

**BRUCE PENINSULA NATIONAL PARK  
BIOPHYSICAL SURVEY**

**for**

**CANADIAN PARKS SERVICE**

**by**

**S.L. ROSS ENVIRONMENTAL RESEARCH LIMITED**

**MOSQUIN BIO-INFORMATION LTD.**

**HORLER INFORMATION INC.**

## **TABLE OF CONTENTS**

	<b><u>PAGE</u></b>
ACKNOWLEDGEMENTS	iv
EXECUTIVE SUMMARY	v
INTRODUCTION	1
METHODS	4
CLIMATE	7
Climatic Influences	7
Climate Statistics	8
Climate's Influence on Park Usage	19
Climate References	24
GEOLOGIC HISTORY	25
Introduction	25
Bedrock Geology	25
Karst Features	38
Glaciation	40
Post-Glaciation	43
Geology References	54
SOILS	57
Soil Development in BPNP	57
Soils Found in the Cyprus-Cameron Lakes and Dorcas Bay Areas	62
Soils Formed on Sand Dunes	70
Soils Formed on Lacustrine Deposits	73
Soils Formed on Tills	75

## **TABLE OF CONTENTS (Cont.)**

## **PAGE**

Soils Formed on Bedrock	77
Soils Formed on Organics	83
Soils References	84
<b>TERRAIN</b>	<b>85</b>
Topography	85
Bathymetry	89
Drainage	94
Fluvial Drainage	94
Holokarst Drainage	97
Immature Fluvio-Karst Drainage	98
Fluvio-Karst Drainage	99
<b>VEGETATION</b>	<b>100</b>
Introduction	100
The Significance of Vegetation	102
Previous Vegetation Studies	103
Methods	104
Definition of Vegetation Attributes	105
Field Work	109
Description of Vegetation by Attributes	111
History of the Vegetation and its Successional Goals	141
Principal Vegetation Communities Today	153
Relative Values of Wetlands in the Study Area	165
Representativeness	165
Rare Species	167
Using SPANS to Deduce Intrinsic Ecosystem Values	168

### **TABLE OF CONTENTS (Cont.)**

	<b><u>PAGE</u></b>
Conclusion	176
Vegetation References	177

LAKES, RIVERS AND SHORELINES	180
Physical and Chemical Data	180
Fish Species Present	183
Bruce Peninsula Shorelines	190
References to Lakes, Rivers and Shorelines	192
 SATELLITE IMAGERY AND PROCESSING	 193
Vegetation Classification	193
Geological Feature Enhancement	200
Miscellaneous Processing	202
 EXAMPLE DATA ANALYSIS	 206
Opportunities or Constraints to Construction	207
Existing Land Use Impacts and Re-habilitation	209
Vegetation Succession Trends	210
Habitat Suitability	210
Sport Fishing	219
Fire History, Risk and Fuel Mapping	220
Insect Infestation and Disease	222
Representative Natural Themes	222
Park Zoning	225
Simple Area Analyses and Map Cross Correlation	225

Appendix A: Lake Bathymetry, Shore Type and Surface Type Maps

Appendix B: Satellite Classification Details

### **ACKNOWLEDGEMENTS**

This study was completed with the valuable assistance and co-operation of the following individuals and groups:

Canadian Parks Service staff both in the Ontario Regional office, Cornwall, and in the Bruce Peninsula Park office. Of particular importance was the direction and input provided by Brian Hutchinson and Bill Stephenson.

Staff of the libraries of the Niagara Escarpment Commission and the Ministry of Natural Resources in both Toronto and Owen Sound.

Gord Frazer who conducted the soil survey and summarized the geologic history of the Park.

Staff of the Ontario Geological Survey in particular Derek Armstrong, who provided the results of their recent surveys of the Bruce Peninsula.

## **EXECUTIVE SUMMARY**

The Bruce Peninsula National Park was established on approximately 275 square kilometres of land in the northern tip of the Bruce Peninsula in 1987. The climate of the Park can be characterized as maritime with cool late summers, mild autumns, mild late winters and long cool springs, and offers a good climate for both summer and winter activities.

The biophysical character of the Bruce Peninsula is very much a product of the geologic history of the area. The Paleozoic bedrock of the area has a regional dip to the southwest and a secondary dip to the northwest in the vicinity of the Park. This results in a high cliff structure on the northeast side of the Peninsula and gentle sloping flat rock (with rubble) beaches in the west. A complete cross-section of the Paleozoic bedrock formations is not found within the Park but is present at nearby Cabot Head.

Post-glacial lake levels and reef-development have played an important role in soil development as have the karst topography, drainage and glaciation. Sand dunes and lacustrine deposits in the Cyprus Lake - Cameron Lake - Dorcas Bay area are a direct result of sedimentation and beach deposition during periods of different lake levels in the past.

Solutional weathering of bedrock and the development of karst features and drainage has resulted in small scale vertical sinks, deep pits and clint and grike features that provide secondary porosity, increase soil drainage, deeper weathering of the soil profile and structural holds for vegetation growing on the surface. The net result has been the development of deep pockets of muck scattered throughout the exposed bedrock of the area.

Isolated pockets of glacial lodgement tills can also be found throughout the area contributing to the variability of soils in the Park.

Vegetation of the study area is much more varied than meets the eye of the casual observer with many kinds of upland and wetland communities being represented. Upland forests have been profoundly affected by major fires which swept the entire peninsula in the first decade of this century. Hence, with rare exceptions trees are uniformly about 80 years old or younger, although the occasional older tree that survived the fire is sometimes found. Very large, rotted stumps of White Cedar and possibly White Pine dating from these fires survive in many areas. Several centuries of succession will need to take place before

these young forests can again be fully representative of the area. Dry alvar associations are scattered throughout the study area, especially nearer to the two shorelines. They have a savanna-like vegetation with scattered coniferous trees and shrubs, vernal pools and rock cracks offering specialized habitat.

Along the Huron shoreline coniferous forest predominates with White Spruce, Balsam, and White Cedar. The south central part of the study area and some spots closer to the Huron shore are dominated by Jack Pine. Mixed forest stretches across the central and northwestern parts of the area and along the Georgian Bay shoreline, dominated by conifers, Aspen and White Birch. The mixed forests represent a successional stage in transition to a coniferous forest. Some mixed forest is dominated by dense stands of the Round-leaved Dogwood which may form nearly solid canopies. Large areas of deciduous forest with fully developed canopies occurs particularly in the more eastern parts roughly in a line from Halfway Dump to Dyers Bay. The most abundant tree in deciduous forests is the Sugar Maple, but with subdominant Beech, Red Oak, White Birch, Large-toothed Poplar and White Ash. Many of the deciduous forests have in the past been converted to field and pasture but are now abandoned and being invaded by native trees and shrubs.

Wetlands of all 4 types (swamps, marshes, fens and a bog) are present, although the bog is being drained and its ecosystem is now rapidly deteriorating. Location of wetlands in the study area is closely linked to the presence of slow moving streams, low lying areas, beaver floods, karst topography and the occurrence of extensive seepage slopes. Fens in particular are common, their location being tied to the emergence of mineralized waters, mainly along the Huron shore, and they are incredibly rich in rare species and beautiful wildflowers. Extremely productive marshes are scattered across the study area. The marshes at Crane and Marsh Lakes were found to support a wealth of bird life.

The lakes of the area are generally very shallow (less than 2 metres in most cases) with the exception of Cameron, Cyprus, Emmett and Gilles Lakes whose depths range from 3 to 10 metres. The lake bottoms are generally a calcareous marl, their shorelines rocky and aquatic vegetation present ranges from sparse round bulrush to areas of productive marsh. The lakes are well buffered with pH's generally in the Alkaline range (pH 7.4 to 9.4). Total dissolved solid concentrations in the deeper lakes are on the order of 150 ppm with values in excess of 200 for the shallower, marshier water bodies. A wide variety of forage fish have been identified in the area lakes. The current sport fishery consists of brook trout, smallmouth bass, yellow perch and northern pike.

Satellite images of the Peninsula were classified for primary vegetation cover types and compared to field survey results. The correlation indicated that the satellite classification identified the general trends of

land cover with some success but mis-classified many areas. The method shows promise for general vegetation cover change detection but should be further investigated and refined.

The analytical capabilities of the SPANS Geographical Information System (GIS) used to map the biophysical data have been used in several ways in the biophysical. Simple area analyses have been used to determine prominent slopes and directions of slope within the park, the prominence of various vegetation types, and the relative areas of drainage types. Two map correlations were used to compare the results of satellite classifications with field survey results and in deer habitat suitability analyses. More sophisticated spatial modelling analyses were utilized to map out fire hazard zones, vegetation succession trends and ecosystem values as further examples of the utility of the GIS in advancing Park management capabilities.



## **INTRODUCTION**

Bruce Peninsula National Park (BPNP) was officially established in 1987. The proposed Park area includes approximately 275 square kilometres of portions of St. Edmunds township in the northern tip of the Bruce Peninsula including the former Cyprus Lake Provincial Park.

The preliminary resource reconnaissance for the Park (Wickware 1987) concluded that, while the natural resource base for the island units of the Park had been studied and documented in considerable detail, the mainland resources had not seen similar attention, with the notable exception being the geology of the area. The biophysical study was thus implemented to initiate the collection of natural resource information for the mainland portion of the Park necessary for Canadian Parks Service (CPS) staff to make informed management decisions. The extent of the Park can be seen in Figure I1. The actual study area included all areas northwest of the heavy line seen in Figure I1. The area was extended beyond the physical park limits to allow future studies the freedom to consider more natural limits such as whole watersheds, geologic structures and vegetation units.

This biophysical differs from some carried out in the past by the CPS in that the data is presented as thematic maps rather than combined "land system" or "ecosystem" maps. The data is also stored on a geographical information system (GIS); specifically, Tydac Technologies' Spatial Analysis System (SPANS). End users will now be able to access data themes either individually or in combination and in greater detail than has been possible in the past. Traditional ecosystem or land system mapping could be generated from these individual themes as in past biophysicals but the more common use of the database on a day-to-day basis will see end users accessing only those items of interest to their immediate analysis or planning problem.

The biophysical survey has dealt with the collection and "cataloguing" of only a subset of the entire database which CPS staff will eventually need for park management. The computerized database which has been put in place as a result of this biophysical will, however, provide a framework for the collection and final storage of additional data that will be gathered in the future. By cataloguing all pertinent Park resource information in a standardized, spatially referenced database more complete ecological modelling will be possible than has been achieved in the past with greater speed and efficiency.

This survey has collected data on the climate, geology, soils, terrain, primary and understory vegetation and physical and chemical characteristics of the Lakes and Rivers. The Lake Huron - Georgian Bay elements of the park were not studied in detail in this survey. Water chemistry and bathymetry were the only data collected in these areas. Landsat Thematic Mapper and SPOT satellite images have also been acquired and analysed to determine their usefulness in data collection for biophysical surveys. Examples of how the GIS could be used in park planning and day-to-day operations are discussed in the final chapter of this report.

## **METHODS**

This chapter briefly discusses the approaches taken in the collection of the various data sets discussed in this report and the final presentation of the data in the GIS.

**Base Map:** The base map layer used for the Park was manually digitized from the Ontario Ministry of Natural Resources 1:10,000 Ontario Base Map (OBM) Series. All of the features (drainage, roads, vegetation, cultural features, topography) from 35 of these sheets were digitized and then joined as a single map for each of the separate data items.

**Climate:** The climate data presented in this report is a summary of information found in the available literature. No new data was gathered for the document. Existing climate information for the Park is regional in scope and therefore not suited to mapping in the GIS. If micro-climate information were gathered in the future it should be incorporated into this computerized database.

**Geology:** The geologic history and structure of the region has been the most comprehensively studied and documented feature of the park in the past. The most up-to-date of this data has been summarized in this document and no new data was collected for this project. The current Paleozoic geology and sand and gravel deposit maps produced by the Ontario Geological Survey (Armstrong 1988) have been digitized and entered into the GIS database as PLEO.map and AGGR.map respectively.

**Soils:** A limited soils field survey was carried out as part of this study. The survey concentrated on the Cyprus Lake, Cameron Lake, Dorcas Bay area due to the unique sand dune structure of this area and lack of soils elsewhere in the Park. Twenty-three (23) control sections were described in detail following the guidelines set by the Ontario Institute of Pedology, Guelph. Recorded data includes: horizon development and thickness, textures, structure, colour, mode of deposition, percentage coarse fragments and C.S.S.C. classifications. This data has been entered into the dBase data files SOILDATA and SOILH. In addition, core samples were taken at numerous locations to check the lateral extent of these soil units. The locations of these sample pits and cores are stored in SPANS in the point file SPT2.pnt. The eleven soil units

identified in this survey also have been entered into the SPANS database as SOLS.map. Mapping from the original soil survey of the area by Agriculture Canada (Hoffman 1954) has been digitized and entered into SPANS as TSOL.map.

**Terrain:** Topography for the Park has been documented by digitizing the elevation contours from the 1:10,000 Ontario Base Map series of MNR (CONT.map). Terrain slope (SLOP.map) and aspect (ASPC.map) maps were then generated using SPAN'S point sample function on this elevation map and implementing Tydac's contouring package. Bathymetry for Georgian Bay and Lake Huron was digitized from available hardcopy sources and entered into the SPANS database as BATH.map. A general drainage map was constructed from the work of Cowell (1976) then digitized and entered into the SPANS database as WTRS.map.

**Vegetation:** The most detailed field program undertaken as part of this study was the collection of primary and understory vegetation and wetland information for the Park. The specific vegetation zones of the Park were documented during this field program with the aid of 1:10,000 aerial photographs, hardcopy satellite images of the Park and photomosaic Forest Resource Inventory mapping. Separate zones were classified according to a detailed checklist and their extents marked on the 1:10,000 air photos with wax pencil. This information was subsequently transferred into the SPANS database as BVEG.map and its concomitant attributes file BVEG.tbl. The extensive attribute information was also entered into DBASE IV database for ease and speed of analysis.

**Lakes, Rivers and Shorelines:** An extensive survey of all major lakes and rivers in and around the Park was conducted by canoe in August, 1988. Total dissolved solids (TDS), alkalinity, pH, secchi disk depth, shore types, bottom types and water depth profile data were collected during this survey. Total dissolved solids and pH were measured using HACH electronic pocket pal meters. Water depths were recorded using a commercial depth sounder where water depths exceeded a metre. Shallower water depths were estimated by dipping with a paddle. Alkalinity was measured using Hach's model AL-AP test kit. Water chemistry was routinely measured at a minimum of 2 locations in the main body of each lake, however, multiple sample locations were not necessary as the recorded chemistry was always constant within each lake. Water chemistry for the major streams in the area was sampled only at major access points.

A field survey of fish species present in the Park was not undertaken. OMNR open file records and other published documents (Smith and Smallwood; OMNR; Owen Sound District Fisheries Management Plan 1986-2000) were reviewed to identify lists of fish species which may be in the Park lakes.

A single map containing each of the surveyed lakes as a separate colour or ty number was generated from the 1:10,000 MNR base mapping (LAKE.map). The physical, chemical and fish species data for each lake has been entered into SPANS as an attribute file (LAKE.tbl). The bathymetry, shoreline type and surface coverage (i.e., open water, marsh, bulrush etc.) of each lake also has been mapped in SPANS as separate maps for each lake. The names used for these lakes were taken from the 1:10,000 Base Mapping except where local residences identified more current useages.

**Satellite Imagery and Processing:** Landsat 5 thematic mapper (TM) and SPOT-1 MLA images were purchased and analysed to determine the utility of remotely sensed data in biophysical surveys. The data from both sources were geocoded and analysed on a DIPIX AIRES system. The resolutions of the Landsat and SPOT images are 30 and 20 metres respectively. The TM image was processed via a maximum likelihood classifier to identify 11 classes: Deciduous Forest >90%; Coniferous Forest >90%; Coniferous 75% Deciduous 25%; Deciduous 75% Coniferous 25%; Fens; Beaver Floods; Alavars; Meadows; Grasses and Rocky Soil; Bare Soils; Rock; Roads; Sandy Soils; and Wetlands. This image is stored in SPANS as the TMAP.map. A similar classification of the SPOT image also has been completed within SPANS using its modelling language (FSA2.map).

## **CLIMATE**

Climate can be defined as the sum of past weather experiences and is described by long term totals, extremes, and averages. The basic elements generally recorded to describe weather are temperature, air pressure, winds and atmospheric moisture (humidity, clouds and fog, precipitation).

### **CLIMATIC INFLUENCES**

Weather systems that can influence climate can be defined, based on size, as macro (large), meso (medium) or micro (small) systems. Macrometeorology is the study of weather processes affecting the climate on a continental basis. The Park is situated between the warm moist air of the Gulf of Mexico, the cold dry air of the Arctic and the maritime airs of the Pacific and Atlantic Oceans.

The winter weather of southern Ontario is influenced approximately 75% of the time by Pacific air masses which are warmer and more humid than the Arctic highs which are present for most of the remainder of the winter season. Only rarely does the warm influence of the Gulf of Mexico affect the winter weather resulting in January and February thaws.

In the summer months the hot, humid air from the Gulf of Mexico dominates southern Ontario weather about 50% of the time. Air from the Pacific Ocean affects the summer conditions about 40% of the time.

Spring and fall months are characterized by very complex weather patterns with contrasting and rapidly changing influences from the various regional air masses.

Mesometeorological or regional influences in the Park area are limited to topographic and Great Lakes effects. The elevation increase across the peninsula from southwest to northeast possibly has an influence on rainfall patterns in the Park area, however, adequate records have not been kept to confirm this. Lake Huron and Georgian Bay significantly moderate the average temperatures of the Bruce Peninsula. Precipitation in the Park area is also influenced by the presence of these lakes, however, the Park area receives less precipitation than areas in central southern Ontario likely due to its narrow peninsular structure.

Micro-climate influences in the Park would include the effects from the many small lakes in the area, the steep cliffs of the northeast shore and the various vegetation groupings in the park (i.e., dense conifer vs. sparse alvar vs. deciduous forest). Detailed discussions of regional and local effects on climate can be found in Campbell, 1979.

## **CLIMATE STATISTICS**

Table C1 summarizes the weather statistics of the various climatic regions in south-central Ontario. The Lake Huron - Georgian Bay region, the extent of which is seen in Figure C1, best describes the Park. Table C2 summarizes the temperature and precipitations at the three weather stations closest to the Park; Tobermory, Cove Island and Wiarton. Figures C2 to C5 illustrate the mean daily temperatures for January, April, July and October for all of southern Ontario. These figures summarize the statistics for the Park area and show the moderating influences of the Great Lakes on the Bruce Peninsula's climate relative to the rest of southern Ontario.

Mean annual precipitation and snowfall for all of southern Ontario are illustrated in Figures C6 and C7. The slightly lower precipitation values (both rain and snow) in the vicinity of the Park are likely due to the limited influence that the narrow peninsula has on the air masses passing over the area when compared to the more interior locations.

Monthly total bright sunshine durations at Wiarton, the closest available data, are listed in Table C3.

TABLE C1

Regional Climates of South Central Ontario  
(from Brown et al., 1968)

Climate Region	Lake Huron Georgian Bay	Dundalk Upland	Huron Slopes	Lake Simcoe	South Slopes	Lake Erie Counties	Niagara Fruit Belt
Altitude (metres above sea level)	213.5	488	335.5	213.5	213.5	213.5	91.5
Mean Annual Temperature °C	7.2	5.6	6.7	6.1	7.2	8.3	8.9
Mean Daily Maximum Temperature °C							
- January	-1.7	-4.4	-2.2	-3.3	-2.2	-.56	.00
- April	10.0	8.9	10.6	10.6	11.1	11.7	11.1
- July	25.6	25.0	26.1	26.1	27.2	27.2	27.2
- October	14.4	13.3	14.4	14.4	15.0	16.1	15.6
Mean Daily Temperature °C							
- January	-8.3	-12.8	-10.0	-13.3	-10.6	-8.3	-6.7
- April	.56	-1.1	.00	-.56	.56	1.7	2.2
- July	14.4	12.2	13.3	13.9	14.4	15.0	16.7
- October	5.6	2.2	3.9	2.8	3.9	5.0	5.6
Daily Range of Temperature °C							
- January	7	8	8	10	8	7	7
- July	11	13	12	13	13	12	11
Extreme Low Temperature °C	-37.2	-32.8*	-41.7	-41.1	-39.4	-36.7	-26.7
Extreme High Temperature °C	38.9	33.9*	38.9	40.0	40.6	41.4	40.0
Mean Date of Last Frost in Spring	May 15	May 31	May 20	May 18	May 15	May 12	May 5
Mean date of First Frost in Fall	Oct. 10	Sept. 20	Sept. 30	Sept. 28	Oct. 5	Oct. 10	Oct. 15
Mean Annual Frost Free Period (days)	150	115	135	135	145	150	165
Start of Growing Season	Apr. 15	Apr. 20	Apr. 17	Apr. 18	Apr. 13	Apr. 10	Apr. 10
End of Growing Season	Nov. 5	Oct. 25	Oct. 31	Oct. 28	Nov. 3	Nov. 8	Nov. 10
Mean Annual Length of Growing Season	205	190	195	195	205	210	215
Mean Annual Precipitation (mm)	838	686	813-991	813	762-965	864	787
Mean Annual Snowfall (cm)	254	254	279	178	178	127	114
Mean Annual Potential Evapotranspiration (mm)	610	559	584	584	609	635	635
Mean Annual Actual Evapotranspiration (mm)	559	533	559	559	559	559	533
Mean Annual Moisture Deficiency (mm)	76	25	25	25	51	76	102
Mean Annual Water Surplus (mm)	330	406	406	305	305	330	254

Note: Most data in this table are based on 30 to 50 years of record, however those indicated with an \* began in 1944.



**TABLE C3**

**Monthly Total Bright Sunshine at Wiarton Averaged  
1951 - 1980**

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Duration												
Hrs	68	103	138.2	193.2	257.2	289.8	295.4	254.7	169.7	133.6	60.4	46.4

Wind data is available from weather stations on Cove Island and at Wiarton. Detailed directional frequency and mean speeds for these stations are summarized in Table C4. Winds at Cove Island are predominately from the southwest to west year round. Summer average wind speeds at Cove Island are 16 to 17 km/hr and increase to 20 to 25 km/hr in the fall and spring. The winds at Wiarton are from the west to southwest in the summer but predominate from the south for the remainder of the year. Wind speeds at Wiarton are less than at Cove Island with summer values ranging from 12 to 15 km/hr increasing to a maximum of 20 km/hr in the winter.

The thermal structure of Georgian Bay was studied in the mid 50's (Anderson and Fry 1967) resulting in the interesting correlation, seen in Table C5, between the average air temperature of the month previous to the water temperature survey and average water temperatures in the Bay.

More extensive aerial infrared radiation surveys of the water temperature of Georgian Bay were conducted in 1972 (Campbell 1979). A summary of water temperatures along the north shore of the Peninsula is provided as Table C6. Ice breakup at Flowerpot Island is approximately April 10 and the ice free season starts at April 17 (mean dates). The first appearance of ice along the northern Peninsula is late January or early February.

In summary the Park's climate exhibits a maritime climate with cool, late summers, mild autumns, mild, late winters, and long, cool springs. Slightly reduced precipitation and more pronounced spring and fall fog in the Park area, when compared to the more southern shores of Lake Huron, is a result of the peninsular location.

**TABLE C5**

### Ratio of Antecedent Air Temperature and Water Temperature

	June	July	August	September	Mean
1953	1.22	1.36	1.52	1.32	1.33
1954	1.20	1.37	1.29	1.31	1.29

**TABLE C6**

### Typical Thermal History of Georgian Bay

Month	Temperature at N. Bruce Peninsula Shore ° Celsius	Comments
January	3-1	-open water throughout, central Bay 4°C
February	0-0	- ice along shore
March	0-0	- ice covers Bay
April	2-3	- open water
May	4-8	- slightly warmer to NW
June	13-17	-water warming to summer temperatures
July	17-18	-uniform temperature along shore;
August	18-16	- water starting to cool
September	13-10	- cooler water to NW
October	10-9	-gradual cooling with uniform temperatures along shore
November	6-5	-as above
December	5-4	- as above

(from Campbell 1979)

### CLIMATE'S INFLUENCE ON PARK USAGE

The results of an extensive study of the effect of climate on outdoor recreation and tourism in Ontario (Crowe et al. 1973) can be used to demonstrate the significance of climate to Park usage. Broad categories of outdoor activities were defined and standard climate statistics utilized to quantitatively evaluate the likely

quality of these activities throughout Ontario. A synopsis of this work, as it pertains to the BPNP, follows; the reader is referred to the original document for further details.

Seven classes of outdoor activity were defined and analysed as follows:

- 1)Landscape touring by automobile
- 2)Passive activities (lounging and non-active pursuits)
- 3)Vigorous activities (hiking, hunting, sports)
- 4)Beaching (sunbathing and other beach activities excluding swimming)
- 5)Swimming and water sports
- 6)Skiing
- 7)Snowmobiling

The following climatic information was then used to determine the suitability of an area for each of these activities on a seasonal basis:

- 1)Temperatures (including wind chill)
- 2)Humidity
- 3)Precipitation (rain and snowfall plus snow cover)
- 4)Sunshine and daylight
- 5)Cloudiness
- 6)Fog
- 7)Thunderstorms
- 8)Wind
- 9)Water temperatures

The seasons were defined as outlined in Figure C8. For the sake of brevity in this report data for five locations have been extracted to demonstrate the suitability of BPNP to various activities relative to other parts of Ontario. Tobermory has been selected to represent the Park. Ottawa is a city at the same latitude as Tobermory but is situated away from a large water body's influence. London represents a south-central Ontario location, Toronto a southern lake-influenced climate, and Thunder Bay a northwestern location. By comparing the data from these locations a better feel for the significance of the climate in the Park area can be gained.

Mean season start and end dates and lengths are shown in Table C7. The park area would appear to have relatively long winters, short summers and a long spring relative to other parts of southern Ontario.

Detailed satisfaction percentiles were developed by Crowe et al. for each individual activity. This detailed information is not presented here, rather, the final summer ratings and classes for the selected cities are presented in Table C8 for comparison. Overall the Park area offers a good climate for summer activities and a fair to good rating for winter. The Bruce Peninsula district achieved a Poor rating for swimming, Fair for beaching, Excellent for vigorous activities, Good for passive activities and Excellent for landscape touring resulting in the overall Good rating for the area in summer activities.

Skiing was rated as Good and snowmobiling Fair to Good resulting in the Fair to Good winter score for the area.

**TABLE C7**

**Mean Season Start and End Dates and Season Lengths**

<b>Location</b>	<b>Start of Winter</b>	<b>End of Winter</b>	<b>Length of Winter (days)</b>	<b>Start of Spring</b>	<b>Length of Spring (days)</b>	<b>Start of High Summer</b>	<b>Length of High Summer</b>	<b>End of Summer</b>	<b>Length of Autumn (days)</b>
Tobermory	Nov. 15	Apr. 6	143	Apr. 21	45	June 5	105	Sept. 17	58
Ottawa	Nov. 26	Apr. 7	133	Apr. 22	22	May 14	133	Sept. 23	63
London	Nov. 22	Mar. 30	129	Apr. 14	31	May 15	143	Oct. 4	48
Toronto	Nov. 30	Mar. 29	120	Apr. 13	38	May 21	126	Sept. 23	67
Thunder Bay	Nov. 9	Apr. 17	160	May 23	33	June 4	97	Sept. 8	61

(derived from Crowe et al. 1973)

**TABLE C8**

**Mean Summer Ratings and Classes for Selected Cities**

<b>Location</b>	<b>High Summer</b>		<b>All Summer</b>		<b>Winter</b>	
	<b>Rating</b>	<b>Class</b>	<b>Rating</b>	<b>Class</b>	<b>Rating</b>	<b>Class</b>
Tobermory	6.0	G	6.6	G	5.5	F
Ottawa	8.2	E	8.2	E	7.6	G
London	9.0	E	9.0	E	4.0	F
Toronto	7.0	G	7.6	G	2.0	P
Thunder Bay	4.8	F	5.6	F	8.5	E

<b>Rating</b>	<b>Quality Class</b>	<b>Ratings were Calculated as Follows</b>	
10, 9, 8, 7, 6 5, 4 3, 2 1, 0	Excellent Good (G) Fair (F) Pool (P) Unsatisfactory (U)	$R = 10 \times \frac{I}{I_x}$	where I is seasonal index at a station, I <sub>x</sub> is maximum value computed in Ontario

(From Crowe et al. 1973)

## CLIMATE REFERENCES

- Anderson, D.V. and F.E.J. Fry. 1967. The thermal regime of Georgian Bay (1953, 1954). Department of Lands and Forest, Research Branch, Research Report No. 80.
- Brown, D.M., G.A. Mackay and L.J. Chapman. 1974. The climate of southern Ontario. Atmospheric Environment Service, Environment Canada. Climatological Studies Number 5.
- Campbell, J.E. 1979. The climate of Georgian Bay Islands National Park. Prepared for Parks Canada.
- Canadian Climate Normals Temperature and Precipitation 1951-1980 Ontario. 1981. Environment Canada. Atmospheric Environment Service.
- Canadian Climate Normals Volume 5 Winds 1951-1980. 1982. Environment Canada. Atmospheric Environment Service.
- Canadian Climate Normals Volume 7 Bright Sunshine 1951-1980. 1982. Environment Canada. Atmospheric Environment Service.
- Crowe, R.B., G.A. McKay and W.M. Baker. 1973. The tourist and Outdoor Recreation Climate of Ontario. Atmospheric Environment Service. Environment Canada. REC-1-73.
- Howard B.J. and C.F. Schenk. 1975. Climatology of the Niagara Escarpment Planning Area. Niagara Escarpment Commission.

## **GEOLOGIC HISTORY**

### **INTRODUCTION**

The unique biophysical character of Bruce Peninsula National Park (BPNP) is the product of the last 680 million years of geologic history. Major geological events having considerable impact on the physiognomy of this area are: reef development during the Middle Silurian, Pleistocene glaciations, post-glacial lake levels and contemporary senescence. Figure G1 illustrates the positions of the periods within the overall geological time scale. Those events which had taken place during the last 40,000 years B.P. (before present) have left a wealth of evidence and therefore are best documented.

The distribution, type and character of soils found in BPNP strongly reflect the geological history of the area. Specific controls on soil development are variations in parent materials, drainage, topography, vegetation, climate and time. This chapter summarizes those geologic events which are relevant to the spatial distribution and development of soils in BPNP. Also, soil development is discussed with special reference to the Dorcas Bay - Cyprus and Cameron Lakes area.

### **BEDROCK GEOLOGY**

Subsequent to the initial erosion of the ancient Precambrian surface to an extensive plain (peneplanation), numerous seas of variable size and duration invaded portions of North America forming extensive sedimentary basins (Douglas 1970). These sedimentary rocks have in turn been subjected to pressures which have caused domes and downwarps throughout the region. The Park is located in one of these downwarps, the Michigan Basin, illustrated in Figure G2. The Michigan Sedimentary Basin is centred on south central Michigan, circular in plan, and covers parts of Ontario, Michigan, Wisconsin, Illinois, Indiana and Ohio. Sediments derived from surrounding Precambrian strata began infilling this basin during the early Cambrian and ended sometime in the late Cretaceous (Douglas 1970). As a result of both increased water temperatures and shallow seas during the Middle Silurian, biostromal (layered) and biohermal (massive) reefs developed along the rim of this basin (Cowell 1973). BPNP occupies the outer northeast rim of the Michigan Basin. Strata outcropping in this area range in age from Ordovician (450-430 million years (m.y.)) to Middle Silurian (430-400 m.y.) and are primarily composed of dolostones with some shale (Liberty 1966; Liberty and Bolton 1971; Armstrong 1988). Dolostone is a carbonate deposit which has been



converted from Limestone through the replacement of some of the calcium ions with magnesium (i.e., magnesium rich limestone).

Bedrock within southwestern Ontario has a regional dip to the southwest at 5.6 m per kilometer; however a secondary dip to the northwest occurs in the park and is related to a structural high paralleling Lake Ontario called the Algonquin Arch (Chapman and Putnam 1966). Vertical joints are present in the exposed surface strata and are arranged both radial and concentric to the centre of the Michigan Basin (Cowell 1973). The strongest orientation strikes NNW-SSE which is parallel to the length of the Bruce Peninsula. A second prominent joint orientation is perpendicular to the former pattern and radial to the centre of the basin. This secondary orientation has been identified from the satellite imagery analysed for the region. A reproduction of a computer screen image of this analysis can be seen in Figure G3. The linear features seen in this Figure were hand drawn by an operator who identified them by visual interpretation.

Different sedimentary rock units or formations are generally classified in either lithostratigraphic; chronologic age and physical composition including fossil type, or biostratigraphic terms; based on the type of fossils distributed vertically in the rock column. Various interpretations of the rock formations in the area have been developed since the early work of Liberty (1966) the most recent being that by Armstrong (1988) seen in Figure G4. These formations have recently been re-mapped by the Ontario Geological Survey (Armstrong 1988) based on a re-survey of the area. This mapping has been entered into the SPANS database as PLEO.map and reproduced in hardcopy as Figure G5. Brief descriptions of each of the formations shown in Figures G4 and G5 are provided in Table G1.

