



Western Michigan University  
ScholarWorks at WMU

---

Master's Theses

Graduate College

---

8-1998

## Comparative Phytogeography of the Ushkanii Island, Lake Baikal, Russia, and the Caribou Islands, Lake Superior, Canada

Robert J. Liebermann

Follow this and additional works at: [https://scholarworks.wmich.edu/masters\\_theses](https://scholarworks.wmich.edu/masters_theses)



Part of the Geography Commons

---

### Recommended Citation

Liebermann, Robert J., "Comparative Phytogeography of the Ushkanii Island, Lake Baikal, Russia, and the Caribou Islands, Lake Superior, Canada" (1998). *Master's Theses*. 4517.

[https://scholarworks.wmich.edu/masters\\_theses/4517](https://scholarworks.wmich.edu/masters_theses/4517)

This Masters Thesis-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Master's Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact [wmu-scholarworks@wmich.edu](mailto:wmu-scholarworks@wmich.edu).



**COMPARATIVE PHYTOGEOGRAPHY OF THE  
USHKANII ISLANDS, LAKE BAIKAL, RUSSIA, AND  
THE CARIBOU ISLANDS, LAKE SUPERIOR, CANADA**

by

**Robert J. Liebermann**

**A Thesis  
Submitted to the  
Faculty of The Graduate College  
in partial fulfillment of the  
requirements for the  
Degree of Master of Arts  
Department of Geography**

**Western Michigan University  
Kalamazoo, Michigan  
August 1998**

Copyright by  
Robert J. Liebermann  
1998

## ACKNOWLEDGEMENTS

In Russia, Valentina Ivanovna Galkina, Sasha Timonin, Vladimir Fialkov, Tamara Nikolaevna Nevedaiskaya and the staff of the Baikal Museum in Listvyanka recognized me as an enthusiastic pilgrim to Baikal from my first visit in 1993. They provided me with assistance which, more than any other, allowed me the opportunities to continue to learn about the nature of Baikal. They provided lodging in the Institute's hostel, and when that was unavailable, on the floor of the museum. They allowed me to use (and browse!) the institute's excellent scientific library. When I needed to go to Irkutsk for meetings or supplies, I often rode in their bus, trucks, or cars. They allowed me to take part in scientific expeditions in the region. Valentina Ivanovna was frequently a gracious hostess over tea in her office, happy to discuss a broad range of scientific and philosophical subjects, and to offer practical advice on many matters. Most importantly, these dedicated *Baikalovedi* understood my attraction to and curiosity of the natural world, and accepted me as one of their own. Nadya Gogina and family in Irkutsk and Moscow, from our first meeting in 1993, attached me as one of their family—with all benefits and respects—as well as acting as logistical experts, customs agents, tour guides, ombudsmen, ticket agents, and other invaluable personæ too varied to mention. Mikhail Grachev, Nikolai Pavlovich Ladeischikov, and the Limnological Institute in Irkutsk were professional and courteous in their help, functioning as intermediaries between myself and the Zabaikalskii National Park. Dr. Ladeischikov, especially, was a true professor of his science, and gave me encouragement in my academic pursuits. Sergei Kazanovsky and Dr. Leonid Bardunov of the Siberian Institute of Biochemistry and Physiology of Plants (СИФИБР) in Irkutsk helped me with my

## Acknowledgements– Continued

Baikal area botany and bryology, and other related help useful in my study of the region. Alexander, Yuri, and the staff of Zabaikalskii National Park, Ust Barguzin, contributed immensely to my research at the Ushkanii Islands. The Captain and crew of the meteorological research vessel *Орион* (Orion) of the Russian Meteorological Service gave me safe, comfortable, and fun passage from the Ushkanii Islands.

In Canada, Dr. John Morton of The University of Waterloo patiently supplied me with his information on Caribou Island on numerous occasions, and offered advice and encouragement on the study of the island. Richard Sims, of Forestry Canada; Sault Ste. Marie; and Phil Kor, Gord Eason, Heather Barnes, Bert Ffrench, Scott Jones, and Irene, of the Ontario Ministry of Natural Resources, helped me with various scientific and technical materials relating to Caribou Island and related areas. Bill, Nick, and Maurice of Batchawana Bay Air Services gave me excellent transport to and from Caribou Island, as well as lodging and hospitality when we were unable to fly because of inclement weather. Dave Lepore of Quattra SCS, Sault Ste. Marie, showed me the proper setup and use of a radiotelephone, and supplied me with the equipment.

In the USA, My thesis committee; Dr. Joseph De Bolt of Central Michigan University and Dr. Rolland Fraser and Dr. Philip Micklin of Western Michigan University, gave me the invaluable assistance that only they could. In particular, I am indebted to Joe De Bolt, who gave me the initial opportunities and encouragement which have lead to my interest and the realization of my studies in the former USSR.

In Belarus, Feodor Piskunov and the Library of the Belarusian Academy of Sciences, Minsk, gave me helpful additional literature assistance for Baikal.

## Acknowledgements– Continued

On the air, the Australian, British and Canadian Broadcasting Corporations were my company on the islands when I was eager for news, entertainment, human voice, and the thrill of radio while otherwise alone in the wilderness.

And on a map, I am indebted to an anonymous cartographer at the Michigan Department of Transportation, who brilliantly included Caribou Island on the top of the Michigan highway map and, unknowingly, provided me with a great question mark.

Спасибо Вам!

Robert J. Liebermann

COMPARATIVE PHYTOGEOGRAPHY OF THE  
USHKANII ISLANDS, LAKE BAIKAL, RUSSIA AND  
THE CARIBOU ISLANDS, LAKE SUPERIOR, CANADA

Robert J. Liebermann, M.A.

Western Michigan University, 1998

Islands are biogeographically unique because of their isolation and the conditions of their surrounding waters. The majority of island biogeography studies deal with oceanic islands, but an interesting variety of islands that have been given less attention are those in large lakes. Islands in large lakes and those in oceans share a number of similarities, as well as many differences, in their biogeography.

Studies have been made on two distantly separated island groups; the Ushkanii Islands, Lake Baikal and the Caribou Islands, Lake Superior. They are the most remote lands in their respective lakes, and the main islands of each of the two groups are similar in size and shape, and forested with a coniferous taiga. They differ in topography, geology, soils, human history, age, and distance from mainland.

The conditions found on these islands and reported by previous researchers show many unusual floristic phenomena, which are explained as expressions of the biogeography of large lake islands. For example, both sites have climates ameliorated by the surrounding lake waters, and both have numerous disjunct species not normally found in their areas—from colder climates as well as warmer.

