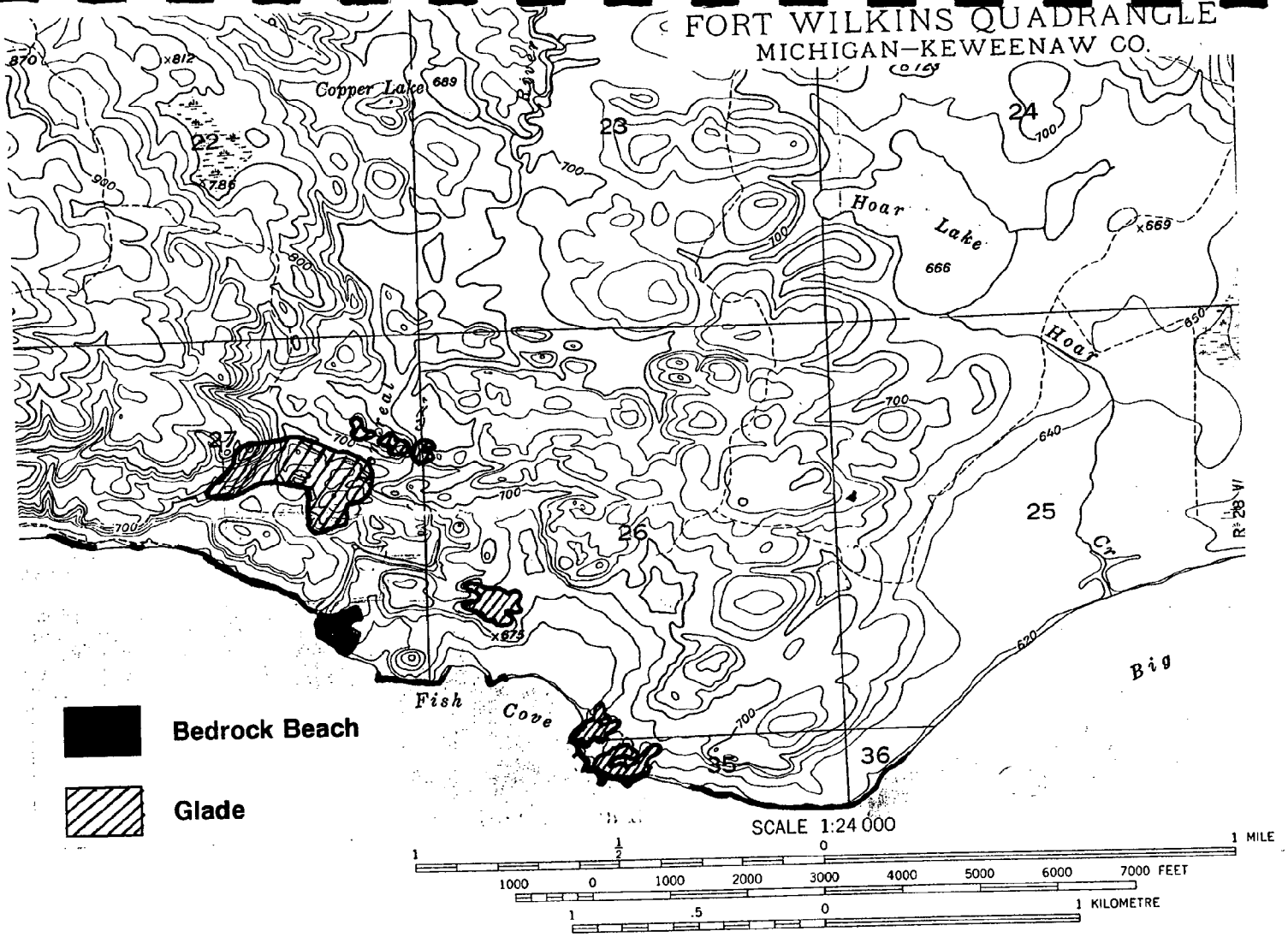
Keweenaw Site 16. High Rock North.

Keweenaw Site 17. Keweenaw Point: High Rock Bay - Keystone Bay.

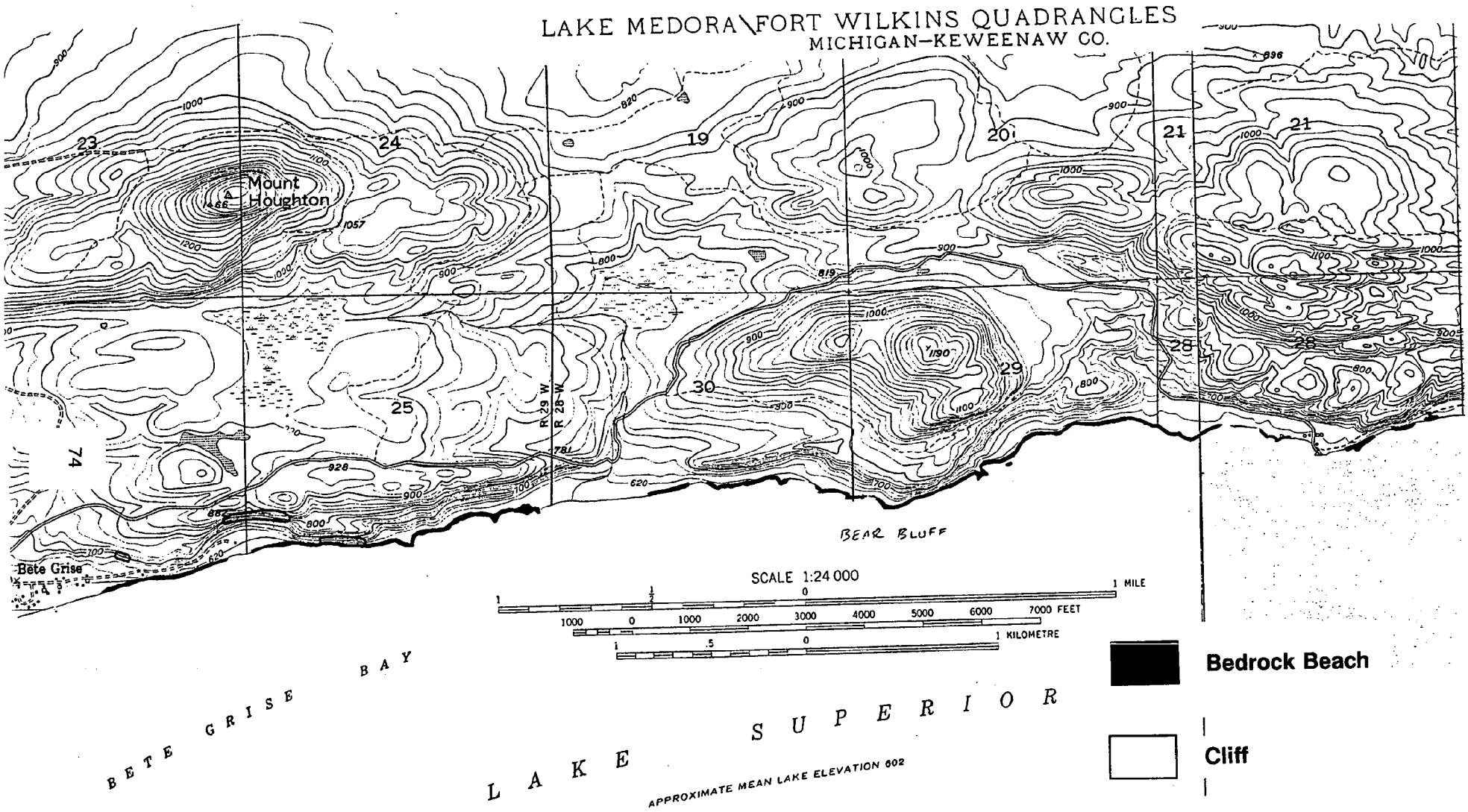


Bedrock Beach

Keweenaw Site 18. Keystone Point.