Unfortunately a complete vertical section is not exposed within the park. The most complete section exposes the Cabot Head Formation through to the younger Amabel Formation and is located along the Georgian Bay coastline 1 km south of Cabot Head. Other good exposures are found at Rocky Bay and Cape Chin (Armstrong 1988). Ninety percent of the bedrock exposed at the surface within BPNP belongs to the Guelph Formation of Middle Silurian age. These resilient strata represent the most recent period of reef development in the outer portion of the Michigan Basin. Evidence of earlier reef development is revealed in stratigraphically older bedrock of the Amabel Formation. The spatial development of these reefs, both at a regional and local level, has had considerable impact on the evolution of the contemporary land surface within BPNP (Cowell 1973).

Figure G6, indicates the orientation of bioherms (hard coral reef-formed rock masses) in BPNP. Bioherm formation has occurred in two general directions. Firstly, growth had taken place along an

orientation of NNW-SSE or parallel to the shoreline of the ancient Silurian seas. Secondly, bioherm formation transgressed or regressed with changing sea-levels along an orientation SSW-NNE (Goodchild 1984).

At a regional scale, the reef formation of the Silurian (Guelph and Amabel Formations) have acted as an extremely resistant caprock, protecting underlying strata from erosion. Those adjacent strata, both younger and older which are not protected, have been preferentially removed creating the Great Lakes basins and a unique semi-circular escarpment. Within BPNP the general topography follows the down dip of the bedrock surface from a high on the Georgian Bay coast to a low on the Lake Huron side.

The dolostone comprising the bioherm is both massive and porous, and shows few signs of jointing and horizontal bedding (Liberty and Bolton 1971). Contrastingly, interreefal rock (i.e., slumping reef material and clastics) is strongly bedded, highly jointed, poorly consolidated and structurally weak. As a result of the disparity in resilience between these two rock types, interreefal material has been preferentially eroded leaving small-scale topographic highs with a long axis orientation trending NNE-SSW. These small scale lineations are highly visible in aerial imagery of the park, and can be seen in the satellite imagery analysed for this study (see Figure G3).

**TABLE G1**  
**Descriptions of Paleozoic Formations in BPNP Area**

**MIDDLE SILURIAN**

**GUELPH INFORMATION**

**MEDIUM- TO THICK-BEDDED, SPARSELY TO MODERATELY FOSSILIFEROUS DOLOSTONE:** light grey to tan-brown; fine to medium crystalline; medium to thick bedded; fossil content varies from sparse (0 - 20%) to moderate (up to 20%), but accurate determination is difficult due to dolomitization; fossils include gastropods, brachiopods, pelecypods, stromatoporoids, corals, echinoderms, and rare stromatolites; fossiliferous beds weather more recessively than sparsely fossiliferous beds; locally good secondary porosity (after fossil molds?).

**BIOHERMAL DOLOSTONE ZONE:** includes outcrops of fossil-rich dolostone and may also include associated outcrops of moderately to non-fossiliferous dolostone; beds of the latter are commonly dipping.

**BIOSTROMAL/BIOHERMAL DOLOSTONE OUTCROPS:** variously stromatoporoid, brachiopod, coral, or echinoderm dominated; cream to tan-brown; medium to very coarse crystalline; medium to very thick bedded; locally, thin, nodular to irregular parting (especially where brachiopod dominated); matrix dolomite in some bioherms is blue-grey mottled.

**MEDIUM- TO THIN-BEDDED, NON-FOSSILIFEROUS DOLOSTONE:** tan to light brown; very fine to medium crystalline; only rare small fossil fragments; dark brown microstylolite swarms or networks; slightly bituminous; may be gradational with the Eramosa Member.

**ERAMOSA MEMBER**

**LAMINATED, ORGANIC-RICH DOLOSTONE:** light grey-tan to black; very fine to medium crystalline; laminated to thin-bedded; platy to slabby parting; planar microstylolites; bituminous; laminations may in part be algal in origin.

**TABLE G1 (Cont.)**  
**Descriptions of Paleozoic Formations in BPNP Area**

**AMABEL FORMATION**

MEDIUM- TO MASSIVE-BEDDED, SPARSELY TO MODERATELY FOSSILIFEROUS DOLOSTONE: light grey to tan-grey to blue-grey; blue-grey to brown-grey mottles, very from faint to distinct and abundant; fine to medium crystalline; planar to undulatory parted; fossil content is obscured by dolomitization; fossils are generally small and fragmented, however long (up to 10 cm) echinoderm columnals occur locally; solution enhanced vertical joint surfaces commonly exhibit a fine-ribbed texture; this unit encompasses the non-biohermal strata of the Wiarton/Colpoy Bay Member.

BIOHERMAL DOLOSTONE ZONE: includes outcrops of fossil-rich dolostone and may also include associated outcrops of moderately to non-fossiliferous dolostone; beds of the latter are commonly dipping/

BIOSTROMAL/BIOHERMAL DOLOSTONE OUTCROPS: predominantly echinoderm or coral dominated; cream to blue-grey; commonly blue-gray mottled; medium to very coarse crystalline; medium to very thick bedded; commonly undulatory to planar parted; this unit encompasses the biohermal strata of the Wiarton/Colpoy Bay Member

THIN- TO MEDIUM-BEDDED, SPARSELY FOSSILIFEROUS DOLOSTONE: light gray-tan to tan-brown; red-purple to grey-brown mottles are locally significant; very fine to fine crystalline; platy to blocky, planar to irregular parted; generally sparsely fossiliferous (rare corals and stromatoporoids); local chert nodules and silicified fossils; this unit corresponds to the Lions Head Member.

**TABLE G1 (Cont.)**  
**Descriptions of Paleozoic Formations in BPNP Area**

**FOSSIL HILL FORMATION**

THIN-BEDDED, FOSSILIFEROUS DOLOSTONE: light brown to brown; fine to coarse crystalline, locally microcrystalline; upper and lower fossil-rich zones are variable pentamerid brachiopod or coralstromatoporoid dominated, and are separated by a fossil-poor barren zone; the fossiliferous

zones exhibit thin, irregular to nodular parting, whereas the barren zone is platy to blocky, planar parted; fossils are commonly silicified.

#### ST. EDMUND FORMATION

THIN - TO MEDIUM-BEDDED DOLOSTONE: light grey-brown to grey-brown; microcrystalline to fine crystalline; sparsely to moderately fossiliferous (corals and brachiopods); platy to blocky, planar to irregular parted; uppermost 1 m contains grey-green shale interbeds.

#### WINGFIELD FORMATION

INTERBEDDED DOLOSTONE AND GREY-GREEN SHALE: dolostone is: grey-brown; fine to medium crystalline; green shale clasts and partings; mudcracks and ripplemarks are common.

#### DYER BAY FORMATION

THIN- TO MEDIUM-BEDDED DOLOSTONE: light gray to dark gray-brown; microcrystalline to coarse crystalline; platy, planar to slightly irregular parted; fossiliferous (abundant bryozoans and brachiopods) and locally bioturbated; abundant sedimentary structures (e.g., ripplemarks and rip-up clasts).

**TABLE G1 (Cont.)**  
**Descriptions of Paleozoic Formations in BPNP Area**

**LOWER SILURAN**

**CABOT HEAD FORMATION**

**SHALE:** predominantly red siliciclastic shale with thin green shale in uppermost 1 m and as minor interbeds; also minor thin dolostone interbeds.

**MANITOULIN FORMATION**

**DOLOSTONE:** light gray-tan to grey-brown; fine to coarse crystalline; thin to thick bedded; fossiliferous in uppermost 1 m (brachiopods and corals?); thin, slightly irregular parted (in fossiliferous zone ) or platy to blocky planar parted; good fine intercrystalline porosity; lowermost 10 cm contains abundant grey-green shale clasts and partings.

**UPPER ORDOVICIAN**

**QUEENSTON FORMATION**

**SHALE:** grey-green and red siliciclastic shale; uppermost 0.5 m is grey-green

Source (Armstrong 1988)

## KARST FEATURES

The word "karst" is derived from slavic roots and has been adopted as the description for barren landscapes deeply dissected by solution processes. The most important Karst feature of the pavement in the park area are the dolomite blocks, called Clint and the joints separating them, called Grike. These features are significant from hydrologic and drainage perspectives. Water penetrates the rock surface along the Grike and either seeps deep into the rock or reappears as springs along the bottom of bedrock ridges. A more detailed discussion of karst drainage features is included in the Drainage chapter of this document. Karst features can be subdivided into small scale "Karren" as defined in Table G2 and large scale sinkholes and caves. Locations in the Park area where some of these features are found are as follows:

- \*Clint and Grike topography is exhibited at Cave Point and Driftwood Cove;
- \*Biologically controlled pitting is observed all along the Lake Huron shore zone but can be readily observed at Dorcas Bay;
- \*Sinkholes are located throughout the Park, particularly good examples are found in the Horse and Marr Lakes area, and at Driftwood Cove where one of the largest known sinkholes in Ontario is found;
- \*Cave development is observed on Flowerpot and Bear's Rump islands and along the Georgian Bay coast at Little Cove (exit of St. Edmunds cave system) and small cave systems at Cave Point (sea caves);
- \*Small scale karren features found throughout the park are associated with the rock pavements and the Lake Huron shore;
- \*Ridged pavement (Guelph Formation) east of Cyprus Lake and west of Marr Lake;
- \*Flat pavements are observed just west of Driftwood Cove and at Overhanging Point.

For in-depth information on karst features in the Bruce Peninsula see Cowell 1973 and 1976.

TABLE G2

The Karren Forms  
(Modified after M.M. Sweeting 1972, p.75)

Type	Other Names	Average Size	Genesis	Flat or Inclined Cover	Inclined or Smoothed Crests
Rillenkarrn	runnels, solution flutes, rillensteine	1-2 cm deep up to 50 cm long	bare surface	inclined	sharp
Trittkarren	solution bevels	3-50 cm high	bare surface	flat	sharp
Rinnenkarren	solution runnels, spitzkarren	50 cm deep up to 20 cm long	bars and partly covered	inclined	sharp, sometimes slightly rounded bases
Meanderkarren	meandering runnels, meanderkarren	50 cm deep up to 20 cm long	bare and partly covered	slightly inclined	sharp, rounded bases
Rundkarren	runnels, furrows	12-50 cm deep up to 15 cm long	covered	inclined	smoothed
Grooverkarren	stylolitekarren	few cm width and depth up to 2 m long	bare and partly covered	usually vertical surfaces	smoothed but sometimes sharp crests
Pitkarren	pits, pot holes, tinajitas	1-5 cm diam. generally quite shallow (<5cm) but variable	bare and partly covered	flat	bases usually rounded edges sharp or smoothed
Kamenitzes	solution basins, solution pans, tinajitas	few cm to over 3 m diam. up to 50 cm deep	bare and covered	flat	sides smoothed when covered, sharp when bare. Flat floor.
Grikes	kluftkarren, trench-karren	few cm to 4 m deep up to 4 m wide	bare and covered	along joints flat or slightly inclined	usually smoothed but have sharp sides
Hohlkarren	mohrkarren, undercut runnels	60 cm - 1 m deep 50 cm wide	covered (under peat)	variable	smoothed
Deckenkarren	root grooves	few mm or cm deep	covered-direct	variable	smoothed



## GLACIATION

Multiple glaciations have affected much of North America during the last 2 million years (Flint 1971; West 1977; Nilsson 1983). The best documented glaciations has taken place in the last one million years. These four major stadial periods are known in stratigraphically ascending order as: Nebraskan, Kansan, Illinoisan and Wisconsin. The glacial history of the Late Wisconsin is best preserved geologically and therefore better documented. The Wisconsin glacial stage lasted from 100,000 to 10,000 years B.P. and was subsequently followed by a warmer interstadial epoch known as Holocene (present day).

Three major glacial advances modified the Southern Ontario landscape during the Late Wisconsin: Nissouri, Port Bruce and Port Huron Stadials. During the Nissouri Stadial, glacial lobes reached a maximum southerly limit to 37°N at 21,500 to 20,000 years B.P. forming the Mt. Olive Moraine in Ohio (Dreimanis 1982). By 15,500 years B.P. (Erie Interstadial) the Nissouri ice sheet had receded 250 km north to the vicinity of Goderich and represented the southerly limit of the Huron Lobe. The subsequent Port Bruce advance moved from the Great Lakes basin in the form of coalescing lobes and reached its' maximum extent of 41°N in Ohio at 14,500 years B.P. Recession of this advance occurred during the Mackinaw Interstadial and exposed the entire Bruce Peninsula by 13,300 years B.P. The last major advance (Port Huron Stadial) moved out of Georgian Bay in 13,300 years B.P. and reached a maximum southerly extent in 13,000 years B.P. forming the Wyoming Moraine south of Georgian Bay. Final deglaciation of southwestern Ontario, including the Bruce Peninsula, took place around 12,200 years B.P. during the Two Creeks Interstadial (Dreimanis 1982).

Striations, chatter marks, concentric fractures and gouges indicate the direction of ice movement and are common in areas along the Bruce Peninsula where bedrock has not been exposed to chemical weathering. Striations in the area of Tobermory town dump have a measured orientation of 235° magnetic (Cowell 1973). Recent removal of Algoma age beach deposits in the Johnstone's Harbour area has exposed a bedrock surface of well preserved striations, chatter marks and fractures indicating ice movement from the northeast and oriented 220° magnetic. South of Cabot head ice movement was to the south, parallel to the peninsula (Cowell 1973). Within BPNP, larger lineations in the form of roche moutonnee also indicate ice movement from the northeast. The glacial remnants have formed in response to differential erosion along lines of weakness (i.e., vertical joint planes, interreefal material) (Cowell 1973).

Unfortunately, few glacial sediments (i.e., till, glacio-fluvial) are present on the upper Bruce Peninsula, particularly in the vicinity of BPNP, and therefore much of its glacial history must be inferred from areas

south. A summary of glacial till deposits in southern Ontario is presented in Figure G7. Isolated pockets of till are found within BPNP and adjacent areas, and have been tentatively correlated with tills in the Wiarton - Chesley and Tiverton areas (Sharpe 1977a, 1977b). East of Miller Lake, a fine grained lodgement till rich in Cabot Head shale can be found. Sharpe (1977b) has correlated this till with a sandy silt till deposited in the Chesley - Tiverton area to the south during the Nissouri Stadial (Catfish Creek Till).

Two lodgement tills were examined as part of this study in the area of Cameron and Cyprus Lakes. Both tills are found in isolated pockets, usually plastered on the stoss or lee sides of roche moutonnée features. The stratigraphically older of the two tills (Till A) is very compact, light olive brown (2.5 Y 5/4 on the Mansell soil colour chart; moist), sandy loam, subangular blocky and calcareous. This till contains 20 - 35% coarse fragments by volume, and contains both gravel and cobble size material, many of Precambrian origin.

The second till (Till B) is dark reddish brown (5 YR 3/4 Mansell 1975; moist) and derives its colour from the red siliciclastic shales on the Cataract Group. Till B is calcareous, has a sandy clay texture and subangular blocky structure with 20 - 35% coarse fragments by volume. Coarse fragments are dominated by gravels of both Paleozoic and Precambrian origin. This till can be found on the south side of Cyprus Lake and on the east side of Cameron Lake. The sample site on the east side of Cameron Lake shows Till B overlying Till A.

Correlation of Till A and B with those found in the Wiarton areas have been based on colour, morphology and stratigraphic position. Till B, because of its unique colour and texture, has been correlated with the Elma Till (Late Port Bruce) found east of Wolseley. Elma Till is thought to represent a major readvance out of Georgian Bay (Sharpe 1977a). Due to its position beneath Till B, Till A is older and probably was deposited during an early Port Bruce readvance or Nissouri advance.

The lack of younger glacial sediments on the upper Bruce Peninsula suggests a rapid deglaciation in this area (Sharpe 1977b). Those glacio-fluvial materials that do exist have been reworked by glacial and post-glacial lakes and now form remnant strand-lines.

## **POST-GLACIATION**

Subsequent to the deglaciation of the Bruce Peninsula (12,200 years B.P.), numerous glacial and post-glacial lakes or variable extent occupied the Great Lakes region. Remnant shorelines associated with these ancient lake levels have had considerable impact on the biophysical characteristics of BPNP.

At the time of retreat of the Late Wisconsin ice sheet, during the Two Creeks Interstadial, a large proglacial lake called Algonquin had developed flooding most of the Bruce Peninsula as far south as Owen Sound (Eschman and Karrow 1985). The Main Algonquin stage existed between 11,500 and 11,000 years B.P. and is preserved at an elevation of 184 m a.s.l. near Port Huron. In the Cabot Head region this same Algonquin strand-line is found at an elevation of 269 m above sea level (a.s.l.) (Sly and Lewis 1972). The difference in elevation between these two points has been used to estimate the relative amount of crustal (isostatic) rebound since deglaciation. Isostatic rebound is considered to have been the main control on glacial and post-glacial lake levels (Eschman and Karrow 1985).

Uplift data presented by Farrand (1962), Lewis (1969a, 1969b), Sly and Lewis (1972), Eschman and Karrow (1985) and Larsen (1985) have been used to establish uplift curves for various geographical locations (see Figure G8). Using an assumed tilted plane model similar to Goodchild (1984), uplift rates can be extrapolated for the BPNP region. BPNP has uplifted 97.8 m since deglaciation (12,200 B.P.), 85 m since 11,500 B.P., 22.5 m since 5500 B.P., 14 m since 4200 B.P., and 5 m since 3000 B.P.

Figure G9, summarizes the history of lake levels during the last 12,200 years B.P. relative to uplift rates both at Cabot Head and significant drainage outlets. As the Georgian Bay lobe receded, an outlet draining water to the east was uncovered at North Bay around 10,500 to 10,000 years B.P. This caused lake levels to drop rapidly. Prior to this drop, much of the Bruce Peninsula was inundated and the Cabot Head area appeared as five small islands. Lake Algonquin drained through nine (9) significant stages (see Table G3) in its glacial phase and reached its equivalent present day shoreline elevation in 9300 years B.P. Lake levels continued to fall until 9000 years B.P. attaining a present day elevation of 101 m a.s.l. (75 m below present shoreline) (Eschman and Karrow 1985).

Subsequent isostatic rebound at the North Bay outlet caused post-glacial lake levels to rise at an equivalent rate. Since uplift rates at North Bay were higher than those at the Bruce Peninsula, water levels continued to rise along the BPNP coastline. Water levels rose to a maximum present day elevation of 205 m a.s.l. between 5500 and 4700 years B.P. (Eschman and Karrow 1985). This maximum stage is known as Nipissing I.

As water levels transgressed southward in response to uplift in the north, earlier southerly outlets were reopened at Port Huron and Chicago. During the Nipissing I stage, water drained from North Bay outlet due to continued uplift and downcutting at Chicago and Port Huron caused a drop in water levels and a new stage called the Nipissing II (4700 to 3700 years B.P.). Ongoing uplift at North Bay created an increased rate of erosion at the southern outlets. Since the Chicago outlet was on bedrock, erosion took place at a slower rate than at Port Huron and as a result was abandoned. This marked the end of the Nipissing I and II phase.

The next significant post-glacial lake stage before present is called the Algoma Stage (3000 years B.P.). This stage is thought to represent a pause in downcutting of the Port Huron outlet and possibly related to the underlying glacial stratigraphy (Hough 1958). Larsen (1985) postulated that the Algoma peak is related to normal climatic fluctuations during a period of continuous downcutting.

**TABLE G3**  
**Name, Elevation and Timing of Glacial**  
**and Post-Glacial Lake Elevations**

<b>Phase</b>	<b>Lake Stage</b>	<b>Present Elevation<sup>A</sup> (M.A.S.L.)</b>	<b>Time<sup>B</sup> (B.P.)</b>
Glacial	1. Main Algonquin	269	11,500 - 11,000
	a. Ardtrea	264	10,700
	b. Upper Orillia	253	10,500
	c. Lower Orillia	247	10,300
	d. Wyebriage	240	10,100
	e. Penetang	228	9700
	f. Cedar Point	222	----
	g. Payette	210	9550
	h. Sheguiandah	199	----
	i. Korah	190	9400
Post-Glacial	a. Stanley (Huron)	>101	9000
	b. Hough (Georgian Bay)	101	9000
	c. Nipissing I	205*	5500 - 4700
	d. Nipissing II	194	4700 - 3700
	e. Algoma	185	3000
	f. I.G.L.D. (Huron)	176.6	Present Day

Note:     A. Sly and Lewis (1972)  
               B. Eschman and Karrow (1985)  
               \* Extrapolated from Cabot Head uplift curve

The history of post-glacial lake levels in BPNP has been well preserved in the form of relic coppice dunes, sand and cobble beaches, and lacustrine sand plains. Strand-lines representing former lake levels are best preserved in the Cabot Head region (see, Sly and Lewis 1972). Numerous changes both in land-use and vegetational patterns in BPNP are closely linked with the spatial occurrence of these deposits.

Table G4, summarizes the kind, age, character and location of sand and gravel deposits found in St. Edmunds Township as determined by Armstrong 1988. The locations of these deposits are mapped in the SPANS database (AGGR.map) and a hardcopy output is provided here as Figure G10. All of the deposits are related to relic shorelines formed between the Nipissing stage and present time; however the Nipissing II features are best represented. Due to the shallow dip slope of the Huron coast, many relic lake and beach deposits are found at a considerable distance inland. Also, this shallow sloping coast in association with the prevailing winds from the north and northwest has favoured the production of sand beaches and dunes. The Georgian Bay coast, in contrast, because of its steep scarp face and bathymetry, is dominated by coarse gravel beach deposits.

One of the largest dune formations found in BPNP is located 1.9 km inland of Lake Huron and south of Cameron Lake, and measures 2.2 km in length, 600 m in width and some 3 to 6 m in height. Individual dunes are circular in plan and overlapping. Inspection of these dunes at a road-cut reveal stratified medium sands which are strongly calcareous (See Photo 1). The bedding planes dip to the west at 10°, suggesting a drift of eolian sands to the east. The topographic setting of this dune complex correlates with the 194 m a.s.l. Nipissing II phase (4700 - 3700 years B.P.). The small lake ponded on the north side of these dunes southeast of Cameron Lake, and McLander Marsh are also remnants of this same period.

**TABLE G4**  
**Summary of Sand and Gravel Deposits in**  
**St. Edmunds Township**

<b>Type of Deposit</b>	<b>Mode of Deposition</b>	<b>Elevation (M.A.S.L.)</b>	<b>Age<sup>A</sup></b>	<b>General Orientation</b>	<b>Size (Km) LXW</b>	<b>Location</b>
Sand	Eolian	190-195	NII	NW-SE	1.9 X .6	SE Cameron Lake
Sand	Eolian	200-205	NI	NW-SE	1.2 x .8	SW Cameron Lake
Sand	Eolian	176.6-185	C-A	NW-SE	1.0 x .15	Dorcas Bay
Gravel	Lacustrine Beach	176.6-185	C-A	ENE-WSW	.5 x .1	Porcupine Point
Gravel	Lacustrine Beach	195-205	NI	NW-SE	.25 x .1	5 km NE of Porcupine Point
Sand	Eolian	190-195	NII	NW-SE	.5 x .2	Johnstone Hrb. Road
Sand	Eolian	190-195	NII	ENE-WSW	.2 x .1	Johnstone Hrb. Road
Gravel	Lacustrine Beach	190-195	NII	NW-SE	.25 X .1	Johnstone Hrb. Road
Sand	Eolian	193-195	NII	N-S	.3 X .2	Johnstone Hrb. Road
Sand	Lacustrine Beach	198-203	NI	NE-SW	.3 x .1	Johnstone Hrb. Road , Hwy 6
Sand	Eolian	180-185	A	NW-SE	.15 x .1	Eagle Harbour
Sand	Lacustrine Beach	180-185	A	E-W	.2 X .15	West Eagle Harbour
Gravel	Lacustrine Beach	176.6-180	C-A	E-W	.6 x .15	Warner Bay
Sand	Lacustrine Beach	195-200	NII	ENE-WSW	1.3 X .2	N. of Eagle Harbour

**TABLE G4 Cont.**  
**Summary of Sand and Gravel Deposits in**  
**St. Edmunds Township**

<b>Type of Deposit</b>	<b>Mode of Deposition</b>	<b>Elevation (M.A.S.L.)</b>	<b>Age<sup>A</sup></b>	<b>General Orientation</b>	<b>Size (Km) LXW</b>	<b>Location</b>
Gravel	Lacustrine Beach	195-200	NII	E-W	1.5 x .2	NE of Hopkins Bay
Gravel	Lacustrine Beach	195-200	NII	E-W	0.7 x .4	N of Hopkins Bay
Gravel	Lacustrine Beach	195-200	NII	NNE-SSW	2.2 x .4	NE of Baptist Harb.
Gravel, Sand	Lacustrine Beach, Plain	194-205	NI,NII --		3 x 3	SE of Tobermory

Note:    A:        Ages are as follows  
              NI:       Nipissing I  
              NII:      Nipissing II  
              A:        Argoria  
              C:        Contemporary

Source: Ontario Ministry of Northern Development and Mines, Armstrong 1988.



Photo 1: Cameron Lake Dunes Road Cut Along East Cameron Lake Road: NIPISSING I Dunes

Attached to the main Nipissing II dune field on the south side of Cameron Lake is a second eolian complex which can be crossed over on the Cameron Lake Road. These dunes occupy a slightly higher elevation (200 to 205 m a.s.l) and appear less well developed than the lower adjacent dunes to the east. The

Nipissing lake stage was at it's highest between 5800 and 4700 years B.P. and is preserved at an elevation of 183 m in the vicinity of Port Huron (Eschman and Karrow 1985). Using the modelled uplift curve for Cabot Head, the maximum elevation of the Nipissing I stage would be 205 m a.s.l. in BPNP. Therefore the Cameron Lake Road dunes were probably deposited during the Nipissing I stage.

Stretching from Dorcas Bay to Highway 6 is a large flat lacustrine plain which was deposited sometime between the Nipissing II (3700 B.P.) stage and the Algoma (3000 B.P.). Relic coppice dunes are also found parallel to the 180 m contour at Dorcas Bay and were formed at 3000 B.P. during the height of the Algoma. A significant agricultural area located 3 km southeast of Tobermory represents the confluence of Lake Huron and Georgian Bay during the Nipissing I and II stages. The underlying sediments are composed of sands deposited in the near-shore zone as well as beach sands and gravels.

**FIGURE G1**  
**Geological Time Scale**  
 (Source: Cowell 1973)

Era	Period	Epoch	Million of Years Ago (Approx.)	Duration in Millions of Years (Approx.)	Relative Durations of Major Geological Intervals	
Cenozoic	Quarternary	Recent			Cenozoic	
		Pleistocene	0-1	1		
		Pliocene	1-13	13		
	Tertiary	Miocene	13-25	12	Paleozoic	
		Oligocene	25-36	11		
		Eocene	36-58	22		
		Paleocene	58-63	5		
Mesozoic	Cretaceous		63-135	72		
	Jurassic		135-181	46		
	Triassic		181-230	49		
Paleozoic	Permian		230-280	50	Precambrian	
	Pennsylvanian		250-310	30		
	Mississippian		310-345	35		
	Devonian		345-405	60		
	Silurian		405-425	20		
	Ordovician		425-500	75		
	Cambrian		500-600	100		
Upper						
Although many local subdivisions are recognized						
Precambrian	Middle	no world-wide system has been evolved. The				
		Precambrian lasted for at least 2½ million years.				
	Low	Oldest dated rocks are about 3300 million years old.				



## **GEOLOGY REFERENCES**

- Armstrong, D.K. 1988. Paleozoic geology of the northern Bruce Peninsula. Mines and Minerals Division, Ontario Geological Survey, Open File Map 102.
- Chapman, L.J. and D.F. Putnam. 1966. The physiography of southern Ontario. Toronto, University of Toronto Press, 386p.
- Cowell, D.W. 1973. Karst geomorphology of the northern Bruce Peninsula. Ontario Division of Parks Report, M.N.R., Parks Planning Branch, Environmental Planning Section. 148p.
- Cowell, D.W. 1976. Karst geomorphology of the Bruce Peninsula, Ontario. Master of Science Thesis, McMaster University.
- Douglas, R.W.J. (ed.). 1970. Geology and economic minerals of Canada. Department of E.M.R., Ottawa, Economic Geology Report No. 1.
- Dreimanis, A. 1982. Synchronism versus diachronism in ice marginal fluctuations during the late Wisconsin in North America. IUGS Report No. 7, Prague 1982, p.73-82.
- Eschman, D.F. and P.F. Karrow. 1985. Huron basin glacial lakes: a review, in P.F. Karrow and P.E. Calkin, ed., Quaternary Evolution of the Great Lakes, Geological Assoc. of Canada, Special Paper 30, 1985.
- Evenson, E.B. and A. Dreimanis. 1976. Late glacial (14,000 - 10,000 years B.P.) history of the Great Lakes region and possible correlations. IUGS report No. 3, Washington.
- Farrand, W.R. 1962. Postglacial uplift in North America. American J. of Sci., 260, p.181-199.
- Flint, R.F. 1971. Glacial and quaternary geology. John Wiley and Sons, New York, 892p.
- Goodchild, M.F. 1984. Final report: resource management study of caves, Tobermory Islands unit, Georgian Bay Islands National Park. Report to Parks Canada, 130p.

Hough, J.L. 1958. Geology of the Great Lakes. University of Illinois Press, Urbana.

Karrow, P.F. 1980. The Nipissing transgression around southern Lake Huron. Canadian J. of Earth Sci., 17, p.1271-1274.

Larsen, C.E. 1985. Lake level, uplift, and outlet incision, the Nipissing and Algoma Great Lakes, in P.F. Karrow and P.E. Calkin, ed., Quaternary Evolution of the Great Lakes, Geological Assoc. of Canada, Special Paper 30, 1985.

Lewis, C.F.M. 1969a. Late quaternary history of lake levels in the Huron and Erie basins. Proceedings of the 12th Conference on Great Lakes Research, p.250-270.

\_\_\_\_\_. 1969b. Recent uplift of Manitoulin Island, Ontario. Canadian J. of Earth Sci., 7, p.665-675.

Liberty, B.A. 1966. Geology of the Bruce Peninsula; GSC Paper 65-41, 8p.

Liberty, B.A. and T.E. Boulton. 1971. Paleozoic geology of the Bruce Peninsula area, Ont.; GSC Memoir 360.

Nilsson, T. 1983. The pleistocene: geology and life in the quaternary age. Dordrecht, D. Reidel Pub. Co. 1983.

OMNDM. 1988. Distribution of sand and gravel deposits, St. Edmunds and Lindsay Twp., Bruce Co. Aggregate Resources Inventory, OGS.

Sharpe, D.R. 1977a. Quaternary geology of the Wiarton-Chesley-Tiverton areas, Bruce and Grey Co. OGS Misc. Paper NO. 29, 1977.

\_\_\_\_\_. 1977b. Quaternary geology of the Bruce Peninsula. OGS Misc. Paper No. 30, 1977.

Sly, P.G. and C.F.M. Lewis. 1972. The great lakes of Canada- quaternary geology and limnology, 24th International Geological Congress, Montreal, Field Excursion Guide A43, 92p.

## **SOILS**

### **SOIL DEVELOPMENT IN BPNP**

As a consequence of the glacial and post-glacial history of BPNP, deep, ubiquitous soils are rare. More often, soils are very shallow, poorly developed and found in isolated pockets. Soils which do exist vary in distribution, type and character and are strongly controlled by: parent material, drainage, vegetation, micro and meso-climates, topography and time.

A (1:62,000) scale soils map was constructed for Bruce County, including St. Edmunds Township, in 1954 (Hoffman and Richards 1954). This map has been entered into the SPANS database (TSOL.map) as is presented here as Figure S1. Table S1 is provided as a detailed legend for this figure. Unfortunately this map excludes many soil units found in BPNP when mapped at a smaller scale. The most prominent soil type found on the upper Bruce Peninsula is named after the Breypen soil series (Hoffman and Richards 1954). The Breypen Series is represented by both soils and non-soils occurring in isolated pockets on a bedrock plain. The six different soil series which have developed on these deposits and include: the Fox, Donnybrook, Brady, Sullivan, Granby and Burford Series. The differences in soil development between these series strongly reflect the age and drainage of the associated parent materials.

Glacial deposits also contribute significantly to the variation in soils present in BPNP. Although glacio-fluvial deposits are rare, numerous lodgement type tills can be found plastered on the stoss and lee sides of roche moutonnee features. These tills occur as isolated pockets and are widespread throughout the park. The best documented till is found in the Cyprus-Cameron Lakes area and the agricultural area bordering the northeast end of BPNP. Most of these tills are medium to coarse textured, and develop under forested conditions as Ferro-Humic Podzols in their well to imperfectly drained phases. As soil drainage becomes more impeded these till deposits evolve pedalogically as Gleyed Melanic or Eutric Brunisols. Poor drainage phases usually result in the development of Ferro Humic Gleysols.

