

NATURAL FEATURES INVENTORY OF
THE GREAT LAKES COASTAL ZONE
OF MICHIGAN

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COASTAL ZONE
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A NATURAL FEATURES INVENTORY
OF THE GREAT LAKES COASTAL ZONE OF MICHIGAN

by the

Michigan Natural Features Inventory Program
(The Nature Conservancy)

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Introduction

The state of Michigan possesses 3200 miles of Great Lakes shoreline, which harbor a diversity of outstanding natural communities and provide habitat for many rare, threatened, and endangered species. This inventory was conducted to document and catalog the occurrences of these communities and species, and of special geologic/geomorphic and other selected natural features in Michigan's coastal zone, as defined by the Michigan Coastal Management Program.

Methods

Inventory Techniques

The term "element" is used to refer to any listed plant or animal species, natural community, or other natural feature considered exemplary, rare, or endangered on a state or national basis (in accordance with the newly revised state list, currently awaiting Legislative approval). Statewide occurrence records on these elements (with emphasis on high- and medium-priority elements) were compiled from various sources. Initially, searches were conducted of pertinent literature sources, including the Michigan Botanist and Jack Pine Warbler (journals), reports of the Michigan Natural Areas Council, theses and dissertations, and miscellaneous books and articles.

Information was then solicited from individuals knowledgeable on the natural features of Michigan's coastal zone. Among these individuals were recognized scientific experts, science and natural history educators, and amateur scientists.

Previous MNFI field surveys (1980 and 1981) also provided leads and general information on element occurrences. For instance, special plant surveys along the Great Lakes shores often collected incidental data on prime natural communities. Similarly, The Nature Conservancy's Michigan Field Office files yielded leads on element occurrences from properties investigated for potential acquisition.

Field surveys were routinely conducted to document occurrences of high- and medium-priority (endangered and threatened) elements, and to collect detailed information on those occurrences when preliminary reports were insufficient. Extensive "de novo" searches were also conducted along much of the state's coastal zone to locate previously unreported element occurrences. Specific inventory and field survey techniques for the various element classes are described below.

Special Animals. All known coastal breeding locations for endangered and threatened species, other than fish and mollusks, were checked in 1982. Partial surveys of fish and mollusks were made. A number of rare and peripheral birds confined to the coastal zone, and the eastern fox snake were also surveyed. This work was carried out under the direction of the MNFI staff zoologist, except for surveys of wolves, eagles and ospreys. Those fish and mollusk

species which were not thoroughly surveyed in 1982 breed primarily outside of the coastal zone and so work was concentrated in non-coastal areas.

Surveys of historic peregrine falcon eyries were made via plane, boat, and on foot by the staff of Ecological Research Services, Inc., under contract with MNFI using US Fish and Wildlife Service funds. This survey included evaluation of potential hacking sites for reintroduction of peregrines to Michigan.

Colonial nesting birds were surveyed by the MNFI staff zoologist, volunteers, Dr. William Scharf and Gary Shugart contracted with assistance from Living Resources Program funding, and by staff of Ecological Research Services, Inc., contracted with assistance from the Bureau of Land Management. All sites were ground checked following reconnaissance by float plane, boat or automobile.

All known piping plover nesting beaches were walked by the MNFI zoologist or by volunteers (Beaver Island archipelago) and all nests were located and checked. Selected sites along the Detroit River, Lake St. Clair, and Lake Erie shorelines were checked on foot for rare bivalves, fox snakes, and king rails. Known coastal sites for the channel darter were searched by Dr. C. L. Smith and his class at the University of Michigan Biological Station.

Historical and current data collected for surveys of the state's eagle, osprey and wolf populations were compiled, computerized and mapped by MNFI staff in 1982.

Special Plants. Michigan's Great Lakes shoreline was intensively surveyed for special plant occurrences either on foot or by car (stopping to spot-check at approximately one mile intervals). In addition to MNFI staff and contractees, several volunteers assisted with this effort. As a result, no large stretches (over 20 miles) of shoreline escaped some level of survey. Even regions with no previously recorded occurrences (e.g., Escanaba to the Wisconsin border) were surveyed.

Infra-red aerial photographs were used to locate areas of potential habitat for several important shoreline species characteristic of sand beaches and foredunes, for example Cirsium pitcheri and Tanacetum huronense. Aerial photography was also used for intensive surveys (partially funded by the Living Resources Program) of Saginaw Bay and the St. Clair River delta, in search of Habenaria leucophaea and other special plant species of wet prairie habitats.

Most Great Lakes islands with known or potential special plant occurrences were surveyed by Ecological Research Services under contract with the US Bureau

of Land Management. This work was conducted in accordance with MNFI recommendations, and a copy of the report was submitted to this program.

Lastly, consultation was provided for intensive studies of two high-priority species, Iris lacustris and Mimulus glabratus var. michiganensis, by graduate students at the University of Michigan Biological Station.

Natural Communities. Aerial photography (color infrared, CIR) proved an invaluable tool for surveying coastal communities. It was used in two ways: for general, comprehensive surveying of one natural community type, and for spot-checking leads from the literature, knowledgeable individuals, and previous field surveys. In this last regard, CIR photography was used to detect the boundaries of communities surveyed this year in order to map them accurately.

In a comprehensive survey, CIR photos are coordinated with maps (topographic, soil, exposed bedrock, presettlement vegetation, etc.), and leads from literature, persons, and previous surveys. This method is very efficient when seeking high-priority natural communities of limited distribution that show a distinct edge and characteristic features on CIR (e.g., prairie, interdunal wetland, boreal forest). Disturbance is usually easily detected. After identifying prospective high-quality examples of a community type, ground-truthing eliminates those which do not meet more restrictive criteria. A nearly exhaustive survey for examples of an element in a particular setting and region is possible. A survey of coastal prairies, accomplished partly through a Living Resources Program grant, was executed in this manner.

Spot-checking of leads requires a knowledge of the characteristics displayed on CIR photos by all natural communities. Though more difficult than a comprehensive survey, many sites can be eliminated upon detection of disturbance, or a decision that the community is too small or difficult to defend can be made. The number of sites which must be ground-truthed is thus reduced.

Organization of Occurrence Information

Each type of element has its own alpha-numeric code, and each occurrence of an element statewide has its own numeric code. In this way, a single

occurrence is distinguished from all others in the state. These codes appear on the topographic maps and on the computerized Element Occurrence Records (EORs).

Each element occurrence on a map has its own margin number particular to that map. Elements are listed simply in order of mapping; they are not grouped in any manner. A circle, triangle or square around the margin number indicates the accuracy with which it was mapped: to the second, to the minute, or in the general area, respectively. The margin number and circle, triangle or square are also written on the map proper, to locate the occurrence. In order to distinguish different types of elements readily, clear color dots are put over the number on the map: red = Special Animal, blue = Special Plant, green = Plant Community, brown = Geologic-Geomorphic Feature, orange = Other. Plant communities and managed areas have had the boundaries drawn in, where possible.

The information given in the map margin includes the official element name, its three-digit numerical occurrence code, the year of the last field observation, and a ten-by-ten grid number for ease in location. The first number given is for the horizontal axis, numbered from left to right; the second number is for the vertical axis, numbered from top to bottom. Common names are given for managed areas, since these have no official element names. Element occurrence numbers are given for Others. Under the element name and accompanying information for a natural community, the cover types (plant communities) present and their occurrence numbers are listed. Plant communities that have not been incorporated into the MNFI data base have been listed separately at the lower end of the map margin, with only the natural community name and ten-by-ten location code given.

Detailed information on each occurrence is stored in a computerized data management system. The format used is described on the following pages.

COMPUTERIZED ELEMENT OCCURRENCE (EOR) INFORMATION

EO-CODE: The 10-digit alpha-numeric element name code and the 3-digit numeric occurrence code.

EL-CODE: The same as the first 10 digits of the EO-code.

NAME: The official element name that corresponds to the EL-code; the scientific plant or animals species name, or the natural community or geologic feature name.

COMMON-NAME: The common name for the plant or animal species, or the plant community (cover type) code(s). The plant community code consist of the first three digits of the natural community code, a seven-digit plant community code, and a three-digit occurrence code specifically for the plant community. The names corresponding to these codes are given under GEN-DESC (see below).

MARG-NUM: The margin number on the appropriate topographic map, given under QUAD-CODE (see below).