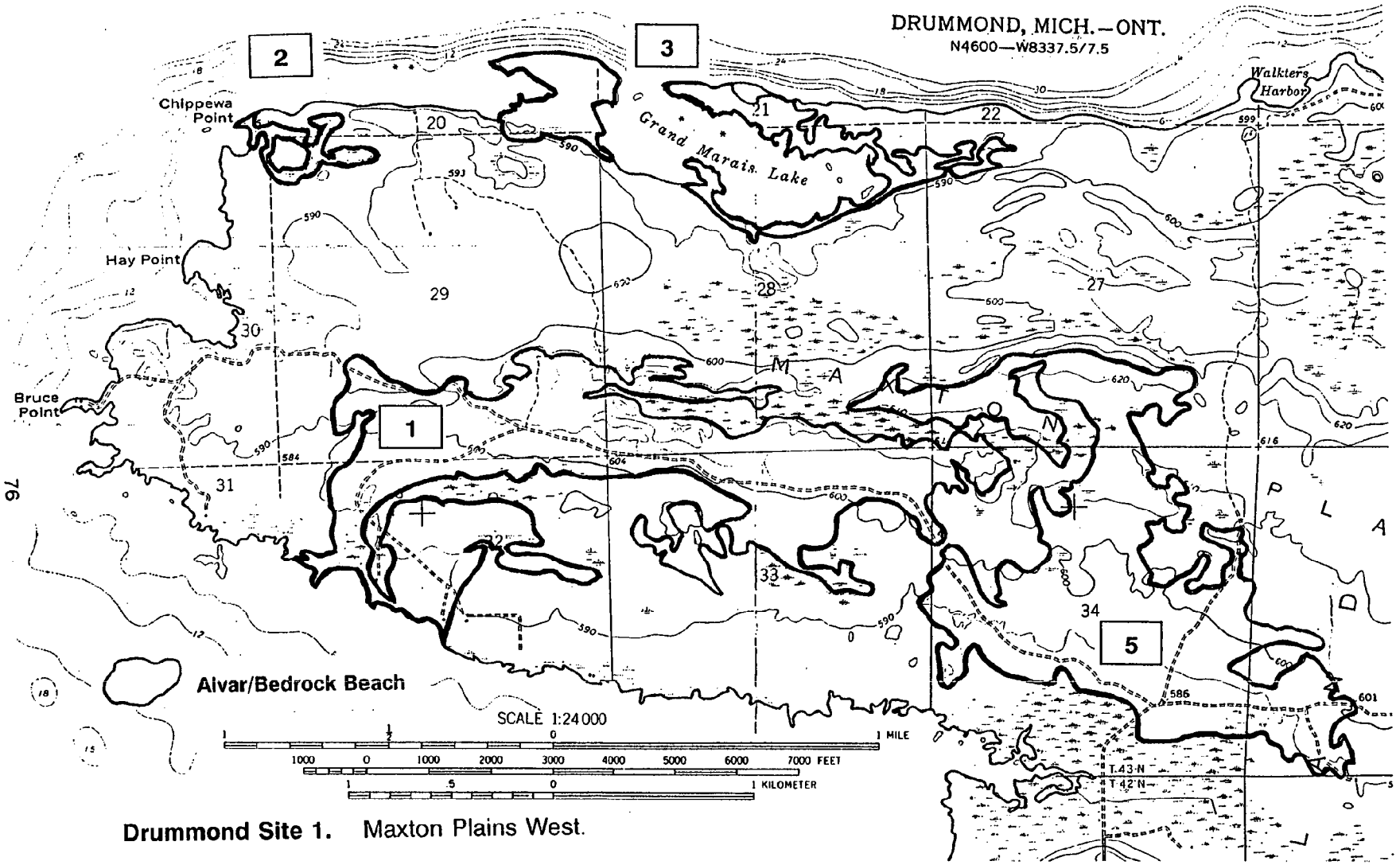
Keweenaw Site 19. Fish Cove.



Keweenaw Site 20. Bete Grise - Bear Bluff.