The islands' settings are described, their physical geographies, floræ, and phytogeographies given, their comparative aspects are discussed in detail, and related to their status as lake islands. Finally, their conservation histories and potentials are addressed in light of their value as natural areas unlike any other.

## TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	ii
LIST OF TABLES.....	viii
LIST OF FIGURES.....	ix
INTRODUCTION.....	1
The Study of Lake Islands.....	1
Problem Statement.....	4
Purpose and Objectives of This Study.....	5
Suitability of the Study Areas.....	8
LITERATURE AND PREVIOUS RESEARCH.....	10
Island Biogeography and Island Ecology.....	10
Lake Shoreline Plant Biogeography and Ecology.....	16
Comparative and Circumboreal Phytogeography.....	18
Limnoclimate.....	22
Previous Investigations at the Study Sites.....	27
STUDY METHODOLOGY.....	33
Field Investigations.....	33
Limitations of the Project.....	36
STUDY SITE 1: THE USHKANII ISLANDS, LAKE BAIKAL.....	39
Location.....	39
Geology.....	45
Soils.....	46
Climate.....	51



Table of Contents–Continued

Animals.....	58
Vegetation of the Ushkanii Islands.....	61
<b>STUDY SITE 2: THE CARIBOU ISLANDS, LAKE SUPERIOR.....</b>	<b>84</b>
Location.....	84
Geology.....	91
Soils.....	94
Climate.....	101
Animals.....	108
Vegetation of the Caribou Islands.....	113
<b>FLORISTIC COMPARISON OF THE OF THE USHKANII AND CARIBOU ISLANDS.....</b>	<b>133</b>
Similarities and Differences.....	133
Numerical Characteristics of the Vascular Floræ.....	136
Influences on the Phytogeography.....	139
Origins of the Vegetation.....	154
Vegetation Change.....	158
Noteworthy Plants.....	171
Similarities to Other Large Lake Islands.....	190
<b>CONSERVATION.....</b>	<b>192</b>
Conservation Issues at the Ushkanii Islands.....	192
Conservation Issues at the Caribou Islands.....	205
<b>CONCLUSION.....</b>	<b>214</b>
Summary.....	214
Recommendations for Further Study.....	216

Table of Contents–Continued

APPENDICES

A. Conspectus of the Floræ of the Ushkanii and Caribou Islands.....	219
B. Noteworthy Plants of the Ushkanii and Caribou Islands.....	265
BIBLIOGRAPHY.....	272

## LIST OF TABLES

1. Climatic Summary for the Ushkanii Islands.....	52
2. Climatic Summary for the Caribou Islands.....	103

## LIST OF FIGURES

1.	Location Map of the Ushkanii Islands.....	40
2.	General Map of the Ushkanii Islands.....	42
3.	View of Bolshoi Ushkanii Island From Tonkii Island.....	44
4.	Geology and Topography Map of the Ushkanii Islands.....	47
5.	Soil Map of Bolshoi Ushkanii Island.....	49
6.	Vegetation Map of the Ushkanii Islands.....	63
7.	Shallow Water on South-Central Shoreline of Bolshoi Ushkanii Island.....	66
8.	Shallow Water on Northwest Shore of Bolshoi Ushkanii Island.....	68
9.	Northwest Shoreline Forest Edge of Bolshoi Ushkanii Island.....	69
10.	Open Larch-Crowberry Woods on Bolshoi Ushkanii Island.....	71
11.	Larch Forest on Bolshoi Ushkanii Island.....	73
12.	Pine Forest on Central Upper Area of Bolshoi Ushkanii Island.....	76
13.	Pine Forest-Steppe Transition on Bolshoi Ushkanii Island.....	77
14.	Poplar Thicket on Bolshoi Ushkanii Island.....	79
15.	Upper Slope of the Maryan on Bolshoi Ushkanii Island.....	80
16.	Location Map of the Caribou Islands.....	85
17.	General Map of the Caribou Islands.....	87
18.	Aerial Photograph of Caribou Island.....	88
19.	Topography and Geology Map of the Caribou Islands .....	90
20.	Aerial Photograph of Features of Southwestern Caribou Island.....	94
21.	Soil Map of the Caribou Islands.....	96

List of Figures—Continued

22.	Windthrown Tree and Soil Exposure in Boreal Forest on Caribou Island.....	98
23.	Soil Profile From Deciduous Forest on Caribou Island.....	99
24.	Vegetation Map of the Caribou Islands.....	114
25.	Shoreline on Northwest Side of Caribou Island.....	116
26.	Dune Zonation on the East Side of Caribou Island.....	118
27.	Character of the Southwest Deciduous Forest on Caribou Island.....	124
28.	Character of the Open West Side Bog on Caribou Island.....	125
29.	Possible Remnant Population of Arborvitæ on Caribou Island.....	127
30.	Sand Flat on Caribou Island.....	130
31.	Numbers of Plant Families of the Ushkanii and Caribou Islands.....	137
32.	Numbers of Species of the Ushkanii Islands Flora.....	138
33.	Numbers of Species of the Caribou Islands Flora.....	138
34.	Species-Area Relationship for Islands in the Great Lakes and Baikal, Showing Positions of the Ushkanii and Caribou Islands.....	141
35.	Species-Area Relationship for Islands of the Ushkanii and Caribou Archipelagos.....	141
36.	Beaver Trail in Boreal Forest of Caribou Island.....	148
37.	Forest Cutting on Bolshoi Ushkanii Island.....	163
38.	Fire Traces in Larch Woods of South-Central Bolshoi Ushkanii Island.....	166
39.	Signs of Fire on Kruglii Island.....	167
40.	The ZNP Ranger Station on Bolshoi Ushkanii Island.....	194
41.	Human Influence Map of the Caribou Islands.....	208

## INTRODUCTION

A species once on an island may find conditions somewhat different from those in its usual mainland abode, yet not intolerable when other choice is unavailable; so from place to place among the islands we find numerous instances of the unexpected, and other cases which, though unusual, are strictly insular in character.

—Hatt, et al. (1948, 137)

### The Study of Lake Islands

As vacation paradises, as private retreats or hideouts, or as inescapable prisons, islands have long attracted and stimulated the curiosity of the traveler and explorer. Their isolation and dissimilarity from the mainland, their unique landscape, and their unusual climate has shaped their value to human activity. For many of these same reasons, the conditions on islands are optimal for uncommon communities of plants and animals—and, as a result, of great interest to the biogeographer. Islands are exclusive environments, like no other, for life of all kinds. The unusual endemic plants and animals of New Zealand and the Galapagos and Hawaiian Islands are famous examples (Carlquist 1965).