IDENT: Y indicates that identification of the element is positive.

EO-RANK: A comparative evaluation of this particular occurrence; A = Excellent, B = Good, C = Marginal, D = Poor, X = Destroyed.

EO-RANK-COMM: Any further information to back up the EO-rank.

FIELD-EVAL-DATE: The date of the field evaluation used to assign the EO-rank.

LAST-OBS: The date the element was last observed extant at this site.

FIRST-OBS: The year in which the occurrence was first reported from this site.

EL-RANK: A priority code based on the need for protection; A1 = highest, D = lowest.

STATE: MI; the two-letter U.S. Postal Service code for the state.

ALL-COUNTY-CODES: MI (Michigan) + the three-digit county code; if an occurrence overlaps into more than one county, all of the codes are given.

COUNTY-CODE: The code for the county that most of the occurrence is in.

ALL-COUNTY-NAMES: Four-letter abbreviations are used; the main county is listed first; than all of the others.

ALL-QUAD-CODES: The numerical code(s) for the topographic map(s), based upon degrees latitude, degrees longitude, and an additional two-digit number; if an element occurs on more than one map, all of the codes are given.

QUAD-CODE: The code for the primary map of occurrence.

ALL-QUAD-NAMES: The names of the topographic maps as listed in their lower right corners.

PRECISION: S = mapped to the second, M = mapped to the minute, G = mapped to the general area; these letters correspond to the circle, triangle, or square, respectively, which are given on the map.

LAT: The precise latitude of the center of the occurrence in degrees, minutes, and seconds.

LONG: The precise longitude of the center of the occurrence.

S: The latitude of the southernmost extent of the occurrence.

N: The latitude of the northernmost extent of the occurrence.

E: The longitude of the easternmost extent of the occurrence.

W: The longitude of the westernmost extent of the occurrence.

TOWN-RANGE: The township, range, section, and partial section where known.

PLAN-REG: The state planning region code.

WILD-DIST: The state wildlife district code.

FOR-DIST: The state forestry district code.

QUAD-SCALE: 75 = 7.5 minute, 15 = 15 minute.

PHYS-PROV: (Physical province) This field is not used in Michigan.

WATERSHED: The eight-digit code as taken from the Hydrologic Unit Map (U.S.G.S.).

NAT-REG: 1 = western upper peninsula, 2 = eastern upper peninsula, 3 = northern lower peninsula, 4 = southern lower peninsula.

DIRECTIONS: the local name for the site followed by simple walking or driving directions.

GEN-DESC: A general description of the community or area in which the element occurs, or, if the element is a community, the name of the plant community(s) (cover type(s)--see also COMMON-NAME), and a general description of the community.

ELEV: The field is not generally used in Michigan; -11111 = unknown.

SIZE: The size in acres, if known; 0 = unknown.

EO-DATA: Data on the element at the site, e.g., numbers, size, condition, etc.

COMMENTS: Additional information.

OWNER-TYPE: FG = federal, SG = state (incl. state universities), LG = local (county, municipal, regional), PO = organizational, PC = corporate, PI = private individual, PY = private college or university, MX = mixed, no one owner type predominant, XX = other.

OWNER: The names(s) of the owner(s).

MULT-OWNERS: Y if there is more than one owner.

MA: Managed area; Y if the EO is on a managed area, N if it isn't, P (partial), if a substantial amount is on a managed area.

MA-NAME: The name of the managed area, if the previous is checked Y or P.

NUM-OWNERS: The total number of the owners of the site, if known.

PROT-STATUS: Protection status; 1 = preserved (officially designated), 2 = protected, 3 = no protection.

DESIG-STATUS: A code indicating whether a special status has been assigned to the site; e.g., SF = state forest, DDS = dedicated state nature preserve, SPK = state park, NNL = national natural landmark, etc.

OWNER-PROT: Y = owner known to be protecting, N = owner known to be not protecting, (blank) = unknown.

PROT-NEED: A = adequately protected, B = needs help, C = probably unhelpable.

PROT-NEED-COMM: Explanation of the above, if needed.

BEST-SOURCE: The single best source of information for this particular occurrence; in formal citation form.

ALL-SOURCE-CODES: All sources of information on this occurrence are listed in code: first digit = letter indicating type (see below); second and third digits = year; fourth, fifth and sixth digits = first three letters of author's or collector's last name; seventh and eighth digits = "breakers," a numerical code for different works of the same author, or, for specimens (S), the two-letter abbreviation of the museum or herbarium.

A = article, B = book, F = field form, J = journal, M = map or aerial photo, O = organization, P = person, S = specimen, U = unpublished literature.

BEST-SOURCE-CODE: The source code for the BEST-SOURCE; always listed first in the previous field.

DATA-SENS: We have not used this field.

BOUNDARIES: Y if a map, sketch or other information on the boundaries is available.

PHOTOS: Y if photos of the occurrence are available.

QUAL-SURV: Y if general field information is available.

QUAN-SURV: Y if information from a quantitative survey is available.

OWNER-INFO: Y if additional information on ownership is available.

TRANSCRIBER: The initials (3) of the person who filled out this form; the date.
form: SJO 82-10-12

EA-REV: Y if the element abstract has been updated is necessary, considering information from this occurrence.

CD-REV: Y if the county-of-distribution map and element occurrence log book have been updated for this occurrence

MA-EO-REV: We have not used this field.

MAPPER: The initials of the person who mapped this occurrence; the date.

QC: Quality control; Y if the computerized record has been checked for errors.

UPDATE: The initials of the person who most recently updated the computerized record; the date.

Results and Discussion

Special Animals

Of Michigan's 42 endangered or threatened animal species, 12 occur primarily or exclusively in the state's coastal zone (Table 1), while another 14 such species occur partly in the coastal zone (Table 2). In addition to these top priority species, 13 rare or peripheral species are confined to the coastal zone, and 12 more are known partly from this area (Tables 1 and 2).

The results of our coastal zone surveys reflect both good and bad news for the animal species concerned. Double-crested cormorants, Forster's terns, ospreys, and bald eagles continue to prosper and expand in the state. Species such as fox snake, king rails, and herons seem to be holding their own for the present despite continuing loss of habitat in the coastal zone. Their persistence can be attributed largely to a number of large protected fresh-water coastal marshes such as The Nature Conservancy's Erie Marsh Preserve and the Erie and St. Clair Flats State Game Areas.

Other species continue to decline. No peregrine falcons were found nesting in Michigan (the last naturally nesting peregrines east of the Mississippi River nested along Michigan's Lake Superior shore in the early 1970's). Piping plovers continue to decline dramatically, down in 1982 to 14 pairs nesting at 7 sites, versus 17 pairs at 12 sites in 1981, and 31 pairs at 19 sites in 1979. Common terns, although seemingly holding their own, show very poor to nonexistent reproductive success at many colonies. No live specimens of endangered or threatened bivalves, or of the channel darter turned up in samples this year. Several species of mollusks and fish may already be extirpated from Michigan, as live specimens have not been recovered for a number of years (Table 2).

Special Plants

A total of 145 special plant species have recorded occurrences in Michigan's coastal zone. Of those, 28 species (Table 5) have not been found since 1940 and likely do not occur at their historically-known localities, though they may persist elsewhere in the coastal zone.