Appendix II

Maps of Drummond Island Bedrock Sites

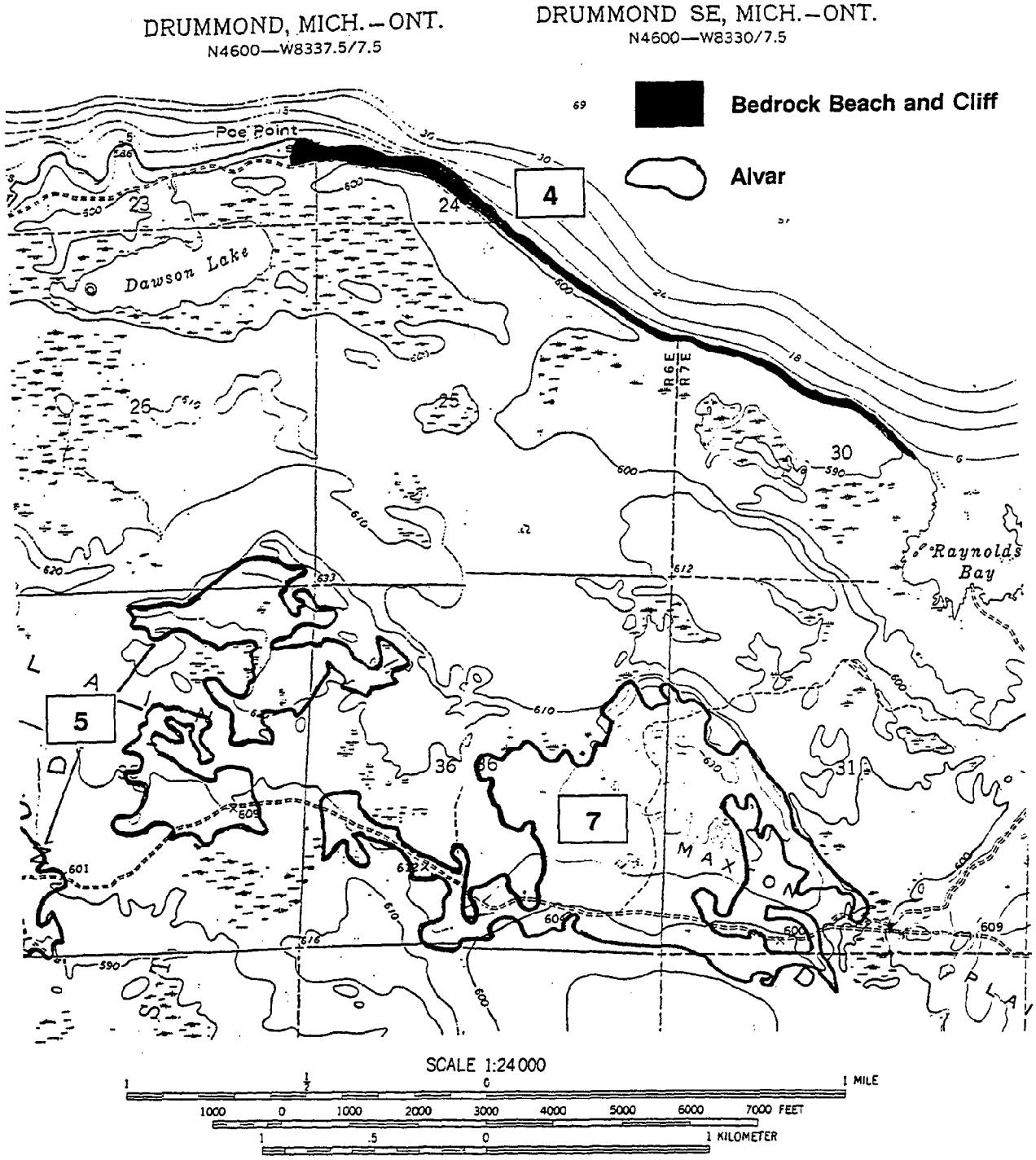


Drummond Site 1. Maxton Plains West.

Drummond Site 2. Chippewa Point.

Drummond Site 3. Grand Marais Lake.

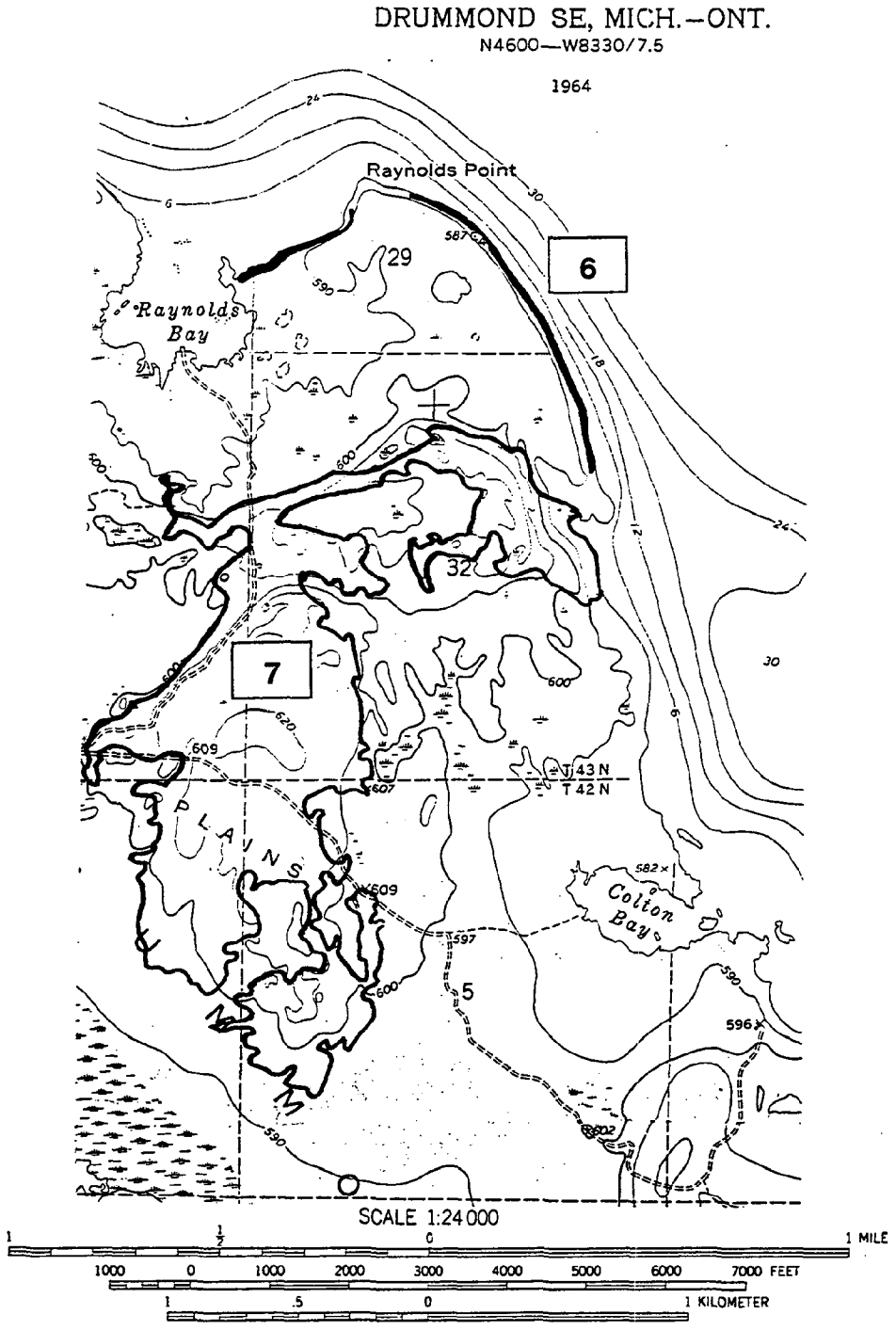
Drummond Site 5. Maxton Plains Middle.



Drummond Site 4. Poe Point - Raynolds Bay.

Drummond Site 5. Maxton Plains Middle.

Drummond Site 7. Maxton Plains East.