**TABLE S1**  
**Soils Classification Summary for Bruce Peninsula**  
**as per Hoffman and Richards 1954**

<b>Symbol</b>	<b>Series</b>	<b>Texture</b>	<b>Parent Material</b>	<b>Drainage</b>	<b>Description</b>
B <sub>p</sub>	Breyden	variable	variable	variable	rock outcrop with pockets of soil
M	Muck <sup>A</sup>	n.a.	organic	poor	black well decomposed organic material over sand, clay or marl
B.L.	Bottom Land	variable	variable	variable (poor)	low lying soils along stream bank; horizons poorly developed
Bis	Bridgman	sand	eolian	very rapid	no profile development; consists of loose, incoherent coarse sand with some gravel
Bg	Burford	sand/gravel	LB	well	podzolic; well developed horizons; well drained developing and gently sloping topography
Cs	Chesley	silt loam	L	poor	gleysolic; poorly drained; profile is poorly developed and shallow



**TABLE S1 (Cont.)**  
**Soils Classification Summary for Bruce Peninsula**  
**as per Hoffman and Richards 1954**

<b>Symbol</b>	<b>Series</b>	<b>Texture</b>	<b>Parent Material</b>	<b>Drainage</b>	<b>Description</b>
Gsl	Granby	sand loam	L	poor	gleysolic; black sandy loam over sands; horizons poorly defined
Bsl	Brady	sand loam	L	imperfect	podzolic; dark grey sand loam over slightly mottled sandy loam
Fsl	Fox	sand	L	well	podzolic; brown sandy loam underlain by well sorted lacustrine sands
Dos	Donnybrook	sand loam	LB	well	brunisollic; dark brown sand over calcareous sand
Li	Listowel	loam	till	imperfect	podzolic; dark brown loam over pale yellow brown stony calcareous till
Sus	Sullivan	sand	L	well	brunisollic; dark brown sand over calcareous sand
Bes	Berrien	sandy loam	LB/till	imperfect	podzolic; dark brown sand loam over slightly mottled sand underlain by heavy clay till

**TABLE S1 (Cont.)**  
**Soils Classification Summary for Bruce Peninsula**

**as per Hoffman and Richards 1954**

<b>Symbol</b>	<b>Series</b>	<b>Texture</b>	<b>Parent Material</b>	<b>Drainage</b>	<b>Description</b>
Hal	Harkaway <sup>B</sup>	loam	till	well	brunisollic; very dark brown loam over pale yellow-brown till, calcarious, very stony
Wl	Wiaraton <sup>C</sup>	loam	till	imperfect	brunisollic; very dark brown loam over pale yellow-brown till, calcarious, very stony
Pal	Parkhill <sup>D</sup>	loam	till	poor	gleysolic; very dark brown loam over pale yellow-brown till, calcarious, very stony

Note: A + B + C + D = Breypen  
 LB - Lacustrine Beach  
 L - Lacustrine Plain  
 LB/Till - Lacustrine Beach over till

Source: Hoffman & Richards 1954

## **SOILS FOUND IN THE CYPRUS-CAMERON LAKES AND DORCAS BAY AREAS**

Various soil units in the Cyprus-Cameron Lake and Dorcas Bay areas were investigated during the period August 8 - 14, 1988. Twenty-three (23) control sections were described in detail following the guidelines set by the Ontario Institute of Pedology, Guelph. Recorded data includes: horizon development and thickness, textures, structure, colour, mode of deposition, percentage coarse fragments, and C.S.S.C. classification. A sample data sheet is included here as Figure S2. The final data has been assembled in dBase files SOILDATA.dbf and SOILH.dbf. In addition, core samples were taken at numerous locations to check the lateral extent of these soil units. The location of these control sections and core sample sites are shown in Figures S3 and S4 respectively. Summary descriptions of the soils encountered in the control sections are provided in Table S2.

The Cyprus-Cameron Lakes and Dorcas Bay area was completely inundated during 11,500-9500 B.P. and 5800-3700 B.P. As a result numerous lacustrine sand deposits are located between the present lake level (176.6 m a.s.l.) and the 228 m a.s.l. contour. Till can also be found in this region and occurs as isolated pockets on the bedrock surface. This diversity in parent materials is associated with other controlling factors (i.e., age of the deposit, topography, drainage, vegetation, climate), have combined to produce a variety of mappable soil types. Eleven (11) individual soil units have been identified in this area of BPNP. Division of the soil units is based on a number of soil parameters, including: parent material, family particle size, soil drainage class, depth to bedrock and C.S.S.C. classification. These soil units have been mapped in the SPANS database as SOLS.map a copy of which is presented here as Figure S5. Table S3 serves as a more detailed legend to this figure.

**TABLE S2**  
**Summary Descriptions of Soils at 23 Control Sections**  
**in the Dorcas Bay - Cameron Lake Area**

<b>Profile #</b>	<b>Texture</b>	<b>Depth to Bedrock (cm)</b>	<b>Family Particle Size</b>	<b>Parent Material</b>	<b>Soil Drainage Class</b>	<b>Depth to Waterbed (cm)</b>	<b>Vegetation Type</b>
SP88-1	MSL	35	LSK	Lacustrine	Imperfect	38	cedar, tamarack, birch
SP88-2	MSL	80	LSK	Colluvium	Mod. Well	66	cedar, balsam, fir, poplar, spruce
SP88-3	MS	---	S	Eolian	Rapid	--	maple, beech, birch
SP88-4	MS	---	S	Eolian	Rapid	--	maple, oak, poplar
SP88-5	MS	53	S	LP	Imperfect	--	cedar, balsam, fir, poplar, maple
SP88-6	MSCL	75	COL	Colluvium	Imperfect	--	cedar, balsam, fir, beech, poplar
SP88-7	S	2	S	BR	Mod. Well	--	maple, balsam, fir, poplar, birch, beech
SP88-8	MS	64	S	LP	Imperfect	--	B. fir, beech, poplar, birch, cedar
SP88-9	MS	81	S	LP	Poor	31	cedar, poplar, birch
SP88-10	MS	---	S	Eolian	Rapid	--	poplar, oak
SP88-11	MS	152	S	LP	Imperfect	75	poplar
SP88-12	MSL	25	COL	Colluvium	Well	--	B. fir, cedar, spruce, birch, juniper
SP88-13	MSL	27	LSK	Till	Imperfect	--	cedar, birch
SP88-13	MSL	49	LSK	Till	Imperfect	--	B. fir, pine, poplar
SP88-15	MSL	51	COL	LP/Till	Imperfect	--	B. fir, beech, poplar
SP88-16	SC/LMS	14	LSK	Till	Imperfect	--	cedar
SP88-17	MS	21	S	LP/E	Imperfect	--	cedar, B. fir, poplar

**TABLE S2 (Cont.)**  
**Summary Descriptions of Soils at 23 Control Sections**  
**in the Dorcas Bay - Cameron Lake Area**

<b>Profile #</b>	<b>Texture</b>	<b>Depth to Bedrock</b>	<b>Family Particle Size</b>	<b>Parent Material</b>	<b>Soil Drainage Class</b>	<b>Depth to Waterbed</b>	<b>Vegetation Type</b>
SP88-18	MS	---	S	LP	Poor	16	cedar, tamarack, grass
SP88-19	MS	---	S	LP	Poor	24	cedar
SP88-20	MS	37	S	LB	Mod. Well	--	cedar, B. fir, poplar
SP88-21	MS	13	S	LP	Well	--	cedar, poplar
SP88-22	MS	128	S	Eolian	V. Rapid	--	pine, birch
SP88-23	SC/SU	---	COL	Till	Mod. Well	--	maple, grass, raspberry

	v. rapid	rapid	well	mod. well	imperfect	poor	
veg	Pine	Maple	Cedar	B. Fir	Cedar	Cedar	Most Dominant
type	Birch	Oak	B. Fir	Poplar	Poplar	Tamarack	
		Poplar	Poplar	Maple	B. Fir	Poplar	
		Beech	Spruce	Cedar	Birch	Birch	
		Birch	Birch	Spruce	Beech		
				Birch	Tamarack		
				Beech	Pine		Least Dominant

**TABLE S3**  
**Soil Units Identified in the Dorcas Bay - Cameron Lake Area**

<b>Symbol</b>	<b>Parent Material</b>	<b>Family Particle Size</b>	<b>Soil Drainage</b>	<b>Depth to Class</b>	<b>Classification Bedrock (cm)</b>
S1	Lacustrine	Sand	Poor-Imperfect	<120	Gleyed Regosol
S2	Lacustrine	Sand	Poor	>120	Gleyed Regosol
S3	Lacustrine	Sand	Mod. Well-Imperfect	<120	Gleyed Regosol-Podzol
S4	Lacustrine	Sand	Mod. Well-Imperfect	<120	Regosolic
S5Dune Sand	Sand	Rapid	>120	Podzolic	
S6	Dune Sand	Sand	Rapid	>120	Beunisolic
S7	Dune Sand	Sand	Rapid	>120	Regosolic
T1	Sandy Loam	Till	Col	Imperfect	<120 Gleyed Regosol-Podzol
T2	Sandy Clay	CSK	Imperfect	<120	Gleyed Regosol-Podzol
B	Bedrock	Variable	Mod-Imperfect	<120	Brunisolic-Podzolic

## **SOILS FORMED ON SAND DUNES**

Some of the largest relic sand dunes found in BPNP have been preserved south of Cameron Lake. These dunes were deposited sometime between 5500 - 3700 years B.P. during the Nipissing I and II lake stages. A mature forest composed of maple, oak, beech, poplar and birch presently covers the dune complex. The topography of the area is characterized by strong, complex slopes which are extremely mounded. These dunes range in depth from 1.5 to 6 m and are composed of well-sorted, stratified, calcareous, medium sands. Soils occurring on these dunes are well-developed and deeply weathered (see SP88-3 and 4) (see Photo 2). Thin LFH and A horizons characterize these soils. Due to rapid drainage through these soils, iron and humic material have been translocated deep in the profile. Under conditions of extremely rapid drainage, weathering is evident at 140 cm below the mineral surface. These soils belong to the Orthic Humo-Ferric Podzol subgroup and are delineated on the map as S5 type soils.

Sand dunes of variable depth and extent are found in the Dorcas Bay area. The Dorcas Bay dune complex is morphologically similar to the Cameron Lake dunes, but are younger and smaller, and range in age from 3000 years B.P. to present. The best developed dunes in this area were formed during the Algoma lake stage (see Photo 3). The Algoma aged soils exhibit far less pedologic development than those evolving on the Cameron Lake dune complex. This disparity has been attributed to differences in age, meso-climate and vegetational composition. Soils formed on the Algoma aged dunes have a well defined eluviated A horizon and a weakly developed B horizon. The B horizon is enriched with both iron and humic material but not to the extent that it would be considered podzolic. Unweathered parent material is encountered at 17 cm below the mineral surface (see SP88-22). These soils are classified as Eluviated Eutric Brunisols and are represented on the soil map as S6.

Contemporary sand dunes are also present in the Dorcas Bay area. Although these dunes are vegetated with grasses and small shrubs, no soil development is evident. Contemporary dunes have been disrupted in the parking area located at Dorcas Bay and sands have been remobilized. These sands are presently moving inland, covering Algoma aged lacustrine plain deposits, and can be classified as Cumulic Regosols (see photo 4). The stabilized contemporary dunes are classified as Orthic Regosols and represented by S7 on the map sheet.

## **SOILS FORMED ON LACUSTRINE DEPOSITS**

The most common and extensive lacustrine features found in the Cyprus-Cameron Lakes and Dorcas Bay area is sandy lacustrine plain deposits. These depositional features were formed during higher lake

stages and are a product of sedimentation in the near-shore zone. These deposits are relatively flat lying and occupy depressional areas. The most extensive lacustrine plain feature regresses from a former shoreline north of Highway 6 to Dorcas Bay. The area south of Highway 6 is flat lying, poorly drained and sparsely vegetated with stunted cedar, tamarack and grasses (see Photos 5). These stands are relatively thin (130 - 160 cm) and well saturated, having a perched water table 16 cm below the organic surface. Soil development is generally very poor, and A and B/C horizons may or may not be present. The character and presence of LFH and A horizons are strongly dependent on the nature of the site vegetation; however these horizons, if present, are generally thin. Gley colours encountered at 30 cm below the mineral surface indicate a sustained lack of oxygen and the presence of a root restricting layer (see SP88-17 and 18). Gleyed Regosols and Gleyed Humic Regosols are typical soil subgroups characterizing the S2 unit.

The land surface becomes more rugged and topographically complex north of Highway 6 and on the proximal side of the Cameron Lake dunes. Depressional areas on this complex surface are also filled with lacustrine plain medium sands. The sand veneer is thin (<120 cm) and drainage is generally imperfect. Cedar is the dominant tree type on this soil unit; however, poplar, birch and some balsam fir are also present. Soils developing on this unit have a thick LFH which is dominated by the H horizon (11 to 21 cm). The mineral fraction underlying the organic mat shows no sign of weathering. Mottling is evident from 0 to 40 cm below the mineral surface and gley colours predominate below 40 cm (see SP88-8 and 9). These soils are classified as Gleyed Regosols and are represented by S1 on the soil map.

Soils evolving on slightly better drained lacustrine sand deposits in the Cyprus-Cameron Lakes and Dorcas Bay area show signs of increased soil development. Soil units on the distal side of the Cameron Lake dune complex, northwest side of Horse Lake and peripheral to the Dorcas Bay lacustrine sand plain, are moderately well to imperfectly drained. These soils are shallow (< 120 cm) and have a moisture regime which is markedly drier than those characterizing the S1 soil unit. Balsam fir, poplar, cedar, maple and beech are commonly found growing on these sites. The LFH horizon ranges in thickness from 3 to 10 cm, with the H horizon being very thin or none existent. Profiles exhibit poorly developed A horizons which may or may not be eluviated. The B horizon is enriched with both humic material and iron; however, enrichment is at a juvenile stage. Mottles are present and commonly found at depths of 15 cm below the mineral surface. Perched watertables and significant seepage are uncommon within this soil unit. Gleyed Eluviated Eutric Brunisols and Gleyed Eutric Brunisols are common soil subgroups formed on the S3 soil unit (see SP88-5, 15 and 20).



Contemporary lacustrine sands having no vegetative cover or soil development are found on the proximal side of recently formed dunes at Dorcas Bay (see Photo 6). These sands were deposited during periods of recent high water, i.e., levels created by seiches (storm stages) and evaporation/precipitation cycles. Due to the shallow dip of the surface topography, small rises in water level have contributed large amounts of sand at a considerable distance inland. These soils are classified as Orthic Regosols and shown as S4 on the map.

## **SOILS FORMED ON TILLS**

Two unique lodgement tills were identified at four different locations in the Cyprus and Cameron Lakes area. Soil development on these two different textured parent materials is dissimilar even though they are comparable in thickness, topographic setting and drainage. The sandy loam textured, calcareous till is found on the northwest side of Cyprus Lake and 4.5 km north of Highway 6 on the Cyprus Lake Road (see Photo 7). This till is thin at both locations and imperfectly drained. Depending on the soil moisture regime and depth to bedrock, balsam fir or cedar will dominate a canopy composed of birch, poplar and pine. The LFH horizon ranges in thickness from 6 to 12 cm and is underlain by a slightly eluviated Ahe horizon. Thicker, better drained soils on this till unit have a more pronounced Ae horizon. The B horizon is poorly developed; however, iron staining and mottling are both evident. Soils developing on the T1 soil unit are classified as Gleyed Eluviated Eutric Brunisols (see SP88-13 and 14).

A second till which is calcareous and sandy clay textured is located on the east side of Cyprus Lake and 2 km north of Highway 6 on the East Cameron Lake Road (see Photo 8). The till unit in the Cyprus Lake region is very shallow (< 50 cm) and imperfectly drained. Cedar is the dominate tree type representing the forest cover on shallower sites (see Photo 9). A well developed H horizon is underlain by a poorly developed B horizon. In many locations the A horizon is very thin or non-existent. Unfortunately, the unique reddish colour of this till masks many of the diagnostic colours normally used to evaluate the kind of weathering taking place in the profile, (i.e., iron staining and mottling).

In the Cameron Lake region, this reddish till is underlain by the sandy loam till described earlier. Consequently, a different soil phase has developed on a thicker, better drained parent material. Maple is the dominant tree type and grasses cover the forest floor. A well developed, but thin (< 10 cm) Ah horizon is overlain by a poorly developed LFH. The B horizon is also poorly developed and unweathered parent

material is encountered 16 cm below the mineral surface. Soils developing on the T2 soil unit can be classified as Gleyed Eutric Brunisols or Orthic Eutric Brunisols (see SP88-16 and 23).

## **SOILS FORMED ON BEDROCK**

In the Dorcas Bay and Cameron-Cyprus Lake area, numerous soil types of variable distribution, origin and extent occupy isolated pockets. The soils series most often found in this Breypen land type are the Muck, Parkhill, Wiarton and Harkaway (Hoffman and Richards 1954). These latter three soil series are loam textured, stony, calcareous tills of identical origin and variable drainage. Also included in the Breypen are laterally confined organic, lacustrine and stratigraphically younger and older tills of variable topographic character and drainage. Humic Gleysols, Melanic and Eutric Brunisols, Ferro-Humic Podzols and Folisols are soil subgroups most often associated with the Breypen land type.

Following the Breypen Series, the next most significant soil series in BPNP is represented by both the Muck and Bottom land. Muck soils are composed of organic material which is in various states of decomposition. These soils occupy topographic depressions and are generally poorly to very poorly drained. Bottom land soils are immature, poorly developed soils found along stream sides which are frequently flooded. These soils are usually poorly drained and have a weakly developed A horizon underlain by unweathered parent material. Gleyed Regosols, Orthic Humic Regosols and Gleyed Humic Regosols are commonly found on mineral deposits of this land type.

More laterally extensive soil units are related to significant glacial and lacustrine deposits. The more significant of the two is the lacustrine deposits dating from the Nipissing I and II and Algoma post-glacial lake stages. These deposits are extensive and vary in texture, composition and age. As a result, numerous soil types have developed on these deposits. A large area bordering BPNP to the northeast is used primarily for agricultural purposes. The underlying parent materials are mostly lacustrine plain, beach and dune, sands and gravels deposits dating from the Nipissing I and II lake stages (5500 to 3700 year B.P.). Hoffman and Richards (1954) have also identified a bedrock surface land unit. Organic, glacial, lacustrine, bedrock and polygenic materials comprise the parent materials of this unit. The soils most often encountered are detailed in previous pages; however, these soils are often too small in areal coverage to be mapped at a scale of 1:10,000. Vegetation growing in this land type include: cedar, balsam fir, spruce, birch, beech, maple,

poplar, tamarack and juniper. Cedar and tamarack dominate poorly drained sites (see Photo 10) and balsam fir, spruce, maple and juniper indicate better soil drainage.

Solutional weathering of the bedrock surface has had considerable impact on soil development in BPNP (see Cowell 1973; Goodchild 1984; for examples of karst formation). In some locations small scale vertical sinks, or deep pits, and clint and grike features have provided a secondary porosity which has helped increase soil drainage (see Photos 11-13). Increased drainage has allowed more advanced and deeper weathering of the soil profile. Also, these features have acted as structural holds for the roots of trees growing on surfaces having little or no unconsolidated material (see SP88-7). As a result, trees have colonized bare rock surfaces, producing thick LFH horizons which have developed into folisols. Soils most often found on the B soil unit are: Gleyed Eutric Brunisols, Orthic Eutric Brunisols, Orthic Ferro-Humic Podzols, Orthic Humic Podzols, Folisols and Orthic Gleysols (see SP88-1, 2, 6, 7, 12).

#### **SOILS FORMED ON ORGANICS**

Organic soils develop in depressional areas which are poorly to very poorly drained. These soils are commonly composed of mosses, sedges or other hydrophytic vegetation, and are found in various states of decomposition. Organic soils must be at least 36 cm deep and may overlie mineral soil or bedrock. Most of the organic soils are saturated with water for prolonged periods. Folisols and Mesisols are the most common great group soils representing the 0 soil unit (see SP-88-1, Figures S1 and S5).

**SOILS REFERENCES**

Hoffman, D.W. and N.R. Richards. 1954. Soil survey of Bruce County. Experimental Farm Service, Canada Department of Agriculture and the Ontario Agricultural College, Report No. 16 of the Ontario Soil Survey. 110p.

Munsell. 1975. Munsell soil colour charts. Munsell Colour MacBeth, Kollmorgen Corporation. Baltimore, Maryland.

West, R.G. 1977. Pleistocene geology and biology, 2nd edition. Longman Group Ltd., London, 427p.



Photo 2:Orthic Ferro-Humic Podzol Formed on NIPISSING I Ages Dune Sands Located South of Cameron Lake



Photo 3:Algoma Aged Sand Dunes at Dorcas Bay

Photo 4:Dorcas Bay Parking Lot: Disrupted Dune Sands moving and covering Algoma Aged Lacustrine Plain Sands



Photo 5:Dorcas Bay Lacustrine Plain

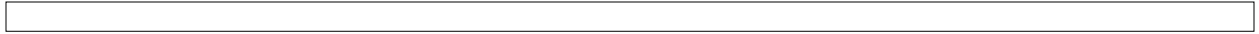


Photo 6:Proximal Side of Dorcas  
Bay: Algoma and  
Recent Dunes

Photo 7:Sandy Loam Till Found in  
Pockets on the N.W.  
Side of Cyprus Lake






Photo 8:Sandy Clay, "Reddish" Till S.E. Cyprus Lake

Photo 9:Shallow Sandy Clay Till Site S.E. of Cyprus Lake



Photo 10Gleysolic Lacustrine Deposits



Photo 11:Typical Karst Surface Features

Photo 12:Shallow Soil: High  
Secondary Porosity



Photo 13: Typical Shallow Soil

---

## **TERRAIN**

### **TOPOGRAPHY**

The elevation contours (topography) of the northern Bruce Peninsula land area were manually digitized from the 1:10,000 Ontario Base Map (OBM) series produced by the Ontario Ministry of Natural Resources. The 5 metre elevation ranges have been entered into SPANS as polygons (CONT.map) and the contour lines as separate, continuous line files (DC01....DC22). Figure T1 is a hardcopy printout of this topography in the Dorcas Bay area.

Terrain slope and aspect maps were then developed for the Park using the following method. The SPANS "points sample" function was applied to the contour map with a uniform sample spacing of 1750 metres to obtain elevations for each OBM map sheet. These point elevations (approximately 1000 for each OBM sheet) were then used in Tydac's Contour module to produce slope and aspect maps for each OBM sheet area. The following classification schemes were used in these contour operations. For slope, 5 degree intervals up to 20 degrees and 10 degrees up to 80 degrees were selected. For aspect, a uniform 22.5 degree interval was selected for the initial classification process. This generated a map with too much detail for practical use. It was then recoloured to identify slopes facing the four major compass directions; N, E, S, W. The points sampling operation was carried out on areas slightly larger than the OBM sheet sizes to ensure correct slope and aspect calculations at the sheet edges. Final slope and aspect maps were then developed for the entire study area as follows. First of all, a single map which represented each OBM sheet area as a unique tynumber or colour was developed and quadded. A modelling equation was then established which selected only those portions of the slope or aspect data from each "over-sized" area of calculation which fell within the actual OBM sheet boundary as determined by the quadded OBM map sheet grid. The final maps generated, SLOPFIN.map and ASPC4COL.map, are illustrated as Figures T2 and T3.

Much of the peninsula is relatively flat; slopes in the 0 to 5% range cover 82% of the Park area. Steeper zones (6-10%; cover 14% of the Park) exist around the rivers and lakes scattered through the Peninsula and steep cliffs occur along the north and east shorelines of the Peninsula. See Table T1. The Cabot Head formation is also evident in the slope map.

The single obvious pattern highlighted by the aspect map (Figure T3) is the general drainage pattern (valleys) in the northeast. The aspect map is generally not as easily interpreted as the slope, even when only four basic orientations are selected, as is shown in Figure T3. The area analysis of the detailed aspect map has been transformed to the bar chart seen in Figure T4. The predominant land orientations are to the north and south with a secondary trend east and west. The least prominent orientations are SSE and NNW. However, because the peninsula is quite flat there is a large variation of land orientation on a localized scale. The selection of aspect angle by the contouring routine does not take into account the slope of the zone and therefore in a relatively flat area the aspect for adjacent zones can vary greatly due to minor hills and depressions.

## **BATHYMETRY**

The Lake Huron-Georgian Bay lake bottom contours (bathymetry) have been manually digitized from the hardcopy mapping provided by Parks Canada. The water depth ranges have been entered into SPANS as polygons (BATH.map) as seen in Figure T5. The area analysis of this map within the Park boundary is presented as Table T2. Islands account for 13% of the area; about 75% of the area is less than 35m deep.

--

**TABLE T1**

**Terrain Slope Area Analysis**

Class	Legend	Peninsula		BPNP Only	
		Area (%)	Area (km sq)	Area (%)	Area (km sq)
1	0-5 degrees	86.42	337.337	81.99	128.223
2	5-10 degrees	10.16	39.677	14.34	22.430
3	10-15 degrees	1.56	6.078	2.01	3.142
4	15-20 degrees	0.70	2.747	0.61	0.954
5	20-30 degrees	0.68	2.660	0.54	0.849
6	30-40 degrees	0.33	1.294	0.35	0.548
7	40-50 degrees	0.11	0.439	0.12	0.189
8	50-60 degrees	0.03	0.098	0.03	0.043
9	60-70 degrees	0.01	0.021	0.00	0.003
10	70-80 degrees	0.00	0.003		
Total of 10 classes		100.00	390.344	100.00	156.381

**TABLE T2**

**Water Depth Area Analysis: Fathom 5**

<b>Class</b>	<b>Legend</b>	<b>Area (%)</b>	<b>Area (km sq)</b>
1	lake shore to -5m	10.60	11.580
2	-5m to -10 m	7.10	7.765
3	-10m to -15m	7.52	8.221
4	-15m to -20m	8.08	8.827
5	-20m to -25m	8.53	9.328
6	-25m to -30m	17.73	19.382
7	-30m to -35m	14.15	15.460
8	-35m to -40m	3.17	3.460
9	-40m to -45m	0.79	0.863
10	-45m to -50m	0.60	0.724
11	-50m to -55m	1.03	1.128
12	-55m to -60m	1.11	1.217
13	-60m to -65m	0.57	0.621
14	-65m to -70m	0.42	0.455
15	-70m to -75m	0.38	0.411
16	-75m to -80m	0.52	0.565
17	-80m to -85m	0.76	0.828
18	-85m to -90m	2.12	2.316
19	-90m to -95m	1.61	1.758
99	Islands	13.16	14.384
Total of 20 Classes		100.00	109.293

**DRAINAGE**



Drainage in the Park is influenced considerably by the karst geology and can be subdivided into the four classes listed below and seen in Figure T6:

- 1)Normal Fluvial (wholly surface runoff);
- 2)Holokarst (wholly sub-surface);
- 3)Immature Fluviokarst (partial capture of surface channel systems); and
- 4)Fluvio-karst (complete capture of surface channels).

Brief descriptions of these four classes have been extracted from Cowell (1976, 1974) the recognized expert on the karst geology of the Bruce Peninsula. For a more complete description of the karst drainage in the Bruce Peninsula refer to Cowell's work. A general drainage map has been constructed based on Cowell's work (1976) and knowledge of the rivers and streams in the Park area (see Figure T7). This map has been entered in the SPANS database as WTRS.map. Area analyses of this map have been completed for the Park area and the peninsula in general. A comparison of the two results (Table T3) shows that the Park is generally representative of the drainage pattern in the peninsula.

### **Fluvial Drainage**

Most of the surface runoff in the vicinity of the Park flows into Lake Huron with the exception of the lakes in Cyprus Lake campground (Figure T6). Willow Creek and Crane River drain thirteen of the peninsula's lakes. Their basins are large, given the lack of surficial deposits which greatly increases the opportunity for underground capture. West of these streams are only a few short, unnamed creeks (except for Sideroad Creek) and much of the area is characterized by either poor drainage (wetlands) or vertical drainage. Vertical drainage dominates the east side along the escarpment. In contrast, the Lake Huron shore is poorly drained because of a low gradient and high water table.

**TABLE T3**  
**Drainage Type Area Analysis**

Class	Legend	Peninsula		Park Only*	
		Area (%)	Area (km sq)	Area (%)	Area (km sq)
1	Holocarst	18.65	66.634	16.17	24.920
2	Fluvio-karst	11.86	42.364	8.99	13.852
3	Fluvial drainage	59.05	211.001	53.85	83.005
4	Immature Fluviokarst	10.44	37.318	21.00	32.376
Total of 4 Classes		100.00	357.318	100.00	154.154

\* Does not include Fathom Five portion

All streams in the Park area are close to bedrock or flow directly on it. Where glacial, lacustrine or alluvial materials occur they are being removed by stream action. The bed of Crane River at highway 6 consists of glacially polished bedrock even though alluvium lies above the river on either side.

### **Holokarst Drainage**

Areas dominated by vertical drainage and lacking normal surface channels (or relict channels) are referred to as holokarstic. At present these correspond to zones where the groundwater hydraulic gradient is greatest, such as along the top of the escarpment and on its promontories. The impetus for underground drainage is very good in such areas, particularly if there is no drift. Precipitation and snowmelt drain almost immediately into grikes and other sinkholes. Only small ponds and swamps remain at the surface. Some runoff probably occurs near the edges of the holokarst, especially during storms, but numerous large grikes in these areas attest to the degree of vertical drainage.

Extension of the holokarst inland is variable. Across the top of the peninsula it is confined to a zone about 1.5 km (1 mi) wide. However, it is as much as 3 km wide on the Cabot Head Promontory.

Very little is known about the internal drainage of these holokarst areas. The lack of concentrated runoff has inhibited the development of explorable passages although several may lie at depth. The only active, explorable cave on the escarpment is associated with a fluvio-karst. Other caves on the escarpment are dry and probably owe much of their development to mechanical processes, such as waves. The presence of many small intermittent springs, as opposed to large perennial resurgences, suggest that the holokarst drainage is completely diffuse. Some may be lost down dip toward the southwest.

### **Immature Fluvio-Karst Drainage**

Because of the lack of drift on the Bruce Peninsula it is likely that many of the surface streams are in the process of being captured underground. The escarpment presents a very high groundwater hydraulic gradient in the opposite direction to the gentle surface gradient. Karst processes presently operating near the edge of the escarpment further increase the likelihood of underground capture.

It is common in karst areas bordered by an escarpment, to have the karst continually expand away from the edge of the scarp. As karst processes become established the effective hydraulic gradient in adjoining zones is increased. The lowest point of vertical solution becomes the new base level resulting in shifts of the greatest potential for vertical solution away from the escarpment. On the Bruce Peninsula this would eventually mean a complete reversal of most of the existing drainage toward the north and northeast.

At least one major basin may be in the process of underground capture. The Crane River was found to be losing water over a distance of about 1000 m. Two discharge determinations were performed on this river on the same day. The flow was found to decrease by 17% which is especially notable because water is added to the river between the two measurement locations by a perennial spring. Thus, on Figure T6 the Crane River basin above the lower gauging station is shown as an immature fluvio-karst. Its headwaters touch the holokarst area and consequently one can expect a high potential for underground capture. The entire immature fluvio-karst area in Figure T6 may not necessarily be captured all at once. It may happen in stages working downstream from the holokarst. Alternatively, the recorded loss in flow could be along bedding planes toward Lake Huron.

---

Similar discharge determinations were made for Willow Creek and no loss was found. However, the discharges were made over a distance of 5.5 km and additional inflow could have overwhelmed any subsurface losses.

### **Fluivo-karst Drainage**

The Cameron Lake-Cyprus Lake basin within the Park possesses regular surface channel systems that feed entirely into sinks. In this basin area, all runoff is drained underground for a least part of the year. During high flow, such as at spring freshet, ponding may occur over the sinkholes and simultaneous surface and subsurface drainage, occurs. Within the basin, Horse Lake drains along joints toward the northwest into Marr Lake which in turn filters through beach cobbles into Georgian Bay. Water levels on Horse Lake can vary up to 2.0 m between spring and late summer.

The St. Edmunds cave system is the best example of fluviokarst on the peninsula. Although the entrance to the cave and parts of the underground drainage lies outside the Park, the exit is at Little Cove. Hydraulic gradients within the cave are low and as a result flooding and ponding within the cave occurs. Evidence of both vadose and phreatic conditions can be found in the cave. Vadose refers to development above the water table where passages are partly air filled, allowing downward entrenchment. Phreatic conditions occur below the water table where voids are completely saturated. Caves formed under this latter condition tend to be circular or elliptical.

Gilles Lake is totally enclosed, being fed by springs and small creeks and drained by a single sinking stream. The exit stream has many sinkholes along its length and continually shortens as summer progresses.

## VEGETATION

### INTRODUCTION

This chapter documents and analyses vegetation in the study area. The aim is to provide a thorough inventory of dominant species and principal vegetation types and to interpret and assess the dynamic nature of the communities, both historically and at the present time. The information assembled provides the basis for defining and comparing communities and habitat, for comprehending relative community value, and for making some predictions about the direction and the goals of successional changes now taking place.