Of those species with recently-documented coastal occurrences, 51 occur exclusively or primarily in the coastal zone, with few or no inland localities. Included in this group are the Great Lakes shoreline endemics Iris lacustris (dwarf lake iris), Cirsium pitcheri (Pitcher's thistle), and Solidago houghtonii

TABLE 1: SPECIAL ANIMALS OCCURRING PRIMARILY OR EXCLUSIVELY IN MICHIGAN'S COASTAL ZONE

<u>SPECIES</u>	<u>STATE STATUS***</u>	<u>FEDERAL STATUS</u>
MOLLUSKS		
** <u>Anodonta subgibbosa</u>	T	
<u>Dysnomia sulcata</u> , white cat's paw pearly mussel	E	E
FISH		
<u>Acipenser fulvescens</u> , lake sturgeon	T	
* <u>Coregonus bartletti</u> , Siskiwit Lake cisco	R	
<u>Hiodon tergisus</u> , mooneye	P	
<u>Hybopsis storeriana</u> , silver chub	P	
<u>Ictiobus cyprinellus</u> , bigmouth buffalo	P	
<u>Noturus stigmosus</u> , northern madtom	E	
AMPHIBIANS AND REPTILES		
<u>Elaphe vulpina gloydi</u> , eastern fox snake	R	
* <u>Pseudacris triserrata maculata</u> , boreal chorus frog	P	
BIRDS		
<u>Charadrius melodus</u> , piping plover	E	
<u>Falco peregrinus</u> , peregrine falcon	E	E
<u>Larus minutus</u> , little gull	P	
<u>Nycticorax nycticorax</u> , black-crowned night heron	P	
<u>Phalacrocorax auritus</u> , double-crested cormorant	T	

TABLE 1, continued

<u>SPECIES</u>	<u>STATE STATUS</u>	<u>FEDERAL STATUS</u>
BIRDS, continued		
<u>Phalaropus tricolor</u> , Wilson's phalarope	R	
<u>Rallus elegans</u> , king rail	T	
<u>Sterna caspia</u> , caspian tern	T	
<u>Sterna forsteri</u> , Forster's tern	R	
<u>Sterna hirundo</u> , common tern	T	
<u>Strix nebulosa</u> , great gray owl	P	
MAMMALS		
* <u>Canis lupus</u> , gray wolf	E	E
* <u>Felis lynx</u> , lynx	T	
<u>Pipistrellus subflavus</u> , eastern pipistrelle	P	
<u>Sorex fumeus</u> , smokey shrew	P	

* Believed to be restricted to Isle Royale in Michigan

** No recent records of occurrence in coastal zone

*** E = endangered, T = threatened, R = rare, P = peripheral

TABLE 2 : SPECIAL ANIMALS OCCURRING PARTLY IN MICHIGAN'S COASTAL ZONE

<u>SPECIES</u>	<u>STATE STATUS***</u>	<u>FEDERAL STATUS</u>
MOLLUSCS		
** <u>Cyclonaias tuberculata</u> , purple warty back	R	
<u>Dysnomia torulosa</u> , northern riffle shell	E	
** <u>Dysnomia triquetra</u> , snuffbox	T	
** <u>Lampsicus fasciola</u>	R	
<u>Obovaria subrotunda</u>	T	
** <u>Simpsoniconcha ambigua</u> , salamander mussel	E	
** <u>Stagnicola contracta</u>	T	
** <u>Villosa fabilis</u>	E	
FISH		
<u>Ammocrypta pellucida</u> , eastern sand darter	T	
<u>Coregonus zenithicus</u> , shortjaw cisco	E	
<u>Coregonus artedii</u> , cisco or lake herring	T	
<u>Fundulus notti</u> , starhead topminnow	P	
** <u>Ictiobus niger</u> , black buffalo	P	
<u>Notropis anogenus</u> , pugnose shiner	R	
** <u>Notropis emiliae</u> , pugnose minnow	P	
** <u>Percina copelandi</u> , channel darter	T	
** <u>Percina shumardi</u> , river darter	P	

TABLE 2, continued

<u>SPECIES</u>	<u>STATE STATUS</u>	<u>FEDERAL STATUS</u>
AMPHIBIANS AND REPTILES		
<u>Chrysemys guttata</u> , spotted turtle	R	
<u>Coluber kirtlandi</u> , Kirtland's snake	E	
BIRDS		
<u>Ardea alba</u> , great egret	P	
<u>Haliaeetus leucocephalus</u> , bald eagle	T	T
<u>Pandion haliaetus</u> , osprey	T	
<u>Tyto alba</u> , barn owl	E	
MAMMALS		
<u>Alces alces</u> , moose	R	
** <u>Microtus ochrogaster</u> , prairie vole	P	
<u>Microtus pinetorum</u> , woodland vole	R	

* Believed to be restricted to Isle Royale in Michigan

** No recent records of occurrence in coastal zone

*** E = endangered, T = threatened, R = rare, P = peripheral

(Houghton's goldenrod). These species grow nowhere else in the world, and Michigan's coasts harbor over 95% of their total world populations. With scattered colonies in Ontario, Indiana, and Wisconsin, Cirsium pitcheri is the most widely distributed of this trio. Its Michigan occurrences number over 100, and it is common on low dunes along several multi-mile stretches of undeveloped shoreline. Solidago houghtonii also occupies sandy shoreline habitats, but is much more limited in its distribution, with ca. 50 occurrences centering around the Straits of Mackinac. Iris lacustris inhabits moist alkaline sandy or gravelly shores, and is similarly distributed around the Straits region, with 60-70 occurrences. Iris colonies are sometimes extensive along the shore and may extend inland, especially along ancient beach ridges of the postglacial Great Lakes.

Only two plant species listed as state endangered grow in the coastal zone. Orchis rotundifolia (small round-leaved orchis) has been found in recent years only on Isle Royale and at one Mackinac County locality, where a very small and declining colony existed in 1981. Habenaria leucophaea (prairie fringed orchid) was newly discovered in 1982 at several coastal prairies on Saginaw Bay. These colonies represent the best Michigan occurrences of this regionally threatened orchid, and are remnants of once-extensive populations on the former coastal wet prairies of Saginaw Bay, now largely under cultivation.

Mimulus glabratus var. michiganensis (Michigan monkey-flower) occurs at one coastal locality which is a Michigan Nature Association preserve. This variety is endemic to the Mackinac Straits region, and though some botanists have questioned its taxonomic validity, this summer's study by a University of Michigan graduate student suggests that its varietal status is justified.

The most dramatic loss of coastally occurring special plants has taken place in the southeastern Lower Peninsula, where land development has been most intense and relatively little shoreline remains unaffected by human activities. Elsewhere in the state, habitat loss has been concentrated near coastal cities and along shorelines with heavy residential/resort development. However, enough undisturbed or minimally disturbed coastal habitat still remains that, with careful planning, most special plants occurring there can be conserved at safe population levels.

TABLE 3 : SPECIAL PLANTS OCCURRING PRIMARILY OR EXCLUSIVELY IN MICHIGAN'S
COASTAL ZONE

<u>SPECIES</u>	<u>STATE STATUS**</u>	<u>FEDERAL STATUS***</u>
<u>Allium</u> <u>shoenoprasum</u> , chives	T	
* <u>Antennaria</u> <u>rosea</u>	T	
<u>Asplenium</u> <u>ruta-muraria</u> , wall-rue	T	
<u>Aster</u> <u>modestus</u>	T	
<u>Braya</u> <u>humilis</u>	T	
<u>Bromus</u> <u>pumpellianus</u>	T	
<u>Carex</u> <u>atratiformis</u>	T	
<u>Castilleja</u> <u>septentrionalis</u>	T	
<u>Cirsium</u> <u>pitcheri</u> , Pitcher's thistle	T	PT
* <u>Cryptogramma</u> <u>achrostichoides</u> , American rock-brake	T	
<u>Danthonia</u> <u>intermedia</u>	SC	
<u>Draba</u> <u>arabisans</u>	T	
<u>Draba</u> <u>cana</u>	T	
* <u>Draba</u> <u>incana</u>	T	
<u>Eclipta</u> <u>alba</u> , yerba-de-tajo	SC	
<u>Elymus</u> <u>mollis</u>	SC	
<u>Empetrum</u> <u>nigrum</u> , black crowberry	T	
* <u>Euphrasia</u> <u>arctica</u> , eyebright	T	
* <u>Hibiscus</u> <u>palustris</u> , swamp rose mallow, or marsh mallow	SC	
<u>Iris</u> <u>lacustris</u> , dwarf lake iris	ST	PT
* <u>Lactuca</u> <u>pulchella</u>	T	
<u>Lonicera</u> <u>involucrata</u>	T	