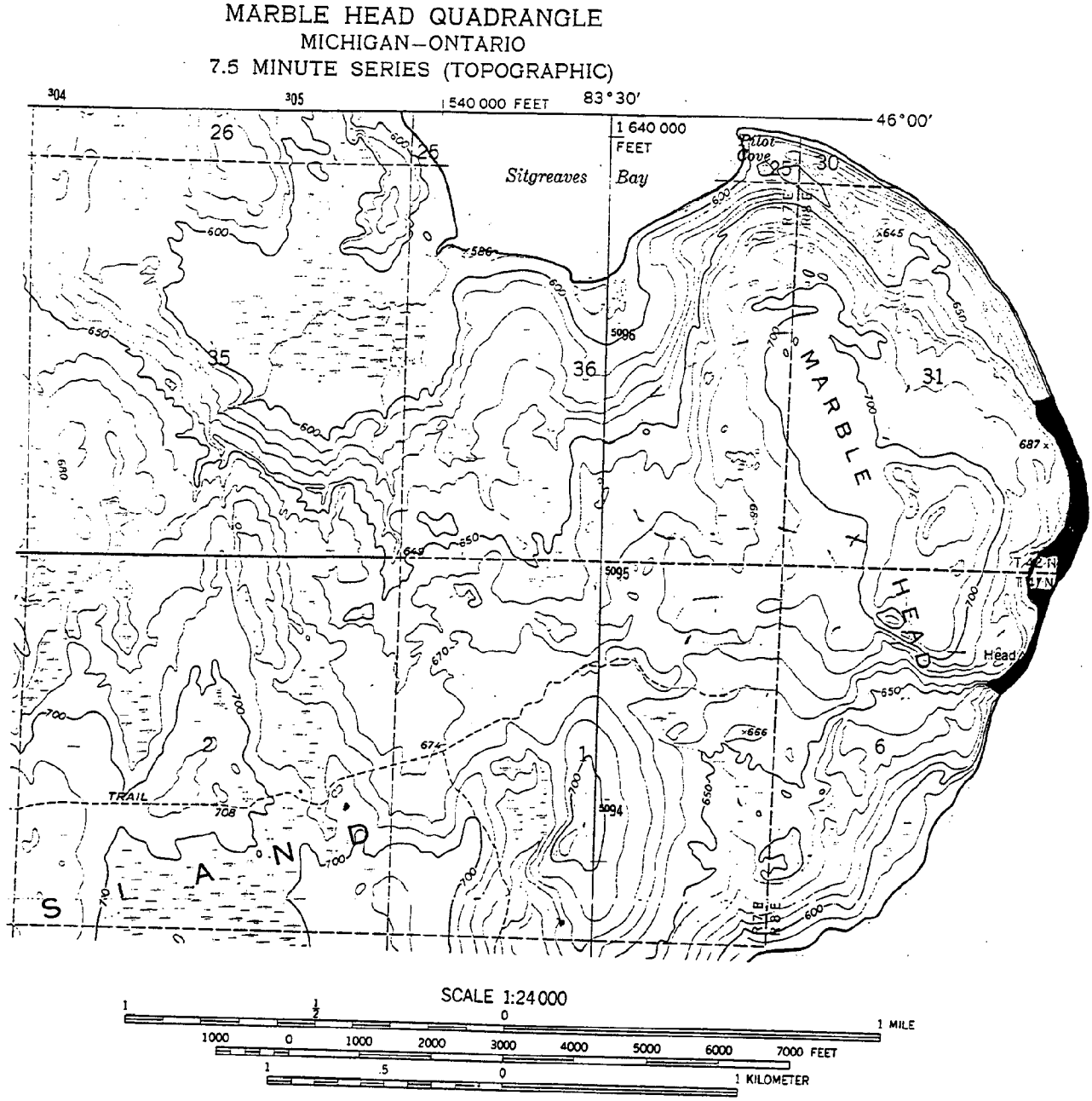


Drummond Site 6. Raynolds Point.

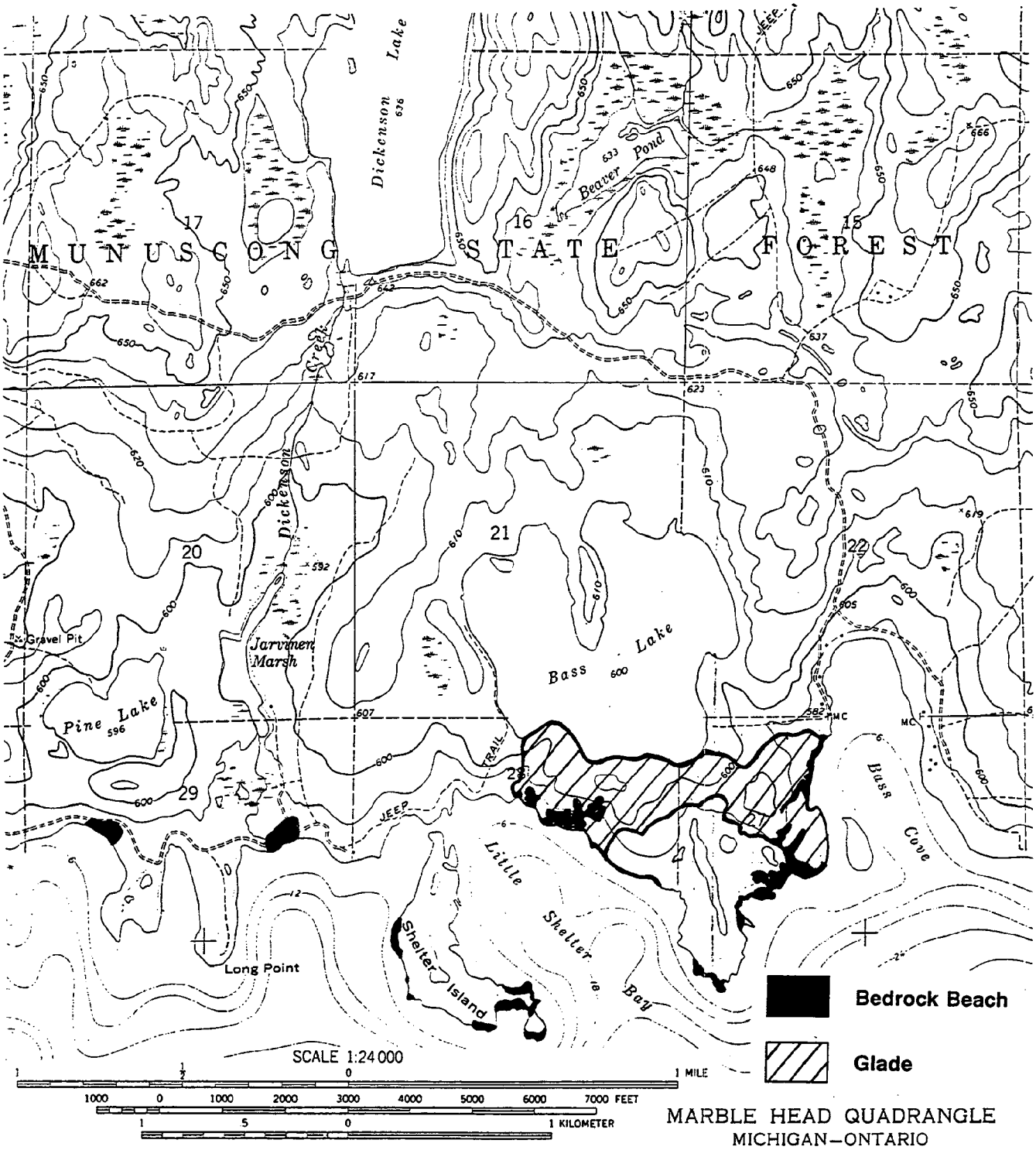
Drummond Site 7. Maxton Plains East.