This vegetation bioinventory focuses upon dominant vegetation forms rather than upon individual species as such. Since trees and shrubs dominate the vegetation of forested areas, the study provides detailed information on these key vegetation forms including the abundance and distribution of key individual species. Herbaceous vegetation in forested lands is not included in this study except incidentally as "unique and special event data" in the field data sheets (Table V1) for possible use in future studies. For non-forested areas such as marshes, open fens, open alvar, and agricultural fields or meadows, the dominant herbaceous vegetation forms are documented, but again the inclusion in the data base of records of rare species or other unusual observations is on an incidental basis.

The maps generated for this chapter from the field data sheets by SPANS provide the principal bases for describing and interpreting vegetation communities in the study area. However, simple field notes were also important. The maps provide a basis for future ecological and biological studies including the occurrence and distribution of rare species of both fauna and flora.

**TABLE V1 BIOPHYSICAL INVENTORY: VEGETATION CHECKSHEET**

UPLAND ____	WETLAND ____
TYPE OF WETLAND:	SWAMP __; FEN __; BOG __;
	MARSH; __;
	BEAVER FLOOD: YES __; NO __;

TREES YES \_\_\_; NO \_\_\_;

2. % CANOPY: >60 \_\_\_; 25-60 \_\_\_; 10-25 \_\_\_; <10 \_\_\_.

3. % CONIFER/BROADLEAF: CONIFER >75 \_\_\_; MIX 25-75 \_\_\_; BROADLEAF >75 \_\_\_;

4. DOMINANT SPECIES: \_\_\_; \_\_\_ (1 OR 2).

5. SUBDOMINANT SPECIES: \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_.

6. OCCASIONAL SPECIES: \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_;

7. HEIGHT: >20M \_\_\_; 10-20M \_\_\_; 3-10M \_\_\_.

SHRUBS YES \_\_\_; NO \_\_\_.

8. % CANOPY: >60 \_\_\_; 25-60 \_\_\_; 10-25 \_\_\_; <10 \_\_\_.

9. % EVERGREEN/BROADLEAF: >75 \_\_\_; MIX 25-75 \_\_\_; BROADLEAF >75 \_\_\_.

10. DOMINANT SPECIES: \_\_\_; AND \_\_\_ (1 OR 2).

11. SUBDOMINANT SPECIES: \_\_\_; \_\_\_; \_\_\_.

12. OCCASIONAL SPECIES: \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_; \_\_\_;

13. HEIGHT: >3M \_\_\_; 1-3M \_\_\_; .2-1M \_\_\_; <.2M \_\_\_.

OPEN UPLAND AREAS

14. % COVER: >75 \_\_\_; 25-75 \_\_\_; 5-25 \_\_\_; <5 \_\_\_.

15. % TYPE OF COVER: >75 GRAMINOID \_\_\_; >75 FORBS \_\_\_; MIXTURE 25-75 \_\_\_.

OPEN WETLAND AREAS

17. % COVER: >75 \_\_\_; 25-75 \_\_\_; 5-25 \_\_\_; <5 \_\_\_.

18. % TYPE OF COVER: ROBUST EMERGENTS \_\_\_  
GRAMINOID/SEDGES \_\_\_  
BROAD LEAVED \_\_\_  
MIXTURE OF THE ABOVE \_\_\_  
FLOATING &/OR SUBMERGENTS \_\_\_  
OPEN WATER (NO COVER) \_\_\_

UNIQUE OR SPECIAL EVENT DATA

FLOATING FEN MAT: \_\_\_ (CHECK = YES).

FIRE HAZARD: DEAD TREES & SHRUBS [WINDFALL, DISEASE, ETC. (CHECK IF EXTREMELY HIGH)] \_\_\_;

\_\_\_; NATURE OF HAZARD \_\_\_\_\_

TREE CAVITIES ABUNDANT: \_\_\_\_\_.

SOILS: \_\_\_\_\_.

OTHER: \_\_\_\_\_ WILDLIFE NOTES:

\_\_\_\_\_.

FIELD DATA BY: \_\_\_\_\_ DATE: \_\_\_\_\_

## **The Significance of Vegetation**

Vegetation is one of the most important aspects of any landscape ecosystem. Trees, shrubs and herbs, create the primary basis for all animal life by providing nesting materials and sites, protection from predators, food, places to roost and loaf, isolation during the breeding season, etc. The more kinds of vegetation communities present in an area and the greater the number of plant species within each, the more diverse can be the faunal portion of the overall ecosystem.

Many studies have shown that for the large majority of vertebrates and many invertebrates, differences in vegetation structure are more important as determinants of habitat than differences in individual plant species making up the vegetation communities. Since faunal composition in any area is linked to the nature of vegetation communities and local habitat, specific details on the structure and composition of vegetation are essential. The dominant vegetation attributes (Table V1) upon which much of the vertebrate fauna is dependent are the ones which are documented in this inventory. The many other physical aspects of the study area as presented in other chapters of this report also have a major bearing on the occurrence and distribution of faunal species.

For many species, the age of a plant community is critical. For example, climax forest communities where old trees contain cavities for nesting and shelter (Fischer & McLelland, 1987/88) are ones upon which dozens of species of cavity nesting, mammals and birds are absolutely dependent. Another example of the importance of age, is the case of floating fens or bogs because they contain unique assemblages of flora and fauna that could only come into existence over periods involving hundreds or thousands of years. Age is thus a critical factor in representativeness of the vegetation of an area.

Further, vegetation communities where certain flower, nut, or fruit bearing tree or shrub species are present are ones that are bound to be suitable for certain dependant faunal species requiring such food sources. Many herbivorous insects (butterflies, moths, and other insects) are often dependent upon one or a few specific species of plants. The occurrence and distribution of such insects in the study area would require documentation of the distribution and abundance of their host plant species.

## **Previous Vegetation Studies**

The Bruce Peninsula has long been a favorite of field botanists; plant collections are well represented in herbaria. While the taxonomy of the flora (species lists, distribution maps for Ontario, etc.) is fairly well understood, this is certainly not the case with ecological processes such as the direction or nature of successional development, the ultimate goals of succession or the particular intrinsic values of local ecosystems at any particular spot.

Some recent studies of vegetation of the Park and vicinity have focussed upon identifying important natural areas for possible Nature Reserves or ANSI sites (Cuddy, Lindsay & Macdonald 1976; Ministry of Natural Resources 1976), upon valued wetlands (Walshe 1968a, 1968b; Ministry of Natural Resources wetland evaluations - Table V5) upon identifying natural values within specific sites such as Dunks Bay (Cuddy & Norman 1972); upon species of specialized habitats - like alvar (Catling et. al. 1975); on Cyprus Lake Provincial Park (Beechy & Macdonald 1972; Johnson 1980); on biologically significant areas at Corisande Bay and Johnston Harbour-Pine Tree Point (Johnson 1982a 1982b); on the Dorcas Bay Nature Reserve (Woodford & Bartman 1966; Nicolson 1983; Hilts 1984), and on popular articles on wildflowers of the Bruce Peninsula (Johnson 1984). No studies to date have systematically documented the occurrence and distribution of valued rare species or their required habitats.

Some workers have documented the flora of the Tobermory Islands (Francis Johnson & McDonald 1983; Brownell 1984; Morton & Venn 1987), but these accounts did not extend to the botany of the mainland portion of the Peninsula. The report by Francis et. al. maps the communities on a number of the islands. The study of the flora of the Tobermory Islands (Morton & Venn 1987) indicates that several of the islands were systematically logged in the late 1800s and up to the 1930s but records of the size of the trees or the composition of the original forests, if available, are not presented. Morton & Venn recognized floristic elements on the islands as representative of floras of different parts of northeast North America and the analysis they provide are also applicable to the entire tip of the Peninsula. No previous vegetation classification systems were used for this report. Basic vegetation attributes were mapped within the Spans GIS; classification schemes can now be applied using the GIS's modelling capabilities.

The first descriptions of the vegetation communities covering all areas of the Park are presented by Wickware & Schiefer (1987). They based their descriptions upon 3 very broad "biophysiographic sections" as defined by Cuddy et. al. (1976). To obtain field confirmation for these aspects of their study, Wickware & Schiefer conducted a "brief field reconnaissance of the park in early June 1987", as well as a boat trip along the coasts and an overflight with a small plane. The analysis of the vegetation of the Park by Wickware and Schiefer was, as stated, preliminary and the areas were not strictly mapped. The vegetation



communities they recognized are considered later in this chapter following presentation and discussion of the methods and results of the present vegetation inventory.

## **METHODS**

One of the prime goals of this vegetation inventory and analysis was to make the conclusions drawn as independent as possible from observer bias (i.e., based on quantified data). Previous approaches to bioinventories in general relied heavily on agreement among several experts regarding the units to be defined and recognized. Such earlier bioinventories carried out in Ontario resembled Forest Management Inventory (FMI) Maps whose principal aim was to determine wood volumes of various tree species, rather than to discover non-timber ecological values of the landscape as a whole. In standard biophysical inventories, once units were delimited, they would be "carved in stone" and all subsequent information would be organized in their context. In contrast, the geographical information system (SPANS) employed in this study is open and entirely flexible. As new data on any aspect of the bioinventory is available and inputted, new boundaries and maps affected by the new data can be generated. The potential for increasing the accuracy of the map units derived and for the addition of new data are almost unlimited.

Attributes were created that would describe the actual vegetation characteristics at any spot. Thus, data generated do not include judgments about the stage of succession or similar dynamics; rather the vegetation as is was documented by ground truthing directly in the field as outlined in the section on field work below.

### **Definitions of Vegetation Attributes**

The approach to the description of the vegetation in this study required the conceptualization, rationalization and delimitation of attributes of vegetation to be described.

The attributes were conceptualized and limits defined so that the categories derived from them have at least some discernible ecological importance. Thus, following application, important ecotonal areas should be revealed on the map generated. As well, areas important or potentially important as habitat or as having food sources for wildlife species can also be derived from various combinations of attributes. Generally, only those attributes (and the ranges of subattributes) that could be defended taxonomically or ecologically were created.

Another aim was to define the attributes in a manner to ensure that when correlations and distributions were generated (i.e., the portrayal of certain values) that an indispensable basis would exist for the preparation of the Park Management Plan, Park Conservation Plan and for operations decisions in the Park by site planners. This means that the system as designed is capable of generating maps (as presented in this chapter) defining the location of species (trees and shrubs only) at several levels of abundance as well as characteristics of the vegetation which are required to define the existing structure of ecosystems. The locations of rare species can be added in the future.

The list of tree and shrub species given in Table V2 were derived from the most recent revision of the book "Shrubs of Ontario" (Soper & Heimbürger 1985) and "Trees of Canada" (Hosie 1979). The reason they are numbered (1 to 102) is to enable ready entry into Table V1, attributes 5, 6, 10 and 11. The SPANS system can then generate maps (see below) giving the geographical distribution of any tree or shrub species in terms of dominant, subdominant and occasional.

The final details, including ranges in attribute characteristics are based upon experience, knowledge and judgement of the innate biological characteristics of shrub & tree species present in the area, including factors such as potential height of mature plants, canopy forming characteristics, food value for wildlife. As well, animal habitat requirements (as determined by vegetation) influenced the final definitions of attributes and their limits. The rationales are outlined in some detail below.

**TABLE V2**  
**Tree and Shrub species Designation**

<b>NUMBER ASSIGNED</b>	<b>LATIN NAME</b>	<b>COMMON NAME</b>
<b>TREES</b>		
1.	<i>Pinus strobus</i>	White Pine
2.	<i>Pinus resinosa</i>	Red Pine
3.	<i>Pinus banksiana</i>	Jack Pine
4.	<i>Larix laricina</i>	Tamarack
5.	<i>Picea glauca</i>	White Spruce
6.	<i>Picea mariana</i>	Black Spruce
7.	<i>Tsuga canadensis</i>	Eastern Hemlock
8.	<i>Abies balsamea</i>	Balsam Fir
9.	<i>Thuja occidentalis</i>	White Cedar
10.	<i>Juniperus virginiana</i>	Eastern Red Cedar
11.	<i>Populus tremuloides</i>	Aspen
12.	<i>Populus balsamifera</i>	Balsam Poplar
13.	<i>Populus grandidentata</i>	Large-toothed Poplar

14.	<i>Juglans cinerea</i>	Butternut
15.	<i>Ostrya virginiana</i>	Ironwood
16.	<i>Betula alleghaniensis</i>	Yellow Birch
17.	<i>Betula papyrifera</i>	White Birch
18.	<i>Fagus grandiflora</i>	Beech
19.	<i>Quercus macrocarpa</i>	Bur Oak
20.	<i>Quercus rubra</i>	Red Oak
21.	<i>Ulmus americanus</i>	American Elm
22.	<i>Prunus serotina</i>	Black Cherry
23.	<i>Acer saccharum</i>	Sugar Maple
24.	<i>Acer saccharinum</i>	Silver Maple
25.	<i>Acer rubrum</i>	Red Maple
26.	<i>Tilia americana</i>	Basswood
27.	<i>Fraxinus americana</i>	White Ash + "red"
28.	<i>Fraxinus nigra</i>	Black Ash

#### SHRUBS

29.	<i>Taxus canadensis</i>	American Yew
30.	<i>Juniperus communis</i>	Common Juniper
31.	<i>Juniperus horizontalis</i>	Creeping Juniper
32.	<i>Salix bebbiana</i>	Bebb's Willow
33.	<i>Salix candida</i>	Hoary Willow
34.	<i>Salix discolor</i>	Pussy Willow
35.	<i>Salix exigua</i>	Sanbar Willow
36.	<i>Salix lucida</i>	Shining Willow

**TABLE V2 (Cont.)**

#### **Tree and Shrub species Designation**

<b>NUMBER ASSIGNED</b>	<b>LATIN NAME</b>	<b>COMMON NAME</b>
<b>SHRUBS (Cont.)</b>		
37.	<i>Salix pedicellaris</i>	Bog Willow
38.	<i>Salix petiolaris</i>	Slender Willow
39.	<i>Salix serissima</i>	Autumn Willow
40.	<i>Myrica gale</i>	Sweet Gale
41.	<i>Alnus incana</i>	Speckled Alder
42.	<i>Betula pumila</i>	Dwarf Birch
43.	<i>Corylus cornuta</i>	Beaked Hazel
44.	<i>Ribes americanum</i>	Wild Black Currant
45.	<i>Ribes cynosbati</i>	Prickly Gooseberry
46.	<i>Ribes hirtellum</i>	Wild Gooseberry
47.	<i>Ribes lacustre</i>	Bristly Black Currant
48.	<i>Ribes triste</i>	Wild Red Currant
49.	<i>Amelanchier arborea</i>	Shadbush
50.	<i>A. humilis, laevis, sang.</i>	Juneberry, etc.
51.	<i>Aronia melanocarpa</i>	Chokeberry

52.	<i>Crataegus</i> sp.	Hawthorn
53.	<i>Physocarpus opulifolius</i>	Ninebark
54.	<i>Potentilla fruticosa</i>	Shrubby Cinquefoil
55.	<i>Prunus pensylvanica</i>	Pincherry
56.	<i>Prunus pumila</i>	Sandcherry
57.	<i>Prunus virginiana</i>	Chokecherry
58.	<i>Rosa acicularis/blanda</i>	Wild Rose
59.	<i>Rosa palustris</i>	Swamp Rose
60.	<i>Rubus canadensis</i>	Smooth Blackberry
61.	<i>Rubus idaeus</i>	Wild Red Raspberry
62.	<i>Rubus pubescens</i>	Dwarf Raspberry
63.	<i>Sorbus decora</i>	Mountain-ash
64.	<i>Spiraea alba &amp; latifol.</i>	Meadowsweet
65.	<i>Rhus typhina</i>	Staghorn Sumac
66.	<i>Ilex verticillata</i>	Winterberry
67.	<i>Acer spicatum</i>	Mountain Maple
68.	<i>Acer pensylvanicum</i>	Striped Maple
69.	<i>Nemophanthus mucronata</i>	Mountain-holly
70.	<i>Rhamnus alnifolia</i>	Alder-leaved Buckthorn
71.	<i>Parthenocissus vitacea</i>	Virginia Creeper
72.	<i>Vitis riparia</i>	Riverbank Grape
73.	<i>Dirca palustris</i>	Leatherwood
74.	<i>Shepherdia canadensis</i>	Buffalo Berry
75.	<i>Cornus alternifolia</i>	Alternate-leaved Dogw.

**TABLE V2 (Cont.)**

**Tree and Shrub species Designation**

<b>NUMBER ASSIGNED</b>	<b>LATIN NAME</b>	<b>COMMON NAME</b>
76.	<i>Cornus obliqua</i>	Silky Dogwood
77.	<i>Cornus rugosa</i>	Round-leaved Dogwood
78.	<i>Cornus stolonifera</i>	Red Osier Dogwood
79.	<i>Chimaphila umbellata</i>	Pipsissewa
80.	<i>Andromeda glaucophylla</i>	Bog-rosemary
81.	<i>Arctostaphylos uva-ursi</i>	Bearberry
82.	<i>Chamaedaphne calyculata</i>	Leatherleaf
83.	<i>Gaylussacia baccata</i>	Black Huckleberry
84.	<i>Kalmia angustifolia</i>	Sheep-laurel
85.	<i>Kalmia polifolia</i>	Bog-laurel
86.	<i>Ledum groenlandicum</i>	Labrador Tea
87.	<i>Vaccinium angustifolium</i>	Low Sweet Blueberry
88.	<i>Vaccinium macracarpon</i>	American Cranberry
89.	<i>Vaccinium myrtilloides</i>	Velvet-leaf Blueberry
90.	<i>Vaccinium oxycoccos</i>	Small Cranberry
91.	<i>Diervilla lonicera</i>	Bush Honeysuckle
92.	<i>Lonicera canadensis</i>	Fly Honeysuckle
93.	<i>Lonicera dioica</i>	Glaucous Honeysuckle

94.	<i>Lonicera hirsuta</i>	Hairy Honeysuckle
95.	<i>Lonicera oblongifolia</i>	Swamp Honeysuckle
96.	<i>Sambucus canadensis</i>	Elderberry
97.	<i>Sambucus pubens</i>	Red-berried Elderberry
98.	<i>Symphoricarpos albus</i>	Snowberry
99.	<i>Viburnum lentago</i>	Nannyberry
100.	<i>Viburnum rafinesquianum</i>	Downy Arrow-wood
101.	<i>Viburnum trilobum</i>	High-bush Cranberry
102. (Add.)	<hr/>	

TREES (According to Hosie: Native Trees of Canada)

SHRUBS (According to Soper and Heimbürger: Shrubs of Ontario)

Most of the attributes defined in Table V1 were selected from a working paper on vegetation classification developed by a group of ecologists from across Canada headed by Wayne Strong a consultant at Edmonton. However, a substantial number of modifications were made so as to take the characteristics of the vegetation in the study area into account. In defining attributes, some additional factors considered were representativeness, valued communities, and species. However, wetland/upland boundaries are defined using different criteria (see attribute section below).

The unique vegetation zones or polygons identified in the survey have been entered into the SPANS database as BVEG.map. A comprehensive SPANS data file has also been developed which contains all of the vegetation attributes collected for each of these polygons (BVEG.tbl).

## **Field Work**

The field methodology underwent considerable discussion and field testing before being finalized. The "Vegetation Checksheet" (Table V1), and the list of tree and shrub species (Table V2) present the attributes and subattributes of the vegetation which were documented during field work.

This vegetation inventory is based upon the following time spent in the study area:

- i) 2 hours overflight in a small plane in early May;
- ii) 2 days preliminary ground reconnaissance May 9 & 10 with Canadian Parks Service staff;
- iii) ground truthing with assistant May 26 to June 1, July 3 to July 15, August 17 to 25 and September 12 to 17.
- iv) 2 days ground truthing by Doug Sweiger (Park Warden) in October to check special areas.

The base for field work was the Maitland Warder "Ranch" just north of Crane Lake. The general strategy for all field work involved following known roads or trails wherever possible. Traverses, using a compass were essential in many of the more remote areas. Following is a description of the actual process involved in carrying out the field work and in preparing the final polygons.

An area to be documented was reviewed the previous evening using the 1:10,000 air photos and stereoscopic lenses, and a route planned. The aim of setting the field route was to traverse as many

vegetation ecotones as possible during the day and return to the starting point (usually vehicle). Circle routes were planned where possible.

Equipment in the field included an orienteering compass, 1978 aerial photos @ 1:10,000 (taken in summer), field check sheets, red, green and blue wax pencils for writing on the photos, field notebook, stereoscopic lenses for examining air photos (when necessary), lunch and plenty of water.

During field work, a key decision involved defining the boundaries of polygons. For each polygon, a check sheet was filled out in the field as one walked along. Decisions are made "in situ" as to the point where a fresh polygon should be recognized (due to a change in the canopy characteristics, dominant or subdominant species present, shrub characteristics, wetland/upland boundaries etc.). Occasional species (see Table V1) had no bearing upon polygon boundaries but were recorded (present only) if seen. Sometimes (especially during traverses with compass) stereoscopic lenses are used in the field. Compass use is mandatory when working from aerial photos to establish an accurate bearing. Sometimes, traverses to reach more remote wetlands or other puzzling vegetation features are absolutely essential. As one walked along "within a polygon" constant adjustments and changes are made to the vegetation checksheet so as to ensure that one is reasonably satisfied that all attributes of the vegetation in that particular polygon are fairly described.

Obviously, since one is walking a line (or following a road, trail, etc.) the data are linear and one only defines the boundary lines between polygons along that line. A great deal of extrapolation on the 1978 aerial photos was necessary to close in many polygons. In making the extrapolation, canopy characteristics were particularly important. Using the wax pencil, lines were drawn directly on the aerial photos, the field number of the corresponding checksheet entered and additional information entered in a notebook if required.

Satellite imagery photos were extremely useful both in planning the field traverses and later in extrapolating to complete the polygons. The three satellite image maps used were:

SPOT 1:30,000 - false colour;

Landsat thematic mapper 1:40,000 true colour, and

Landsat thematic mapper, bands 2,3 & 4.

The satellite imagery photos were particularly valuable for drawing accurate boundaries between deciduous and mixed forest and in locating isolated pockets of deciduous forest. Forest Management Inventory Maps (scale of 1:10,000) were used for transferring air photo data to larger maps and it was found that the FMI maps were generally accurate only for major ecotonal discontinuities such as alvar/canopied forest, open wetland/forest, and some others. Thus, a combination of field truthing, interpretation of 1978 aerial photographs (using stereoscopic lenses), satellite imagery and FMI maps was used to determine the final boundaries of the polygons.

## **DESCRIPTION OF VEGETATION BY ATTRIBUTES**

The following account of the rationale and field methodology follows the sequence of attributes as presented in Table V1. Discussion of the known significance of the various attributes is included here.

### **Upland/Wetland Boundaries**

Upland/wetland boundaries are defined by the criteria set out in the publication: An Evaluation System for Wetlands of Ontario South of the Precambrian Shield (Ministry of Natural Resources and Environment Canada 1984). Hence, it should be understood that these boundaries are based upon field judgement; they are not deduced by the SPANS system from the attribute data. The alternative approach - basing the boundaries upon attributes listed in the field data sheets would result in major errors entering the data base with consequences to the interpretation of other vegetation attributes.

The single criterion used to draw wetland boundaries is "the edge of wetland vegetation". This boundary is determined by trees and shrubs which are the principal objects of study for this biophysical inventory as well as on site judgement (coupled with extrapolations from maps, aerial and satellite photos) of a complex of factors in which the presence or absence of herbaceous wetland plants is taken into account



when available. This means that herbaceous vegetation (i.e., whether it is indicative of a wetland or upland state) cannot be used unless data from field work or air photos is in hand.

Some specific reasons why field judgement plus interpretation of aerial photos must be the basis for drawing wetland/upland boundaries include:

1. some key wetland species, as for example Red Maple and White Cedar very frequently grow in uplands along with a wide variety of upland natives. This means that were these species relied upon to draw wetland boundaries, major unacceptable errors would enter the data base;
2. some upland species, as for example White Pine, White Birch, and herbaceous species like the Canada Goldenrod are often found in wetland sites;
3. small areas of springs, seepage areas or narrow flood plains along permanent or intermittent streams contain wetland species in abundance and are indeed true wetlands. It would be virtually impossible to recognize such areas on the basis of attribute data and hence direct establishment of boundaries using judgement in the field (combined with aerial photos) is used; and
4. the activities of Beaver can and do create very complex upland/wetland interfaces in areas where beaver dams and floodouts are natural. For example, an area of upland forest flooded out 20 years ago but abandoned 10 years ago may now contain a complex of wetland and upland species and if an attempt were made to consistently apply attribute data to interpret vegetation categories of the area, major unacceptable errors would certainly result. Likewise, a freshly flooded upland forest in which upland trees and shrubs are dead or dying and where no wetland vegetation has yet invaded will be impossible to describe in a meaningful way. And finally, Beaver are native species and only now completing the recolonization of their "pre-fur trade" range. All beaver flood areas are considered to be future meadows, swamp borders or shallow water marshes. Therefore, any areas behind beaver dams where flooding has taken place in the past or is in fact present today has been designated as wetland and recorded as beaver maintained.

The above method of determining the limits of wetlands should meet management requirements in a practical way. Indeed, it appears to make no common sense to approach wetland delimitation in any other way. However, once wetland boundaries are fixed, vegetation attributes are applied in a manner identical to that of uplands.

## **Type of Wetland**

The wetland type (swamp, marsh, fen or bog) was determined according to definitions presented in Ontario's wetland evaluation system (Ministry of Natural Resources and Environment Canada, 1984). However, as the study area is very large, and wetlands (particularly very small ones) number in the hundreds, most could not be visited, and hence extrapolations from aerial photos were necessary. Thus, Figure VI excludes the numerous very small wetlands that are clearly visible on the aerial photos.

An important characteristic of wetlands is that several or indeed all 4 major types of wetland may occur adjoining or intergrading into one another. In the study area this was particularly true of sedge dominated fens and shallow water marshes.

Figure VI presents all wetlands of the study area which were visited or were otherwise large enough to be identified from aerial photos. The large majority of wetlands are fens. Beaver flooded wetlands are considered below.

## **Beaver Floods**

Many wetland areas (particularly, areas with meandering creeks) contain abundant evidence of past activities of Beaver. Beaver were, however, rare in the Park in 1988. Virtually every beaver dam was abandoned and indeed had been abandoned for many years. Upland areas immediately adjacent to lakes that were or are occupied by Beaver contain few if any of the tree species so favoured by Beaver - e.g. Trembling Aspen, although old stumps of Aspen are often common along borders of lakes and beaverfloods beneath solid conifer forest. Examples would be the north shore of Emmett Lake, the east side of North Andrew Lake, and numerous other areas.

Beaver flooded areas, past or present, have all been designated as wetlands on the grounds that Beaver may return when conditions are suitable for them in the future. Many such formerly flooded areas are indeed wetlands still - seasonally flooded wet meadows, shrub swamps or a combination of both.

Beaver flooded areas identified during the field work are shown in Figure V2. These should be considered the minimum areas known to be affected by Beaver. Even some of the larger lakes (Upper Andrew, Lower Andrew, Moore, Umbrella, Quenlin) have old beaver dams on their exit creeks. But during the 1988 field season, water levels were low and in many cases the beaver dam was located in dry land. Possibly, in some instances the Karst topography is also the cause of the lack of stream flow causing beaver dams to be located considerable distance away from the edge of a lake or pond. Such old beaver dams were obviously built during periods of high water levels.

### **Trees: % Canopy**

Judgments regarding % canopy cover were subjective. As a general rule, a >60% canopy means that the canopy of trees above 2 metres is closed or nearly so. Areas with closed tree canopies are ones where in a strong wind, tree branches would tend to touch from time to time. On the other hand <10% canopy would include an open and/or shrubby area where only a few trees were present. One of the aspects of tree canopies in the study area is the presence over large areas of a mixture of trees of virtually all age classes, particularly so in the more open alvar areas.

The importance of canopy for wildlife species and for its effect upon herbaceous and shrub vegetation is well known and there is a growing literature on the ecological importance of canopy. With the exception of alvar ridges and rock pavement, the development of full canopies in those areas capable of growing trees should be considered as one of the natural goals of the vegetation community (i.e., through time, the community at the site becomes more representative - see discussion below).

Figure V3 summarizes the % canopy cover of trees in the study area. The map shows open areas such as farm fields, pastures, fens, marshes and rocky alvar scattered about the study area. Semi-open forest (canopy 25 to 60%) includes areas where some soil or cracks on alvar are sufficient to support a modest forest. Canopies of over 60% occur in non-farmed areas where sufficient soil and moisture exist to support denser forest. The area covered by the various tree canopies is as follows:

		<b>Peninsula</b>		<b>Park</b>	
		<b>Area</b>	<b>Area</b>	<b>Area</b>	<b>Area</b>
		<b>(km sq)</b>	<b>(%)</b>	<b>(km sq)</b>	<b>(%)</b>
<10%	=	19.3	6	9.6	7.2
10 - 25%	=	16.4	5	18.0	7.5
26 - 60%	=	88.2	27	26.1	19.6
>60%	=	200.1	62	84.3	63.4

### **Trees: Conifer/Mixed/Broadleaf**

This attribute is not particularly difficult to judge but it should be recognized that within many of the polygons, considerable diversity in this attribute is present. For example, an area with a 25 to 75% mix may contain local pockets of >75% conifer or >75% broadleaf.

The ecological significance of the conifer/broadleaf attribute is varied. Winter cover is clearly provided by conifers for a wide variety of birds and mammals. White Cedar provides food for deer. In summer, many species of wildlife prefer conifer forests over broadleaf and vice versa. Conifers are obviously fire prone and therefore a greater diversity of habitat due to succession following fire can be expected.

Figure V4 presents the distribution of broadleaf, mixed and conifer forests in the study area. Area covered by three types of forest today are as follows:

	<b>Peninsula</b>		<b>Park</b>	
	<b>Area</b>	<b>Area</b>	<b>Area</b>	<b>Area</b>
	<b>(km sq)</b>	<b>(%)</b>	<b>(km sq)</b>	<b>(%)</b>
>75% conifer	116.4	36.3	49.5	36.5
Mixture 25-75%	154.3	48.1	63.4	46.7
>75% broadleaf	49.8	15.5	20.0	14.7

Deciduous forests are far more prevalent in the study area, including the Park than previous reports (Wickware, 1984) suggest. Significant areas of forest dominated by full canopied Sugar Maple with various deciduous subdominant trees occur in the areas around Crane Lake and toward Dyer Bay, north of Lymburner, Quenlin, around Upper Andrew and north of Emmett, southwest of Cameron and in many small pockets elsewhere as indicated on the map (Figure V4).

Areas which were cleared for agriculture all have deciduous (sometimes mixed) forest woodlots (particularly Sugar Maple) and the conclusion is inescapable that the natural forest communities in open farm fields (along the Dyer Bay Road and just southeast of Tobermory) were former deciduous forest.

Mixed forests occur over much of the study area, along the escarpment and in a broad but broken zone up the central and along the northern portion of the study area. Conifers dominate in a large area southwest of Miller Lake, at the south entrance to the Park and along major stretches of the Huron shoreline.

#### **Trees: Dominant/Subdominant/Occasional Species**

This attribute is "determined" by entering the assigned number of the tree species (Table V2) into the appropriate blank on the checksheet (Table V1).

Field truthing is essential to document this attribute. A decision was made to limit the number of possible dominants to two. Generally, this was satisfactory for in those cases where there appear to be 3 (or more) equally abundant tree species at one spot, some additional exploration of the area resulted in a satisfactory decision.

The particular tree species present in an area may have a powerful ecological chain effect upon the fauna. Nut bearing trees such as oaks and beech provide essential food for deer, bears, squirrels, chipmunks, mice and some birds. Other seed bearing trees such as Sugar and Red Maple, and catkin bearing birches and Ironwood provide food for grouse, squirrels, mice. And taken together many of these animals provide the essential basis for life of some avian and mammalian carnivores.

A dominant trees map has been prepared (Figure V5). It shows the complex mosaic of dominant species throughout the study area. In interpreting this map it needs to be borne in mind that the forests are only about 80-85 years old and that as described below, succession is still occurring. Thus, some forests are young (i.e., old fields) but others are site dependent (i.e., conifer mixes).

This map records areas where single species are sufficiently abundant in the community to be designated the principal dominant. When two species are present in roughly equal abundance, two dominants were designated. The designations on the map should serve only as general guides to forest dominants since pockets of other species frequently occur within each designated type. As well, combinations of dominants tend to occur together. For example, Jack pine occurs alone, with Cedar or with Red Pine but not with Sugar Maple; Cedar tends to occur with many other dominants.