Mac Arthur and Wilson's *Theory of Island Biogeography* (1967) focused attention on the study of island biogeography and island population ecology three decades ago. They presented evidence and theory, gained from their own research and that of others, for the rules of insular populations and their formation, demographics, and evolution. Subsequent island biogeography studies, building on, refining, and modifying the general theory of Mac Arthur and Wilson, have added to the wealth of data on islands and other insular populations (Quammen 1996). Comprehensive as

subsequent study has been, it has not covered equally *all* of the many varieties of islands having distinctive biogeographical patterns.

Islands of lakes are interesting and enigmatic in their own right. Their biogeographical conditions are distinct from oceanic islands, and their plant communities are no less biogeographically interesting than their animal communities. The intriguing study of lake island biogeography, seldom studied and little known, is an especially unique area for further research. The moose and wolves of Isle Royale and the caribou of the Slate Islands in Lake Superior have been long studied as examples of animal populations in isolation from their "normal" habitats, supports, and perils, and therefore interesting in their population ecology. The principles involved in lake island biogeography, as will be shown in this study, are often different from those of oceanic islands, as are the resulting ecological conditions.

Perhaps most biogeographically unique are the islands of very large lakes of the temperate areas, where the interactions of air over land and water are most influential on local climate. Here the changing temperatures of the seasons are moderated by the thermal lag and physical properties of the water to produce a limnoclimate which is neither oceanic nor completely continental. As a result, microclimatic conditions on such islands often mimic the climates of other regions, such as those of more northern or southern areas. These climatic conditions are often sufficiently different from mainland areas away from the lakes to host plants which are ordinarily not found in the region (Given and Soper 1981). In addition, the islands of the world's largest lakes are isolated by relatively short distances of water, which present a more "porous" barrier than remote islands of oceans. This "intermediate isolation" of islands of large lakes bears closer attention. What is the biogeographical signifi-

cance of having a mainland much closer—often connected by ice during winter—than that of oceanic islands?

The limnoclimatic and isolation conditions are among the most deterministic elements of large lake island biogeography (Вьхристюк 1982, Hazlett 1988). Islands in large lakes do share some properties, albeit modified, with those of oceanic islands. Examples are fewer taxa per area and higher rates of endemism than on the mainland, and unique ecological contexts related to isolation and limited genetic diversity. Limited studies have been made on the subject of islands in large lakes. Previous reports, though often excellent, are frequently obscured in various published and unpublished formats, and usually focus on only a small area, while seldom noting their differences and similarities with those of other areas. It is also significant that much of the work relates to Lake Baikal, and is available only in difficult to access Russian language sources. There are also far fewer large lake islands than there are oceanic islands, and they are, like oceanic islands, as endangered as they are rare. These lake island habitats deserve serious study as natural laboratories of population ecology and isolation, while there are still many that are relatively undisturbed.

Many large lake islands are now experiencing unprecedented threats from development and recreational uses. In the Great Lakes, some of the most distinctive and unique island habitats are endangered, or even lost (Nature Conservancy Great Lakes Program 1994). On Beaver Island, Lake Michigan (as on many other shoreline areas of the Great Lakes) lakeshore construction threatens much of the natural shoreline. On Isle Royale National Park, Lake Superior, increasing numbers of recreational users are beginning to stress the island's capacity, and at Lake Baikal, an increasingly mobile and affluent upper class places new demands on that lake's re-



sources—including the few islands in Baikal. It is important that, before these lake island habitats are irreversibly altered, we learn about their history, their ecology, and their perils. It is only with this knowledge that we will be able to make intelligent and effective decisions for their stewardship or, in absence of their conservation, know what we have lost.

There are two particular isolated lake island groups, on opposite sides of the world, which are worthy of further study. One group is on Lake Baikal, the other on Lake Superior. Lake Baikal is the largest volume of freshwater in the world, containing an impressive 23,000 km<sup>3</sup> of water—an estimated 20% of the total volume of freshwater on earth, and its surface area, though not the largest in the world, is still quite large at 31,500 km<sup>2</sup>, and the lake has a shoreline 2,000 miles long. Lake Superior contains a “mere” 12,200 km<sup>3</sup> (10% of the world’s freshwater), only half that of Baikal, but its area, 82,300 square kilometers, is over twice Baikal’s, and is the largest lake, by area, in the world, with a shoreline length of over 4,700 km. The drainage basins of Baikal and Superior are different as well; Baikal drains 560,000 km<sup>2</sup>, while Superior drains just under 124,000 km<sup>2</sup>. As with their parent lakes, the islands that are examined in this study—the Ushkanii Islands on Baikal and the Caribou Islands on Superior—have contrasting and corresponding superlatives, as will be shown.

### Problem Statement

Because of limited previous study of the phytogeography of islands in large lakes, important questions remain to be clarified. This study addresses several, which I list below:

1. What are the phytogeographical conditions of the Ushkanii and Caribou Is-

lands?

2. How phytogeographically similar and different are they?
3. How do the similarities and differences relate to and express geographic variables such as climate, nearby mainland vegetation, topography, soils, geology, and human activities?
4. Do they show recurring patterns of phytogeography?
5. Are observations made on the Ushkaniis and Caribous applicable to other islands in large temperate lakes?
6. How might scientific knowledge of the islands be used to better manage and protect the natural features of these and other lake islands?

#### Purpose and Objectives of This Study

Carlquist stated in the introduction to his book *Island Biology*:

At a time when insular biotas are, in many respects, little known beyond the floristic and faunistic level, yet when a number of these same biotas are endangered, apology is not necessary for presentation of materials that could be called "natural history". The material in this book will not reveal how much is known but how many very interesting questions remain to be asked and answered, largely by field studies. (Carlquist 1974, vii)

I agree with this view, and this study might also be called a natural history, or autecology, of two lake island archipelagoes. The phytogeography of two small lake island groups are examined, similar as well as different phenomena at each are identified, and this information is interpreted as expressions of the islands' conditions. The study integrates phytogeographical studies of the islands with other available ecological and conservation data to provide a framework for further botanical study and conservation management of the unique botanical features of the Caribou and Ushkani Islands, and may be applicable to other large lake islands.

This study focuses on the presence, distribution, and absence of certain indicator plants and the distribution of plant communities on the islands. Indicator plants in this study include those which have unusual environmental requirements which are met on the islands. Many plants of the islands in this study are likely dependent on limnoclimate. These plants, by their distribution on the islands, give important clues to the phytogeographic history and present conditions. Examples include arctoalpine, steppe, and other disjunct plants. Other examples are the semi endemic forms on the Ushkanii Islands, and species of plants which are particularly well-suited to dispersal to islands, such as the steppe grasses at the Ushkanii Islands.