Bedrock Beach and Cliff

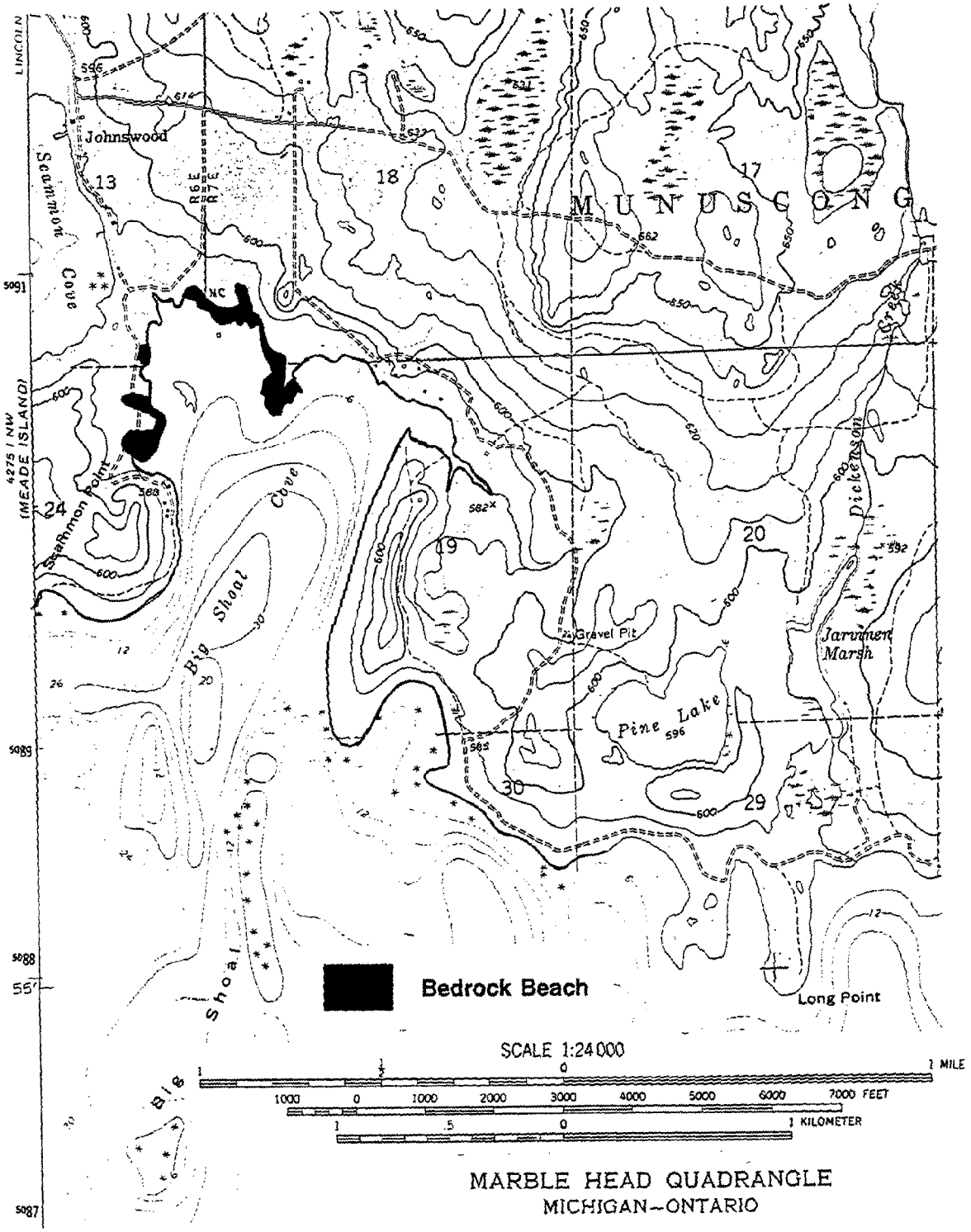
Alvar



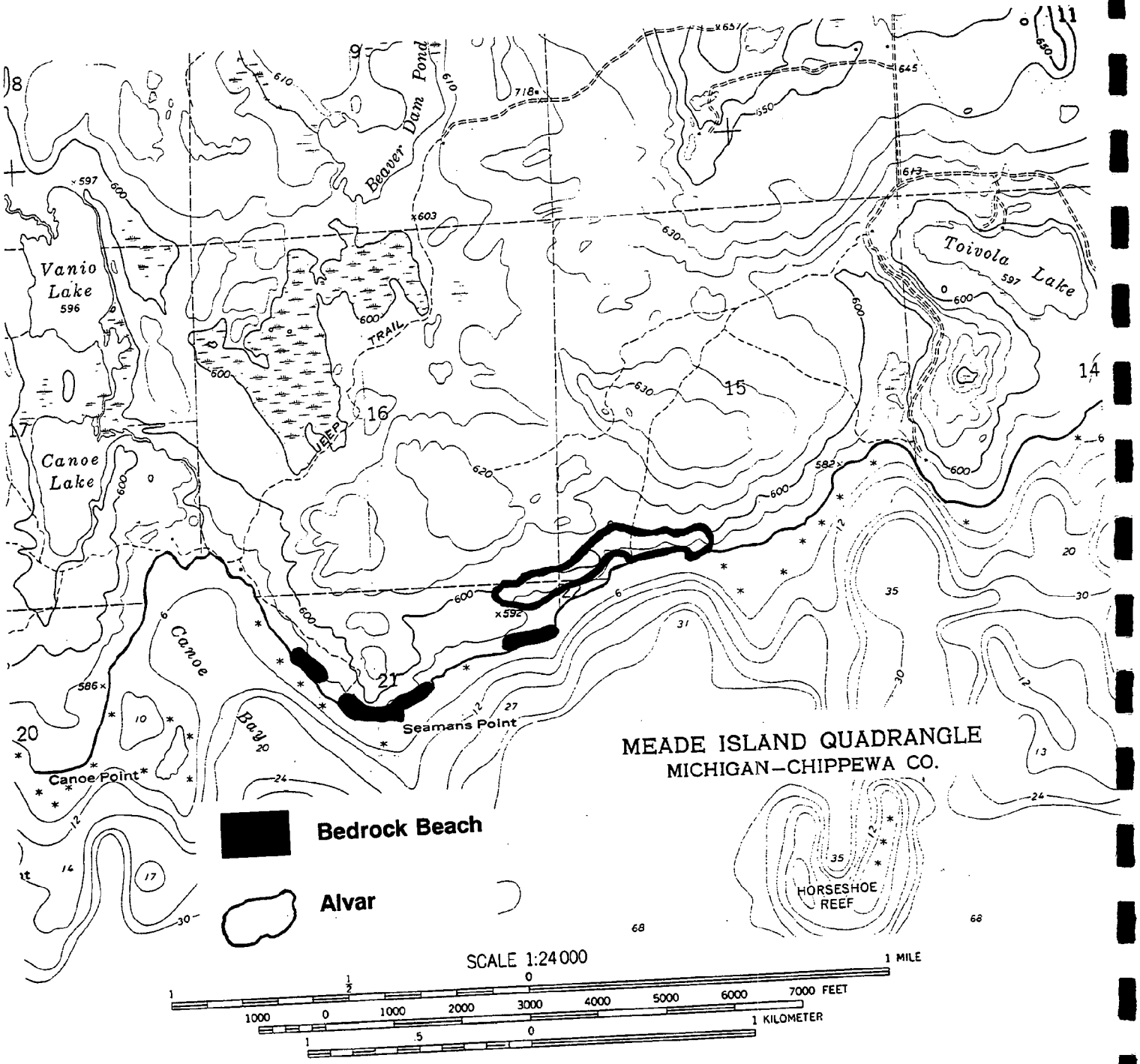
Drummond Site 8. Marble Head.