A series of maps for some key tree species have been generated as part of this report (Figures V6, V7, V8, V9, V10 and V11). While these maps show how information on abundance and range of individual species can be obtained, it also indicates much of value to faunal habitat. Very old Sugar Maple trees (Figure V6) provide some of the best cavity and snag habitat for the range of wildlife (see section on tree cavities below). Red Oak (Figure V7) provides acorns, a high energy food for deer, squirrels, chipmunks and mice, all of which are essential for the maintenance of carnivore populations. Jack Pine distribution and abundance (Figure V8) is a fairly good index of fire hazard and areas where this species is dominant can be identified as being in a high risk category. Jack Pine also provides cones for Red Squirrel, possibly affecting future success of reintroduction of the Fisher, Lynx or Marten, all of which depend upon tree squirrels in part for their diet (Banfield 1974). Mature Hemlock (Figure V9), much like White Cedar offers excellent winter cover for deer. Beech and Red Maple (Figures V10 and V11) often produce abundant seed crops used as food by a variety of wildlife.

## **Trees: Height**

Tree height, summarized in Figure V12, is a relatively subjective and complex attribute. In many areas, particularly the more exposed alvar sites, one can find the height of trees to include seedlings, saplings, half grown, and fairly old individuals. Such areas are certainly in an early to mid successional state, developing in the decades ahead into ever taller forests, but with lower density of stems per unit area. The most prevalent "average height level" (excluding saplings) determined the particular subattribute which was checked for height. However, in many areas, particularly in the deciduous and mixed forests, fully developed canopies were present although height varied from less than 10 metres to over 20.

Obviously, given sufficient time for a fully grown forest to develop, the height of trees of the study area would be much higher than at present. This attribute can be used with discretion to assist in locating areas currently undergoing the slow successional change to fully mature forests. Discretion is required because the presence of tall trees means we have a permanent forested site but the presence of open areas with few trees may also be a natural long term condition as for example in exposed alvar or sedge dominated fens with scattered or dwarf trees. Alvar communities, where considerable rock pavement is present or where soils over rock is very thin can have complex succession patterns. Prolonged drought (or fire) can set back the direction of succession. Further, the process of soil formation from rock can take thousands of years and hence these communities can (in practical terms) be considered to be in a "steady state".

Height of forest, diameter of trees and spacing clearly reflect the stage of succession, although trees obviously will grow taller and quicker on deeper soils than on alvar. With the complex impacts of logging, fires, pastures and clearing over the past hundred years, the pattern of forest height in the study area is closely tied to these factors. Some of the more obvious intrinsic values of taller, older forests is their provision of cavities for wildlife species, rotting wood for ants, salamanders and other insects which in turn are food for wildlife. Canopies are also required by a range of woodland birds, warblers, vireos, Red-shouldered Hawks and the like. In future decades, wildlife species dependent upon fully mature forest ecosystems should increase in abundance assuming the present forests are managed in a manner which allow natural biological processes to continue.

The tree height map shows that the tallest forests today are found in scattered pockets: on the east and north side of Upper Andrew Lake, on the east side of Gillies Lake, some larger areas north of Emmett and Cyprus Lakes, and northeast of Umbrella Lake. For the most part these areas contain Sugar Maple, Large-toothed Poplar and some Beech, Red Oak and other species.

## **Shrubs: % Canopy**

In considering canopy characteristics of shrubs in the study area it is well to bear in mind that as many as 73 species may be present (according to Soper & Heimbürger 1985). However only fifty-seven species were found, indicating that the balance are very rare in the study area. Each species has its own particular capability to form canopies. Extremely decumbent species such as Creeping Juniper and Bearberry whose stems and branches lie flat on the ground were not distinguished in any of the canopy data (i.e., were included in the <10% range).

True canopies (i.e. >25%) were formed by only a few shrub species, the most notable being Round-leaved Dogwood, Mountain Maple, Staghorn Sumac (in abandoned fields and pastures undergoing succession to forest) and Leatherwood and Beaked Hazel (in some Maple-dominated deciduous woods. In wetlands, Sweet Gale, Shrubby Cinquefoil, Red-osier Dogwood, willows and Speckled Alder tended to form canopies to various degrees. All other shrub species occur mainly as individual plants or as isolated scattered individuals. As a general rule, except where canopies are recorded as >25% and particularly >60%, the ecological value of canopy per se is probably minimal.

Shrub canopies, when present, are obviously important ecologically. For example, willow swamps, shrub dominated fens, mixed escarpment forests with solid canopies of Mountain Maple, areas with "impenetrable" Round-leaved Dogwood canopies, or areas of Sugar Maple/Beech forest with Leatherleaf or Beaked Hazel, all provide protection from intense sun, hiding places from predators, bird feeding and living areas, and other benefits to many species. As noted earlier, the role played by canopies in influencing faunal species is a growing field of study. While the dominant uppermost canopy (whether tree or shrub) is clearly important, special studies would be required to comprehend the role which multilayered canopies play in helping to define or maintain the integrity of the local ecosystem.

Figure V13 summarizes the data on shrub canopy for the study area. This figure should be interpreted with the caveat noted above. In other words, <25% represents only scattered individuals and may have little or no value as canopy to wildlife. However, the mere presence of certain species may provide essential food for host-specific or host-selective herbivorous vertebrates and invertebrates. Dense shrub canopies (>60%) are not at all common with small areas in the vicinity of Gillies Lake, the Wingfield Basin and more local areas along the northern escarpment to Tobermory falling into this category. As well, occasionally either Common or Creeping Juniper occasionally can form locally dense canopies.



### **Shrubs: % Evergreen/Broadleaf**

The term evergreen as applied here refers only to species numbers 29, 30, and 31 (Table V2), all of which are Gymnosperms. A number of broadleaf species do retain their leaves over the winter, as for example some members of the Blueberry Family (Ericaceae) but these were placed in the broadleaf category.

In assessing the biological significance of this attribute, perhaps the most important point to consider is that the two most abundant evergreen shrubs (Common and Creeping Junipers) occur in open alvar and other disturbed cleared areas where they no doubt provide cover for ground dwelling fauna and affect the microclimate during hot, dry spells in the summer. The Common Juniper in particular is an aggressive invader of repeatedly burned, logged areas, overgrazed pastures and abandoned fields. Hence, it clearly became quite abundant throughout the peninsula in the earlier part of this century. Remnants of this evergreen shrub are found throughout much of the forests. Since both Junipers are shade intolerant, they cannot survive in areas with well developed overhead canopies. In areas where forests can develop a full canopy, these species will largely disappear. Hence, their presence in abundance can be used to some degree to measure succession although they should remain abundant on rocky shorelines, drier alvar ridges and flats and various disturbed areas.

### **Shrubs: Dominant/Subdominant/Occasional**

The application of this attribute was identical to that of trees. However, many forested areas lacked shrubs, or various shrub species were present only as an occasional scattered individual. Hence the meaning of "dominant" when applied to the presence of only a single record of a shrub in a polygon can be misleading if not clearly comprehended for purposes of data analysis. Thus a "dominant" shrub may not be common at all but rather it was simply the most abundant of shrubs found. For this reason it is not considered useful to generate a map from this particular attribute. Unless shrubs were present in any significant abundance, the <10% canopy characteristic was checked. More often than not, the <10% meant <1%.

The ecological significance of the relative abundance of shrub species derives from their structural characteristics, food provided for various faunal herbivores such as pollinating insects. For example, very

early in the spring, all willows and Leatherleaf offer an abundance of nectar and pollen, enabling populations of emerging pollinators to sustain themselves and establish nests, thus affecting the abundance of these pollinators later in the season.

Figure V14 shows the primary locations of both species of Juniper in the study area. Areas along the Huron coast marked between 25 and 60% shrub cover obtain this rating as a result of Common Juniper and Creeping Juniper, both of which are sometimes abundant. The white areas on this map should not be taken as "juniper free"; rather, they reflect the relative rarity of these evergreen shrubs due mainly to canopy closure of overhead forest canopies, agriculturally cleared lands or wetlands.

In mixed forest from the Wingfield Basin to Tobermory, the Round-leaved Dogwood is the most dominant shrub often forming impenetrable thickets.

### **Shrubs: Height**

This attribute was relatively easy to check but in reality, height is largely a function of the particular species involved. Unlike trees, which may take several hundred years to attain their full height, most shrub species in the study area were already at the full height, or nearly so, depending on disturbance, etc. Thus, as a general rule, height can be deduced from the presence of the species itself, and interested individuals can seek such information from published floras, when and if required.

### **Open Upland Areas: % Cover**

Open upland areas include agricultural fields, pastures and formerly cleared but now abandoned land in which early successional forests - usually a mix of young trees and invading shrubs. But mainly the areas are dominated by non-woody vegetation. The percent cover depends upon the estimated percent cover of woody vegetation. Care was taken to ensure that total cover of trees, shrubs and herbs did not exceed 100%.

This attribute is highly significant to future park management. This is because artificially cleared forests are not representative of National Park lands. Clearly, it is these areas that would become the focus of environmental restoration efforts in future since a key management goal in the National Parks is to allow natural processes to prevail.

The area analyses of open uplands follows:

		<b>Peninsula</b>		<b>Park</b>	
		<b>Area</b>	<b>Area</b>	<b>Area</b>	<b>Area</b>
		<b>(km sq)</b>	<b>(%)</b>	<b>(km sq)</b>	<b>(%)</b>
>75%	=	23.06	27.31	5.39	16.90
25 - 75%	=	5.08	6.02	3.18	9.97
5 - 25%	= 49.22	58.29	20.68	64.88	
<5%	=	7.06	8.37	2.63	8.25

Of course, agricultural fields, whether still in use or abandoned, harbour numerous species which would otherwise not be present - the Upland Plover, Killdeer, various sparrows, Bobolink, Canada Goose, Eastern Meadowlark, and others. As well, the abundance of voles in fields and early successional forest can mean that carnivores such as the Coyote, Red Fox, various raptors may be present in greater abundance than if the areas were in their natural state.

#### **Open Upland Areas: % Type of Cover**

As this biophysical survey was intended to describe only the general characteristics of the vegetation and as there are hundreds of herbaceous species in the study area, this attribute was designed to measure only the graminoid/forb mix of species present.

The >75% graminoid would suggest agricultural fields, while forbs generally increase after land is abandoned. Open alvar areas, which were also scored under this attribute would naturally contain a mixture.

The amount of forbes in open upland areas increases following the abandonment of agricultural lands and is highest in open alvar areas.

### **Open Wetland Areas: % Cover**

Open wetland areas are ones where trees and shrubs are absent. If a designated polygon in an open wetland area contains some trees and shrubs, this is recognized under the <10% canopy attribute (Sections 4.3.4 and 4.3.8 above).

Open wetlands include graminoid/sedge fens and marshes, two wetland types which grade into each other in subtle ways. These are among the most valued ecosystems in the study areas since open water (marshes) and open fens are used by many wildlife species (waterfowl, amphibians, Sandhill Crane, etc. etc.). Fens, and particularly ones which are highly calcareous or floating contain numerous rare plant species.

### **Open Wetland Areas: Type of Cover**

The purpose of this attribute is to provide a general picture of the nature of the vegetation present as well as to indicate whether open water is present. One can see that if "floating &/or submergents" were present, this would immediately provide critical clues to the nature of the habitat. The five types of cover identified follow closely the ones considered to be of ecological significance as defined in Ontario's wetland evaluation system (Ministry of Natural Resources & Environment Canada 1984).

The data in all the above wetland attributes (i.e., whether the wetlands contained trees, shrubs, herbs and/or open water) have been combined and included in the vegetation map (Figure V15) which shows the distribution in the study area of all swamps, marshes, bogs and fens within the context of principal upland communities.

The map indicates that fens are the most prevalent in the study area although many of them are small. Other major wetland areas are identified and discussed below in the section on vegetation communities.

### **Unique or Special Event Data**

A number of attributes were identified to ensure that they were kept in mind during field truthing, and recorded in the checksheet.

**Floating Fen Mat:** Floating fen mats are considered to be an extremely important vegetation type for 2 reasons: first, they are very old ecologically and once destroyed, would take thousands of years to "grow" back to their present state; second, they invariably contain rare orchids and other species of plants and probably animals, particularly insects. They are also fragile environments and need attention through the management of people.

**Fire Hazard:** While the vegetation checksheet includes a section for scoring fire hazard, field work soon demonstrated that data entered in other parts of the checksheet provided superior information on fire loading and indeed a fire hazard map (showing a graded scale of fire hazard) has been generated from the data and is presented in the Data Analysis section of this report. The greatest incendiary potential lies in Jack Pine and other coniferous forests and open wetland areas where the percentage of vegetation cover is high.

**Tree Cavities:** The presence (and potential presence) of tree cavities is an important attribute. Older forests with numerous trees having woodpecker holes, rotted out trunks and branches and with large trees rotting about on the ground provide for a marked enrichment of the ecosystem because many wildlife species can nest and seek shelter. The forests of the study area are young (i.e., many of them date back to the fire of 1905) and trees have not yet had the time required to develop their full potential as elements in the natural ecosystem. As noted earlier, it would take about 300 more years for the forests of many parts of the study area to approach their "normal" ecosystem goal. However, some cavities were noted in older trees. A subjective estimate is that the forests today contain less than 5% of the number of cavities that will be available once natural processes are allowed to operate for several hundred more years. Areas where the tree height is >20 m would be ones where tree cavities would be expected to become more prevalent sooner. However, it should be noted that any forested areas subject to beaver flooding, and where dead trees are common, are favoured places for Downy, Hairy, and Red-headed Woodpeckers to build nests and indeed many such cavities were recorded for such swamps. As an aside, competition with Starlings at such open nest sites is severe.

It should be noted that (with the exception of the specialized cliff cedar communities) because old growth forests of the study area have been completely destroyed, and because it will take many more decades for such forests to redevelop, few trees with major rotted trunks or snags were observed during the entire field season. Thus the process of natural decay of trees which have reached their optimum size and

age is not yet apparent in the study area. Rather, holes excavated by woodpeckers are today one of the principal causes of the presence of larger cavities. Pileated Woodpecker cavities were observed in only a few areas; nestholes were noted in the tall forest immediately east of Upper Andrew Lake. Otherwise woodpecker holes were most prevalent in recent and old beaver floods where Downy, Hairy and Red-headed woodpeckers have left the evidence of their work on dead tree trunks. The data are insufficient to generate a meaningful map.

**Soils:** A special effort was made to note down areas with either alvar or sand. Both these rock/soil types have a major bearing upon the vegetation that can potentially develop. Rare or otherwise beautiful wildflowers can be found on either. This subattribute was used only to confirm open alvar areas and sandy spots and incorporated elsewhere in this chapter and report.

**Other (Vegetation) Data:** On the vegetation checksheet, a special category was created for "other" data. This usually included what were considered to be potentially useful comments upon the vegetation, data from increment borings, and notes on ecological processes, cause and effect phenomena for use in general discussions of the vegetation elsewhere in this chapter. As well, some of the data entered here is the basis for Tables V4 (increment borings & sizes of trees) and 5 (old trees and stump information), and these matters are discussed in appropriate sections below.

**Wildlife Notes:** Wildlife notes were kept throughout the field work but included only species which were thought to be of interest in the study area. For example, a pair of Yellow-billed Cuckoos were seen at Upper Andrew Lake, Sandhill Cranes at Crane Lake, staging waterfowl at Marsh Lake and Red-headed Woodpeckers at Crane Lake. This information may be of value in future ecological and management work on wildlife and has been included in the database. As well, the original field data books can be consulted by future workers if and when required. The field books and notes are on file at the Ontario Region and Park libraries.

## **HISTORY OF THE VEGETATION AND ITS SUCCESSIONAL GOALS**

An understanding of the history of vegetation can provide clues to its present condition, to current succession trends and to some degree, the ultimate goals of the vegetation communities. Clues to the history of vegetation come from:

1. historical records based upon first hand descriptions or observations including interviews with long time residents, and

2. inferences drawn from evidence present in the field including:

- a) age and size of present tree species - because generally botanists know the maximum age and size that any particular tree species can attain on suitable sites if natural processes are allowed to prevail. For example, it is known that trees like White Pine or Sugar Maple can attain diameters a metre or more at breast height, while White Cedar can attain diameters of nearly a metre and ages of many hundreds of years;
- b) size of remnant old stumps such as White Cedar (which is slow to decay) or annual ring counts in any old stumps or trees that have not yet fully decayed;
- c) past fires as indicated by charred stumps and logs;
- d) inferences from site potential such as alvar, cliffs, natural wetlands, and other physical features.

Evidence of various kinds on all of the above has been assembled with the aim of interpreting and understanding the vegetation patterns in the study area and gaining some insights into its future successional goals.

Two studies have been recently completed on the early history of St. Edmunds Township (Folkes 1974; Wyonch 1985) and these provide some general insights into the original state of the vegetation at the time of European settlement of the area.

A brief unreferenced description of the vegetation of St. Edmunds township appears in the chapter on lumbering in Wyonch (1985) distilled presumably from various old records. It states:

"...In St. Edmunds, primeval forests of rich and valuable timber waited for the timber men. In the east lay the hardwoods; maple, beech, elm, oak, ash and birch. In the west lay the conifers; spruce, cedar, tamarack, hemlock, and the pine which was considered to be the most valuable. For these

prizes the timber barons would compete, striving to denude the land as quickly and as efficiently as possible".

With the exception of age and size of trees, and possibly understorey characteristics, forest composition today is probably not much different than that described above and there are few biological reasons for claiming that major changes should be expected following only fires and cutting. Agricultural activities, however, can and do affect major changes but even these have to be maintained artificially. Given sufficient time (measured in many hundreds (and sometimes thousands) of years, natural processes would work to produce a forest very similar to those originally found in the study area, assuming climate and other major factors remained equal.



One kind of data which does not seem to exist in the records is the actual size of the larger pines, maples and other trees which were cut. There are many references to the cutting of fence posts and railway ties and many indications that with the exception of highgrading for White Pine vast areas of smaller trees were regularly cut.

On fires Wyonch (1985) reports:

"in 1869 a surveyor by the name of Charles Rankin resurveying the Bury Road reported that there were many areas that were burned out, a sure sign of bush fires";

"in 1884 brush fires and poor crops dealt the settlers a severe blow";

"The year 1903 was another distressful year for the people of St. Edmunds... During that summer, brush fires began on August 21, and continued until a downpour washed out the blaze on August 24.

"In 1906, timbering in St. Edmunds experienced a slowdown due to lack of snow.."

"The greatest catastrophe that ever hit the land of St. Edmunds occurred in 1908. A great brush fire razed the Bruce Peninsula destroying everything in its path. The damage done to the southern section of St. Edmunds paled the damages done by fire in 1903."

Folkes (1974) notes that a directive was issued by the Superintendent of Indian Lands allowing settlers to obtain a licence to "cut and remove Railway Ties, Telegraph Poles, Tamarack Knees, Shingle Bolts,, Cordwood and Hemlock,..." and that in 1877 this directive was amended by Order in Council to include the disposition of "all pine trees of larger growth than twelve inches in diameter at the butt,..." In 1888 the restriction was lifted and "any bonafide actual settler" was permitted to buy "the Pine and Spruce Timber thereon, on such terms as....".

The above indicates that coniferous forest trees of substantial size and of several species were abundant.

Elliott (1962) describes the forest of the Bruce Peninsula during the period of European settlement. He notes that "At that time the entire Peninsula contained huge stands of white pine. The remains of the stumps and old timbers can still be seen today in some areas." But no reference to this information is given. Elliott notes that lake schooners sailed to Stokes Bay (considerably south of the study area) to pick up loads of White Pine.

Today, due to the fires and cutting, the forests of the study area are young and, with some exceptions (as noted below), are uniformly less than 90 years old. The oldest trees in these forests date back to an intense 3-day fire which swept a large part of the Township in 1903 and another which burned the southern part of St. Edmunds in 1908 (Wyonch 1985; Maitland Warder pers. comm.). It is of interest that Maitland Warder noted that "even when I was a boy, you could see right across the peninsula in many areas." A wealth of circumstantial and direct field evidence suggests that this is indeed the case for most areas. Charcoal remains are everywhere. In some spots, however, increment borings and "ring- counting" of tree stumps (Table V3) on cut lines or trails indicates that more recent fires also occurred. In examining the data in Table V3 one needs to bear in mind that during the field work, an effort was made to seek out the largest trees. Thus, trees larger (or older) than the ones indicated in Table V3 do not exist or are very rare. And in all cases where tree age was greater than 86 years, evidence from the site indicates that a small local patch survived the fires following the turn of the century. Some of the forests around Bartley Lake, a swamp just north of George Lake (along the cut line) and some patches of cedar swamp along the shores of Lake Huron were the only areas of the Park which were found to have escaped the fire but it should be noted that these oldest trees would have been only several dozen years old (likely remnants of earlier local logging or fires). However, no studies of White Cedar growing on the escarpment face were carried out during field work. It is the escarpment White Cedars (although they are relatively small) which are the oldest trees in the study area. Doug Larson, of the University of Guelph, has recently counted the number of rings on trees (unpublished data) from escarpment face White Cedar to be in the many hundreds (highest was 550) indicating that the "face of the escarpment flora" is virtually unchanged by the activities of humans.

**TABLE V3**

**Age at DBH of Various Tree Species at Bruce Peninsula National Park  
in 1988 (in Rement Bored, Largest Trees Only)**

<b>Species</b>	<b>D.B.H in cm</b>	<b>Age in Years</b>	<b>Location in Study Area and Other Comments</b>
Quercus rubra	49 45 49	70-75 79 150	polygon 91; end of road northwest of Emmett Lake polygon 91; end of road northwest of Emmett Lake polygon 166; east of Bartley Lake
Acer saccharum	51  51 58	70+  85 86	polygon 91; end of road northwest if Emmett Lake; hollow centre polygon 166; east of Barley Lake polygon 186; W of small lake just NW of Crane Lake;
Acer rubrum	?	110+/-5	polygon 105; escaped fire of 1903 this is a swamp
Populus tremuloides	24	85	polygon 94; east of Cave Point; largest poplar here
Populus grandident	36	100	polygon 160; just SW of Bartley L.
Thuja occidentalis	23 2866@ ? 48	69+  57 185	polygon 94; east of Cave Point largest tree but hollow centre polygon 100; north of George Lake stump cut line E border Indian Reserve polygon 100; near W end of Lower Andrew Lake; largest cedar here polygon 151; near-coast swamp due W of Dorcas Bay; escaped "fire of 1903"; some other large cedars too

**TABLE V3 (Cont.)**

**Age at DBH of Various Tree Species at Bruce Peninsula National Park  
in 1988 (in Rement Bored, Largest Trees Only)**

Species	D.B.H in cm	Age in Years	Location in Study Area and Other Comments
	33	185	polygon 161; just W of Bartley Lake this swamp escaped "1903 fire"
	27	64	polygon 179; S of George Lake, on cut line W of Ind. Reserve
	22	71	@polygon 271; between Moore & Upper stump Andrew Lakes
	21	68	@polygon 271; between Moore & Upper stump Andrew Lakes; largest stumps
Picea glauca	30	81	polygon 94; east of Cave Point largest tree here
Pinus strobus	29	75-80	polygon 94; east of Cave Point
	41	70	polygon 179; cut line S of George Lake next to Indian Reserve
Pinus resinosa	45	60	polygon 100; cut line N of George Lake, W end of Indian Reserve
	46	85	@polygon 100; cut line N of George stump Lake, W edge of Indian Reserve
	42	86	polygon 162; W of Bartley Lake

**TABLE V4****Some Observations on Older Forests in the Study Area**

LOCATION	COMMENTS	DIAMETER @ STUMP
Polygon 10, NW of Cameron Lake	"occasional large stumps"	?
Polygon 102, 1100 metres SSE of S tip of Cameron Lake	Cedar remnant of old fire still with good annual rings	77 yrs ?
Polygon 160, NW of Bartley Lake	Dead White Pine	77 cm
Polygon 269, E of Upper Andrew Lake	"High quality natural ecosystem"; closest to old growth forest seen to date; 2 Pileated Woodpecker nest holes	not recorded
Polygon 294, E of Marsh L.	numerous large stumps of cedar (burned)	79
Polygon 339, E of Umbrella L. (N of Conley L.)	"at least 10 Beech trees with bear claw marks" AND Sugar Maple decline	
Polygon 347, Just W of Dyers Bay	severe Sugar Maple decline plus some other species	
Polygon 348, N edge of Crane Lake	Large old cedar stumps	60
Polygon 397, N side of Gilles Lake	burned after logging	84; 90
Polygon 402, N of Gilles Lake	Pileated Woodpecker nesthole	
Polygon 513, 1.6 km N of Crane Lake	old cedar stump	ca. 80

One of the striking aspects of the vegetation in a great many places (especially the eastern half of the study area) is the presence of large stumps, dating back to fierce cutting and fire (see Table V4) of the turn of the century. Whether the cutting which produced the stumps took place before the fire or whether many of the stumps resulted from post-fire salvage operations is not known. Likely, it was the former. At one spot (just north of Gillies Lake) fire clearly followed the cutting of an extensive forest of White Cedar trees.

The existence of evidence of past tree size and of fire is important to management because it defines quite well some key ultimate goals of the vegetation. For example, not only are stumps found throughout the study area but also, trees in the better sites (lowlands or deeper soils or both) regularly reached a size of nearly a metre in diameter. One fire scarred White Cedar, about a kilometre SSE of Cyprus Lake still had not decayed and had an estimated 337 annual rings (most of which were perfectly countable). Its time of death presumably dates back to the fire. Thus, a conclusion to be drawn from the above observations is that the normal (i.e., relatively constant through time) ecosystem of the Park will require a minimum of an additional 250 years to develop, assuming a relatively stable world climate. Beyond the 250 years, additional time would be required for the ecosystem to attain its more or less dynamic steady state. The implications of these predictable changes in vegetation to future wildlife in the region are obviously important, as for example for cavity nesting or requiring animals & birds. Implications to any long term management considerations such as possible animal re-introductions are also significant.

Another line of evidence which indicates the direction of successional change comes from areas of coniferous forest (Figure V4). In many coniferous areas the forest is completing a transition to a more coniferous condition, a process whose origins dates back to the fires at the turn of the century. On the Huron coastline conifers of several species (White Cedar, Balsam Fir, White Spruce) dominate the immediate shoreline and may extend several kilometres inland. In this coniferous zone there is much evidence of remnant dead and dying Aspen and White Birch, with occasional living individuals or groups of these deciduous trees overtopping the conifers. This zone, already >75% conifer, promises to reach near 100% in the decades ahead, since there is only scant regeneration in the intense shade of the native conifers while the conifers themselves are found in all age classes from seedlings to large trees.

As one moves away from the shoreline into the mixed forest, both Aspen and White Birch may be present and sometimes dominate. However, again as a general pattern, the understory is controlled by ascending conifers and as the overtopping Birch and Aspen canopy trees topple, coniferous forest will predominate. This pattern of successional change is not surprising. Both Aspen and White Birch are shade intolerant species and due to their seed dispersal characteristics are among the first colonizers following

burns, and should there be a re-burn, the established saplings sprout from the root into the sunlight above. Should any of these areas be burned in future, both these deciduous species can be expected to become established immediately following the burn and the same cycle can be expected to start anew. The process of conifer succession can be readily seen first hand in many areas as for example, along the main road to Emmett Lake or just north of the Dorcas Bay Nature Sanctuary.

Some puzzling succession patterns were noted and these are described here for the record. One is the presence of sometimes extensive stands of young Balsam Fir (seedlings, and saplings to 2 metres tall) among the remains of a completely dead (and almost completely decayed) Balsam Fir forest (trees broken off & many stems 10 to 25 cm. dbh.) all in a forest of scattered older White Cedar. Polygons 142 and parts of 391 (both S of Johnson Harbour) on the Huron shore are the best examples of this phenomenon whose explanation probably lies in Spruce Budworm herbivory upon older Balsam Fir stands several decades ago. A similar puzzling vegetation succession phenomenon occurs where extensive stands of young Balsam Fir (again, seedlings to saplings up to several metres tall) occur under what is otherwise a well developed deciduous forest dominated by Sugar Maple and/or Large-toothed Poplar. This occurs in polygons 4 (N of Horse Lake), 82 (E of Emmett Lake), 83 (N of Upper Andrew), 87 (SW side of Emmett Lake), 89 (W of Emmett Lake), 91 (.5 km N of Bartley Lake), 110 (N of George Lake), 185 (NW of Crane Lake); 276 (N of Moore Lake), 292 (SW of Quenlin Lake); 294 (1.5 km S of Umbrella Lake), 406 (W of Conley Lake) and 410 and 411 (both N of Emmett Lake) (see Figure V15). In interpreting the above, it should be noted that older Balsam Fir trees are found scattered throughout the study area and particularly as individuals or small groups in the mixed forests as defined in Figure V4. It may be that here at the tip of the cool Bruce Peninsula, Balsam Fir is a "normal" element of the rather extensive areas of deciduous forest but that its ability to survive in dense stands (such as will surely develop in all or parts of the above polygons) is governed by the shade tolerance of its seedlings and saplings but also by the natural herbivory of the Spruce Budworm and its pronounced cycles whose high points were likely fixed by the fires of the early 1900s (when more or less uniform aged Balsam Fir stands would have started afresh).

The often rocky terrain coupled with a variety of efforts by the Ministry of Natural Resources at protecting vegetation from fire and logging have enabled the natural processes of succession to operate. Hence, patterns and directions of succession are emerging, and (with the exception of areas still in agriculture), the natural local ecosystems of the study area have slowly reasserted themselves. Indeed sufficient time has passed since the widespread fires of the turn of the century to enable succession to rebuild forests which, we believe, have some considerable similarity (although they are still much younger) to those of the past.

A succession map (Figure V16) for uplands has been produced from the attribute data using combinations of tree height and open upland cover. Here are the attributes:

Pre-Succession	:percent open upland < 75%
Very Early Succession	:minimum tree height = 1 m maximum tree height = 3 m percent open upland 25-75%
Early Succession	: minimum tree height = 1 or 3 m maximum tree height = 10 m percent open upland 25-75% <u>or</u> 5-25% <u>or</u> <5% <u>AND</u> minimum tree height = 1 or 3 m maximum tree height = 20 m percent open upland 25-75%
Mid Succession	:minimum tree height = 1 or 3 or 10 m maximum tree height = 20 m open upland cover 5 to 25%
Late Succession	: minimum tree height = 20 m (i.e., trees are 20 m+) open upland cover <5%

As the above suggests, the phenomenon of succession in the study area is not at all simple and therefore the succession map should be seen as only a very general guide to the successional stages of the upland forest today. No "true" succession map can be created from the attribute data because of the complexity of interaction of the subattributes. On the basis of the above selected attributes the most "advanced" communities are the Sugar Maple dominated forests. Large areas throughout the peninsula are now in the "early to mid succession" stage. The "pre-succession" stage is primarily farm fields although some alvar communities have been identified by the attribute combinations selected. It should be stressed that slight alterations in the above attributes could be tested. This would result in some modifications of Figure V16 but



would not necessarily be more accurate in view of the complexity of the phenomenon of succession in the study area.

## **PRINCIPAL VEGETATION COMMUNITIES TODAY**

For practical purposes, it is convenient to delimit and describe the most important plant communities of the study area. Yet, how does one draw boundaries and what sort of rationale can be advanced to justify them?

### **Historical Perspective**

The first attempts at a scientifically based description of the vegetation of the study area were those of Cuddy et. al. (1976) whose three main groupings were adopted by Wickware & Shiefer (1987) with further subdivisions. This is historical information and not the basis for community groups in this report (these are provided after this historical account).

#### **Lake Huron Shore**

- Coastal shrub and herb associations
- Backshore mixed wood scrubland forest
- Coastal wetlands

#### **Georgian Bay Shore and Escarpment Complex**

- Coastal forest and shrub associations

#### **Inland Rock Pavement and Wetlands**

- Upland mixed wood forest associations
- Upland coniferous forest association
- Open scrubland association
- Wetland forest swamp association
- Open wetland associations

The classification of upland communities (which follows) has some similarities to the above historical groupings of Cuddy et. al. (1976) and Wickware & Shiefer (1987). The major difference is that the present inventory recognizes deciduous forest as a separate community. As well, this vegetation inventory does not recognize the escarpment itself as deserving of a special grouping because the attribute data do not reveal the escarpment as deserving of any distinct category. Further, this inventory makes no distinction between coastal and inland wetlands but rather uses wetland types (swamp, fen, marsh and bog) as the basis for wetland groupings a practical approach which is identical to that used in evaluating wetlands of the province (Ministry of Natural Resources and Environment Canada, 1984).

### **Classification System (1988)**

The divisions below should be seen as recognizing that there are dozens of tree, shrub and herb species that can be used either individually or in combinations to define vegetation communities, and just how many species and which ones one uses is largely a matter of belief or opinion (or as in the case of this report - of practical application) rather than one which is subject to some kind of scientific test. And once one begins to combine the actual vegetation characteristics of a spot with physiographic features, boundaries can become quite abstract, as indeed is the case in the above Wickware & Shiefer presentation.

It would appear that on the basis of a number of authors as well as literature on population biology generally that the only scientifically defensible delineation of "natural limits" of any vegetation zone should best be based on a view first put forth by Gleason (1926) who noted that:

"...it may be said that every species is a law unto itself, the distribution of which in space depends upon its individual peculiarities of migration and environmental requirements. Its disseminules migrate everywhere, and grow where they find favourable conditions. The species disappears from areas where the environment is no longer endurable..."