The floræ and phytogeographies of the islands are examined in detail, and attention is drawn to some of the common and uncommon floristic conditions, their distributions, and how they relate to the other physical features. The vascular floræ have been more studied at the islands, and are therefore addressed more than the non-vascular, though occasional mention is made of bryophytes and lichens when information is available and they are important to the vegetation communities (although unless expressly stated, "flora" in this thesis refers to *vascular* flora). The study directs greater attention to the main islands of each group (Bolshoi Ushkanii Island and Caribou Island) than to the outlying islands (Tonkii, Kruglii, Dolgii, Lighthouse, and Gull), as more information is available for the main islands than the smaller. The outlying islands, however, are considered integral parts of their associated archipelagoes, and relevant information is incorporated throughout the thesis. Physical and human geography of the islands is examined, and related to their influence on the phytogeography and natural environment of the islands. Interpretation is offered for the relationship between the floræ and phytogeography, their physical environment

and history, and the islands' isolation. Examples from other islands are, when appropriate, incorporated to illustrate similar patterns of lake island biogeography.

Likewise, the composition and location of communities can give insight into the conditions present on the islands which govern the distribution of plants and communities there (Weaver and Clements 1938). For example, the steppe communities on the Ushkanii Islands are very definitely affected by their large amount of insolation during the growing season, and the resultant high temperatures and evapotranspiration (Вьхристюк 1980, Иванова 1969). On Caribou Island, the areas of deciduous forest may be related to the high winds during the fall and winter in the area, as well as the characteristics of the soil and hydrology of the site.

A comparison of the Ushkanii and Caribou Islands with each other is given, the phytogeography and flora of the islands is compared with that of other areas of their respective lakes and regions, and the floræ of the Caribou and Ushkanii Islands is compared to that of other lake islands. Based on the phytogeographic characteristics of the islands and comparison with other areas, patterns of plant distributions according to limnoclimate and other aspects of island biogeography are interpreted.

The result is an account of two large lake island groups which, although separated by great distance and history, share similar problems in their climatic, phytogeographical, and conservation settings. It is demonstrated that lake island phytogeography has unique attributes which set it apart from "standard" (oceanic) island phytogeography, and that it is worthy of further research. Finally, several ideas for future management are related to problems of the study sites, in response to their current and historical situations.

This study is not intended as the most comprehensive account of the floræ of

the islands in the study. Although I add several new plant records and detail on other features of the landscapes and revise phytogeographical information of the islands, the more comprehensive accounts of the floræ in the literature are relied upon often. I attempt in this thesis to give as complete a description as practical to make a critical comparison between the islands and their phytogeographies. It is not an exhaustive treatise on lake island biogeography, but rather a brief, empirical introduction. It is not a comparison of *identical* ecosystems, but of ecosystems with similar "controls", and therefore subject to some arbitrary categorizations when comparisons are made. It is not strictly a test of the theories of island biogeography, though some of the information given may prove to support it. The reader is referred to the literature cited in this thesis for references to more comprehensive coverage of the above topics, where excellent sources may be found. I hope primarily that this thesis will show that there is much more to be learned of the interesting topic of lake island biogeography.

### Suitability of the Study Areas

Two separated island groups are examined in this study, and are described more fully later in this thesis. The first group is the Ushkanii Islands, also known as the Ushkanii Archipelago, which are situated near the center of Lake Baikal, and are approximately 10 kilometers west of the east-central shoreline. The second group is the Caribou Islands, which are situated near the east-center of Lake Superior, approximately 55 kilometers west of the shoreline. Caribou Island and Ushkanii Island are remarkably similar in many aspects:

1. Both island groups are comprised of a small (<7 km<sup>2</sup>) main island and

several smaller islands, and are situated far from the mainland shore, near the middle of their respective lakes.

2. Both archipelagoes represent the most remote land points in their lakes.
3. They are both shaped approximately as an oval (and thus compact); therefore, each island has distinct north, east, south, and west shorelines.
4. The islands are largely forested in a natural state (with exceptions which will be noted).
5. Both island groups are on lakes with well-developed limnclimates; these are strongly expressed in the vegetation of their shorelines.
6. Many floristic characteristics and patterns are similar to both island groups as well, notably the regional variant of the circumboreal forest characteristic of each region, and the phytogeographic influence of isolation.

In other respects the island groups are quite dissimilar. The large number of wetlands exclusive to Caribou Island, and steppe areas exclusive to the Ushkaniis are two of the most dramatic ecological examples. Other characteristics of the islands are likewise quite different from one another; for instance the topography, geology, soils, fauna, and disturbance history of the islands differ greatly. Perhaps most serious to the conservation future of the islands is the fact that the two groups have had very different human histories, values and management regimes. Because of these easily delineated contrasts, the islands are ideally suited to a comparative study.

## LITERATURE AND PREVIOUS RESEARCH

There are few previous studies strictly on the problem of lake island phytogeography. As this is primarily a phytogeographical study, familiarity with that field is assumed, although the literature consulted in this thesis provide essential background. The peripheral literature is excellent albeit scattered, and island biogeography, shoreline vegetation of the Great Lakes and Lake Baikal, boreal ecology, and circumboreal plant geography have all been well studied. Because this project has an interdisciplinary emphasis, literature and other sources have been consulted from various fields to better document and understand the nature of the Ushkanii and Caribou Islands. The sources cited here represent a necessarily abbreviated mention of some of those I found most useful in this project, and they are likewise indispensable reference for further study. In addition, this survey of previous studies suggests which areas are less understood than others, and where the need for further investigations is implied.

### Island Biogeography and Island Ecology

#### General and Oceanic

Island biogeography, the study of the biogeography of islands and the distinctive problems of species immigration, survival, and extinction on islands, has developed steadily over several centuries of careful observation and scientific research. Darwin (1839, 1859) and Wallace (1892) published famous 19th century studies on the Galapagos Islands and other remote islands. They are a notable early landmark in the recognition and study of islands as unique biogeographical subjects, and were the first to bring knowledge of unusual island life forms to the attention of a mass au-

dience. Well over a century later, *The Theory of Island Biogeography* by Mac Arthur and Wilson (1967) gave an attentive and comprehensive examination of island biogeography's population and demographic problems, along with some quantitative models of the processes and factors involved. They examined the positive correlation of species numbers on islands with their size, age, and closeness to mainland and other factors governing their biocenoses.