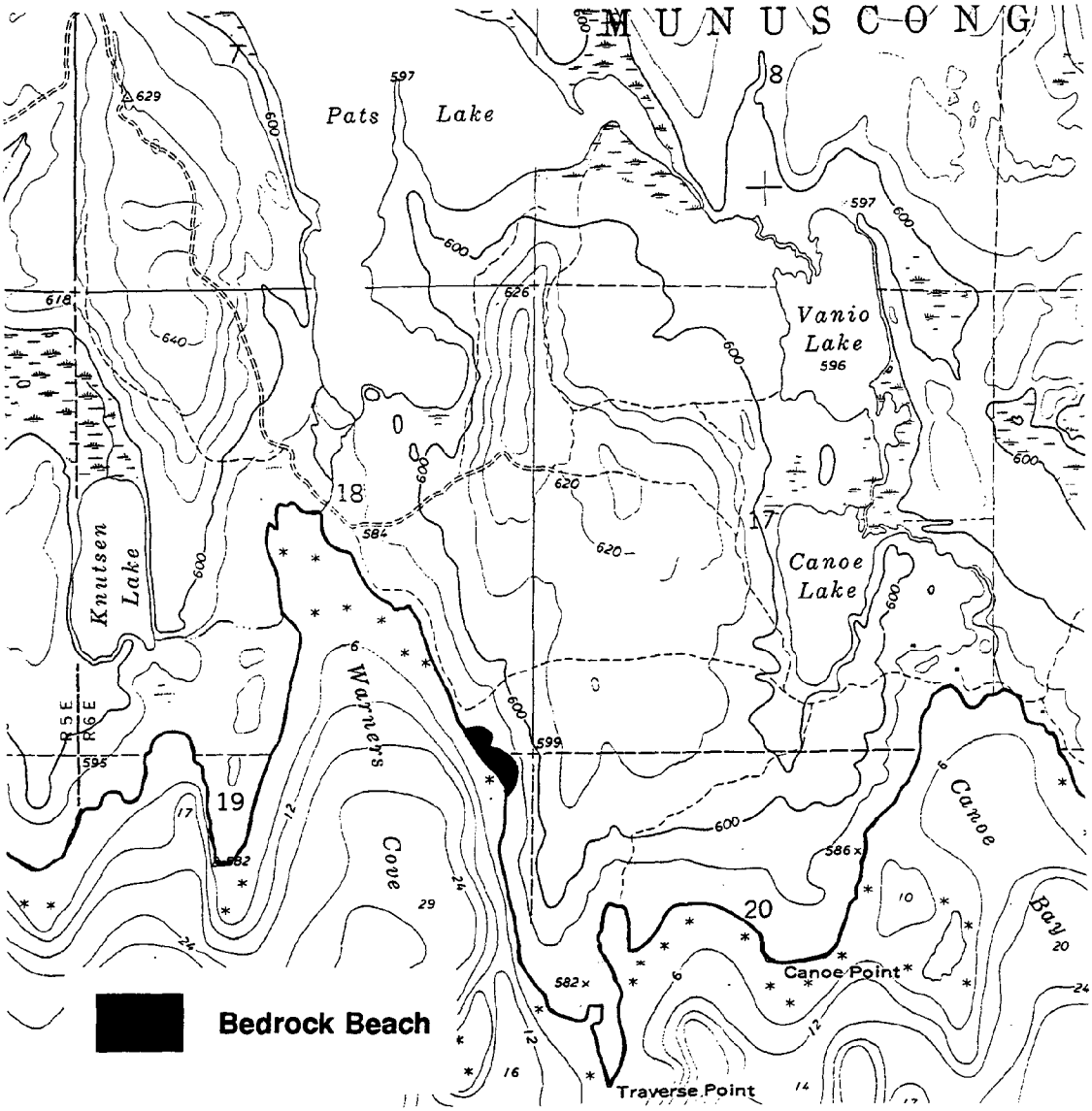
Drummond Site 9. Bass Cove - Little Shelter Bay.



Drummond Site 10. Big Shoal Cove.

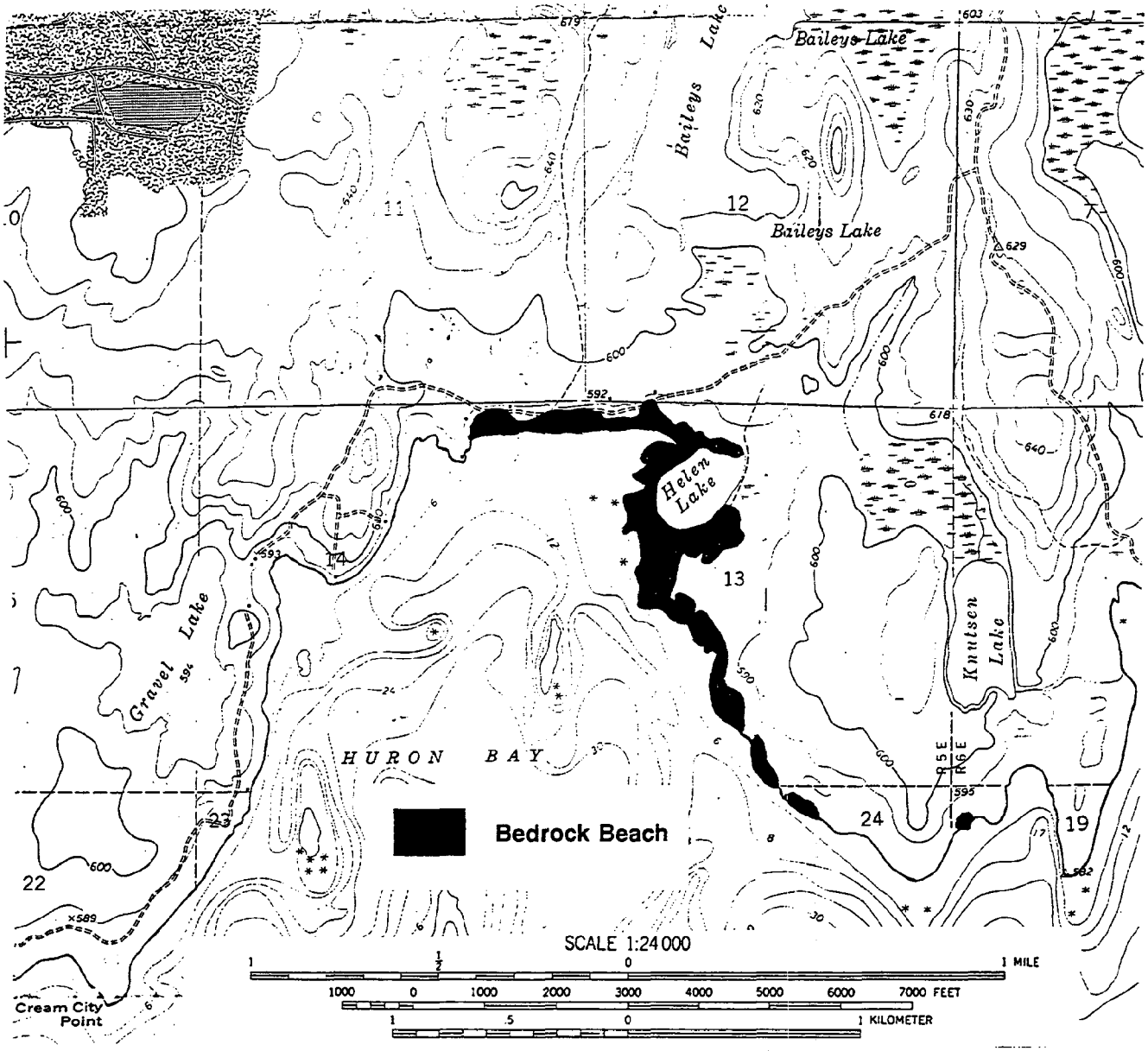


Drummond Site 11. Seamans Point.