For the above reasons, communities are delimited strictly for purposes of practical application (Figure V15). In forests, dominant tree species together with percent composition of the deciduous/conifer mix are the principal attributes used (see Figure V4). As well, alvar communities, since they tend to be open (savanna-like) to various degrees and agricultural fields (major human destruction of local ecosystems) also

are worthy of recognition since both the 3-D ecological structure of the communities as well as species composition are radically altered.

The communities as defined by SPANS maps are based upon original field data obtained during the 1988 field season as outlined earlier in this chapter and elsewhere in this report. Previous studies of vegetation, particularly those of Morton & Venn (1987) for the Tobermory Islands and the literature review by Wickware & Shiefer (1987) for the Park helped to provide a framework for defining attributes (Table V1) developed for the SPANS system. But while, as noted above, there are strong similarities between the vegetation communities recognized here and those of previous authors, it must be stressed that the descriptions which follow are based largely upon original data obtained directly in the field and that the groupings are calculated to have practical application to management. As well, the attributes of vegetation used in this study were adopted following many discussions, meetings and field trips with a number of staff of the Canadian Parks Service at the Park, in the regional office at Cornwall and at Headquarters. Hence, while this study builds upon previous works and knowledge, an entirely new set of vegetation data has been obtained using attributes not previously used in vegetation studies in this national park.

The 9 groupings (5 upland and 4 wetland; Figure V15) which follow provide only simplified, practical descriptions of the vegetation communities. When one gets to visit the many different parts of the study area, the full extent of vegetation diversity gradually becomes more evident. The casual observer generally does not get to see or experience the tremendous vegetational diversity of the study area. Plant communities are of many types and succession phenomena create a changing, dynamic mosaic.

Wetlands of the study area, since they tend to be open are less subject to long term impact by fire than are uplands. Open wetlands, since they are comprised of grasses, sedges, forbs and shrubs recover much more quickly from the effects of fire and hence, for the most part, wetlands are considered to be quite similar today to those during settlement days.

Vegetation of wetlands is more complex and diverse with regard to vegetation types and dominant species present. All four types of wetlands described in Ontario (Ministry of Natural Resources & Environment Canada 1984) are present, namely swamps, bogs, marshes and fens, with fens being by far the most abundant although many are very small. The distinguishing characteristics of the 4 wetland types are outlined in the above noted publication. They are:

"BOGS are peat-covered areas of peat-filled depressions with a high water table and a surface carpet of mosses, chiefly Sphagnum. The water table is at or near the surface in the spring, and slightly below during the remainder of the year. The mosses often form raised hummocks, separated by low, wet interstices. The bog surface is often raised, or if flat or level with the surrounding wetlands, it is virtually isolated from mineral soil waters. Hence, the surface bog waters and peat are strongly acid and upper peat formed in situ under closed drainage and oxygen saturation is very low. Although bogs are usually covered with Sphagnum, sedges may grow on them. They may be treed or treeless, and they are frequently characterized by a layer of ericaceous shrubs."

"Bogs are almost always covered by Sphagnum, and are usually dominated by a low layer of ericaceous shrubs. Herbaceous species specifically adapted to bogs are usually present, such as a number of sedges and cotton grasses. Bogs may be open or treed with black spruce or occasionally tamarack."

"FENS are peatlands characterized by surface layers of poorly to moderately decomposed peat, often with well-decomposed peat near the base. They are covered with a dominant component of sedges, although grasses and reeds may be associated in local pools. Sphagnum is usually subordinate or absent, with the other more exacting mosses being common. Often there is much low to medium height shrub cover and sometimes a sparse layer of trees. The waters and peats are less acid than in bogs of the same areas, and sometimes show somewhat alkaline reactions. Fens usually develop in restricted drainage situations where oxygen saturation is relatively low and mineral supply is restricted. Usually very slow internal drainage occurs through seepage down very low gradient slopes, although sheet surface flow may occur during spring melt or periods of heavy precipitation."

"Fen peats generally consist of moss and sedge peats. Sphagnum, if present, usually composed of different Sphagnum species than occur in bogs. Trees typical of fens are White Cedar and Tamarack."

"SWAMPS are wooded wetlands where standing to gently flowing waters occur seasonally or persist for long periods on the surface. Frequently there is an abundance of pools and channels indicating subsurface water flow. The substrate is usually continually waterlogged. Waters are circumneutral to moderately acid in reaction, and show little deficiency in oxygen or in mineral nutrients... The vegetation cover may consist of coniferous or deciduous trees, tall shrubs, herbs and mosses."

"Many swamps are characteristically spring-flooded, with dry relict pools apparent later in the season. There is usually no deep accumulation of peat."

"Swamps include both forest swamps (having mature trees) and thicket swamps (or shrub carrs). Thicket swamps are characterized by thick growth of tall shrubs such as willow, dogwood and Spiraea, and alder. Both forest and thicket swamp have similar characteristics of water levels and chemistry. Both are assessed as "swamp" wetland type, but can be distinguished on the wetland vegetation map by the predominance of either the "tree" or the "shrub" form. Soft Maple, Elm and Black Ash are among the best indicators of hardwood forest swamp, and White Cedar, Tamarack and Black Spruce of conifer forest swamp."

"MARSHEs include wet areas periodically inundated with standing or slowly moving water, and/or permanently inundated areas characterized by robust emergents, and to a lesser extent, anchored floating plants and submergents. Surface water levels may fluctuate seasonally, with declining levels exposing drawdown zones of matted vegetation or mud flats... Water remains within the rooting system of plants during at least part of the growing season. The substratum usually consists of mineral or organic soils with a high mineral content, but in some marshes there may be as much as 2 metres of peat accumulation. Waters are usually circumneutral to slightly alkaline, and there is a relatively high oxygen saturation. Marshes characteristically show zones or mosaics of vegetation, frequently interspersed with channels or pools of deep or shallow open water. Marshes may be bordered by peripheral bands of trees and shrubs but the predominant vegetation consists of a variety of emergent nonwoody plants such as rushes, reeds, reedgrasses, and sedges. Where open water areas occur, a variety of submerged and floating aquatic plants flourish."

"The "Marsh" wetland type includes areas of open shallow water. These are areas of permanently open water, usually less than 2 metres deep, with water chemistry closely related to the type of water body they flank. Areas of open shallow water are associated with flowing or standing lakes, rivers or ponds, and usually have floating, submergent, or to a lesser degree, partly emergent vegetation in shallower areas. The deep water boundary of a marsh is drawn where water depth is 2 m or over."

It is not uncommon for two or more of above described wetland types to be part of the same wetland and when that is the case, ecotones between wetland types range from narrow to very broad.

The presence of many wetlands within an otherwise upland landscape adds greatly to faunal diversity since many upland dwelling animal and bird species require wetlands for a portion of their life cycle and vice versa.

The following vegetation communities appear to be deserving of recognition and separate description from a practical, management perspective. But it is understood that if one wished to use different criteria or combinations of attributes, community definitions and boundaries would necessarily change.

### **Upland Deciduous Forest**

This striking forest type (Figure V4) is far more widely distributed in the study area than previously thought (e.g., see Wickware & Shiefer 1987). It occurs in rather discrete areas in a triangle roughly from Conley to Crane to George and Emmett lakes and is well developed in several coast and near coast areas between Cave Point and Rocky Bay, including some of the gentler slopes of the escarpment along this Georgian Bay shoreline and along the flanks and between the 3 large buttes facing the Wingfield Basin. As well, historically it was apparently well developed in the farming area immediately SE of Tobermory, on farming areas along the Dyer Bay Road and just north of Crane Lake. It is present in patches throughout these farmed areas.

Development and persistence of deciduous forest may be linked to better soils and warmer summer temperatures in the interior and perhaps to warm air drainage patterns along the northern shoreline west of the Wingfield Basin and along the sides of the 3 buttes overlooking the Basin.

The most characteristic and abundant species is the Sugar Maple (*Acer saccharum*). However, trees of this species, while usually dominant, are relatively young (Table V3), due likely to a combination of fire and active logging. Other than Sugar Maple, other species of the canopy are Beech, Basswood, Red Oak, White Ash, White Birch and the occasional Ironwood. In some sites, these deciduous forests harbour an understory of young Balsam Fir as discussed in the above section. In some areas, Hemlock was occasional and in a few local spots, subdominant. While in many areas White Birch is a subdominant of this forest, its abundance is no doubt linked to the fires of early part of the century. It is not shade tolerant as are some of its companion hardwood species and there are ample areas in the field where as older trees fall they are not replaced.

Understory shrubs rarely form continuous canopies under these deciduous forests. Leatherwood (Dirca palustris) and Beaked Hazel (Corylus cornuta) are by far the most prevalent but usually as scattered individuals or small groups. In one area (the sandy ridge just SW of Cameron Lake), the Striped Maple (Acer pensylvanicum) was common.

## **Upland Mixed Forest**

As evident from Figure 4, this is the most widespread vegetation community type in the study area. It includes forests not immediately adjoining the Lake Huron shoreline and most of the forests along the escarpment. It extends inland and generally grades into the deciduous forests described above. In parts of this vegetation type there is much evidence of remnant dead and dying Aspen and White Birch, with occasional live individuals or stands of these older deciduous trees overtopping the conifers. In other areas the deciduous species predominate but an ascending forest of White Spruce, Cedar, Balsam Fir, and in some places, Red and White Pine indicate that the general trend is toward a greater predominance of conifers for the immediate future.

Both Trembling Aspen (*Populus tremuloides*) and White Birch (Betula papyrifera) are usually present and sometimes dominate. Large-toothed Poplar is also abundant and in small local spots occurs in pure stands with >75% canopy. However, again (with spotty local exceptions) as a general pattern, the understory is controlled by ascending conifers and as the overtopping deciduous trees topple (causes speculative: possibly competition from the conifers or "old age" for the particular site), coniferous species are gaining the upper hand. On the Georgian Bay side, and particularly on the escarpment itself and in scattered areas to the inland, the forests are also mixed with conifers slowly becoming more prevalent as individual White Birch (mainly) and Aspen fall over and are not replaced. This emerging pattern of successional change has been described in the above section.

Many species of shrubs are found occasionally in these mixed forests (Buffalo Berry, Common Juniper, Bebb's Willow, Prickly Gooseberry, Shadbush species, Choke Cherry, Bush Honeysuckle, Downy Arrowwood and others, but only in limited areas do we see a major development of a closed canopy. Species abundant enough to close the canopy are the Round-leaved Dogwood (most often) and Mountain Maple (local along the escarpment).

## Upland Coniferous Forest

This vegetation type (Figure V4) extends all along the Lake Huron shoreline and inland often for several kilometres. Coniferous forest also occurs in narrow (50 to 100 metre) bands along shorelines of lakes, streams and beaver floods throughout the study area where Beaver were active in the recent past. Such areas bear much evidence of remnant (now largely decayed) beaver cut stumps of Aspen, Birch and possibly other deciduous trees.

The Huron shoreline is an area of extensive private property holdings with cottages replacing natural systems. Cutting of the conifers for firewood and other reasons is causing a patchwork of mixed forest to develop on many private properties.

Coniferous forests are dominated by White Cedar (Thuja occidentalis), Balsam Fir (Abies balsamea), White Spruce (Picea glauca), and in some areas by Jack Pine (Pinus banksiana). Red and White Pine are occasional and in some places locally abundant. Hemlock is only found sporadically.

The most common dominant shrubs of coniferous forests and particularly near to the coast are both Common and Creeping Juniper and Arctostaphylos uva-ursi but many other low shrubs may be locally abundant (e.g. Rubus idaeus) or occasionals.



## **Upland Open Alvar**

Considerable upland areas are alvar. These generally harbour an open to semi-open forest, either mixed or dominated by conifers. Conifer species vary greatly: some alvar areas contain mainly White Cedar, others White Spruce, while still others have combinations of conifers. Deciduous tree species are White Birch, Trembling Aspen and often Large-toothed Aspen. Such alvar communities are clearly under moisture stress with considerable evidence of dieback of the deciduous species. Generally, the open alvar communities are tending toward a more coniferous tree cover.

Some open alvar communities are strongly dominated by Common and Creeping junipers, shade intolerant species which die out in places where trees, particularly conifers develop overtopping canopies.

## **Cleared Farmland and Pasture**

Some of the upland areas (usually on deeper soils) have been cleared and pastured. For example, the area just north of Crane Lake, sections north of the Dyer Bay Road and extensive portions on both sides of the main highway to the west of Cameron Lake in the general area of the Tobermory Airport. These agricultural fields are usually clear of trees but many abandoned fields and meadows exist and where they do, seedlings of adjacent forest trees are slowly becoming established. Most agricultural upland areas would return to a maple dominated deciduous forest if rehabilitation through natural succession were allowed to proceed.

Common Juniper is one of the best indicators of past disturbance of the land particularly by intense overgrazing. In many former pastures and fields, juniper is dying back as overhead canopies of conifers or deciduous trees develop by succession.

## Swamp

Swamps, dominated by trees, shrubs or both occur in a number of areas, as for example along the narrow flood plain of the Crane River, at the west end of Gillies Lake, the east end of Crane Lake, and in some low lying areas usually next to agricultural fields or pastures (Figures V1 and V15). Treed swamps are dominated by Black Ash, Speckled Alder, some Red Maple, the occasional Balsam Poplar. Shrub swamps tend to be local and are commonly dominated by various willow species and Speckled Alder.

## Fen

Botanically, fens are among the most interesting of the vegetation types present in the study area. They are the most common along the Huron side of the study area (Figures V1 and V15) where seepage provides a secure water supply and the limestone rocks provide the necessary calcium for the formation of extensive areas of marl. Fens range from treed to open and in several places floating fen mats extend considerable distances into shallow marl lakes and ponds. Treed fens occur generally along the Huron coastline; they are dominated by White Cedar and Tamarack, often with an essentially closed canopy. Invariably, the fen-indicating shrub Shrubby Cinquefoil (Potentilla fruticosa) is present. The more open fens are dominated by sedges (Carex spp) and are frequently bordered by scattered individuals of the fen-indicating shrubs, Salix candida, Potentilla fruticosa, Cornus obliqua and Myrica gale.

The open fen vegetation frequently occurs directly on wet alvar where permanent seepage provides the moisture required by herbs like Pinguicula vulgaris, Lobelia kalmii, Sarracenia purpurea, Spiranthes romanzoffiana, Tofieldia glutinosa, Rhynchospora capillacea, Parnassia, Drosera intermedia, Drosera linearis, Gerardia purpurea, Triglochin maritima, Gentiana procera and some others.

Some of the most interesting fens in the study area are floating mats. These occur either at the edges of ponds or small lakes or in depressions where the floating vegetation may have completely closed in at the centre. One of the best developed floating mats found occurs on a small lake 300 metres directly north of Cameron Lake (polygon 12).

Fens in the study area intergrade with marshes (open water areas with potamogetons, Scirpus, water lilies). As well, in more inland areas cedar swamps today may have been open fens in the past. As well, a good example of a marsh intergrading with a fen is that of Lower and Upper Andrew Lakes where the open water areas are decidedly marshy.

## **Marsh**

Marshes have developed on some shallow lakes, as for example, Crane and Marsh Lakes (Figure V1 and V15). Marsh habitat is also found at the open water edges of shoreline fens throughout the study area and particularly on the Lake Huron side of the peninsula.

Some marshes as for example, those at Crane and Marsh lakes provide excellent habitat for a rich variety of wildlife and staging areas for waterfowl. Many Beaver floods develop into marsh vegetation, although the flooding may be intermittent depending upon the presence of Beaver and the condition of the dam.

## **Bog**

Only one bog occurs in the study area - the Tobermory Bog just southeast of the town of Tobermory (Figures V1 and V15). It is located on private land. Bog ecosystems are rare in the Bruce Peninsula and on this basis, the value of this ecosystem is vastly underestimated. There is no other place like it in the entire study area. The immediately adjacent Sugar Maple dominated gravel ridges are being actively mined, and it appears that with these ridges the remaining source of groundwater discharge for this bog will vanish completely. A fresh drainage ditch was constructed in 1987 along its northwest side and gravel extraction activities continue along its margins. Hence, the bog is now undergoing rapid degradation through loss of its formerly secure water supply and consequent oxidation of organic material. Both shrubs and trees are invading.

Unless the drainage of this bog is restored, it will be gradually transformed into a swamp.

## **RELATIVE VALUES OF WETLANDS IN THE STUDY AREA**

Wetlands differ from each other profoundly with respect to both quantitative and qualitative values. A method has been developed by Ontario to evaluate wetlands for the purpose of rating them in relation to each other. The system of evaluation (Ministry of Natural Resources and Environment Canada, 1984) has been applied across southern Ontario. The Ministry of Natural Resources, Owen Sound, has completed the evaluation of 4 wetlands in the study area (Table V5). These evaluations have revealed that Dorcas Bay is a

Class 1, Wingfield Basin a Class 2, Corisande Bay a Class 3 and the Tobermory Bog a Class 6. Table V5 also lists 5 other wetlands in the study area that are large and complex enough to warrant evaluation at a future date. Experience of T. Mosquin in evaluating wetlands across Ontario has been used as the basis to suggest the possible ratings of the 5 additional wetlands as noted in Table V5. Crane Lake, and Marsh Lake (which appears to form a continuous wetland with Quenlin Lake) are of particular interest as they may rank as Class 1 or 2.

## REPRESENTATIVENESS

The concept of representativeness needs to be discussed in the context of the objectives of this vegetation inventory because the more representative a community of plants, the more its natural values must be protected according to the National Parks Act and National Parks policies. Thus, if any parts of the study area are judged to be more representative than others, they would be more readily targeted as areas whose preservation meets the requirements and goals of the national parks. Conversely, if an area is not as representative of its natural area as it could be or if it is only partially representative, a case could be made for restoration or rehabilitation through the Park Management Plan.

In its simplest form, "representativeness" is a function of ecological age of a community. The longer a community has been left alone, the more representative it would become. Exceptions to this rule occur when the natural ecosystems are completely destroyed by agriculture, urbanization or other forces or when alien species are introduced causing natural processes to be interrupted or seriously impaired.

**TABLE V5**

**Evaluations of Wetlands in the Study Area (MNR Data from  
John Morton, Ministry of Natural Resources, Owen Sound)**

Name of Wetland	Biological	Social	Hydrological	Special	Total	Class Feature
Corisande Bay (Complex of 7)	193	124	81	250	648	3 (MNR)
Dorcas Bay (Complex of 8)	189	186	110	250	735	1 (MNR)

Tobermory Bog	146	68	43	164	421	6 (MNR)
Wingfield Basin	183	156	69	250	671	2 (MNR)
Crane Lake	about	about	about	about	about	
(not evaluated)	180	160	130	250	720	1
Marsh Lake	-	-	-	-		probably
area						2
(not evaluated)						
Lower & Upper	-	-	-	-		probably
Andrew Lakes						2 or 3
(not evaluated)						
Horseshoe Marsh/	-	-	-	-		possibly
Bartley Lake						3 or 4
(not evaluated)						
Lymburner Lake	-	-	-	-		possibly
(not evaluated)						4

All other wetlands in the study area are probably classes 4 to 7 (except if large wetland complexes were to be recognized).

As noted earlier in this chapter, agriculture, lumbering and fires have had a profound impact upon the representativeness of the vegetation of the study area. Some areas are obviously more affected than others. But since much of the area has been more or less left alone in recent decades, natural processes (mainly succession) are operating and representativeness is on the increase. Exceptions to this rule are those areas that are still maintained as agricultural fields, or are periodically logged and as noted earlier, perhaps 250 to 1000 years would be required to return the study area to a near perfect state of representativeness. As for wetlands, they have not been impacted as seriously as uplands and generally, one must consider that fens, swamps and marshes of the study area are fully representative of their respective local sites. The exception is the Tobermory bog, which is now rapidly deteriorating and which in some decades, will almost certainly become transformed into a swamp. This implies the loss of bog species and the invasion of swamp species such as Red Maple, Black Ash, White Cedar, Speckled Alder, willows and various herbaceous species. This trend could be arrested if the loss of groundwater through drainage ditches were stopped and removal of adjoining gravel ridges ceased.

## **RARE SPECIES**

This vegetation inventory did not include the study of rare species, although some rare species were included in the data sheets (Table V1) as "other" information when opportunity provided. Thus, the boundaries of polygons do not reflect presence or absence of rare species. For example, the rare Prairie White-fringed Orchid occurs in a part of the open area at the west end of George Lake, but its presence did not help to define the boundaries of this polygon. As has been noted earlier (but with the exception of wetland/upland boundaries), the delineations of the 9 communities described in this inventory are based upon attribute data. Hence, it is these attributes on the data sheets which could be reviewed in future when searching for suitable habitat for rare species. Wetland/upland polygon boundaries are fairly permanent, but the boundaries of upland polygons will be slowly influenced by succession in future decades.

## USING SPANS TO DEDUCE INTRINSIC ECOSYSTEM VALUES

One interesting and potentially useful application of the SPANS system should be for obtaining a measure of ecological values in an area relative to other areas. One such analysis has been attempted here with the results presented in Table V6 and Figure V17. This example is presented here only to demonstrate the potential utility of SPANS in this respect.

Defining, grouping and numerically rating natural values is essential. The amount or degree of value, the absence of value, or the presence of negative values is based upon experience, observation, knowledge, professional opinion and common sense regarding what is valued in ecosystems. The process results in a "set of rules" that can be applied through SPANS.

The basic information units used in this analysis were those used to generate the polygons during the vegetation survey but these recorded values could be combined with information from other chapters in this inventory which follow different boundaries.

The idea of measuring ecological values using a numerical system is not well known. This approach to assessing values has been developed to evaluate different wetlands in Ontario ( Ministry of Natural Resources & Environment Canada 1984). There, it took a committee of experts 18 months to balance out the numbers used although this included field testing. The intrinsic ecosystem values map generated here (Figure V17) is, however, an extension of the MNR system because it tries to compare values within a single unit of land.

Total and relative points to be accorded to any defined value must go through substantial revisions and testing before agreement on numbers and balancing can be reached. As Table V6 did not benefit from such a protracted process, it should be considered as a starting point for running tests and holding discussions aimed at developing an agreed-upon evaluation of intrinsic ecological values in the study area.

**TABLE V6**  
**Intrinsic (Ecosystem Value) Assignments**

Attribute	Assigned Value		Rationale
SINGLE ATTRIBUTES			
1. WETLAND TYPES			
Swamp	30	Bogs are very rare in the study area, marshes are somewhat rare. Bogs take 60thousands of years to develop. Fens (of the floating type) also take a long time but this intrinsic value of a fen is considered below.	
Fen	45		
Marsh			
TREES			
2. % Canopy Cover >60	30	Many species of wildlife require or prefer closed canopies for living, nesting, movement, etc.	
3. Species	Dominant	Subdominant	
Eastern Hemlock (7)	10	5	The above are the major nut, or winter food producing trees for some key wildlife species.
White Cedar (9)	10	5	
Beech (18)	15	10	
Red Oak (20)	15	10	
Sugar Maple (23)	20	15	



**TABLE V6**  
**Intrinsic (Ecosystem Value) Assignments (Cont.)**

Attribute	Assigned Value		Rationale
4. Height >20 metres	30Tall stands are older, and have more "snags" meaning trees with cavities for wildlife. Suitable nesting sites become available for woodland hawks and other canopy dwelling birds (vireos, flycatchers, very). More rotting wood for producing insect diversity.		
SHRUBS			
5. Canopy			
>60%	20	"Shrub thickets" or significant understory	
25-60%	10	development of shrubs provide protective cover for bird and animal species	
	Dominant	Subdominant	
6. Species			
Willow (32 thru 39)	20	10	The above species produce abundant
Leatherwood (73)	20	10	supplies of nectar and pollen very early in the spring, thus enabling an early pollinator fauna to become established.

**TABLE V6**  
**Intrinsic (Ecosystem Value) Assignments (Cont.)**

<b>Attribute</b>	<b>Assigned Value</b>	<b>Rationale</b>
OPEN UPLAND AREAS		
7. % Cover		
>75	-50	(Note that these are negative numbers).
25-75	-20	This attribute will identify all farm fields. Such fields are ecologically unnatural (unrepresentative) and hence negative. As well, abandoned but now early successional pasture now reverting to the natural ecological system is given some negative points. The scoring here would also identify as negative those open alvar areas which have low canopy cover. Open alvar areas have considerable intrinsic value. To "compensate" see the handling of "Alvar" below.
OPEN WETLAND AREAS		
8. % Cover		
>75%	30	Open wetlands should catch all grassy
25-75	25	fens, marshes, shallow lakes (with
5-25	20	some vegetation), and semi-open fens,
<5%	10	shrub swamps and marshes. All of these have considerable intrinsic value and not the least reason is that they provide diversity within otherwise forested upland systems.

**TABLE V6**  
**Intrinsic (Ecosystem Value) Assignments (Cont.)**

Attribute	Assigned Value	Rationale
9. % Type of Cover		
Robust emergents	5	This is a complex variable but reflects the importance attached to the presence of water as well as life and as drinking water, etc. for upland wildlife. The above numbers are additive, that is cover can be one or more of any of the above types.
Graminoid/sedges floating &/or	10	
submergents	40	
open water (no cover)	10	
UNIQUE OR SPECIAL EVENT DATA		
10. Floating Fen Mat	300	Such mats contain orchids and other rare or beautiful wildflowers. As well, the mats take thousands of years to develop. Hence, this "habitat" is valuable due to its known ecological age.
11. Tree Cavities		
Abundant or Occasional	50	Tree cavities add inestimable value to a forested ecosystem by providing homes, shelter, etc. for large numbers of animals, birds, insects, etc. which would otherwise not be present in an area.

**TABLE V6**  
**Intrinsic (Ecosystem Value) Assignments (Cont.)**

<b>Attribute</b>	<b>Assigned Value</b>	<b>Rationale</b>
12. Soils		
Alvar	20	Entered only to offset the negative points
Sand	30	which alvar will receive from application of negative values of open upland areas (see No. 7 above).
COMBINATION OF ATTRIBUTES		
13. Upland + Tree Canopy >60%		
+ Tree Height	>10 m	This is aimed at recognizing much of the
+ Trees Broadleaf >75%	50	Sugar Maple and mixed forest and ensuring that it does receive the points it should (due to its being rather unrepresented in the study area).
14. Trees Conifer >75%		
+ White Cedar (9)	30	Conditions required for deer winter range.

The process of creating an agreed upon (this is important) intrinsic ecosystem values map is as follows:

- 1) conceptualize and define each value;
- 2) aim at making the values mutually exclusive (strictly speaking this is not possible because we are, after all, dealing with ecological systems);
- 3) justify each value by writing a rationale (with literature references);
- 4) bring together a group of knowledgeable people to decide what each value is worth numerically (when compared and contrasted to every value);
- 5) decide on the number of subdivisions each value should receive (from 1 to possibly 50 or more; numbers may or may not be negative);
- 6) group the values so that they can be compared as ecologically meaningful blocks (optional);
- 7) using the above values develop polygons and assess their "ecological values" using the GIS system;
- 8) if the map (or parts of it) generated by the computer "don't make sense" to ecologically informed people, alter some relative values, scales, delete some values or whatever is required to correct and/or better balance the system;
- 9) revise until satisfied.

The rationales upon which the assignment of numerical values in Table V6 is based is included in the table and their bases are self-explanatory or self-evident. Faunal values (although poorly documented) have been incorporated into some of the defined attributes.

The relative values defined in the "intrinsic ecosystem values" were adopted from the attribute data (Table VI) of this bioinventory. These value areas were not created in advance with the aim of preparing such a values map. The weaknesses and gaps in the above stem from the following:

- 1) the attributes used were prepared (preset) for a different purpose;
- 2) rare plants and animal values are not included;
- 3) the valuation conclusion did not benefit from repeated review and discussion by experts; and
- 4) this was a minor part of this project and therefore did not receive the full effort that this subject deserves.

Nevertheless while this is only a crude first attempt, some useful interpretation is possible:

- 1) the Tobermory Bog stands out as extremely significant;
- 2) the farm fields stand out as being least important;
- 3) the maple/beech forests have intermediate importance as do many fen and marsh wetlands;

- 4) much of the area (mainly mixed forest) is of relatively low value;
- 5) the "305-400 areas" near the base of the map are inconsistent with the values generated for other areas.

This should be examined and the reason for the differences found and corrected if necessary.

To reiterate, the purpose of this map is only to provide an idea of how this approach to valuation of ecosystems might work. It would appear to have strong promise for management but a systematic application of the method is necessary.

## **CONCLUSION**

This vegetation bioinventory and evaluation should provide the basis for a rational approach to the development of a Park Management Plan. As well, the inventory tells us a great deal about the kinds of natural values which exist in lands immediately adjacent to the defined Park boundaries. This information will be useful in identifying priority areas in adjacent lands whose protection would benefit, strengthen and enhance the integrity of natural ecosystems in the Park.

## VEGETATION REFERENCES

- Banfield, A.W.F. 1974. The Mammals of Canada. National Museum of Natural Sciences, Ottawa. University of Toronto Press.
- Beechy, T.J. & I.D. Macdonald, 1970. Inventory of Cyprus Lakes Provincial Park. Ministry of Natural Resources, Toronto.
- Brownell, V.R. 1984. A Resource Management Study of Rare Vascular Plants of the Tobermory Islands Unit, Georgian Bay Islands National Park. Parks Canada, Ontario Region, Cornwall.
- Catling, P.M. 1975. Alvar Vegetation Southern Ontario. Ontario Field Biologist 29(2): 1-25.
- Cuddy, D.G., K.M. Lindsay and I.D. Macdonald, 1976. Significant Natural Areas along the Niagara Escarpment. Field Check sheets by D.G. Cuddy & K.M. Lindsay. Park Planning Branch, MNR Library, Owen Sound.
- Cuddy, D.G., & R.R. Norman, 1972. An Ecological Assessment of the Little Dunks Bay Property (Fathom Five Land Base). Ministry of Natural Resources, Owen Sound. 31 pp.
- Elliott, H. Vincent, 1962. The Bruce Peninsula. The Bulletin, Federation of Ontario Naturalists. 97:11-17
- Fischer, R.V. & B.R. McLelland, 1987/88. A Cavity Nesting Bird Bibliography, Including Related Titles on Forest Snags, Fire, Insects, Disease and Decay. Intermountain Forest & Range Experiment Station. Ogden, Utah.
- Folkes, Patrick, 1974. The Early Settlement of Tobermory & St. Edmunds Township. Fathom Five Provincial Park, Ministry of Natural Resources, Owen Sound, Ontario.
- Francis, J., J. Johnson, & I.D. McDonald, 1983. An Ecological Land Classification of the Tobermory Islands Unit, Georgian Bay Islands National Park. Parks Canada, Ontario Region, Cornwall.
- Gleason, H.A., 1926. The Individualistic Concept of Plant Succession. Bulletin of the Torrey Botanical Club 53: 7-26.

- Hilts, Stewart, 1983. Vistors to the Dorcas Bay Nature Reserve. Federation of Ontario Naturalist's files. 2 pages.
- Hilts, Stewart, 1984. The FON's Nature Reserves. Seasons (Spring Edition) Hosie, R.C., 1979. Native Trees of Canada. Fitzhenry & Whiteside Limited. 380 pp.
- Johnson, J., 1980. Cyprus Lake Park Botanical Study. Ministry of Natural Resources, Owen Sound Library.
- Johnson, J., 1982a. Biologically Significant Areas, Site No. 9: Corisande Bay, Ministry of Natural Resources, Owen Sound Library.
- Johnson, J., 1982b. Biologically Significant Areas, Site No. 10. Johnston Harbour-Pine Tree Point. Ministry of Natural Resources, Owen Sound Library.
- Johnson, J., 1984. Orchids, Orchids, Orchids. Seasons 24 (1).
- Ministry of Natural Resources, 1976. Nature Reserve Candidates in the Niagara Escarpment Planning Area. Environmental Planning Series VIII. (Miscellaneous Report). Park Planning Branch. 33pp.
- Ministry of Natural Resources & Environment Canada, 1984. An Evaluation System for Wetlands of Ontario South of the Precambrian Shield. 169 pp.
- Morton, J.K., & Joan M. Venn, 1987. The Flora of the Tobermory Islands, Bruce Peninsula National Park. University of Waterloo. 92 pp.
- Nicholson, Beverly A., 1983. The Dorcas Bay Nature Reserve, Evaluation Report. Federation of Ontario Library, Toronto.
- Soper, James H., and Margaret Heimbürger, 1985. Shrubs of Ontario. Royal Ontario Museum, 495 pp.
- Walshe, S., 1968a. A Survey of Wetlands of the Bruce Peninsula (Field Notes), Mimeograph. Ontario Ministry of Natural Resources, London.



- Walshe, S., 1968b. A Comparison of Wetland Vegetation at Dorcas Bay and Ira Lake. (Field Notes). Mimeograph. Ministry of Natural Resources, London.
- Wickware, G.M., & K. Schiefer, 1987. Preliminary Resource Reconnaissance and Evaluation, Bruce Peninsula National Park.
- Woodford, James, & G. Marshall Bartman, 1966. A Garden Northward. The Ontario Naturalist, March Edition. Pages 4-9.
- Wyonch, Cathy, 1985. Hewers of the Forests and Fishers of the Lakes; the History of St. Edmunds Township. Township of St. Edmunds, Tobermory, Ontario.