TABLE 3, continued

<u>SPECIES</u>	<u>STATE STATUS</u>	<u>FEDERAL STATUS</u>
<u>Luzula parviflora</u>	T	
<u>Nelumbo lutea</u> , American lotus	T	
* <u>Nymphaea tetragona</u>	T	
* <u>Oplopanax horridus</u> , devil's club	T	
<u>Orobanche fasciculata</u>	T	
* <u>Parnassia palustris</u>	SC	
* <u>Phacelia franklinii</u>	T	
<u>Pinguicula vulgaris</u> , butterwort	T	
<u>Poa alpina</u>	T	
* <u>Poa canbyi</u>	T	
* <u>Polygonum viviparum</u> , alpine bistort	T	
* <u>Potentilla pensylvanica</u>	T	
* <u>Ranunculus macounii</u>	T	
<u>Sagina nodosa</u> , pearlwort	T	
<u>Sagittaria montevidensis</u>	T	
* <u>Saxifraga aizoon</u> , yellow mountain saxifrage	T	
* <u>Saxifraga tricuspidata</u>	T	
<u>Senecio indecorus</u>	T	
<u>Solidago houghtonii</u> , Houghton's goldenrod	T	PT
<u>Stellaria longipes</u>	SC	
<u>Subularia aquatica</u> , awlwort	T	
<u>Tanacetum huronense</u> , Lake Huron tansy	T	
* <u>Tofieldia pusilla</u>	T	
<u>Trichostema brachiatum</u>	T	

TABLE 3, continued

<u>SPECIES</u>	<u>STATE STATUS</u>	<u>FEDERAL STATUS</u>
* <u>Vaccinium uliginosum</u> , alpine blueberry	T	
<u>Verbena simplex</u>	SC	

*Believed to be restricted to Isle Royale in Michigan

**E = endangered, T = threatened, SC = special concern

***PT = proposed threatened

TABLE 4: SPECIAL PLANTS OCCURRING PARTIALLY IN MICHIGAN'S COASTAL ZONE

<u>SPECIES</u>	<u>STATE STATUS**</u>	<u>FEDERAL STATUS***</u>
<u>Adlumia fungosa</u> , climbing fumitory	SC	
<u>Arenaria macrophylla</u>	T	
<u>Armoracia aquatica</u> , lake cress	T	
<u>Arnica cordifolia</u> , heart-leaved arnica	T	
<u>Asclepias sullivantii</u>	T	
<u>Asplenium viride</u> , green spleenwort	SC	
<u>Aster nemoralis</u> , bog aster	SC	
<u>Berula pusilla</u>	T	
<u>Boltonia asteroides</u>	SC	
<u>Cacalia plantaginea</u> , prairie Indian plantain	T	
<u>Calamagrostis lacustris</u>	T	
<u>Calamagrostis stricta</u>	T	
<u>Callitriche hermaphroditica</u>	SC	
<u>Callitriche heterophylla</u>	SC	
<u>Calypso bulbosa</u> , fairy-slipper	T	
<u>Camptosorus rhizophyllus</u> , walking fern	SC	
<u>Carex platyphylla</u>	T	
<u>Carex rossii</u>	T	
<u>Carya laciniosa</u> , big shellbark hickory	SC	
<u>Ceanothus sanguineus</u>	T	
<u>Chimaphila maculata</u> , spotted wintergreen	SC	
* <u>Collinsia parviflora</u> , small blue-eyed Mary	T	
<u>Cryptogramma steller</u> , slender cliff-brake	SC	
<u>Cypripedium arietinum</u> , ram's-head lady-slipper	SC	

Table 4 (continued)

<u>SPECIES</u>	<u>STATE STATUS**</u>	<u>FEDERAL STATUS***</u>
<u>Drosera anglica</u>	SC	
<u>Dryopteris assimilis</u>	SC	
<u>Dryopteris filix-mas</u> , male fern	T	
<u>Eleocharis compressa</u>	T	
<u>Elymus glaucus</u>	SC	
<u>Geum triflorum</u> , prairie smoke	T	
<u>Gratiola lutea</u> , hedge-hyssop	T	
<u>Habenaria leucophaea</u> , prairie fringed orchid	E	PT
<u>Habenaria unalascensis</u> , Alaska orchid	T	
* <u>Juncus stygius</u>	T	
<u>Juncus vaseyi</u>	T	
<u>Justicia americana</u> , water-willow	T	
<u>Listera auriculata</u> , auricled twayblade	SC	PT
<u>Littorella americana</u>	SC	
<u>Ludwigia sphaerocarpa</u>	T	
<u>Lycopodium selago</u> , fir clubmoss	SC	
<u>Mimulus glabratus</u> var. <u>michiganensis</u> , Michigan monkey-flower	T	PT
* <u>Myriophyllum alterniflorum</u>	SC	
<u>Myriophyllum farwellii</u>	T	
* <u>Nuphar microphylla</u>	T	
<u>Orchis rotundifolia</u> , small round-leaved orchis	E	
<u>Panax quinquefolius</u> , ginseng	T	
<u>Panicum leiberqii</u>	T	
<u>Pellaea atropurpurea</u> , purple cliff-brake	T	

Table 4 (continued)

<u>SPECIES</u>	<u>STATE STATUS**</u>	<u>FEDERAL STATUS***</u>
<u>Phleum alpinum</u> , mountain timothy	SC	
<u>Potamogeton hillii</u> , Hill's pondweed	T	
<u>Pterospora andromedea</u> , pinedrops	T	
* <u>Ranunculus rhomboideus</u> , prairie buttercups	T	
<u>Ribes oxycanthoides</u>	SC	
<u>Rumex maritimus</u> , golden dock	SC	
<u>Salix pellita</u>	SC	
<u>Salix pyrifolia</u> , balsam willow	SC	
<u>Scirpus torreyi</u>	SC	
<u>Solidago decumbens</u>	SC	
<u>Solidago houghtonii</u> , Houghton's goldenrod	T	PT
<u>Sporobolus heterolepis</u> , prairie dropseed	T	
<u>Strophostyles helvola</u> , wild bean	SC	
<u>Thalictrum venulosum</u>	T	
<u>Triplasis purpurea</u> , sand grass	T	
<u>Trisetum spicatum</u>	SC	
<u>Viola labradorica</u>	SC	
<u>Zizania aquatica</u> var. <u>aquatica</u>	T	

* Michigan coastal occurrences restricted to Isle Royale

** T = threatened, SC = special concern

*** PT = proposed threatened

TABLE 5: SPECIAL PLANTS WITH OLD RECORDS (NONE SINCE 1940) IN MICHIGAN'S
COASTAL ZONE

<u>SPECIES</u>	<u>STATE STATUS*</u>	<u>FEDERAL STATUS</u>
<u>Aristida longispica</u>	T	
<u>Asclepias hirtella</u>	T	
<u>Beckmannia syzigachne</u>	T	
<u>Camassia scilloides</u> , wild hyacinth	T	
<u>Carex synchnocephala</u>	T	
<u>Cuscuta polygonorum</u>	SC	
<u>Fimbristylis puberula</u>	T	
<u>Gentiana alba</u> , yellowish gentian	T	
<u>Gerardia gattengeri</u>	T	
<u>Gymnocladus dioica</u> , Kentucky coffeetree	SC	
<u>Habenaria ciliaris</u> , yellow fringed orchid	T	
<u>Helianthus hirsutus</u>	T	
<u>Hydrastis canadensis</u> , golden seal	T	
<u>Juncus brachycarpus</u>	T	
<u>Ludwigia alternifolia</u> , seedbox	T	
<u>Mimulus alatus</u>	T	
<u>Muhlenbergia cuspidata</u>	T	
<u>Polygala incarnata</u> , pink milkwort	T	
<u>Polygonum careyi</u>	T	
<u>Pycnanthemum verticillatum</u>	SC	
<u>Sabatia angularis</u> , rose-pink	T	
<u>Scleria pauciflora</u>	T	
<u>Senecio congestus</u>	T	
<u>Sisyrinchium hastile</u>	T	

TABLE 5 (continued)

<u>SPECIES</u>	<u>STATE STATUS</u>	<u>FEDERAL STATUS</u>
<u>Solidago lepida</u>	T	
<u>Vaccinium vitis-idaea</u> , mountain cranberry	T	
<u>Woodsia alpina</u> , northern woodsia	T	
<u>Woodsia obtusa</u> , blunt-lobed woodsia	T	

* T = threatened, SC = special concern

Natural Communities

Beach. Defined as the low strand adjacent to the water's edge, beach substrate is highly variable (sand, cobble, gravel, bedrock) and the extreme exposure to waves and winter ice keeps diversity (number of species and their abundance) and cover low. Bedrock beaches exhibit greater diversity than the others because the substrate is more stable. Sand beaches are abundant and widespread, concentrated to the greatest extent along Lake Michigan in the Lower Peninsula. Other significant concentrations lie along Lake Huron, east of the Straits to Rogers City and between Sand Point and Port Austin in Saginaw Bay; in the Upper Peninsula along Lake Michigan just west of the Straits; and scattered on Lake Superior from Grand Sable Dunes to Whitefish Point. Cobble and gravel beaches are of sporadic occurrence and absent from the lower two-thirds of the Lower Peninsula. Bedrock lies chiefly along Lake Superior, from Wisconsin east around the Keweenaw Peninsula. Isolated examples can be seen in the rest of the western Upper Peninsula, along the Niagara Escarpment where it meets water (e.g. the Garden Peninsula and Drummond Island), and in the Lower Peninsula most notably at Pointe aux Barques in the Thumb.