MEADE ISLAND QUADRANGLE
MICHIGAN–CHIPPEWA CO.

Drummond Site 12. Warners Cove.



Drummond Site 13. Huron Bay.

Appendix III

Vascular Flora of Copper Harbor Conglomerate (from Reschke 1985).

HERBS

FERNS & FERN ALLIES

Athyrium filix-femina (L.)Roth., lady fern
Cystopteris fragilis (L.)Bernh., fragile fern
Equisetum arvense L., common horsetail
Polypodium vulgare L., polypody
Selaginella rupestris (L.)Spring., rock spike-moss

GRAMINOIDS

Agropyron trachycaulum (Link.)Malte, slender wheatgrass
P = 3.3%
Agrostis gigantea Roth., giant redtop
P = 0.6%
Agrostis hyemalis (Walter)BSP var. tenuis (Tuck.)Gleason, ticklegrass
P = 4.7%
Calamagrostis canadensis (Michx.)Beauv., blue-joint grass
Carex buxbaumii Wahl., sedge
included in "Carex spp." P = 6.9%
Carex castanea Wahl., sedge
included in "Carex spp." P = 6.9%
Carex crawei Dewey, sedge
included in "Carex spp." P = 6.9%
Carex cryptolepis Mack., sedge
Carex garberi Fern., sedge
Carex gynandra Schw., sedge
Carex rostrata Stokes, sedge
Carex umbellata Willd., sedge
included in "Carex spp." P = 6.9%
Carex viridula Michx., sedge
included in "Carex spp." P = 6.9%
Danthonia spicata (L.)Beauv., poverty grass
P = 11.4%
Deschampsia cespitosa (L.)Beauv. var. glauca (Hartm.)Lindm., tufted hairgrass, P = 12.5%
Eleocharis elliptica Kunth., spike rush
Elymus glaucus Buckley, wild rye
Festuca saximontana Rydb., northern fescue
P = 7.2%
Juncus dudleyi Wieg., rush
Muhlenbergia glomerata (Willd.)Trin., muhly grass
Oryzopsis asperifolia Michx., rice grass
P = 0.6%
Oryzopsis pungens (Sprengl.)Hitchc., slender rice grass
P = 1.7%
Phleum pratense L., timothy
P = 0.6%
Poa compressa L., Canada bluegrass
P = 10.0%

Scirpus cespitosus L., tufted clubrush

This species was observed only at Horseshoe Harbor (east of Copper Harbor. This species has a distribution that is probably circumpolar. It is common in low arctic and subarctic regions, and it occurs less frequently in the western and eastern mountains of North America, as well as in boreal regions of Saskatchewan, Manitoba, the Great Lakes, and the Gulf of St. Lawrence. This is a characteristic species of arctic and alpine tundra. (Given and Soper 1981; Voss 1972; Gleason and Cronquist 1963)

Scirpus cyperinus (L.)Kunth. var. brachypodus (Fern.)Gilly, wool grass

Scirpus hudsonianus (Michx.)Fern., alpine cotton-grass

Tofieldia glutinosa (Michx.)Pers., false asphodel

Trisetum melicoides (Michx.)Scribner, false oat grass

Trisetum spicatum (L.)Richter, spiked false oat grass

P = 0.6%

The specimens I collected are probably var. molle (Michx.)Beal. The species has a circumboreal distribution. It is widespread and common in high arctic, mid-arctic, and low arctic regions, and occurs less frequently in subarctic regions, the western and eastern mountains of North America, and boreal regions of Manitoba, the Great Lakes and the Gulf of St. Lawrence. Its range extends from Greenland to Alaska and southward; it has also been reported from Mexico and southern South America. (Given and Soper 1981; Gleason and Cronquist 1963)

FORBS

Achillea millefolium L., common yarrow

P = 8.1%

Antennaria neglecta Greene, pussy toes

Arabis lyrata L., rockcress

P = 1.4%

Artemisia campestris L., wormwood

P = 61.7%

Aster ptarmicoides (Nees)T.& G., stiff aster

P = 19.4%

Braya humilis (C.A.Meyer)Robinson (identity uncertain)

Campanula rotundifolia L., harebell

P = 29.2%

Castilleja septentrionalis Lindl., northern paintbrush

P = 1.4%

This arctic-alpine species is common in the low arctic, and occurs less frequently in subarctic regions, the mountains of New England, and the Gulf of St. Lawrence. It has also been reported from the western U.S. and Canada, extending from South Dakota to Alberta, and south to Colorado and Utah. (Given and Soper 1981; Gleason and Cronquist 1963)

Comandra umbellata (L.)Nutt., false toadflax

Cornus canadensis L., bunchberry

Epilobium angustifolium L., fireweed

Fragaria virginiana Duchesne, wild strawberry
P = 8.3%
Habenaria hyperborea (L.)R.Br., tall northern bog orchid
Habenaria psychodes (L.)Spreng., purple fringed orchid
Halenia deflexa (Sm.)Griseb., spurred gentian
Hieracium canadense Michx., Canada hawkweed
included in "Hieracium spp." P = 11.4%
Hieracium pratense Tausch., hawkweed
included in "Hieracium spp." P = 11.4%
Hypericum perforatum L., St. John's-wort
P = 2.8%
Iris versicolor L., wild iris
Lathyrus maritimus (L.)Bigel., beach pea
Lilium philadelphicum L. var. andinum (Nutt.)Ker., wood lily
Lobelia kalmii L., Kalm's lobelia
Maianthemum canadense Desf., Canada mayflower
Melampyrum lineare Desr., cow-wheat
P = 0.6%
Pinguicula vulgaris L., butterwort
This species has an amphiatlantic, but almost circumpolar distribution. It is common in low arctic and subarctic regions, and occurs less frequently in North America in the western mountains, the eastern mountains, and in boreal regions of Alberta, Saskatchewan, Ontario, the Great Lakes, and the Gulf of St. Lawrence. (Guire and Voss 1963; Given and Soper 1981)
Polygala pauciflora Willd., fringed polygala
Potentilla arguta Pursh., tall cinquefoil
P = 0.8%
Potentilla tridentata Ait., three-toothed cinquefoil
P = 20.0%
Prenanthes racemosa Michx., swamp rattlenake-root
Primula mistassinica Michx., bird's-eye primrose
This species is common in subarctic regions of North America, extending across the continent from Labrador to Alaska, and occurring less frequently southward along the shores of Lakes Superior, Michigan, and Huron, with several inland localities in the southern portion of its range. (Guire and Voss 1963; Given and Soper 1981)
Prunella vulgaris L., heal-all
Sanicula marilandica L., black snakeroot
Sedum acre L., mossy stonecrop
Senecio pauperculus Michx., ragwort
Sisyrinchium montanum Greene, blue-eyed grass
P = 1.4%
Solidago sp., goldenrod (unidentified)
P = 3.6%
Solidago spathulata DC. ssp. randii (Porter)Cronq. var. racemosa (Greene)Cronq., Rand's goldenrod
P = 38.1%