## **LAKES, RIVERS AND SHORELINES**

### **PHYSICAL AND CHEMICAL DATA**

An extensive survey of all major lakes and rivers in and around the Park was conducted by canoe in August, 1988. Total dissolved solids (TDS), alkalinity, pH, secchi disk depth, shore types, bottom types and water depth profile data were collected during this survey. Total dissolved solids and pH were measured using HACH electronic pocket pal meters. Water depths were recorded using a commercial depth sounder where water depths exceeded a metre. Shallower water depths were estimated by dipping with a paddle. Alkalinity was measured using Hach's model AL-AP test kit. Water chemistry was routinely measured at a minimum of 2 locations in the main body of each lake, however, multiple sample locations were not necessary as the recorded chemistry was always constant within each lake. Water chemistry for the major streams in the area was sampled only at major access points. Wetlands (swamps, marshes, fens, bogs) are discussed in the vegetation chapter.

A summary of the collected data is presented in Table L1. Figure L1 shows the locations of these lakes. In the Park lakes TDS ranged from 110 to 240 ppm, alkalinity from 116 to 290 ppm and pH from 7.4 to 9.4. The waters of Georgian Bay and Lake Huron consistently had a TDS of 100 ppm, alkalinity of 102 ppm and pH of 8.6. Due to shallow lake depths, secchi depth was measurable in only seven of the lakes. Values ranged from 2.3 to 3.3 metres with Gillies Lake recording 6.5 metres and Georgian Bay 9 metres. Lake bottom types were predominantly marl or organic with isolated instances of rocky and sandy bottoms. Shore zones are a mix of rock and marsh with a combination of trees, standing dead, and dead fall along most lakes. Water depths were virtually identical to those recorded by the Ministry of Natural Resources in the early 1970's (OMNR open file records).

TABLE L1  
Summary of Data Collected in Lake Survey

Column	Data
1	Lake name
2	Area [Sq Km]
3	Average depth [m]
4	Max depth [m]
5	TDS [ppm]
6	Alkalinity [ppm]
7	pH
8	Secchi Depth [m]
9	Morphoedaphic Index
10	Annual Fish Yield [lbs/acre/year]
11	Primary Shore Type 1:rock 2:sand 3:marsh 4:organic 5:standing dead 6:marsh+standing dead 7:dead fall
12	Bottom Type 1:marl 2:organic 3:rock 4:organic-marl mix

Lake Name	2	3	4	5	6	7	8	9	10	11	12
Barney Lake	.27	1	1	160	143	8.6	-	49	14	3	1
William Henry Marsh	.24	1	1	210	210	8.8	-	64	16	3	1
Loon Lake	.15	.5	.5	120	136	9.3	-	73	17	3	1
Marr Lake	.05	1	1	150	177	9.0	-	46	14	1	3
Horse Lake	.15	.5	.5	140	177	9.0	-	85	18	3	1
Cyprus Lake	.74	3.9	7	140	177	8.5	2.3	11	7	1	1
Cameron Lake	1.6	4.5	14	150	177	8.5	2.3	10	6	1	1
No Name #1	.04	1	1	160	190	8.5	-	58	15	4	2
McLander Marsh	.16	1	1	120	150	8.4	-	36	12	5	1
Scugog Lake	.41	.5	.5	220	204	8.6	-	134	23	3	1
Horseshoe Marsh	.16	0	-	-	-	-	-	-	-	5	2
No Name #2	.36	1	1	120	163	8.5	-	36	12	6	1
Bartley Lake	.1	1.5	3	120	150	8.9	2.6	24	10	1	1
Emmett Lake	.98	2.5	10	130	150	8.6	3.3	16	8	1	1
Lower Andrew Lake	.97	.5	.5	240	285	7.4	-	146	24	3	2
George Lake	1.74	1.9	7	130	177	8.7	3.3	21	9	1	1
Johnson's Mud Lake	.19	.5	.5	190	190	8.0	-	116	21	3	2
No Name #3	.08	0	-	-	-	-	-	-	-	7	2
Marley Lake	.11	0	-	-	-	-	-	-	-	3	2
Moore Lake	.42	.5	1	130	150	8.9	-	79	18	5	4
Upper Andrew Lake	.69	1	1.5	130	150	8.7	-	40	13	3	1
Umbrella Lake	.36	1	1.5	120	150	8.8	-	36	12	1	4
No Name # 4	.09	0	-	-	-	-	-	-	-	5	2
Clear Lake	.06	1	1.5	140	150	8.9	-	43	13	1	1
Big Marsh	.38	.5	.75	120	156	9.1	-	18	8	3	1
Mudd Lake	.27	.5	1	160	211	8.4	-	97	20	3	1
Crane Lake	1.17	.75	1	150	190	8.2	-	61	16	3	1
Shouldice Lake	.28	1	2	140	163	8.5	-	43	13	1	4
Conley Lake	.12	.75	1	110	116	9.4	-	45	13	1	1
Lymburner Lake	.38	.25	.5	170	184	7.9	-	207	29	3	2
Quenlin Lake	.22	.5	1	155	290	7.5	-	94	19	1	2
Gilles Lake	2.19	6.5	32	130	170	8.7	-	6	5	1	1
Britain Lake	1.15	2	4	130	150	8.8	2.3	20	9	3	4
Georgian Bay/ Lake Huron	-	-	-	100	102	8.6	9	-	-	1	3
Crane River	-	-	-	190	218	7.9	-	-	-	-	-
Willow Creek	-	-	-	140	177	7.9	-	-	-	-	-
Sideroad Creek	-	-	-	200	211	8.5	-	-	-	-	-

note: lakes where depth is listed as 0 were dry during the survey period.

## **FISH SPECIES PRESENT**

The sport fishery primarily consists of brook trout, smallmouth bass, yellow perch and northern pike with lake trout, lake whitefish, and walleye present in a few of the deeper lakes. See Tables L2 and L3 for a summary of the resident fish communities and management schemes proposed by OMNR for the larger lakes and streams in the region. Unfortunately the reference document from which this was taken does not provide more detail concerning the procedures used to implement the general management schemes stated in this table. The presence of forage and other fish species in these lakes is indicated in Table L4. This information is outdated and often incomplete and is in need of extensive re-survey prior to actual use in fisheries management work. None of the fish species reported in these documents are found in the COSEWIC list of rare and endangered species (Campbell 1987).

The morphoedaphic index (MI) for each of the lakes has been calculated as per Ryder 1965 ( $MI = TDS \text{ (ppm)}/\text{average water depth (ft)}$ ), as has the potential fish production (P) (lbs/acre/year) ( $P = 2 \sqrt{MI}$ ). It should be noted, however, that these values are undoubtedly not accurate for most of the Park lakes since Ryder's correlation applies only to lakes larger than 1 square mile that would not be subjected to any unusual extremes such as winter kill, a likely occurrence in the shallow lakes of the Park. Gillies is the only lake in the vicinity of the Park for which Ryder's correlations would seem to be valid.

All of the limnology data has been entered in the SPANS system in the following formats. First of all, a single map has been developed which represents each lake as a unique colour or tynumber (LAKE.map). An attribute file has then been developed in which lake area, average and maximum depth, TDS, alkalinity, pH, secchi depth, morphoedaphic index, potential fish yield, predominant shore type, bottom type and major fish species present has been entered. This attribute file is essentially Tables L1 and L4 combined. This will permit future users of the database to access all of this information on a Park wide basis via SPANS modelling sessions. Secondly, individual bathymetric maps have been developed for each lake for hardcopy presentation and depth-area analysis. Finally another set of individual maps for each lake which show bottom and shore type have been established. Hardcopies of these maps are provided in Appendix A, accompanied by a summary data sheet describing the water chemistry and physical characteristics of the lake.

**TABLE L2**  
**OMNR Fisheries Management Designation for**  
**Inland Lakes Within the Park Vicinity**

<b>Lake/Pond</b>	<b>Township</b>	<b>Resident Fish Community</b>	<b>Comments</b>
Gillies Lake	Lindsay	Lake Trout Smallmouth Bass	Lake trout Lake Whitefish population given priority but lake will be managed for coldwater and warmwater fish communities
Lymburner Lake	Lindsay	Smallmouth Bass Y. Perch	Management strategy to be determined after lake inventory
Barney Lake	St. Edmunds	Y. Perch	Management strategy to be determined after lake inventory
Cameron Lake	St. Edmunds	Smallmouth Bass Walleye	Smallmouth bass, Perch population given priority but lake will be managed for both coolwater and warmwater fish communities
Cyprus Lake	St. Edmunds	Smallmouth Bass Walleye Y. Perch N. Pike	Smallmouth bass population given priority but lake will be managed for both coolwater and warmwater fish communities

X From OMNR - 1986 - Owen Sound District Fisheries Management Plan

**TABLE L2 (Cont.)**  
**OMNR Fisheries Management Designation for**  
**Inland Lakes Within the Park Vicinity**

<b>Lake/Pond</b>	<b>Township</b>	<b>Resident Fish Community</b>	<b>Comments</b>		
William Henry	St. Edmunds	Unknown Marsh	Management strategy to be determined after lake inventory		
Unnamed Lake #7	St. Edmunds	Unknown	Management strategy to be determined after lake inventory		
Crane Lake	St. Edmunds	Smallmouth Bass N. Pike Y. Perch	Lake will be managed for both coolwater and warmwater fish communities		
Emmett Lake	St. Edmunds	Smallmouth Bass N. Pike Y. Perch	Lake will be managed for both coolwater and warmwater fish communities		
George Lake	St. Edmunds	Smallmouth Bass N. Pike Y. Perch	Lake will be managed for both coolwater and warmwater fish communities		
Horseshoe Marsh	St. Edmunds	N. Pike	Management Strategy to be determined after lake inventory		
Lower Andrew Lake	St. Edmunds	Smallmouth Bass N. Pike Y. Perch	Lake will be managed for both coolwater and warmwater fish communities		
Marley Lake	St. Edmunds	Unknown	Management strategy to be determined after lake inventory		
Moore Lake lake inventory	St. Edmunds	N. Pike	Management strategy to be determined	Y. Perch	after

**TABLE L2 (Cont.)**  
**OMNR Fisheries Management Designation for**  
**Inland Lakes Within the Park Vicinity**

<b>Lake/Pond</b>	<b>Township</b>	<b>Resident Fish Community</b>	<b>Comments</b>		
Quenlin Lake	St. Edmunds	Unknown	Management strategy to be determined after lake inventory		
Shouldice Lake	Lindsay	Smallmouth Bass Y. Perch	Smallmouth bass population given priority		
Umbrella Lake lake inventory	St. Edmunds	N. Pike	Management strategy to be determined	Y. Perch	after
Upper Andrew Lake	St. Edmunds	N. Pike Y. Perch	Lake will be managed for resident coolwater fish community		
Warder Lake	St. Edmunds	Smallmouth Bass	Smallmouth bass population given	Y. Perch	priority
Britain Lake	Lindsay	Smallmouth Bass Walleye (?) Y. Perch	Management strategy to be determined after lake inventory		
Ira Lake inventory	Lindsay	Smallmouth Bass  Y. Perch	Management strategy to be determined	N. Pike	after lake
Miller Lake warmwater fish communities	Lindsay	Smallmouth Bass  Y. Perch	Lake will be managed for both coolwater	N. Pike	and

**TABLE L3**  
**OMNR Fisheries Management For Streams**  
**in the Park Vicinity**

<b>Stream Name</b>	<b>Fish Community Designation</b>	<b>Fish Species Involved</b>	<b>Partitioning</b>	<b>Comments</b>
William Henry Marsh Runoff	Coolwater/ Warmwater	N. Pike Smallmouth Bass	N/A	----
Crane River	Transitional (Coldwater)	Brook Trout Brown Trout	N/A	Rehabilitate resident trout populations
Dorcas Bay	Coldwater	Brook Trout	N/A	Investigate, protect Creek and rehabilitate if required
Other small Unnamed Creeks	Coldwater	Brook Trout	N/A	Investigate, protect and rehabilitate if required
Sideroad Creek	Coolwater	N. Pike	N/A	Investigate for fisheries management potential
Willow Creek	Coldwater	Brook Trout Brown Trout	Maintain beaver required dam(s) or	Beaver dam removal (upstream) construct weirs near mouth to restrict rainbow trout and chinook salmon access upstream



**TABLE L4**

**Summary of Fish Species Present in Lakes (Based on Historical Records)**

<b>COLUMN</b>	<b>SPECIES</b>
13	Brook Trout (1 = present, - = absent)
14	Lake Trout
15	Northern pike
16	Largemouth bass
17	Smallmouth bass
18	Rock bass
19	Yellow perch
20	White sucker
21	Longnose dace
22	Northern redbelly dace
23	Finescale dace
24	Central mudminnow
25	Fathead minnow
26	Bluntnose minnow
27	Brook stickleback
28	Least darter
29	Iowa darter
30	Johnny darter
31	Pumpkinseed
32	Common shiner
33	Blacknose shiner
34	Golden shiner
35	Blackchin shiner
36	Emerald shiner
37	Brown bullhead
38	Creek chub
39	Tadpole madtom
40	Lake herring (Cisco)

**TABLE L4 (Cont.)**

**Summary of Fish Species Present in Lakes (Based on Historical Records)**

<b>Lake Name</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>18</b>	<b>19</b>	<b>20</b>	<b>21</b>	<b>22</b>	<b>23</b>	<b>24</b>			
	<b>25</b>	<b>26</b>	<b>27</b>	<b>28</b>	<b>29</b>	<b>30</b>	<b>31</b>	<b>32</b>	<b>33</b>	<b>34</b>	<b>35</b>	<b>36</b>			
	<b>37</b>	<b>38</b>	<b>39</b>	<b>40</b>											
Barney Lake	-	-	-	-	-	-	1	-	-	1	1	1	1	1	1
William Henry Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Loon Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marr Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horse Lake	-	-	-	-	-	1	1	1	-	-	-	1	-	1	1
Cyprus Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cameron Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
No Name #1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
McLander Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scugog Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horseshoe Marsh	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-
No Name #2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bartley Lake	-	-	1	-	-	-	1	-	-	1	-	1	-	-	1
Emmet Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Andrew Lake	-	-	1	-	1	1	1	-	-	-	-	1	-	-	-
George Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Johnson's Mud Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
No Name #3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marley Lake	-	-	1	-	1	1	1	-	-	-	-	1	-	-	-
Moore Lake	-	-	1	-	-	-	1	-	-	-	-	1	-	-	-
Upper Andrew Lake	-	-	1	-	-	1	1	-	-	-	-	1	-	-	-
Umbrella Lake	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-
No Name #4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clear Lake	-	-	1	1	1	1	1	-	-	-	-	1	-	-	-
Big Marsh	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
Mud Lake	-	-	-	-	-	1	1	1	-	1	-	1	-	-	-
Crane Lake	-	-	-	-	-	1	1	1	-	1	-	1	1	1	1
Shouldice Lake	-	-	-	-	1	1	1	-	-	-	-	-	-	1	-
Conley Lake	-	-	-	-	-	-	1	-	-	1	1	1	-	-	1
Lymburner Lake	-	-	-	-	-	-	1	-	-	1	1	1	1	-	1
Quenlin Lake	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1
Gilles Lake	1	1	-	-	1	1	1	-	1	1	-	1	1	1	1
Britain Lake	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-
Georgian Bay/Lake Huron	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

## **BRUCE PENINSULA SHORELINES**

The shorelines of all interior Park lakes were documented in the lake surveys conducted during this study. The data collected is provided in the Figures in Appendix A. The following briefly discusses the shoreline types of the Bruce Peninsula along Lake Huron and Georgian Bay.

The Bruce Peninsula slopes upwards from the southwest at Lake Huron to Georgian Bay in north and east with a total elevation difference of up to 100 metres. This results in two very distinct shore zones on the opposing sides of the peninsula. The Lake Huron shore is predominantly a gently sloping bedrock plain extending into the water. Because of the low dip angle of the bedrock and the subsequent shallow water near shore the high energy waves generated on Lake Huron are generally dissipated prior to reaching the actual shore (Owens 1979). The wide, rock platform making up the shore is often littered by boulders and marshes exist only in isolated embayments and sheltered areas. The one exception to this shore type on the Lake Huron side of the Peninsula is the extensive sand beach present at Dorcas Bay. This sand beach was likely formed during Nipissing II and Algoma post glacial lake stages. This is discussed fully in the soils section of this document.

The north and eastern shore of the peninsula is dominated by a high backshore relief with cliffs up to 100 m high. The beaches in this vicinity of the Park are primarily boulder-cobble. A short length of shingle beach is present south of Wingfield Basin at Cabot Head. The wave-energy levels along this coast are generally not high since the winds are predominantly offshore (Owens 1979). However, severe storms associated with onshore winds do occur resulting in significant short-term wave energies along this coast.

The shore types for the entire study area have been classified and entered into the SPANS database for the Park. Figure L2 is a hardcopy output of this mapping.

## **REFERENCES TO LAKES, RIVERS AND SHORELINES**

- Campbell, R.R. 1987. Rare and endangered fishes and marine mammals of Canada: COSEWIC Fish and marine mammals subcommittee status reports: III. The Canadian Field Naturalist 101(3): 165-170
- OMNR. 1970. Open file records of Ontario Ministry of Natural Resources, Owen Sound.
- OMNR. 1986. Owen Sound District Fisheries Management Plan 1986-2000. Ontario Ministry of Natural Resources.
- Owens, E.H. 1979. The Canadian Great Lakes: coastal environments and the cleanup of oil spills. Environmental Protection Service, Environment Canada. EPS-3-EC-79-2.
- Ryder, R.A. 1965. A method of estimating potential fish production of north-temperate lakes. Transactions of the American Fisheries Society. Vol. 94 No. 3.
- Smith, P.A. and C.A. Smallwood. ????. Fisheries Resources of the Niagara Escarpment Planning Area. Ontario Ministry of Natural Resources.
- Video Tape of Shoreline. 1978. The Bruce Peninsula Douglas Point to Hay Bay to Mallory Beach. Produced by Inland Waters Directorate, Environment Canada. Tape available in Parks Canada Cornwall office.

## **SATELLITE IMAGERY AND PROCESSING**

Landsat 5 thematic mapper (TM) and SPOT-1 MLA images were purchased and analysed to determine the utility of remotely sensed data in biophysical surveys of this type. The data was processed on an ARIES-II system (DIPIX Technologies Ltd., Ottawa) and then downloaded to the SPANS system.

The following imagery was ordered:

1. one Landsat 5 TM image, the NW quadrant. Imaged on June 4, 1984, with image centre latitude 44 degrees 37 minutes N, longitude 81 degrees 9 minutes W. Bands 1 - 7;
2. one SPOT-1 MLA image. Imaged on September 1, 1986, with image centre latitude 45 degrees 7 minutes N, longitude 81 degrees 32 minutes W. Bands 1 - 3.

An initial visual check of the imagery indicated that it was of high quality and therefore it required no radiometric corrections. The cloud cover was 0% over the study area for both the SPOT-1 and Landsat 5TM images.

The satellite images were rectified and registered (geocoded) to a Universal Transverse mercator projection using 21 Ground Control Points (GCP's) selected from 1:50,000 scale NTS map sheets. SPOT-1 imagery was rectified to the map sheets. LANDSAT 5 TM imagery was rectified to the SPOT-1 imagery. The standard error of line and pixel estimates for processing of the imagery (see Appendix B) was at the subpixel level. At this stage of the processing the imagery was ready for classification based on known ground values or training locations.

## **VEGETATION CLASSIFICATION**

The maximum likelihood classifier was used in evaluating the vegetation and ground cover types. This method evaluates the variance and correlation of each classification categories' spectral response patterns when classifying an unknown pixel. A number of training locations of known surface make-up are established and the pixel values sampled for each spectral band. The training data is assumed to be normally distributed (Gaussian) and the distribution of each categories' response pattern is determined by calculating a mean vector and covariance matrix. The probability that a given pixel lies within each separate category is

evaluated based on these probability density functions and then assigned to the most likely class (or labelled as unknown if the values are below a pre-described probability threshold).

Classification of the TM bands was carried out in this manner based on information gathered during the field program. Initially 18 classes were derived for processing of the scene. Several of the training areas selected were found to have spectral signatures which were similar. As such, the original 18 classes were reduced to 11 classes based on signature distances. A description of the 11 classes can be seen in Table S1. Open water areas were classified using a parallelepiped classification method, which made use of near infrared bands. The signature distances of the signatures used in the maximum likelihood classification can be seen in Appendix B.

**TABLE S1**  
**Class Descriptions**

DEC1	DECIDUOUS FOREST >90%
CON1	CONIFEROUS FOREST >90%
CN75	CONIFEROUS FOREST 75% DECIDUOUS FOREST 25%
DC75	DECIDUOUS FOREST 75% CONIFEROUS FOREST 25%
FENS	FEN
BVRF	BEAVER FLOODS
ALVR	ALVAR
MEDO	MEADOWS
GRSR	GRASSES AND ROCKY SOIL
BARE	BARE SOILS; ROCK OUTCROPS; ROADS; SANDY SOILS
WETL	WETLANDS

The classification produced the following results (Table S2) using Landsat 5 TM bands 1 - 5 and band 7. TM band 6 (thermal infrared) is omitted from vegetation classifications.

**TABLE S2**  
**Initial Classification Results**

	<b>#pixels</b>	<b>%total</b>
DECIDUOUS FOREST >90%	120939	2.51
CONIFEROUS FOREST >90%	226579	4.71
CONIFEROUS FOREST 75% DECIDUOUS FOREST 25%	242524	5.04
DECIDUOUS FOREST 75% CONIFEROUS FOREST 25%	225642	4.69
FERNS	23162	0.48
BEAVER FLOODS	30489	0.63
ALVAR	63479	1.32
MEADOWS	43301	0.90
GRASSES AND ROCKY SOIL	15667	0.33
BARE SOILS; ROCK OUTCROPS; ROADS; SANDY SOILS	122502	2.55
WETLANDS	48038	1.00
OPEN WATER (UNCLASSIFIED)	<u>2353157</u>	<u>75.84</u>
TOTAL	3102792	100.00

The above classification was filtered using three passes of a 3 x 3 pixel minimum area filter to remove the speckled appearance of the classification. This procedure is used to remove possible errors of commission, or omission, by replacing a theme in a small area with the larger theme which surrounds it. The resulting image classification after filtering can be seen in Table S3.

**TABLE S3**  
**Final Classification Results**

	<b>#pixels</b>	<b>%total</b>
DECIDUOUS FOREST >90%	120931	3.90
CONIFEROUS FOREST >90%	220873	7.12
CONIFEROUS FOREST 75% DECIDUOUS FOREST 25%	242086	7.80
DECIDUOUS FOREST 75% CONIFEROUS FOREST 25%	224990	7.25
FENS	23154	0.75
BEAVER FLOODS	30480	0.98
ALVAR	63320	2.04
MEADOWS	43301	1.40
GRASSES AND ROCKY SOIL	15667	0.50
BARE SOILS; ROCK OUTCROPS; ROADS; SANDY SOILS	122005	3.61
WETLANDS	47761	1.54
OPEN WATER (UNCLASSIFIED)	<u>1958224</u>	<u>63.11</u>
TOTAL	3102792	100.00

The map generated by the classification defined in Table S3 was converted to SPANS format as TMAL.map. The final surface characteristic map (from the vegetation field survey) was re-coloured in SPANS to the same classes used in the satellite image classification where possible. The coniferous and deciduous classes were combined to a single class each (>75%) since the field survey did not differentiate between >75% and 100%. The field survey also did not uniquely identify bare soils and rocks and grasses and rocky soil. A two map correlation was then performed as a quick check on the ability of the satellite classification to reproduce the field survey results. The correlation statistics are summarized in Table S4. It is evident from this analysis that the initial satellite classification was a qualified success. To compare how well the AIRES Landsat classification matched the field survey results read across the rows of Table S4. As an example, for the deciduous tree category (areas >75% deciduous) the landsat analysis classified a considerable amount of coniferous area (as determined by the field survey) as deciduous. A June image was used in this classification which may have resulted in the fully leafed deciduous trees being mistaken as conifer. The coniferous classifications matched the field survey quite well with the exception that some alvar and deciduous areas were identified as coniferous. For the smaller areas, such as fens, beaver floods, meadows and wetlands only general trends are evident when comparing the field and landsat results. The landsat classification of these categories identified significant areas which matched the same field category



but also routinely identified considerable areas in many of the other field category locations. A good example of this is the wetland classification where as much or more wetland area is identified in the field classes fen, alvar, deciduous and coniferous as in the matching wetland areas. Most of the alvar identified by the landsat was indeed alvar in the field survey but less total alvar area was classified by the landsat method.

The total areas of each class as identified by the two methods are quite similar with the possible exception being the underestimation of alvar by landsat analysis. However, as discussed in the preceeding paragraphs, the two methods did not necessarily identify these areas in the same location within the peninsula. The training set used in this analysis was based on preliminary field work. A new training set has been taken from the final field survey and a similar classification conducted for the entire Park; this time within SPANS and using the SPOT image. The results of this analysis (FSA2.map) was again compared to the field results (Table S5).

The classification of the SPOT image within SPANS exhibits similar trends to the landsat results when compared to the field data but overall the classification does not appear to be as good as the AIRES results. The conifer classifications match well with the exception that in this analysis the total area of coniferous forest is underestimated and has been misclassified as primarily deciduous or fen. More alvar has been identified in this classification when compared to the landsat results. The correlations for the smaller areas followed the same trend as the landsat classification and in some cases were poorer. The most likely reasoning for the limited success of this classification was the need to perform the classification in multiple steps within SPANS due to modelling equation size limitations. The SPOT imagery also does not contain as much data as the Landsat TM data which may have affected the final classification somewhat.

TABLE S4: SPANS AREA CROSS TABULATION:  
AIRES LANDSAT CLASSIFICATION VS. FIELD CLASSIFICATION

Row : lsat - rec - Landsat Classification  
Col : veg\_fld - Field Classification  
Window : 00 - Universe

Contingency Coefficient 0.6111  
Tschuprow's T 0.2848  
Cramer's V 0.3152

Area (km sq)								
Total %								
Row %								
Col %	Fen	Beaver	Wetland	Alvars	Meadows	Decid	Conifer	Total
Water	0.704	0.286	1.371	0.086	0.000	0.195	0.4819	3.124
	0.22	0.09	0.42	0.03	0.00	0.06	0.15	0.96
	22.53	9.17	43.90	2.758	0.00	6.25	15.40	
	7.36	5.02	11.04	0.171	0.00	0.32	0.28	
Decid	0.277	0.536	2.453	6.810	2.960	35.885		79.236
	0.08	0.16	0.75	2.09	0.91	11.00	9.29	24.28
	0.356	0.68	3.10	8.595	3.74	45.29	38.26	
	2.90	9.39	19.75	13.17	24.01	58.06	17.54	
Conifer	2.443	1.484	3.088		0.537		103.783	150.664
	0.75	0.45	0.95	6.59	0.16	5.46	31.80	46.17
	1.62	0.99	2.05	14.27	0.36	11.83	68.88	
	25.57	26.01	24.86	41.57	4.36	28.85	60.05	
Fen	1.047	0.619	0.904	1.731	0.057	0.397	1.866	6.621
	0.32	0.19	0.28	0.53	0.02	0.126	0.57	2.03
	15.81	9.35	13.66	26.15	0.86	6.00	28.18	
	10.95	10.85	7.28	3.35	0.46	0.64	1.08	
Beaver	1.214	1.205	1.693	0.5304	0.115	0.790	3.034	8.580
	0.37	0.29	0.52	0.16	0.04	0.24	0.93	2.63
	14.15	14.04	19.73	6.17	1.34	9.21	35.36	
	12.71	21.12	13.63	1.02	0.93	1.28	1.76	
Alvars	1.033	0.461	0.560		0.9407	1.441		18.322
	0.32	0.14	0.17	2.41	0.29	0.44	1.84	5.61
	5.64	2.51	3.06	42.98	5.13	7.87	32.82	
	10.81	8.08	4.51	15.23	7.62	2.33	3.48	
Meadows	0.161	0.165	0.278	3.159	2.810	1.327	3.2886	11.188
	0.05	0.05	0.09	0.97	0.86	0.41	1.01	3.43
	1.44	1.48	2.48	28.24	25.11	11.86	29.39	
	1.69	2.89	2.24	6.11	22.80	2.15	1.90	
Grs-Rock	0.001	0.037	0.020	0.227	2.883	0.793	0.193	4.155
	0.00	0.01	0.01	0.07	0.88	0.24	0.06	1.27
	0.03	0.90	0.48	5.46	69.40	19.09	4.65	
	0.01	0.65	0.16	0.44	23.39	1.28	0.11	
Soil-Rd	1.160	0.298	0.627	7.448	1.967	1.939	18.982	32.421
	0.36	0.09	0.19	2.28	0.60	0.59	5.82	9.93
	3.58	0.92	1.93	22.97	6.07	5.98	58.55	
	12.14	5.23	5.05	14.40	15.96	3.14	10.98	
Wetlands	1.515	0.613	1.426	2.350	0.057	1.204	4.870	12.036
	0.46	0.19	0.44	0.72	0.02	0.37	1.49	3.69
	12.59	5.09	11.85	19.53	0.47	10.01	40.46	
	15.86	10.75	11.48	4.54	0.46	1.95	2.82	
-----	-----	-----	-----	-----	-----	-----	-----	-----
Total	9.555	5.705	12.420	51.713	12.325	61.802	172.826	326.347
	2.93	1.75	3.81	15.85	3.78	18.94	52.96	

TABLE S5

SPANS AREA CROSS TABULATION: SPANS SPOT VS. FIELD CLASSIFICATION

Row : fsa2 - Sat data classified by SPANS equation  
Col : veg\_fld - Field Classification to Match LSAT  
Window : 00 - Universe

Contingency Coefficient 0.5983  
Tschuprow's T 0.2933  
Cramer's V 0.3048

Area (km sq)								
Total %								
Row %								
Col %	Fen	Beaver	Wetland	Alvars	Meadows	Decid	Conifer	Total
Alvar	1.658	0.840	0.857	6.515	0.776	1.652	14.429	26.726
	0.53	0.27	0.27	2.09	0.25	0.53	4.62	8.56
	6.20	3.14	3.21	24.38	2.90	6.18	53.99	
	18.99	16.00	8.30	12.81	4.50	2.93	8.82	
Beaver	0.417	0.223	0.538	0.583	0.005	0.183	0.860	2.808
	0.13	0.07	0.17	0.19	0.00	0.06	0.28	0.90
	14.86	7.96	19.14	20.75	0.16	6.52	30.61	
	4.78	4.26	5.21	1.15	0.03	0.32	0.53	
Conifer	1.156	0.675	0.860	11.147	0.134	6.383	47.380	67.735
	0.37	0.22	0.28	3.57	0.04	2.04	15.17	21.68
	1.71	1.00	1.27	16.46	0.20	9.42	69.95	
	13.25	12.85	8.32	21.92	0.78	11.32	28.96	
Decid	0.765	1.018	3.734	8.844	2.642	35.788	41.616	94.407
	0.24	0.33	1.20	2.83	0.85	11.46	13.32	30.22
	0.81	1.08	3.96	9.37	2.80	37.91	44.08	
	8.77	19.39	36.16	17.39	15.33	63.46	25.44	
Fen	2.600	0.899	1.446	11.014	0.047	1.513	19.012	36.531
	0.83	0.29	0.46	3.53	0.02	0.48	6.09	11.69
	7.12	2.46	3.96	30.15	0.13	4.14	52.04	
	29.79	17.12	14.00	21.66	0.27	2.68	11.62	
Meadow	0.345	0.611	0.932	1.327	12.357	3.636	3.116	2.325
	0.11	0.20	0.30	0.42	3.96	1.16	1.00	7.15
	1.55	2.74	4.18	5.95	55.35	16.29	13.96	
	3.96	11.64	9.03	2.61	71.68	6.45	1.90	
Soil	1.354	0.696	1.419	8.630	0.899	5.054	28.756	46.808
	0.43	0.22	0.45	2.76	0.29	1.62	9.21	14.98
	2.89	1.49	3.03	18.44	1.92	10.80	61.43	
	15.51	13.25	13.74	16.97	5.22	8.96	17.58	
Wetland	0.432	0.288	0.541	2.787	0.380	2.182	8.433	15.043
	0.14	0.09	0.17	0.89	0.12	0.70	2.70	4.82
	2.87	1.92	3.60	18.53	2.52	14.50	56.06	
	4.95	5.50	5.24	5.48	2.20	3.87	5.15	
-----	-----	-----	-----	-----	-----	-----	-----	-----
Total	8.728	5.249	10.326	50.848	17.239	56.391	163.602	312.384
	2.79	1.68	3.31	16.28	5.52	18.05	52.37	

The two satellite classification methods have been compared in a two map cross correlation (Table S6). This table indicates that the results from the two methods were quite similar for the coniferous, deciduous, fen, alvar, and meadow classification; the Beaver flood and wetland classifications did not correlate very well. Some of this variability may be due to the fact that the two images were taken in different years. This would indicate that the SPANS classification method has merit in this type of application.