Sand, gravel, and cobble beaches are not threatened in the state. They are dynamic environments, constantly degraded and rejuvenated by natural forces. Human influence can be devastating at a time, but if localized, recovery is rapid. Bedrock beaches are moderately threatened and should be monitored. They are more susceptible to damage by foot traffic, which removes the cover of delicate lichen and moss. The upper beach (which is partially forested) above the tilted sandstone and shale beaches of Lake Superior has been virtually destroyed west of the Porcupines because runoff from the uplands was increased when the forest was clear-cut; in such a case the integrity of the lower beach is damaged.

Long stretches of sand beach are protected in several state parks along Lake Michigan. Gravel and cobble beach are not well-documented, but certainly exist within some northern state parks and the two national lakeshores. The best examples of bedrock beaches, high in biological diversity, are on Copper Harbor Conglomerate along the north shore of the Keweenaw Peninsula. A short stretch of Freda Sandstone in the west portion of the Porcupines Wilderness State Park may be significant because the wooded uplands above it have not been cut, and the beach is probably in a natural state.

Open Dune. Comprising this community are essentially any non-forested coastal areas of potentially blowing sand, which includes foredunes, parabolic dunes (chiefly blowouts in high wooded dunes), complex dune fields (generally low), and dune features perched on moraines. Most of the cover is provided by grass and woody species, and this is typically sparse. Beach grass (Ammophila breviligulata) predominates in places where sand is being deposited (e.g. foredunes) while sand reed grass (Calamovilfa longifolia) is most important where dunes have stabilized. Other significant and locally dominant species include sand cherry (Prunus pumila), bearberry (Arctostaphylos uva-ursi), creeping juniper (Juniperus horizontalis), and dune willow (Salix cordata).

The greatest number of open dune communities lie along Lake Michigan in the Lower Peninsula, including those of greatest extent (up to 2500 acres) and height (windblown up to 200 feet above the lake; perched up to 460 feet above the lake). Low dunes are scattered along the Lake Huron shore, most being north of Alpena or between Sand Point and Port Austin on Saginaw Bay. Low dunes also occur in the Upper Peninsula on both Lake Michigan and Lake Superior, but they are not well developed on the latter. The westernmost example is at Great Sand Bay in the Keweenaw. The best developed windblown dunes are in southwest Lower Michigan as far north as Point Betsie, but for biological diversity the dunes nearest the Straits excel. At the far edge of distribution (Port Crescent, Great Sand Bay, etc.) number of species falls off greatly.

Open dunes are not threatened in the state, but they should be closely monitored. Sand-mining and off-road vehicle traffic constitute the greatest threats to them, but foot-traffic has a tremendous impact as well by initiating breaks in foredunes. Probably every dune region in the state has been traversed by a vehicle, and in a few cases the community has been nearly destroyed (e.g. Silver Lake, Point Betsie). Although some movement of sand takes place naturally, humans can accelerate the process, which replaces one set of dominants with another, changes the typical contours of the surface, and enables exotic species to colonize on a large scale. Recovery may be fairly rapid, but changes in surface topography and introduced species remain. Several good examples of dunes, both windblown and perched, are in the hands of state and federal government and private conservation organizations. The problem is not land acquisition; the problem is preventing disruption of the community by humans.

The best windblown duneland in the state is at Big Sable Point near Ludington, encompassing state park and national forest land, though the latter is

disturbed. Some of the best windblown high dunes (up to 200 feet above lake-level) are included at Hoffmaster State Park, with other fine, but small, examples at The Nature Conservancy's Tower Preserve near Onekama, Lake Michigan Methodist Church Camp near Pentwater, and Thunder Mountain Blowout south of Van Buren State Park. The best perched dune is not on Lake Michigan, but rather along Lake Superior--Grand Sable Dunes in Pictured Rocks National Lakeshore, an expanse of open duneland second only to Big Sable Point in size and pristine nature. Other very good perched dunes occur on the west shore of South Manitou Island and at Pyramid Point in Sleeping Bear National Lakeshore.

Interdunal Wetland. This natural community occupies low areas within open dunes which periodically contain water and are strongly influenced by the lake. These influences are principally exposure to drifting sand, the excavating effects of wind, and a fluctuating water level in synchrony with changes in lake level. The sand and water is alkaline (pH 7.2-8.0). Generally a community dominated by herbs develops, with twig rush (Cladium mariscoides) dominant or very important at sites with high water table, and lake shore rush (Juncus balticus) more important on drier sites. Jack pines (Pinus banksiana) often surround the open areas, or have overgrown the most mature swales. Characteristic species include Panicum lindheimeri, Lobelia kalmii, Carex flava, Eleocharis elliptica, and Utricularia cornuta. Shrubby cinquefoil (Potentilla fruticosa) and Kalms's St. John's wort (Hypericum kalmianum) sometimes can be very important.

Typically interdunal wetland develops in the trough between the outermost foredune of a parallel series of arcuate dune ridges within a former embayment of a great lake. This setting is found on Lake Michigan in the eastern Upper Peninsula and northern Lower Peninsula (e.g. west of Platte River Point, Sturgeon Bay, Pointe aux Chenes Bay). In the southern Lower Peninsula it occurs within chaotic low dune complexes between Lake Michigan and an inland lake (e.g. Hamlin Lake at Big Sable Point, Crystal Lake) and also at river mouths (e.g. Muskegon River, Grand River at Grand Haven, Kalamazoo River at Saugatuck). Swales occur sporadically from Tawas Point on Lake Huron to the Straits; on Bois Blanc Island and on the Upper Peninsula side of Lake Huron; on Beaver Island and west on the Lake Michigan side of the Upper Peninsula perhaps almost to the Garden Peninsula. Only one swale is known to exist on Lake Superior--

at Deer Park. The diversity of interdunal wetlands is greatest near the Straits, the number of species decreasing in any direction away from that general area.

Interdunal wetlands are not threatened in the state, but they should be closely monitored. As with the open dune community, interdunal wetlands can probably recover fairly quickly from degradation, but changes in land contours and the introduction (or loss) of species may result. Because they are low and wet, only occasionally do vehicles or pedestrians traverse them. Their persistence, however, certainly is tied to that of the surrounding open dunes. Major forces of destruction do exist. Highway Two in the Upper Peninsula has disrupted areas of interdunal wetland, and sand-mining and home construction have encroached on several sites in the Lower Peninsula. It may be that the migration of a river back and forth across a dunefield at its mouth is important in creating new topography for dune pools in southwest Michigan, in which case construction of a fixed channel eventually may bring about the loss of interdunal wetland at that spot. Despite these threats, several good examples are preserved, but, as with open dunes, watchfulness is required to insure their survival.

Prairie. The prairies of the coastal zone are of a type distinct from those in the great prairie region west of Indiana. Having developed under conditions associated with the coast, they are generally on alluvial fine sandy loam that typically is alkaline (pH 7.4-8.2) but can be acidic in dry situations. A deep dark A horizon is present. The moistness of the prairies depends on their position relative to the shore. While the wettest prairies are nearly treeless, the drier prairies may support scattered trees (oaks chiefly), meriting the name "savanna." The wettest prairies are dominated by sedges (principally Carex aquatilis) and blue-joint (Calamagrostis canadensis); but blue-joint is replaced by little bluestem (Andropogon scoparius) and Indian grass (Sorghastrum nutans) where conditions are drier. A characteristic set of species makes up the rest of the community. In species composition, setting, and soil characteristics, the coastal prairies suggest relationships to interdunal wetland and fen.