As Quammen (1996) showed, the study of island biogeography increasingly became a key area for research following Mac Arthur and Wilson's book. He made a simple survey, using the *Science Citation Index*, of the number of times that Mac Arthur and Wilson's 1963 article "An Equilibrium Theory of Insular Zoogeography", and their 1967 book *The Theory of Island Biogeography* were referenced in academic monographs, and found that, despite little reference to their 1963 article (until after their 1967 monograph), and a slow start to their 1967 book, references rose to unprecedented numbers through the 1970s and beyond. *The Theory of Island Biogeography* remains one of the most influential and oft-referenced books in ecology. There have been a great number of island biogeography studies stimulated by their work, and the field has progressed rapidly during the last 30 years. Articles continue to appear regularly in journals, applying island biogeography theory and models to many timely areas of applied and theoretical ecology. Quammen has written a very readable and informative account of the history of island biogeography studies, linking together in context many of the important studies and their investigators.

### Lake Island Biogeography

Studies of lake island biogeography are far more limited than those of oceanic



islands. As noted above, a major portion of what has been reported is for either the North American Great Lakes or Lake Baikal, and available reports vary greatly in scope and depth. Furthermore, there is a conspicuous lack of study relating to more comprehensive areas, such as from multiple or distant sites, comparison with other lake islands, or inquiry into the principles of lake island biogeography. Despite these limitations, there are several excellent sources that are immediately relevant to this study. For the Ushkanii Islands particularly, there is a wealth of scientific literature available. For Caribou Island, the data are less extensive, though increased interest in recent years by a small and interested "elite" of researchers has produced some important preliminary contributions.

A particular problem of classification in lake island biogeography is that islands are often classified in general island biogeography studies as either "continental" or "oceanic" (e.g., Mac Arthur and Wilson 1967), but neither of these terms are adequate for this study. Pielou's (1979) definition is typical: continental islands are those islands nearshore to continents, which have become separated only by a change in sea level, while oceanic islands are those which "have risen from the deep ocean, and have never been linked to a continent by a land bridge". As will be shown, neither of these definitions are appropriate for the islands in this study, nor most others in Lakes Baikal and Superior, nor for many other large lake islands. Moreover, lake islands have also been called "continental islands" (e. g., Timoney 1983). Adding to this confusion, continental islands have also been defined by Gorman (1979) and others as any insular habitat on continents—though, apparently, not as any type of islands surrounded by waters! In this thesis it is necessary to refer to two main types of islands, simply defined as oceanic islands (in oceans, including

nearshore and offshore) and lake islands (in lakes). Occasionally in this thesis I have made reference to "typical" islands, referring to any land mass which is surrounded by water, as opposed to other types of insular areas such as habitat fragments or nature reserves.

Island phytogeography, botanical island biogeography, addresses problems such as the principles of propagule transport and dispersal vector (animal carried, wave carried, windblown, etc.) to the islands. Propagules are the plants or portions of plants (seeds or spores, vegetative parts, entire plants, etc.) which are sufficient to establish a plant on an island. John Morton of the University of Waterloo, in association with other investigators, has been involved in a number of island phytogeography studies in the Great Lakes. In addition to his work on Caribou Island (Morton 1982, Morton and Venn 1996), he has done research on islands in Lake Huron and the means and demography of plant establishment on lake islands (Hogg and Morton 1983; Hogg, Morton, and Venn 1989; Morton and Hogg 1989), as well as a comprehensive flora and phytogeography of Manitoulin Island in Lake Huron (Morton and Venn 1984). These studies show some of the salient properties of lake island floræ which are also found on the Caribou and Ushkanii Islands. They address important questions—of flora size, dispersal vector, rare species, and conservation problems—in the study and management of lake islands.

Hazlett conducted studies on several islands and groups in northern Lake Michigan (Hazlett and Vande Kopple 1983, Hazlett et al. 1986, Hazlett 1988), and showed the importance of several factors to the phytogeography, including limnoclimate, distance from shore, geological origin, and disturbance history. In his dissertation (1988) he also made comparisons with the mainland flora, indicating some

of the difficulties for certain species to become established on the islands. Surprisingly, he did not find a larger flora on islands which had been connected to the mainland than on those which were not, indicating that the islands may have reached equilibrium in the approximately 8000 years since a land bridge existed.

A small number of floræ and natural inventories are available for individual islands and groups which add valuable information on the biogeographical *milieu* of lake islands. Though the scale of the studies mentioned below varies, many phenomena of lake island phytogeography are repeatedly demonstrated, including the presence of disjunct species (often near the shorelines) and other limnoclimatic influences on the vegetation; relationships of flora size to isolation, island size, and island age; and management concerns related to their isolation and delicate ecology.

For Lake Baikal, Litvinov (ЛИТВИНОВ 1982) gives a thorough summary of the history of island studies, including botanical, zoological, geological, and others. The most intensively studied island on Baikal is undoubtedly the largest: Olkhon Island, (остров Олхон; a large island to the southwest of the Ushkaniis on the west-central side of the lake). Olkhon's steppe climate and vegetation are one of the most unique features of the Baikal landscape (Попов 1990). In addition to studies on the Ushkaniis Islands several other islands on Baikal have received attention. Islands of the Maloye Morye Strait, and the Chivyrkuisky Bay are particularly noteworthy. Important studies include Litvinov (ЛИТВИНОВ 1982), Molozhnikov (МОЛОЖНИКОВ 1974), Skryabin (СКРЯБИН 1987), and Litvinov and Petrenko (ЛИТВИНОВ И ПЕТРОЧЕНКО 1990). Other islands which might also be worthy of attention at Baikal, but for which I was unable to locate reports, are those of the Selenga and Verkhnyaya

Angara Deltas. Because of the geomorphology of the region (as evidenced by steep mountains and cliffs surrounding nearly all of Baikal), there are few other islands in the lake (Галазий 1988).

For Lake Superior, there are also several important published reports. The lake's largest island group, Isle Royale and its archipelago are, as Olkhon on Baikal, the best represented. Most notable are Adams (1909), Brown (1937), Cooper (1913 and 1914), and Slavick and Janke (1987). Manitou Island, Keweenaw County, Michigan has been described by Thompson and Wells (1974), and the Slate Islands by Euler, Snider and Timmermann (1976). In addition, The Ontario Ministry of Natural Resources (OMNR) has undertaken research on various scales on several islands of Lake Superior, including Michipicoten Island (Noble 1984); the North and South Sandy Islands (Kor 1995b, Crins 1996); as well as studies of Caribou Island, mentioned in more detail below. The OMNR studies on the islands are similar to this thesis, in that they emphasize the conservation aspects of the islands, including rare features and their status in Ontario. Given and Soper (1981) discuss several islands and their arctoalpine-disjunct plants which have their main distribution centered in either arctic or alpine areas (often both).