## **GEOLOGICAL FEATURE ENHANCEMENT**

Landsat TM band 5 data were directionally filtered to enhance geological features. TM band 5 was selected for processing because of its ability to separate cultural linear features from naturally occurring lineaments based on a visual inspection of the imagery. Two 3 x 3 weighted masks were passed over the image to highlight directional features in the north and northeast directions (see Table S7).

TABLE S6: SPANS AREA CROSS TABULATION:  
LANDSAT VS. SPANS SPOT CLASSIFICATION

Row : lsat\_rec - AIRES Landsat Classification BPNP  
Col : fsa2 - Sat data classified by SPANS equation  
Window : 00 - Universe

Contingency Coefficient 0.6431  
Tschuprow's T 0.2981  
Cramer's V 0.3174

Area (km sq)									
Total %									
Row %									
Col %	Alvar	Beaver	Conifer	Decid	Fen	Meadow	Soil	Wetland	Total
Water	0.052	0.146	0.004	0.001	0.173	0.016	0.027	0.006	0.425
	0.02	0.05	0.00	0.00	0.06	0.01	0.01	0.00	0.14
	12.23	34.43	0.90	0.27	40.66	3.69	6.47	1.35	
	0.19	5.41	0.01	0.00	0.47	0.11	0.06	0.04	
Decid	1.072	0.018	2.508	52.045	0.633	3.865	5.722	3.102	68.964
	0.35	0.01	0.82	17.10	0.21	1.27	1.88	1.02	22.66
	1.55	0.03	3.64	75.47	0.92	5.60	8.30	4.50	
	3.92	0.65	3.60	57.51	1.72	26.26	12.10	20.10	
Conifer	9.969	0.568	55.777	28.387	18.811	0.441	27.030	7.664	148.645
	3.28	0.19	18.33	9.33	6.18	0.14	8.88	2.52	48.84
	6.71	0.38	37.52	19.10	12.65	0.30	18.18	5.16	
	36.45	21.01	80.11	31.37	51.25	3.00	57.14	49.65	
	0.366	0.766	0.230	2.525	0.232	0.828	0.224	6.478	
	0.43	0.12	0.25	0.08	0.83	0.08	0.27	0.07	2.13
	20.17	5.66	11.83	3.55	38.99	3.58	12.78	3.45	
	4.78	13.56	1.10	0.25	6.88	1.58	1.75	1.45	
Beaver	1.217	0.579	0.947	0.723	2.317	0.428	1.173	0.432	7.816
	0.40	0.19	0.31	0.24	0.76	0.14	0.39	0.14	2.57
	15.57	7.41	12.12	9.26	29.64	5.47	15.01	5.52	
	4.45	21.43	1.36	0.80	6.31	2.90	2.48	2.80	
Alvars	4.885	0.096	2.015	2.004	2.826	1.253	3.700	1.492	18.270
	1.61	0.03	0.66	0.66	0.93	0.41	1.22	0.49	6.00
	26.74	0.53	11.03	10.97	15.47	6.86	20.25	8.17	
	17.86	3.56	2.89	2.21	7.70	8.51	7.82	9.67	
Meadows	1.225	0.016	0.533	2.752	0.323	3.062	1.813	0.807	10.530
	0.40	0.01	0.17	0.90	0.11	1.01	0.60	0.27	3.46
	11.63	0.15	5.06	26.13	3.07	29.07	17.22	7.67	
	4.48	0.58	0.76	3.04	0.88	20.80	3.83	5.23	
Grs_Rock	0.198	0.000	0.002	0.333	0.003	2.965	0.148	0.094	3.741
	0.06	0.00	0.00	0.11	0.00	0.97	0.05	0.03	1.23
	5.29	0.00	0.04	8.90	0.07	79.25	3.95	2.50	
	0.72	0.00	0.00	0.37	0.01	20.14	0.31	0.61	
Soil_Rd	6.217	0.247	5.216	2.571	5.844	2.210	5.300	1.183	28.787
	2.04	0.08	1.71	0.84	1.92	0.73	1.74	0.39	9.46
	21.60	0.86	18.12	8.93	20.30	7.68	18.41	4.11	
	22.73	9.13	7.49	2.84	15.92	15.01	11.20	7.67	
Wetlands	1.209	0.667	1.862	1.444	3.251	0.251	1.566	0.432	10.681
	0.40	0.22	0.61	0.47	1.07	0.08	0.51	0.14	3.51
	11.32	6.25	17.43	13.52	30.43	2.35	14.66	4.05	
	4.42	24.68	2.67	1.60	8.86	1.70	3.31	2.80	
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Total	27.350	2.703	69.629	90.489	36.704	14.721	47.306	15.435	304.338
	8.99	0.89	22.88	29.73	12.06	4.84	15.54	5.07	

**TABLE S7**  
**Directional Filters Used on TM Band 5**

**A.North Box Car Convolution Kernel**

Line	#	Pixel #		
		1	2	3
	1	0.133	0.133	0.133
	2	0.000	1.000	0.000
	3	-0.133	-0.133	-0.133

**B.Northeast Box Car Convolution Kernel**

Line	#	Pixel #		
		1	2	3
	1	0.000	0.133	3.000
	2	0.133	1.000	0.133
	3	-0.133	-0.133	0.000

After filtering images were interpreted on screen for linear features and the results photographed from the screen. Figure S1 is a composite photo of this result.

Attempts were made to enhance shoreline types, but spectral signatures of these areas were much too similar to allow classification.

## **MISCELLANEOUS PROCESSING**

Hardcopy large format enhanced imagery was produced on the CCRS Fire Colour Film Recorder. Imagery was contrast stretched using a simple linear stretch on all bands. These hardcopy products have been delivered to Parks Cornwall separate from this document.

Archives of Landsat imagery available at the Ontario Centre for Remote Sensing in Toronto were reviewed for ice extent and fire history over a period of several years. The survey included LANDSAT'S 1, 2, 3 and LANDSAT TM. Due to the nature of MSS data four image centres were searched. The centres were [track, frame] [19, 29] [20, 29] [20, 28] and [19, 28]. Imagery was available in several MSS bands and was discontinuous. TM imagery searched were all false colour composites.

In total some 15 MSS winter images were available for the selected study area for ice extent mapping. Several of the winter MSS imagery were found to be cloud covered or contain no ice to be mapped, this reduced the number of useful images to the 7 listed in Table S8.

The data in these images was of such limited value that it has not been reproduced in this report.

Finally, all of the bands of the Landsat and Spot images purchased for this project have been downloaded into SPANS format and delivered to the Parks Cornwall office to permit additional processing inside SPANS. The seven Landsat bands are named as follows: TB1F - TB7F.map. The three SPOT bands are labelled SPOT1 - SPOT3.map.

**TABLE S8****Imagery Reviewed for Ice Extent**

image	date	comment
20 28	26 MAR 73	BAND7
20 29	13 APR 73	BAND7
20 28	13 APR 73	BAND7
20 29	08 APR 74	BAND7
20 28	08 APR 74	BAND5
20 29	09 MAY 75	BAND4 NO ICE
20 29	27 MAY 75	BAND5 NO ICE
20 29	19 APR 77	BAND6
20 28	07 MAY 77	BAND5

Table S9 lists the TM colour composite imagery used in the fire history interpretation. No fires were identified in the imagery as would be expected since there have been no major fires in the Peninsula for several decades.

**TABLE S9****Imagery Reviewed for Fire History**

image	date	comment
19 29	12 JUL 83	NO FIRES DETECTED
	30 SEP 83	NO FIRES DETECTED
	01 NOV 83	NO FIRES DETECTED
	04 JUN 84	NO FIRES DETECTED
	14 JUL 84	NO FIRES DETECTED
	22 JUL 84	NO FIRES DETECTED
	02 OCT 84	NO FIRES DETECTED
	19 SEP 85	NO FIRES DETECTED
	23 APR 86	NO FIRES DETECTED
	22 MAY 87	NO FIRES DETECTED

**EXAMPLE DATA ANALYSIS**



The ultimate objective of this project is to provide a computerized database of geo-coded bio-physical information of the Park area which can then be used in ongoing Park management processes. The data sets which will be available from this biophysical in sufficient detail to be of use in this type of analysis are as follows:

- Lake limnology; depths, total dissolved solids, morphoedaphic index, pH, secchi disk depth, shore type, bottom type, fish species present;
- Shoreline types of Bruce Peninsula;
- Terrain - elevation (topography & bathymetry), slope and aspect;
- Geology - paleozoic, karst features, caves, building materials;
- Soils - type, depth, texture, rockiness etc.;
- Primary & Understory Vegetation - including attributes;
- Wetland classes;
- Basemap data - roads, buildings, fences, gravel pits, cliffs, power lines.

Possible uses or interpretations of these data sets that are discussed in this short summary are as follows.

To Identify:

- Opportunities or constraints to construction;
- Existing land use impacts and rehabilitation requirements;
- Vegetation succession trends;
- Areas of suitable habitat for species: Fisher, Wild Turkey, Deer, Bear;
- Sport fishing limitations and constraints;
- Fire risk and fuel loading;
- Susceptible areas to insect and disease infestation;
- Representative natural themes;
- Park zoning;
- Simple resource area analyses and cross correlations.

These types of interpretations will always be unique in terms of the factors which govern the ultimate definition of a "suitable" area. Some of the discussions which follow are general in scope and intended only to illustrate the types of analyses which will be possible with the database being assembled. Other sections of this report include detailed analysis performed using the available datasets. Table A1 summarizes which of the resource themes could be used in the suggested interpretations.

## **OPPORTUNITIES OR CONSTRAINTS TO CONSTRUCTION**

The type of construction or development which could occur in the park include buildings (service, visitor centres, accommodations), campgrounds (back country or central), and trails or roads. The type of analysis which could be conducted with Spans relate to identifying suitable sites for such facilities.

Suitable locations for major buildings will depend upon an adequate building site (bearing strength in footings, septic bed requirements, slope, proximity to existing roads, etc.) and minimizing impact on the local environment (in non-sensitive soils/surficial materials zones). These sites could be identified with a relatively straight-forward modelling session within Spans using the terrain, soils, vegetation and basemap datasets. For example a new map could be generated by Spans by identifying all areas in the Bruce (or in a predefined and mapped sub-section of the study area) which i) have slopes less than 10% ; ii) do not have sand or deep organic soils i.e., limit construction to rocky areas; iii) are not alvars (or any other sensitive areas); using a simple modelling session.

The siting of group campgrounds could be established via a modelling session which identifies those areas within specified distances of major service requirements (i.e., roads and hydro), points of interest to visitors (i.e., a major lake or shoreline, geological features, caves, hiking trails etc.) but are a safe distance from specific sensitive habitats (such as alvars or sand dunes). It may also be important to develop the group campsite facilities in an area of flat terrain. Back country campsites could be identified by specifying that they are within a minimum distance from an existing hiking trail, are not in a sensitive habitat (i.e., alvar, sand dune), are outside a specific influence (or distance from) an existing campsite or other park facility, are in a vegetation type which provides an adequate cover, and are not in an area of excessive slope etc.

The direct selection of road or trail routes by Spans is not possible. All that can be done is the identification of areas that are suitable for the establishment of a trail. These suitable areas could be defined using overlays of the terrain, soils, vegetation and basemap themes. A number of possible corridors could then be proposed and entered into Spans as a new map. The Spans system could then be used to determine which of the proposed trails best meets the needs of the park. For example, each trail corridor could be combined with the terrain and vegetation maps to determine the percentage of the trail areas that cover unsuitable terrain or impinge upon sensitive terrain. The best trail alternative could be determined by a weighted assessment of these and other factors.

## **EXISTING LAND USE IMPACTS AND RE-HABILITATION**

Land use impacts that have been entered into the Spans database include features such as sand and gravel pit locations, roads and trails, buildings, power lines, fence rows and pasture land or open fields. A simple modelling session could be designed to show the location of all, or sub-sets of these features on one map for reference. Analysis of re-habilitation requirements for these types of impacts could take the form of calculating the length of fence, roads or powerlines which would require either removal or relocation. Cost or effort needed for these operations could be estimated based simply on this length or could include the soil type and slope of the area in the cost equation as well. This could all be dealt with within Spans if the "costing" relationships are known. The areas of sand and gravel pits and open fields which exist could be calculated. These areas could then be used to determine effort or cost to perform re-habilitation (filling gravel pits, re-planting of open fields etc.).

**TABLE A1**  
**USE OF BIOPHYSICAL DATA SETS IN INTERPRETATIONS**

**DATA USE OR INTERPRETATION**

Opportunities or constraints to construction	X	X	X	X	X	X	
Land use impacts	X		X	X		X	
Vegetation succession				X	X	X	
Habitat suitability	X			X	X	X	
Sport fishing	X						
Fire risk and fuel loading				X	X		
Areas susceptible to disease and insect infestation			X	X	X		
Representative natural themes	X	X	X	X	X	X	X
Park zoning	X	X	X	X	X	X	X



## VEGETATION SUCCESSION TRENDS

The attribute data collected during the vegetation survey has been used to identify the various successional stages of development which exist throughout the park. The simple succession model shown below has been implemented as an example. More details concerning this model are presented in the Vegetation Chapter.

	<b>Tree Height</b>	<b>Open Area</b>
Pre-succession	0	>75%
Very Early	0-3	25-75%
Early Succession	0-10	0-75%
Mid Succession	0-20	0-25%
Most Advanced	>20	<5%

The resulting map SUCC.map has been entered in the Park's SPANS database and provided here in hardcopy as Figure A1 (also in Figure V16 in the Vegetation chapter).

## HABITAT SUITABILITY

The most difficult task in the modelling or identification of suitable habitats with the GIS is likely the development or acceptance of an accurate habitat suitability profile for the species in question and not in the interpretation of this model with the computer system. It is not within the scope of this project to develop these habitat profiles and so the following discussions deal with habitat models developed by others and available in the literature. Habitat suitability models for Deer, Fisher and Eastern Wild Turkey are discussed in considerable detail. The model for Deer has been implemented using the data entered into the SPANS database.

## DEER HABITAT

A deer habitat suitability model suggested by C.P.S. Staff in Cornwall has been implemented. The model is based on assigning weighted habitat values to 1 km by 1 km zones in the Park. The following habitat values and weightings have been proposed for the winter and spring-summer-fall habitats.

### Winter Range

weight	habitat element		score
2	% of grid area that is 100% conifer cover	<10%	0
		10-30%	3
		>30%	2
1	% of grid area that is south facing slope (SE-SW)	0-25%	1
		>25%	2
1	presence of shrubs	conifers only	0
		low	1
		deciduous	
		mid-high deciduous	2

### Spring/Summer/Fall Ranges

weight	habitat element		score
1	% of grid area that is open	<1%	0
		1-5%	1
		5-20%	2
		20-60%	1
		>60%	0
1	% of grid area with tree height <10 m	<20%	0
		20-40%	2
		40-70%	3
		>70%	2
1	% of grid area with presence of oak or beech	0-1%	0
		1-5%	1
		>5%	2

This model has been implemented in SPANS as follows. First of all, a map of 1 km square areas (GRID.map) has been developed which covers the entire Park area. Each square on this map has been

assigned its own colour or tynumber. Separate maps for each of the habitat elements have been generated in SPANS by re-colouring the vegetation map using its attribute file. Two map cross tabulated area analysis were then completed for the zone map and habitat element maps to determine the percentage of suitable habitat in each zone. An attribute file was then generated with the scores for each habitat element for each of the enumeration zones on kilosqua.map. This attribute file was then used to re-colour kilosqua.map to a range of habitat suitability values for summer and winter as seen in Figures A2 and A3 and in the SPANS database as WINTDEER.map and SUMRDEER.map. The results of this preliminary habitat model should now be compared with the current knowledge of the existing deer population and modified where necessary.

## FISHER

The U.S. Fish and Wildlife Service (USFWS) have developed Habitat Suitability Index Models for several species, including the Fisher (report PB 84-154871 Oct 1983, A.W. Allen). The following is a brief discussion of one possible method of implementing such a model within SPANS.

The fisher model considers canopy closure ( $V_1$ ), average dbh of overstory trees ( $V_2$ ), trees canopy diversity ( $V_3$ ), and percent of overstory comprised of deciduous species ( $V_4$ ) in the following manner:

$$HSI = (V_1 \times V_2 \times V_3)^{1/3} \times V_4 \quad (\text{single stand})$$

and

$$\sum_{i=1}^n \frac{HSI_i \times A_i}{\sum A_i} \quad (\text{area weighted average for an area comprised of various stands})$$

Where HSI - habitat suitability index

$A_i$  - stand area

$V_1, V_2, V_3, V_4$  - as in text above and Figure A4.

Suitability indices for individual stands could be generated in a modelling session within Spans, using the attributes collected in the vegetation survey for the entire park area. The resulting map could then been



used to calculate the overall suitability of the park to support a fisher population. According to the U.S. F&W report fisher populations require approximately 250 sq km of contiguous habitat to survive; an area larger than the currently proposed park.

## **EASTERN WILD TURKEY**

Donovan, Rabe and Olson (Wild. Soc. Bulletin 15:574-579, 1987) developed a GIS based Habitat Evaluation Procedure and applied it to the eastern wild turkey. The following is a discussion of how this model could be implemented within SPANS. The model they developed for the habitat suitability is as follows:

$$CI_s = (2 SI_h + SI_w + 2SI_s + SI_a)/6$$

$$CI_s = (SI_{ms} + SI_e)/2$$

$$CI_n = (SI_{mhu} \times SI_{hu})^{1/2}$$

$$HSI = \min(CI_c, CI_s, CI_n)$$

where variables are as described in Figure A5.

Unfortunately only the habitat composition index could easily be determined with Spans using the vegetation database. The remaining indices all require edge calculations which cannot easily be handled within Spans. The human use index would probably not be the limiting factor in the Bruce due to the limited development in the area so this could probably be omitted from the calculations. It may be possible to do the edge calculations by developing new maps which are corridors of a known width at the edge of each vegetation type polygon. The areas of the polygons could then be determined which would indicate the length of the cover type "edge". A separate map could also be generated to estimate minimum distance to all habitat types. This could be accomplished by defining corridors around the polygon boundaries of varying widths and then overlaying these polygons to identify areas where all habitat types exist within these varying distances. Alternatively a points sample could be done on the habitat map at a specified grid spacing. A voronoi map of these points could then be constructed and overlain with the habitat map in a modelling session to identify areas where all habitat types exist within the voronoi squares.

## **SPORT FISHING**

Any analysis of sport fishing potential could include lake areas, lake depths, littoral types, morphoedaphic index, fish species type and access potential data. However, with only a few exceptions (Cyprus: 25', Emmett: 35', Bartley: 12', and George: 20') all lakes within the Park are very shallow, 5 feet or less, and therefore can support only limited population of pike and bass species. It is doubtful that these populations could sustain any significant fishing pressure. Large pike and bass were sighted, however, during our survey of many of these shallow lakes and the local residents gave accounts of good fishing on many of the more remote lakes.

Spans could be used in various ways to illustrate the fisheries support capabilities of the various lakes. Maps of all lakes of certain maximum depths or areas could be generated. Lakes with known occurrences of certain fish species could be mapped. The absence of major fish species coupled with shallow water depths could be an indication of winter kill. These potential winter kill areas could be identified via Spans. Virtually all significant lakes are accessible by some form of public or private trail (2 or 4 wheel vehicle) which may or may not be gated at this time. A map of present ease of access to the various lakes could therefore be generated and combined with other lake attributes to determine the likely survival of present fish stocks.

## **FIRE HISTORY, RISK AND FUEL MAPPING**

Large forest fires burned the Bruce Peninsula in both 1903 and 1908 resulting in forests that are uniformly less than 90 years old. Some evidence of more present fires was found during the vegetation survey undertaken for this biophysical but historical accounts of them have not been identified. Fuel mapping has been generated using the Spans system and data collected in the vegetation survey. Canopy cover, species type and height were used to estimate basic fuel loading classes used in forest fire modelling. This information is stored as attributes to each unique vegetation zone in the park. Zones of varying fuel loading have been established via a modelling session in Spans which re-classifies the district based on the following conditions.

**Fire Hazard Level**

**Vegetation Characteristics**

Maximum hazard Jack Pine Dominant tree canopy >60% conifer >75% tree height >10 m  
 High hazard tree canopy >60% conifer >75% tree height >10 m  
 Moderate hazard tree canopy >60% conifer/deciduous 75/25 tree height >10 m  
 grass fire hazard marsh or fen open cover >75% graminoid/sedges or mixed  
 minimal hazard all other areas

The map resulting from this analysis, FIRE.map, can be seen in Figure A6. The modelling equation used to generate it and the final map have both been entered into Park's SPANS database. The following area analysis shows that a higher percentage of the park is prone to fire when compared to the peninsula as a whole.

	Peninsula		Park	
	Area (km sq)	Area (%)	Area (km sq)	Area (%)
Maximum Hazard	6.261	1.58	3.386	2.14
High Hazard	10.066	2.55	7.354	4.64
Moderate Hazard	79.895	20.22	19.648	25.02
Grass Fire Hazard	0.087	0.02	0.082	0.05
Other Areas	298.835	75.63	103.724	54.45

#### **INSECT INFESTATION AND DISEASE**

Areas susceptible to disease or insect infestation could be identified simply by mapping the vegetation types which are vulnerable. Other factors such as vegetation density (from canopy and height data), soil type, and terrain slope and aspect might also be used to further define susceptible areas.

#### **REPRESENTATIVE NATURAL THEMES**

The following is offered only as an example to demonstrate how SPANS can be used to obtain new understandings about ecological values. This discussion is repeated in the Vegetation chapter of this report.

The objective of this exercise is to evaluate intrinsic values. The amount or degree of value, the absence of value, or the presence of negative values is based upon experience and knowledge of what is important, what is normal ecologically within the landscape ecosystems of the study area.

The basic aerial unit used in these analyses are the polygons generated in the vegetation survey. As more information on the nature of the described variables present in each polygon is gathered the values of that polygon would change.

Another aspect of this analysis is that it should recognize the importance of dissimilar adjacent habitat. The total value at a location is affected by the attributes at habitats nearby and indeed at habitats quite distant from that being evaluated. For example, many animal species require both wetlands and adjacent uplands (in a certain condition) in order to have suitable habitat for living and reproducing, or a certain kind of community structure needs to be present within its living range (e.g., winter cover in the form of conifers or tree cavities, habernacula). The approach is calculated to ensure that the assessed value of a spot takes into account the nature (value) of nearby habitat because together, the two habitats are more valuable than either habitat when present alone. In this exercise, we only deal with this aerial matter in a limited way. In actual life, areas required by some species can be very large. For example, in an extreme case, one can consider vast regions of the Earth, as when space is required by birds during migration.

The idea of measuring ecological values using a numerical system is well known, but one has to recognize that the concept of value and the relative amount (number given to attributes or combinations thereof) of value are matters of knowledge, experience and judgement. A comparable system was developed to evaluate wetlands in Ontario (Ministry of Natural Resources and Environment Canada 1984). There, it took a committee of experts 18 months (including field-testing the system) to agree more or less as to the number of points to be allotted to a particular agreed upon value. So, the development of what would likely be seen as a satisfactory system does require the participation of various professionals knowledgeable about the workings of the natural world.

Another important aspect of values is mutual exclusivity. It is impossible to develop a system in which natural values are mutually exclusive. This is because the mere presence of a species or of some vegetational or physical aspect of the site provides values in many different ways.

In view of the above, for a system to be understood and acceptable, rationales should be adequately developed and agreed upon. As is evident from the various rationales presented below, faunal values are frequently invoked to justify ascribing a value to certain vegetation circumstances. Table V6 (vegetation chapter) summarizes the draft values assigned to the significant ecosystem attributes presently in the SPANS database.

These attribute values have been assigned the vegetation polygons and summed to provide an estimate of intrinsic ecological value for each cell. The result is seen in Figure A7 and is presented in the SPANS database as map LSTVALUE.map.

This initial map must be reviewed in detail to see if it makes sense based on our understanding of known places. If not, the attribute values should be adjusted to better reflect this knowledge and a new map generated. A recommended procedure for developing a final eco-value map is presented in the vegetation chapter.

## **PARK ZONING**

The biophysical data could be used to assist in the mapping of the five classes of zones established for national parks management (Zoning in National Parks, 1979). The five zones in this classification are 1: Special Preservation, 2: Wilderness, 3: Natural Environment, 4: Recreation, and 5: Park Services. The information sets required to establish these are listed in this publication as: resource significance, resource sensitivity, interpretive potential, recreational capability, visitor characteristics, regional considerations, and existing land uses. Some of the data requirements listed here clearly are not within the scope of this project and would have to be provided by others prior to a final zone classification. The biophysical data sets could be manipulated within Spans to identify areas of significant and sensitive resources, zones with particular interpretive potential or recreation capability and also existing land use characteristics. To further define "resource zones" appropriate buffer zones around unique or rare species and representative features could easily be added within Spans using its corridor feature. The road and trail maps of the Park could be re-worked to include corridors of influence or potential impact by visitors as a function of trail use, for example. These maps could then be used to define those areas that would be too close to such access to allow classification as wilderness or natural environment. A similar road-corridor analysis could be generated that would identify all locations close enough to major access roads to consider zoning as recreation or park services areas. This type of analysis would parallel that discussed under opportunities or constraints to construction.

## **SIMPLE AREA ANALYSES AND MAP CROSS CORRELATION**

A simple yet very powerful and useful capability of the SPANS software is its ability to calculate areas on maps and perform cross-correlations between different maps. These functions have been used in various

sections of this report to provide information about the resources being mapped. Some examples of such analyses are listed below.

- i) single map area analyses have been used to determine; a) the prominent slopes and directions of slope in the Park area; b) the prominence of the various vegetation cover types in the Park; c) the relative area of the various drainage types within the Park; and d) the water depth distribution in the water of Georgian Bay and Lake Huron within the Park.
- ii) two map correlations were used a) to compare the results of the satellite image classifications with the field survey results; and b) in the deer habitat suitability analyses;

## **APPENDIX A**

### **LAKE BATHYMETRY, SHORE TYPE AND SURFACE TYPE MAPS**

**APPENDIX B**

**SATELLITE CLASSIFICATION DETAILS**



**TABLE B1: STANDARD ERROR IN GEOCODING OF IMAGERY**

GEOCODING OF SPOT-1 MLA:

<b>GCP NO.</b>	<b>SLAVE LINE</b>	<b>SLAVE PIXEL</b>	<b>UTM NORTH</b>	<b>UTM EAST</b>	<b>LINE RESID</b>	<b>PIXEL RESID</b>	
1	713.0	760.0	5017000.0	443600.0	8.0	-3.7	
2	966.0	961.0	5011095.0	446450.0	-34.5	-5.3	
3	1194.0	1017.0	5006460.0	446600.0	-1.5	-0.8	
4	994.0	1078.0	5010100.0	448650.0	24.0	26.5	
5	1046.0	1186.0	5008600.0	450500.0	6.0	-15.1	
6	1261.0	1250.0	5004150.0	450850.0	5.5	-13.4	
7	1371.0	1415.0	5001300.0	453650.0	3.5	30.9	
8	988.0	1568.0	5008060.0	458245.0	-24.5	18.9	
9	1150.0	1415.0	5005575.0	454540.0	0.0	-7.7	
10	1254.0	1649.0	5002550.0	458635.0	13.0	-42.6	
11	1509.0	1566.0	4997945.0	456990.0	-25.0	1012.0	E
12	1356.0	1871.0	4999595.0	462610.0	4.0	28.9	
13	1167.0	2192.0	5001900.0	469650.0	17.0	-4.6	
14	965.0	2349.0	5005175.0	473555.0	21.0	-19.3	
15	722.0	2566.0	5009415.0	476900.0	-7.5	4.1	
16	1526.0	2123.0	4995150.0	466750.0	-42.0	-29.5	
17	1268.0	2399.0	4998999.0	473300.0	-19.5	26.9	
18	1531.0	2416.0	4993975.0	472350.0	151.0	-141.4	E
19	1596.0	2629.0	4991600.0	476695.0	-36.5	310.2	E
20	1742.0	2195.0	4990710.0	467255.0	39.5	11.9	
21	1813.0	2556.0	4987700.0	474000.0	-1.0	0.6	
22	1897.0	2042.0	4988310.0	463535.0	-14.0	-15.2	
23	1957.0	2374.0	4985660.0	469785.0	-1.5	16.6	
24	1907.0	2764.0	4984945.0	477650.0	1.0	-9.2	

ORDER OF CURRENTLY CALCULATED TRANSFORM = 3

STANDARD ERROR OF PIXEL ESTIMATE = 18.43126106

STANDARD ERROR OF LINE ESTIMATE = 17.84016800

**TABLE B2: GEODCODING OF LANDSAT 5 TM (REGISTERED TO SPOT-1 DATA)**

<b>GCP NO.</b>	<b>SLAVE LINE</b>	<b>SLAVE PIXEL</b>	<b>MASTER LINE</b>	<b>MASTER PIXEL</b>	<b>LINE RESID</b>	<b>PIXEL RESID</b>
1	654.0	1277.0	150.0	527.0	-0.2	0.0
2	822.0	1410.0	455.0	674.0	-0.3	0.3
3	972.0	1445.0	678.0	681.0	0.2	-0.1
4	841.0	1487.0	498.0	782.0	1.2	0.4
5	877.0	1559.0	572.0	876.0	-0.4	-1.0
6	1019.0	1599.0	794.0	894.0	-0.6	0.5
7	1093.0	1708.0	937.0	1031.0	0.1	-0.4
8	843.0	1813.0	598.0	1261.0	0.3	0.0
9	947.0	1710.0	722.0	1078.0	-0.5	-0.2
10	1018.0	1865.0	875.0	1285.0	-0.1	0.5
11	1185.0	1808.0	1103.0	1150.0	0.1	-0.2
12	1087.0	2012.0	1022.0	1480.0	-0.2	0.5
13	965.0	2228.0	907.0	1834.0	0.5	0.4
14	834.0	2335.0	743.0	2030.0	-1.0	-0.1
15	674.0	2415.0	530.0	2196.0	0.3	0.1
16	1201.0	2179.0	1242.0	1690.0	0.1	-0.1
17	1033.0	2366.0	1050.0	2015.0	0.5	-0.7
18	1202.0	2370.0	1305.0	1972.0	23.9	1.3 E
19	1252.0	2516.0	1419.0	2171.0	0.0	0.6
20	1344.0	2225.0	1468.0	1713.0	-0.3	-0.3
21	1394.0	2465.0	1616.0	2051.0	-0.1	-0.3
22	1444.0	2122.0	1585.0	1530.0	0.2	0.3

ORDER OF CURRENTLY CALCULATED TRANSFORM = 3

STANDARD ERROR OF PIXEL ESTIMATE = 0.37853894

STANDARD ERROR OF LINE ESTIMATE = 0.42052269

**TABLE B3: MAXIMUM LIKELIHOOD SIGNATURE DISTANCES**

-1.0 = SIGNATURE FILE READ ERROR

-2.0 = DIMENSION MISMATCH

-3.0 = FEATURE FIEL NAME MISMATCH

-4.0 = MATRIX SUM NON-INVERTABLE

	<b>Dec1</b>	<b>Con1</b>	<b>Cn75</b>	<b>DC75</b>	<b>FENS</b>	<b>BURF</b>	<b>ALVR</b>
BGS DEC1	0.000	11.383	10.647	1.279	17.107	10.875	13.051
BGS CON1	11.383	0.000	0.406	2.177	3.786	2.929	2.809
BGS CN75	10.647	0.406	0.000	2.277	4.528	3.476	4.538
BGS DC75	1.279	2.177	2.277	0.000	5.533	4.008	3.772
BGS FENS	17.107	3.786	4.528	5.533	0.000	1.963	2.065
BGS BVRF	10.875	2.929	3.476	4.008	1.963	0.000	3.456
BGS ALVR	13.051	2.809	4.538	3.772	2.065	3.456	0.000
BGS MEDO	14.618	6.004	12.782	4.024	8.633	12.424	1.065
BGS GRSR	18.138	21.131	27.966	7.233	19.722	20.516	6.866
BGS BARE	12.509	3.072	3.944	3.951	3.066	4.654	2.053
BGS WETL	8.154	2.335	2.540	3.567	1.898	1.734	3.145

	<b>MEDO</b>	<b>DRSR</b>	<b>BARE</b>	<b>WETL</b>
BGS DEC1	14.618	18.138	12.509	8.154
BGS CON1	6.004	21.131	3.072	2.335
BGS CN75	12.782	27.966	3.944	2.540
BGS DC75	4.024	7.233	3.951	3.567
BGS BVRF	12.424	20.516	4.645	1.734
BGS ALVR	1.065	6.866	2.053	3.145
BGS MEDO	0.000	5.191	2.563	8.859
BGS CRSR	5.191	0.000	6.649	16.521
BGS BARE	2.563	6.649	0.000	3.793
BGS WETL	8.859	16.521	3.793	0.000