Coastal prairies exhibited two centers of distribution in southeast Michigan: along and behind the Saginaw Bay shore between Tobico Marsh (Bay County) and Bay Port (Huron County) as well as up local major rivers (e.g. Saginaw,

Quanicassee); and in the lakebed of glacial Lake Whittlesey, primarily in the St. Clair River Delta, along the Detroit River, and at isolated spots on the shores of Lake Erie (e.g. mouth of the Huron River). Such prairies certainly also existed as far inland as the bounds of the ancient lakebed.

The coastal prairies of Michigan are highly threatened and efforts should be continued to discover and preserve examples of them. The suitability of the prairie soil for agriculture, and historic events which placed two large metropolitan areas at the center of each prairie region brought about the destruction of over 99 percent of this community. Loss of even the few tracts that survived continues today. Diking and draining can convert even the wettest sites to cropland, and industrial and urban expansion along rivers is an ever-present threat. Any parcel of this prairie type which is reasonably undisturbed would qualify for preservation. Unfortunately many prairies which occurred on state land in the Saginaw Bay region were plowed and planted to corn, and vehicular traffic and road construction in Algonac State Park disturbed the small tracts of mesic prairie there.

MNFI fieldwork resulted in the discovery of nearly all the good quality prairie of this type known in the state. Aerial photo surveys gave the best results. In the Fish Point Wildlife Area a high quality prairie was found at Sebawaing Bay. Another one, though small, can be found in the fairways of the Middle Channel Golf and Country Club on Harsen's Island. Known for many years and formerly sixteen acres in size, it was reduced to less than three acres when more fairways were established. A degraded (but significant because it is the most northwesterly example of the type) persists on the east shore of the Tobico Marsh Flooding at Tobico Marsh State Game Area.

Coastal Wetlands. Wetlands along the coast exhibit a wide range of variation in vegetation and setting. Some repeating assemblages of plants can be detected, and these fall for the most part within the following natural community types: Peripheral Lacustrine Marsh Wetland; Peripheral Riverine Marsh Wetland; Delta Wetland; and Peripheral Lacustrine, Riverine, or Insular Swamp Wetland. The first three are herbaceous communities while the last three are wooded. All are wet to varying degrees, although the herbaceous communities may extend into open water where the vegetation is chiefly emergent and sometimes submerged. Wetlands have traditionally been ignored by most ecologists, so much less is known about them than about upland communities. Part of this

neglect is due to the difficult terrain and often dense and tangled growth which impede movement in them. Except for catastrophic disturbance associated with large-scale human endeavors (e.g. lumbering, dredging, filling) the same factors making wetlands difficult to study also tend to protect them. They are probably not threatened in the state except on a local level, especially near large population centers (southeast Michigan, Saginaw Bay), but further investigation may reveal that some sub-types of natural communities are threatened. However, no study is needed to show that Delta Wetland is threatened in the state.

Peripheral Lacustrine Marsh Wetland describes most appropriately large expanses of vegetation that develop on lee shores of the Great Lakes. In this instance they can be called Great Lakes marshes. They are typically mono- or duocultures of cattail (*Typha*) and bulrush (*Scirpus* spp., mainly *S. americanus* and *S. acutus*) which often extend far into the lake. The community is not very diverse but, as with other herbaceous wetlands, contributes to the sustenance of waterfowl and other animals and may be significant in nutrient cycling and other functions of ecosystem maintenance. Good examples of coastal marsh occur in Green Bay, Waterfowl Bay, off the lee side of the Thumb's tip and the Garden Peninsula, off Point au Gres (Arenac County), and in the Erie State Game Area south of Luna Pier. Also in the coastal zone are communities within this category that occur principally in low areas of arcuate recessive dune ridges that develop within a lake embayment (e.g. Vermillion), or simply in shallow embayments that were cut off by a bar at the lake. In this respect they are later stages of interdunal swale development as long as they remain open, or along Lake Superior where such earlier stages are not possible they become boglike (e.g. Pequaming, Middle Bay west of Marquette, Shot Point east of Marquette). The examples given have all resulted from single bar formation across an embayment.

Peripheral Riverine Marsh Wetland develops along the margins of larger streams that empty into great lakes. A particularly distinct type of this wetland has arisen along the dune-covered coast of the Lower Peninsula, south of Point Betsie and generally south of the Algonquin Hinge Line. During a low water stage, rivers flowing into Lake Michigan downcut their beds. When water levels rose, the mouths of the rivers were "drowned" and became large estuaries which may be slightly influenced by the lake. The vegetation exhibits patchy monodominance of several species, including cattail, bulrush, bur-reed

(chiefly Sparganium eurycarpum), sedges, and blue-joint (Calamagrostis canadensis). Despite dredging of channels and construction of breakwaters at river mouths, the estuaries persist, seemingly undamaged. The greatest threat to them could be diking and draining for cultivation of truck vegetables. For extent and lack of disturbance some of the best examples are on the Pentwater River, Flower Creek (Muskegon County), and the Betsie River (Benzie County).

Delta Wetland is very rare in Michigan due to the scarcity of conditions permitting its development. Required seems to be a large stream, unhindered by bedrock, which flows into perhaps a shallow portion of a great lake at a protected spot so that dunes cannot form. Only the St. Clair River Delta and deltas of certain rivers that flow into Lakes St. Clair and Erie possess the right conditions. The Rapid River in Delta County may also qualify. The vegetation is chiefly a zonation monoculture composed of bulrush, cattail, and sedge. Delta wetland is severely threatened, for all have been extremely disturbed by alteration of channels and manipulation for wildlife production, and because they are located, unfortunately, within Michigan's industrial heartland.

The wooded communities traditionally have been given such names as cedar swamp, tamarack swamp, bog forest (black spruce, Picea mariana, is most characteristic of this), and southern swamp forest. Many of these are second growth, especially if the dominant trees grew to a girth and height (as in southern swamp forest and cedar swamp) that made cutting worthwhile. However, a ragged, stunted appearance may be quite natural for certain types (e.g. black spruce swamp), particularly in the northern portion of the state. All are widespread and, though restricted to certain topographic features, fairly commonly encountered. But the tension zone seems to represent a division in the state, some types being mostly above and some below it. Generally they are not threatened, though some sites should receive high priority. For example, uncut swamp forest south of the tension zone may be quite rare. The largest tracts of coastal wetland are possible in low areas between successive dune ridges that have developed in lake embayments. This setting parallels that of certain herbaceous communities, and indeed the wooded communities eventually do succeed the open ones. Examples of this situation exist behind Sand Point in Pictured Rocks National Lakeshore and at Sturgeon Bay in Wilderness State Park. Bars can be deposited to leeward, into a lake, with the same ridge and trough topography resulting, as at Point Lookout in Arenac County, or behind a single bar, as at Point Isabelle in the Keweenaw Peninsula. At more exposed sites, single

bar embayments can become wooded wetlands, evident at Eagle Harbor in the Keweenaw Peninsula or Grand Mere in Berrien County.

Wooded Uplands. Dry, forested land is the commonest feature along Michigan's coast, covering more area than all the other communities combined. As with the wetland communities, much variation is seen. Generally, all the types that exist inland in Michigan can be found along the coast, with few exceptions. The following natural communities cover most of the wooded tracts encountered: Dry, Dry-Mesic, and Mesic Northern Forest; Dry, Dry-Mesic, and Mesic Southern Forest; Pine Savanna; and Boreal Forest. The most frequently encountered types are Mesic Northern Forest and Boreal Forest, though Dry Northern Forest is fairly common. Virtually all of the forests along the coast have been cut in some way, and clear-cutting of large virgin tracts was practiced into the 1950's. Occurrences include mature second-growth stands or those which were selectively cut, although virgin timber receives first priority.

Mesic Northern Forest along the coast grows on moderately drained soils which are often poorly suited for agriculture. Its defining traits are in the dominance of the canopy by combinations of certain trees--sugar maple (*Acer saccharum*), hemlock (*Tsuga canadensis*), yellow birch (*Betula lutea*), American beech (*Fagus grandifolia*), and to a lesser degree basswood (*Tilia americana*)--the presence of species with a generally northern distribution (*Dryopteris intermedia*, *Viburnum acerifolium*, *Galium triflorum*, *Aralia nudicaulis*, *Aster macrophyllus*, *Maianthemum canadense*, etc.), and the absence of others of principally southern distribution (e.g. *Carya* spp., *Juglans* spp.). South of the tension zone the forest occupies dunes and ravines along Lake Michigan, especially the north slopes of dunes and in pockets between them. In the south tulip tree (*Liriodendron tulipifera*) and a number of other southern species can be very important, which makes the woods appear intermediate between Mesic Northern and Southern Forest. Virgin stands of this southern sub-type may exist in difficult to enter dune pockets, such as on the Martin-Marietta Mt. Edward Tract near Bridgman. In the north, where the forest was originally abundant, scraps of virgin woods are frequently encountered, and a few large uncut tracts have also been preserved. The best of these adjacent to the coast is in the west portion of Porcupines Wilderness State Park. Much virgin timber remained west of the Porcupines well into this century, but is now gone. An aberrant but significant tract is located in the Valley of the Giants on South Manitou Island. Here a

forest of extremely large white cedar (Thuja occidentalis) has developed in a protected dune ravine.