Important studies on other Great Lakes islands include Forzley et al. (1993), Herdendorf and Herdendorf (1983), and Wells et al. (1975). Timoney (1980, 1983) briefly addressed some of the interesting questions of species diversity and number on islands in Lake Nipigon. An interesting recent study by Crête et al. (1997) looked at the biodiversity of newly created islands in a large reservoir in Québec, comparing them to older, naturally-formed islands in a neighboring lake. Their study gave important insight to the dynamics of small islands, relaxation rates, and habitat fragmen-

tation.

### Other Applications of Island Biogeography

Island biogeography is also important in the study of individual areas which are not surrounded by water; islands in these cases are not necessarily islands in water bodies, but instead may be isolated—permeably or absolutely—by other community types; disturbed areas; or other arbitrary delineations convenient to the researcher. “Islands” in this broader context refer to any discrete or insular areas which are somehow detached from others by barriers physical or otherwise, including “typical” islands, ecosystem fragments, and even artificially delineated areas. The effects of separation from outside environments, communities, and organisms are significant to the ecology of those within such isolated and discrete areas. This concept of island biogeography is increasingly recognized as a valuable asset to the research on the problems of conservation biology including nature reserve design and management, habitat fragmentation ecology, “edge effect” conservation biology, and landscape ecology (Shafer 1990, Meffe and Carroll 1997, Schwartz 1997). This conservation application is also particularly relevant to this thesis, as both sites in this study have conservation management concerns relating to their insularity.

### Lake Shoreline Plant Biogeography and Ecology

Previous literature suggests that the influence of large lakes on climate (and in turn vegetation) is similar at Baikal and Superior, and on islands as well as on other shorelines. Most study of this topic has been done for the mainland shores, though most is also applicable to islands. As in many other areas of study, the Lake Baikal

region's shoreline phytogeography has been more thoroughly examined than Superior. The major work on Baikal's flora is by Popov and Busik (Попов и Бусик 1966), who give an annotated conspectus of the shoreline flora, including a wealth of phytogeographical, ecological, and historical information. Other monographs on shoreline vegetation at Baikal are limited to smaller areas, and provide excellent accounts. For the Svyatoi Nos Isthmus, the work of the Svyatoi Nos 1991 expedition (Mlikovsky and Styblo 1992) gives an account of the area incorporating ornithological and other zoogeographical studies, as well as vegetation and phytogeography. The prominent Siberian botanist M. G. Popov has, in addition to the above mentioned work with Busik, written several important studies on rare plants on Baikal. His account of the steppe and cliff vegetation (Попов 1957), and endemism (Попов 1956) are particularly relevant to this thesis. Molozhnikov (Моложников 1969) studied the distribution of *Pinus pumila* in the Barguzin Mountains (Баргузинский хребет) near the Ushkanii Islands, as well as its second distribution—along the shores of Baikal. L. I. Tulina has done extensive study of the vegetation zonation from the Baikal shoreline to the mountains, noting the distribution of characteristic arctoalpine species on both the shore and alpine areas (Тюлина 1975, 1976, 1981). Her *Humid Pribaikal-Type Zonal Vegetation* (Тюлина 1976) is one of the most highly regarded ecological studies of recent years at Baikal, and a model study of microclimatic and topographic influences on vegetation.

A number of important studies addressing the phytogeography of the Lake Superior area provide valuable background for this study. Arctoalpine and other disjunct plants have been a primary area of botanical study at Lake Superior. The most comprehensive document relating to rare plants at Lake Superior is *The Arctic-Alpine*

*Element of the Vascular Flora at Lake Superior* (Given and Soper 1981), which addresses the occurrence of arctoalpines found at various locations on the lake. Other notable studies include Berquist (1937), Butters and Abbe (1953), Euler, Snider and Timmermann (1976), Fernald (1935), Hosie, Taylor and Clarke (1938), Lindsay (1969), Soper (1963), Soper and Maycock (1963), Soper and Voss (1964), Soper, Voss and Guire (1965), Soper, Garton and Given (1989), and Wells and Thompson (1974).

### Comparative and Circumboreal Phytogeography

Although the study of phytogeography is quite well developed in many respects, in others it is far from complete. One such area in need of further documentation is that of circumboreal phytogeography. Though the floræ of many individual regions (political entities, ecological regions, continents) are well documented, there is a dearth of information concerning the distribution of plants and their geographic variations on a larger scale. The circumboreal (referring to the boreal regions of North America and Eurasia as a single biogeographical entity) and circumpolar (which is frequently used to describe all areas north of approximately 45° north, including the circumboreal areas) areas are important delineations in the geographical study of taiga (e.g., Hultén 1964), and if an understanding of the circumboreal vegetation is to be approached, a knowledge of the differences and similarities of the floræ on different continents is essential.

*Taiga* (тайга) is the Russian word which is interchangeable with "boreal forest", and this type of forest includes those of the Ushkanii and Caribou Islands. Although there is occasionally a distinction made, with "taiga" referring to the Eura-

sian component of the forest and "boreal forest" to the American, I find this contrary to the recognition of circumboreal phytogeographical connections, and taiga is used in this thesis to refer to the entire boreal forest. There is clearly a deficit in study of the circumboreal forest as a single, interactive system influenced by similar forces. It is unfortunate that many western phytogeographers know little of the Russian taiga, due to the language difference and relative inaccessibility of relevant academic literature in the West. All too often the English language sources—including academic—that I have consulted cite older, outdated, "popular", or inaccurate translated works. Larsen, for example, in his book *The Boreal Ecosystem*, states:

It is, of course, absurd to attempt to treat the boreal vegetation of Eurasia in any less detail than has been accorded that of North America; the experience of the author, however, is limited to North America and, in addition, the literature available in translation, hence available to most North American readers, is also of limited extent. The available literature, moreover, does not present community data in a form that would be statistically comparable to that obtained by the author in North America... (Larsen 1980, 225)

Adding to the argument for better understanding of the circumboreal is the fact that the Russian taiga comprises the largest forest of any type on earth, and the largest portion of the circumboreal world!

Hultén made extensive study of the botanical problem of the circumboreal lands. His works *The Amphi-Atlantic Plants and Their Phytogeographical Connections* (1958), *The Circumboreal Plants 1 and 2* (1964 and 1971), and *Flora of Alaska and Neighboring Territories* (1968) show the distribution of many taxa across several continents and worldwide; the interesting patterns near several large lakes (including Baikal and Superior) are easily examined in his works. No less useful are the thorough accounts of the regional intergradation and subspeciation, as well as phytogeographical and ecological differences according to areas of the range. Information



given for the differences in North America and Eurasian distributions is an example: some plants (e.g., *Potentilla multifida*, *Isoëtes echinospora*, *Vaccinium vitus-idaea*) are shown to have a much more restricted range on one continent than the other, though the climates are similar. Hultén's studies highlight—and often provide critical explanation of—one of the central problems of the study of circumboreal taxa and their phytogeography: the divergent and often dissimilar character of many species in different areas of their range. Though some of the species names have changed, Hultén's books remain absolutely essential references to the study of multi-continental plant distribution.