Taraxacum officianale Weber, dandelion
P = 0.6%
Trifolium pratense L., red clover
P = 1.4%
Vaccinium macrocarpon Ait., cranberry
This species was observed only at Horseshoe Harbor (east of Copper Harbor).
Vicia americana Muhl., American vetch
P = 1.1%
Viola adunca Sm., violet
included in "Viola adunca/conspersa" P = 18.1%
Viola conspersa Reichenb., violet
included in "Viola adunca/conspersa". P = 18.1%
Viola nephrophylla Greene, northern bog violet
P = 20.3%
Waldsteinia fragarioides (Michx.)Tratt., barren strawberry

WOODY PLANTS

SHRUBS
Alnus crispa (Ait.)Pursh, green alder
Amelanchier sanguinea (Pursh)DC., shadbush
included in "Amelanchier spp." P = 1.1%
Amelanchier spicata (Lam.)K.Koch, low shadbush
included in "Amelanchier spp." P = 1.1%
Arctostaphylos uva-ursi (L.)Spreng., bearberry
P = 3.9%
Ceanothus ovatus Desf., redroot
Cornus stolonifera Michx., red-osier dogwood
Diervilla lonicera Mill., bush-honeysuckle
Juniperus communis L. var. depressa Pursh, old-field juniper
Juniperus horizontalis Moench., creeping juniper
Lonicera dioica L., twining honeysuckle
Lonicera villosa (Michx.)R.& S., fly honeysuckle
Myrica gale L., sweet gale
Physocarpus opulifolius (L.)Maxim., ninebark
P = 5.8%
Potentilla fruticosa L., shrubby cinquefoil
P = 0.6%
Prunus pumila L., sand cherry
Prunus virginiana L., choke cherry
Rosa acicularis Lindl., prickly rose
included in "Rosa spp." P = 5.3%
Rubus parviflorus Nutt., thimbleberry
Rubus pubescens Raf., dwarf raspberry
P = 0.6%
Salix bebbiana Sarg., Bebb's willow
Salix humilis Marsh., willow

Shepherdia canadensis (L.)Nutt., buffalo berry
P = 3.3%
Sorbus decora (Sarg.)Schneid., mountain ash
Symphoricarpos albus (L.)Blake, snowberry
Vaccinium angustifolium Ait., low blueberry
P = 1.4%

TREES
Abies balsamea (L.)Mill., balsam fir
Betula papyrifera Marsh, paper birch
Picea glauca (Moench.)Voss, white spruce
P = 2.5%
Pinus banksiana Lamb., jack pine
Pinus resinosa Ait., red pine
Populus balsamifera L., balsam poplar
P = 1.1%
Populus tremuloides Michx., quaking aspen
P = 1.1%
Thuja occidentalis L., northern white cedar
P = 1.7%

Appendix IV

Bedrock Insect Study Locations

I. Dudley Bay (Mackinac County):
   A. T41N R2E Sec: 3 SENE (Coastal Bedrock)
   B. T41N R2E Sec: 3 SWNE (Prairie Fen)

II. Maxton Plains (Chippewa County):
   A. T43N R6E Sec: 32 SE & NE (Alvar Grassland)
   B. T43N R6E Sec: 34 SE (Alvar Grassland)
   C. T43N R6E Sec: 35 SW (Alvar Grassland)

III. South Drummond Island (Chippewa County):
   A. T41N R5E Sec: 13 NW (Coastal Bedrock)
   B. T41N R5E Sec: 12 SE (Coastal Bedrock)
   C. T41N R7E Sec: 19 NW (Coastal Bedrock)
   D. T41N R6E Sec: 21 NE (Coastal Bedrock)

Appendix V
1994 Insect Collections from Alvar

DB=Dudley Bay, MP=Maxton Plains, SD=South Drummond Island Sites

SPECIES	DB	MP	SD
HEMIPTERA			
Family Pentatomidae			
Homaemus aenifrons (Say)		X	
Eurygaster alternata (Say)		X	
Mormidea lugens (F.)		X	
Chlorochroa persimilus Horvath		X	
Neottiglossa undata (Say)		X	
HOMOPTERA			
Family Cercopidae			
Clastoptera obtusa (Say)	X		X
Clastoptera saintcyri Provancher		X	
Neophilaenus lineatus (Linnaeus)	X	X	
Philaenarchys bilineata (Say)		X	
Philaenus spumarius (Linnaeus)	X	X	X
Family Cicadellidae			
Acertagallia sp.		X	X
Amplicephalus inimicus			X
Athysanus argentatus F.	X	X	X
Balanocerus provancheri (Van Duzee)		X	
Balclutha sp.		X	
**Chlorotettix* sp.	X	X	X
Cicadula subcupraea X			
Cidadula smithi (Van Duzee)		X	
Colladonus eburatus (Van Duzee)			X
Doratura stylata (Boh.)		X	
Elymana sp.	X		
Empoa latifasciata Christ.		X	
Fitchana vitellina (Fitch)		X	X

Appendix V (cont.)

SPECIES	DB	MP	SD
**Flexamia* sp.		X	X
**Graminella* sp.		X	
Helochara communis Fitch	X		X
Idiodonus morsei (Osborn)		X	X
Latalus sp.	X	X	
**Laevicephalus* sp.	X	X	X
Limotettix sp.		X	
Macropsis quadrimaculata (Fitch)		X	
Macrosteles sp.	X	X	X
Neokolla hieroglyphica (Say)		X	
Paraphlepsius sp.			X
Scaphytopius sp.		X	
Verdanus evansi (Ashm.)		X	
Family Dictyopharidae			
Scolopes sulcipes (Say)		X	
Family Issidae			
Bruchomorpha occulata Newman		X	
Family Membracidae			
Campylenchia latipes		X	X
LEPIDOPTERA			
Family Lassiocampidae			
Tolype velleda (Stoll)			X
Tolype laricis (Fitch)			X
Family Notodontidae			
Clostera albosigma Fitch		X	
Gluphisia tentriognis Walker		X	
Family Arctiidae			
Grammia virguncula (W. Kirby)		X	
Family Noctuidae			
Faronta diffusa (Walker)		X	

SPECIES	DB	MP	SD
Leucania multillinea Walker		X	
Plusia contexta Grote		X	
Syngrapha epigaea (Grote)		X	
Syngrapha rectangula (Kirby)		X	
Anagrapha falcifera (Kirby)		X	
Pseudoplusia includens (Walker)			X
Catocala relicta Walker		X	X
Catocala concumbens Walker		X	
Catocala unijuga Walker		X	X
Catocala semirelicta Grote		X	
Ochropleura plecta (Linnaeus)		X	
Xestia smithii (Snellen)		X	
Enargia decolor (Walker)			X
Enargia infumata (Grote)		X	
Nedra ramosula (Guenee)		X	
Helotropha reniformis (Grote)			X
Sunira bicolorago (Guenee)			X
Litholomia napaea (Morrison)			X
Oligia bridghami (Grote & Robinson)			X
Amphipoea prob. *interoceana*		X	
Spodoptera frugiperda (J.E. Smith)			X
Papaipema harrisii (Grote)			X
Papaipema ptersii Bird			X
Family Geometridae			
Ennomos magnaria Guenee			X
Cingilia catenaria (Drury)			X
Lambdina fiscellaria (Guenee)			X