Since some of the largest tracts of virgin Mesic Northern Forest in the United States are found in Michigan's Upper Peninsula, this type is not threatened. Several small stands scattered in the Upper Peninsula and Northern Lower Peninsula are preserved within state or federal parks, which further secures this type. The forests of southwest Michigan, as a slightly different version of this forest and because they nearly all were at least selectively lumbered, should receive more attention, especially virgin stands, if they exist. But large tracts of nearly mature second-growth forest are protected within certain state and federal parks (e.g. Hoffmaster State Park) to offset concern.

Boreal Forest should not exist in Michigan, the bulk of its range being much farther north. Nevertheless, it is present along exposed shores just behind open beach or dune where exposure to the harsh lake conditions is greatest. Proximity to the lake is also necessary to generate cool temperatures and high humidity during the summer, which enables the northern species of Boreal Forest to maintain themselves. Most diagnostic of this community is the presence, in good numbers, of balsam fir (Abies balsamea), paper birch (Betula papyrifera)--which are more frequent on the whole than any other canopy species--and sometimes white spruce (Picea glauca). White cedar is a fairly regular member of this community and is sometimes quite important. Other species often found in the Boreal Forest are white pine (Pinus strobus), mountain ash (Sorbus americana, S. decora), mountain (Acer spicatum) and red maple (Acer rubrum). Because of conditions poorly suited to tree development, stands may be virgin despite a ragged, tangled appearance and the presence of trees which are relatively small. Isolated large individuals of white spruce, white pine, and white cedar within such a tract may indicate that it is virgin.

This community thrives on moist to mesic sites along the shore of Lake Superior at numerous locations, but never where red pine (Pinus resinosa) forest covers the low dune and trough topography of a former lake embayment. It is present to a lesser degree on the Lake Michigan side of the Upper Peninsula, and extends increasingly sporadically southward along Lake Michigan to Point Betsie and along Lake Huron to Alpena. Boreal forest is not threatened in Michigan, but stands of high diversity which contain large trees should be sought out and protected. Stands in situations favorable to the production of large trees are apparently rare, probably because such conditions are rare and, where they exist

ted, they attracted loggers. Even if the large trees in a stand have been removed, the community is still intact and virtually indistinguishable from uncut, ragged-looking forest. Many of these are protected at state and federal parks (e.g. Wilderness State Park, Beaver Island) and by private conservation organizations (e.g. Michigan Nature Association's Keweenaw Preserves). Virgin stands also exist as islands within large expanses of open dune, as at Point Betsie and on Grand Sable Dunes in Pictured Rocks National Lakeshore.

Of the dry upland forests, Dry Northern Forest, dominated by red pine and lesser amounts of jack pine (*Pinus banksiana*), is the commonest. On the coast this type grows primarily on the dune and trough topography of recessive dunes in old lake embayments. The dunes are high enough so that even the swales stay dry. Ericaceous species (chiefly *Vaccinium angustifolium*) occupy an important position in the structure of the groundlayer. Not surprisingly, the poor soil (mostly sand) and dry situation result in low diversity for this community. But the pines were very attractive to lumbermen, and a coastal stand of uncut Dry Northern Forest may not exist today. Moreover, many of these experienced fires which may have rendered the soil even less fertile. Second growth stands are commonest, but not plentiful, along Lake Superior (e.g. Lake Superior State Forest, Marquette Bay), becoming less common in the upper third of the Lower Peninsula. Overall the community is moderately threatened, for harvesting of second-growth stands is proceeding today. More study is needed to firmly establish the status of this community and to confirm the complete loss of virgin stands.

A community seemingly intermediate between pine forest and open dune can be found on the same dune and trough topography of old lake embayments. It is dominated by low woody species like bearberry (*Arctostaphylos uva-ursi*), common (*Juniperus communis*), and creeping juniper (*J. horizontalis*). Taking up the spaces between the masses of these species are bare sand and clumps, or individuals, of pines (mostly white and jack) under which species of pine woods grow. Open dunes lie toward the water, and it is uncertain whether this community represents a stage of succession following cutting and burning of Dry and Dry-Mesic Northern Forest, the dune species having colonized the damaged soil beneath surviving pines. However, at one site (Betsie River State Forest in Good Harbor Bay) the white pines are quite large and apparently unburned. Not enough is known about this type of Pine Savanna to judge its status and extent, nor to determine whether it is actually natural. All known examples are found in

Sleeping Bear National Lakeshore (South Manitou Island, Platte Bay, Sleeping Bear Bay, Good Harbor Bay).

In the south the dry forests on dunes probably have all experienced the loss of their pine component (red and white). In some spots, where conditions are hot and dry (such as on southerly slopes at the landward edge of the barrier dune in Berrien County), black oak (Quercus velutina) may be the natural dominant. In the Bridgman Dunes such forests exist in which the dominant oaks are large. But in the Muskegon area, where the black oaks are of small to moderate size, considerable tracts of forest certainly suffered the removal of pines at the end of the last century. Closely related to southern oak forest is a type of community which may have its origin in fire but which persists despite its absence. Best described as a heath bald, this community occupies the tops of high dunes typically located at the landward edge of the barrier dune complex. It may also be found on low dune ridges away from the lake's influence (i.e. windward of it). Stunted oaks and occasionally pines form a broken canopy, and the ground is dominated by low blueberry (Vaccinium angustifolium) and huckleberry (Gaylussacia baccata). Only a few examples are known (Muskegon State Park, Tobico Marsh State Game Area, Thunder Mountain) and these are disturbed because a bald dune top attracts sight-seers. The ecological significance of this community may be only slight.

None of the types described (except oak-dominated woods) grow along the coast of southeast Michigan. In fact, upland forest cover from Bay City to Ohio is either cut or completely absent. Particularly between the Thumb and Port Huron the coast is free of woods to a remarkable extent, certainly attributable to the suitability of the region for agriculture. Any tract of mature woods here, however, would not be different from stands of the same type located farther inland, for the lake effect on the upland communities is not as great as it is along Lakes Michigan, Superior, and upper Lake Huron.

Cliffs. Less is known about assemblages of species which occur on cliffs in the coastal zone than about other communities there. Few occurrences for the state have been documented, and much fewer for the coast despite the many obvious cliffs that are visible along it. Part of this is the difficulty posed by sheer cliffs which rise from water, and by cliffs generally--it is hard to get around on them. Classification of cliffs is the second difficulty: many of the species present are those of the surrounding uplands which blurs distinctions

between types. Often the vascular vegetation is sparse and lichens or mosses very important, in which case a bryologist rather than a terrestrial ecologist would be best equipped to study them. It is evident that cliff must be defined broadly to include any natural outcrop of bedrock (not moraine) that is fairly sheer and high. Some bedrock beaches in their upper levels may actually be called cliff, but if vegetation of the two communities does not differ significantly the separation would be pointless. One important distinction may be whether a cliff is wooded or not, and if not, whether it is severely exposed to the sun. Another distinction may depend on the substrate. Calcareous and non-calcareous cliffs each support at least a number of ferns not found on the other, and mosses, lichens, and some vascular plants may exhibit the same habitat dichotomy.