With the exception of Hultén notwithstanding, the phytogeography of separated boreal regions is an understudied theme. Larsen (1980, 1982) has written informative primers on the boreal ecosystem, though as mentioned above, their focus is mainly restricted to North American areas. Likewise, there are relatively few studies on the subject of comparative floristics and phytogeography. There have been some investigations made into the similarities and differences of floræ on different continents, and they vary greatly in scope and methodology.

The earliest noteworthy account on the topic is that of the 19th century interdisciplinary scientist Louis Agassiz. Agassiz made notes on the flora and other features found during his 1848 Lake Superior north shore expedition, and compared them with those of the Jura and Alps, which he knew well, in central Europe (Agassiz 1850). Botanical nomenclature has changed significantly in the 150 years since his investigation, but it remains nonetheless among the most concise and relevant studies of comparative boreal phytogeography. Particularly interesting are his parallel comparisons of the vegetation and flora of the two regions, and notes on species analogs.

Among the most applicable later accounts to this thesis are those of Hultén as mentioned above and those relating to the Transberingia and North Atlantic connections (Hultén 1958, 1960, 1961, 1963, 1964, 1968, 1971), Kornas (1972), Hara (1972), Böcher (1972) and others in Valentine (1972), Cody and Mooney (1978), and various monographs in Löve and Löve (1963). The comparison of alpine areas of North America and Eurasia by Major and Babberg (1967) addresses the problem of circumboreal species, regional endemics, and local climates – all very important concepts in this thesis.

Islands occasionally appear as the subjects of comparative phytogeographical studies. The comparison of Gotland and Öland, Sweden, by Pettersson (1965) is a precise and well developed approach to the topic. He addresses the similarity of the islands as well as their differences, and how these comparisons affect the vegetation and phytogeography. Origins and composition of the islands' floræ are also discussed in relation to their landscape and human influence.

Though few, there have been several noteworthy comparative analyses of lake islands made. Skryabin's investigation of the islands of the Maloye Morye Strait of Baikal contains a significant comparative element (Скрябин 1987), emphasizing the steppe vegetation and its distribution in the region, the climatic effect of the Primore Mountains and the Maloye Morye on the flora, and other aspects of the natural environment and landscape.

Barclay-Estrup and Nuttall (1974) studied the distribution of *Empetrum nigrum* on Bowman Island, Lake Superior, and relate its occurrence to other areas at Superior and elsewhere. On Lake Michigan, Forzley et al. (1993) made a small study of islands, concentrating on similarity indices. Although it is mainly a zoogeo-

graphical study of islands in northern Lake Michigan, the investigations of Hatt et al. (1948) are one of the most comprehensive and well-written studies on lake island biogeography, and they address the landscape, vegetation and climate of the islands and discuss the modification of the islands' environment by human activity. Perhaps the focus on the landscape as a whole is the most striking feature of their work, written decades before an increased emphasis on landscape geography in ecological studies became common. Peattie (1922) and Guire and Voss (1963) discussed certain shoreline plants of the Great Lakes region in comparison to their distribution along ocean seashores and relating to other phytogeographical aspects. In a more popular style, the comparison between Lakes Baikal and Superior by Swain (1989), gives an introduction to some of the most salient comparative aspects of the two lakes, and why they should be considered analogous and complimentary to each other.

### Limnoclimate

The term *limnoclimate* was first proposed by the Soviet researcher Nikolai Ladeischikov in 1967 to refer to the climate which is influenced by lakes (personal conversation with N. P. Ladeischikov August 1995), and limnology is the study of this subject. The term limnoclimate is used mainly in the Russian literature, while in North America, where there has been much study devoted to the influence of the Great Lakes on climate, the term "lake effect" is used as a noun, and refers to the climatic and meteorological results of the Great Lakes limnoclimate (see Eichenlaub 1979). As an adjective, lake effect is analogous to the term limnological. I find the term limnoclimate more precise, and it is used in this thesis.

The influence of large water bodies such as oceans and seas on climatic pat-

terns is an integral part of the world's weather and climate mechanism. It is the influence of the world's oceans which is ultimately responsible for the climate which drives much of human economic activity such as agriculture, tourism, and forestry industries (Eichenlaub 1979).

The influence of smaller water bodies is, albeit on a smaller scale, no less important to the climates of the areas concerned. The presence of large bodies of water such as lakes and reservoirs also greatly influences the climate of the surrounding area due to physical properties of water, including thermal capacity, thermal conductivity, density differences according to temperature, and the optical properties of transparency and reflectivity (albedo) (Ладейщиков 1982, Wetzel 1983; Yoshino 1975; Geiger, Aron, and Todhunter 1994; Eichenlaub 1979). These properties together control the heating and cooling speeds of the lake waters, resulting in temperature differences between lake and land. Properties of the lakes themselves which affect the severity of limnoclimate include the stratification (mictic) regime of the waters; the volume, depth, surface area and shape of the lake; the directional orientation and presence of islands, peninsulas, and other lands in the lake; latitude and altitude of the lake; the presence and extent of ice cover during winter; and topography and relief of the surrounding landscape. Localized influences also include the morphology and topography of the shorelines, vegetation and land cover, and human landscapes. The main control on the climate of large lakes, however, is the macroclimate, and all lake effects are merely modifications of this. For example, lake islands often have a greater annual range of temperature than most oceanic islands of similar latitudes, because of their continental location. The weather and climate of near-lake areas have, as a result, some aspects of a maritime climate, and some of a

continental, but are certainly unlike either (Ладейщиков 1982).

Limnoclimatic influence is variable. In general, the larger the lake, the greater the limnoclimatic effects, and closer to the lake limnoclimate is stronger (Ладейщиков 1982). For example, areas near the Great Lakes shorelines of North America are excellent wine and fruit producing regions because of the amelioration on the mesoclimate by the lakes, while areas inland by as little as several dozen kilometers are unsuitable (Eichenlaub 1979). Likewise, the intensity of the climatic influence of the lakes is controlled by the relief of the surrounding landscape. At Lake Superior, which has much lower relief than that of Baikal, the climatic influence along the shores is often most intense, and decreases over considerable distance inland (Saulesleja 1986). At Baikal, which is largely surrounded by mountains, the climatic influence near the shores is often greater than that at Lake Superior and, because of the isolation of mesoclimatic air masses, rapidly attenuates outside the mountain barrier (Ладейщиков 1982, Байкал атлас 1993). The influence of limnoclimate, therefore, is a major force differentiating the local natural and human landscape from other regions. Likewise, a significant factor on the phytogeography of large lake islands is the influence of limnoclimate on vegetation.