Cliffs in the coastal zone show the same pattern as cliffs all over Michigan: they are much more plentiful in the Upper Peninsula than in the Lower. The following is a brief account of the distribution and composition of cliffs along the coast. The few cliffs of the Lower Peninsula are limestone, except at Pointe aux Barques (sandstone), although these at the tip of the Thumb are mostly so low they are not distinct from the bedrock beach. El Cajon Bay north of Alpena is ringed by cliffs composed of limestone in the Traverse Group. In the lower Upper Peninsula the Niagara Escarpment, composed of Engadine Dolomite, forms steep, high cliffs on the north shore of the Garden Peninsula. The cliffs of Mackinaw Island are in the same formation. Exposed shale of Ordovician age can be seen in the valley of the Escanaba River. The most renowned cliffs in the state are the Pictured Rocks, Munising Formation sandstone cliffs that rise straight out of the water sometimes to a height of two hundred feet. Other sandstone cliffs, chiefly of Jacobsville sandstone, are exposed elsewhere along Lake Superior, two of these areas being north of Marquette and Baraga. A long escarpment of shale which enters the coastal zone in a couple places winds from Marquette to south of the mouth of the Tahquamenon River. A Cambrian age rock called the Cambro-Ordovician Cuesta, this escarpment is responsible for some of the falls and adjacent cliffs (e.g. Miner's Falls) in Pictured Rocks National Lakeshore. Cliffs of Freda Sandstone and Nonesuch Shale lie just upstream from Lake Superior in and near the Porcupines, producing beautiful waterfalls.

Cliffs may be moderately threatened in Michigan, but more study is necessary to determine their actual status. Although true that cliffs along the

coast, particularly sandstone cliffs, are exceedingly poor in vascular species and possess low cover, it is obvious that heavy human visitation in recent years has accelerated erosion of the uplands (and hence of the cliff face) by completely removing the ground vegetation back from the cliff. This was evident at popular spots, such as the Porcupines and Pictured Rocks, but probably holds true elsewhere. Higher and steeper cliffs would be less affected than lower ones. Recovery may be possible since the habitat is a primary successional one, but if species are lost from a site, especially an isolated one, chances are that no recolonization will take place.

Others

The Natural Features Inventory Program has collected and will continue to refine information on five distinct types of natural phenomena which, because they do not fit within the major classifications, are inventoried under the inclusive term "others". So far as we have been able to determine there are no occurrences of bat caves within Michigan's coastal zone. While a number of American chestnut (Castanea dentata) groves flourish near Lake Michigan in the Lower Peninsula (at some distance from the original, natural distribution of the species), none of these is close enough to the shore to qualify as a strictly coastal occurrence.

The inventory has identified 37 coastal sites which have become traditional concentration points for birds in their spring and/or fall migrations. These areas are further distinguished in their usage by waterfowl, shorebirds, raptors, and passerines. The MNFI's heron rookery survey, a cooperative effort with the Living Resources Program, has documented 184 rookeries in the state. Thirty of these lie within the coastal zone.

Due to the often indefinite locations given by those who report state record-size trees and shrubs, it is not possible to determine the exact number of these that are found strictly within the coastal zone. Although there are six definite occurrences there, as many as twenty may exist.

Recommendations

Special Animals

Through the use of artificial nesting platforms and boxes eagles, ospreys, and barn owls should be encouraged to occupy their former nesting sites along the coasts of Michigan. Hacking of artificially bred peregrines will probably be required to bring this species back to the state. The protection of Michigan's remaining large tracts of coastal fresh-water marshes will ensure the continuance in Michigan of species such as king rail, fox snake, Forster's tern, and numerous other less rare species which depend upon these communities for their existence. Active management such as fencing, selective predator removal, erosion control, as well as habitat protection may be required to ensure the continued survival of colonially-nesting terns in the state. Continued improvement in water quality, especially in southeastern Michigan, is urgently needed to save several very rare fish and mollusk species, some of which may already be extirpated from the state, such as the federally listed endangered Dysnomia sulcata. Also urgently required are measures to protect the Great Lake's last remaining piping plovers. Such measures might include banning off-road vehicles and dogs, and restriction of human access to the nesting beaches during the brief critical nesting season (late May to early July).

The dramatic decline in the piping plover population and the changes in locations, sizes and success of nesting tern, heron and eagle populations, and other species indicate the need for close, continued monitoring of their populations. For many species, our knowledge of their current distribution in the coastal zone is still very incomplete. This is especially true as regards mollusks, several of which are in danger of extinction on a world-wide basis. Many other rare species such as king and yellow rails, short-eared owl, fox snake, channel darter, and eastern sand darter are in need of much additional survey work in Michigan's coastal zone.

Special Plants

Although no large contiguous stretches of shoreline went unsurveyed in this inventory, some areas were not completely covered, due mostly to inaccessibility. This is true of the Keweenaw Peninsula's outermost tip (where only select portions were surveyed) and certain islands not included in the BLM study (e.g., Whitefish Bay islands, and Sugar Island, in part). These areas should eventually be

thoroughly inventoried.

Because of time and resource limitations, fieldwork for this inventory focused on endangered and threatened species, and in most cases, only incidental field data were collected on the lower-priority "special concern" plants (which are not legally designated or protected). Comprehensive field surveys should eventually be extended to include these species.

Populations of the two endangered coastal plants Orchis rotundifolia (small round-leaved orchis) and Habenaria leucophaea (prairie fringed orchid) should be monitored annually, so that serious declines can be noted and reversed, if possible. Intensive studies of these species' life histories and specific habitat requirements will be necessary to develop successful management strategies. At present, we know very little about what these plants require to thrive and reproduce. In the meantime, our best conservation strategy must be to prevent human disturbance to their habitats.

As noted in the Results section, Michigan's three plant species endemic to the Great Lakes shoreline have not declined in the state to perilous levels. Large, healthy colonies of each species still exist, although some have been damaged or destroyed by concentrated shoreline development (especially urban and residential). Off-road vehicle traffic and heavy pedestrian traffic have also contributed to habitat degradation for these (and other) coastal species. The protection of several large, undisturbed colonies of each of these endemic species will ensure their conservation in the state. Many ideal sites already lie on publicly-owned land--for instance, the dunes at Ludington (State Park and National Forest) and Sleeping Bear National Lakeshore support excellent populations of Pitcher's thistle, and can function as preserves for this species. However, to prevent these plants from becoming "museum pieces"--i.e., restricted to only two or three sites where they have been preserved--other occurrences, large and small, should be conserved whenever possible. This will ensure maintenance of a diverse gene pool, which is critical for the long-term survival of any species.

Natural Communities

Clearly the most threatened natural community in the coastal zone is prairie. Little work remains to be done in the Saginaw Bay Region before the possibilities are exhausted, and the St. Clair River Delta is less promising.

The lower Detroit River and the mouth of the Huron River may still harbor coastal prairie: a tract of this type supporting hundreds of plants of the prairie white fringed orchid (Habenaria leucophaea) was found just last year on Lake Erie in Ohio. All stands of wet prairie should be given immediate protection. Delta Wetland is severely threatened, though much more of it exists than prairie because it can cover so much area. As little more of this community will likely be found, known sites should receive all possible protection to prevent further degradation and reduction in size.

Natural communities requiring further study and which may be moderately threatened are bedrock beaches, cliffs, and red pine forest (Dry Northern Forest). The first two are damaged by foot-traffic and the latter may not be found in a virgin state. None of the other communities are as threatened as these, although overuse could easily damage communities which seem particularly attractive to humans, such as open dune and included interdunal wetland. Monitoring of the most vulnerable and heavily used communities should be initiated to prevent a change in their status as a consequence of degradation. As indicated in the Results section, however, some sub-types may already be in danger. The Erie marshes, though partially protected, have been changed tremendously to accommodate human endeavor along the coast. The aspect and composition of remaining tracts may even have changed from that of presettlement times.

The survey for communities was nearly exhaustive along two-fifths of the coast: Lake Michigan from Indiana to the Leelanau Peninsula and Lake Superior from Wisconsin nearly to Whitefish Point. Much information existed for the rest of the coast but certain gaps remain. Because roads were unsuitable or absent, portions of the Porcupines and Pictured Rocks as well as the tip of the Keweenaw Peninsula were inadequately surveyed. Whitefish Bay, the western portion of the Upper Peninsula along Lake Michigan, a stretch of Lake Huron north of Alpena, and the islands off the tip of the Upper Peninsula need more work. A distinct phenomenon, which should mandate careful planning for natural community preservation, is the long strings of homes that have disturbed the integrity of communities along the coast without destroying them. These are particularly evident along Lake Michigan, near the Straits, near Alpena, as a continuum from the Thumb south to Detroit, between Menominee and Escanaba, along the north shore of the Keweenaw, and in sandy bays and near towns all along the rest of the coast.

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