Limnoclimate has drawn limited but steady attention, and studies have often been applied to such themes as shipping, agriculture, tourism, settlement, as well as vegetation as influenced by lakes and their climate. Most notable in the literature are studies from the Great Lakes of North America, Lake Baikal and other lakes of the former USSR, and studies from various areas of Europe and Japan (e.g., Eichenlaub 1979, Ладейщиков 1982, Визенко et al. 1984, Wetzel 1983, Yoshino 1975).

In the Great Lakes region, early studies such as those of Leighly (1942) exam-

ined the role of the lakes in influencing local climate. Phillips (1978) succinctly explained the relationships between landscape and lakescape, as well as data from weather stations at locales on Lake Superior to show the unique limnoclimate—and often harsh conditions—there. It is notable in the scope of this thesis that many of the data used in Phillips' study are from Caribou Island. Studies by Lindsay (1969) applied questions of limno- and microclimate to their influence on phytogeography of shorelines on the northwest of Lake Superior. Eichenlaub (1979) and Keen (1993) gave comprehensive popular coverage of the variety of climatic forces which are modified and affected by the Great Lakes, including some satellite photography which dramatically show this. Dericki (1976) also addressed somewhat differently the problem of climatic effects of the Great Lakes, and his study adds detail unavailable in other sources. Rondy (1976), in the same volume, explained very well the distribution and dynamics of ice cover and its influences on the Great Lakes. A more recent overview by Scott and Huff (1996) shows continued interest in the study of Great Lakes limnoclimate.

By far the largest amount of information on limnoclimate is for Lake Baikal. Ladeischikov and other Soviet researchers of the USSR Academy of Sciences have made extensive investigation into the nature and extent of Baikal's climate (Ладейщиков 1977, 1982; Ладейщиков и Моложников 1989; Визенко et al. 1984). Ladeischikov's monograph *The Fundamentals of the Climate of Large Lakes* (Ладейщиков 1982) is a comprehensive and precise treatment of the problem. Data from the Ushkanii Islands are frequently given as examples, because of the particularly "pure" limnoclimate on the islands. He also has addressed the history and development of the study of limnoclimate at Baikal (Ладейщиков 1982, 1987).

Limnoclimate and lake effects are seldom covered at an introductory level in texts, though three which are particularly useful are Geiger et al. (1994), Yoshino (1975), and Borisov (Борисов 1967). Wetzel, in his comprehensive limnology text (1983), includes useful background on the limnology and physics of water fundamental to the understanding of limnoclimate. The influence of limnoclimate on plant distribution is one area in particular where more study would be appropriate, although several reports have given some stimulating examples. Those of Vuikhristyuk (Вьхристюк 1980), Ladeishchikov and Molozhnikov (Ладейщиков и Моложников 1989), and Given and Soper (1981) attest to the appeal and importance of the topic.

Geiger, Aron, and Todhunter (1994) give a useful definition of the scales of climate which is adapted for use here: macroclimate is the climate of larger scales, such as Siberia or North America, with a horizontal scale of more than 200 km and a vertical scale of 1-10 km; mesoclimate is medium scale climate, as in the regional climate of the Baikal basin or the Great Lakes area, and has a horizontal scale of 1 km to 200 km, and a vertical scale of 500 meters to 4 km; and microclimate is the climate of the smallest scales, from millimeters to 1 km in scale, and a vertical scale of -10 meters (which includes soil and bedrock conditions, as well as caves, etc.) to 500 meters, as on the south slope forests of Bolshoi Ushkanii Island or the dunes on Caribou Island. Their coverage of small-scale climate—including its influence on vegetation and animals—is particularly applicable to the study of microclimate and its impacts on ecology. Yoshino's (1975) introduction is likewise useful to the study of the problems of plant distribution according to microclimatological and limnological influences.

## Previous Investigations at the Study Sites

### Studies at the Ushkani Islands

There has been a longer and more comprehensive history of investigation at the Ushkani Islands for several reasons, including the large number of scientists historically employed by the USSR Academy of Sciences (and now the Russian Academy of Sciences), the establishment of several major research institutions specializing in or close to Lake Baikal, the establishment of the Zabaikalskii National Park (ZNP) in the area surrounding the Ushkaniis, the large numbers of *nerpa* (Baikal seals) at the islands, and the enigmatic nature (and therefore immense scientific interest) of Baikal. Because of its richness, review of scientific research at the Ushkaniis is attenuated here. The most important research to date has been that conducted under the auspices of the Limnological Institute (LIN) of the USSR (now Russian) Academy of Sciences; the main research institution engaged in Baikal studies. LIN initiated in 1959 a program of comprehensive, multidisciplinary landscape geography investigation of the nature of the Ushkani Islands, including floristic and phytogeographical studies (Природа Ушканых Островов на Байкале 1967, Галазий и Моложников 1982). Likewise, many of the later Ushkani Island studies, indeed many of the Baikal studies referred to in this thesis were undertaken as LIN research.

Sukachev and Lamakin (Сукачев и Ламакин 1952) gave an overview of the study to 1950 of the vegetation on the Ushkani Islands. In addition, Galazii and Molozhnikov (Галазий и Моложников 1982) concisely review the history of botanical and ecological study at the islands, including the period between Sukachev and Lamakin's study and their review. An important aspect of them is the fact that both of



these reviews provide accounts of otherwise unpublished studies and other information such as habitat modification and fire influence.

The earliest botanical investigation of the Ushkanii Islands which I have found reference to is that of V. N. Sukachev, who made a cursory inventory of the vegetation and phytogeography of the island in 1914, noting such features as shoreline arctoalpine plants, the endemic forms of birch, poplar and larch, and several other salient aspects of island biogeography (Сукачев и Поплавская 1914). Dyagilev (Дягилев 1936) made a small survey of the vegetation of Bolshoi Ushkanii Island in 1931, but I was unable to obtain this report, and the study is not described in detail in other publications I have seen. L. N. Tulina made collections at Bolshoi Ushkanii Island around 1940, although no monograph was written directly reporting those findings. Many of her earlier studies, however, have supplemented her research for later publications (e.g., Тюлина 1981).

In 1952, V. V. Lamakin incorporated a study of the islands' vegetation in his book on the geology of the Ushkanii Islands (Ламакин 1952), written with Sukachev (Сукачев и Ламакин 1952). This study incorporated data of Sukachev's 1914 expedition (much of it unpublished) and those collected by Lamakin in his studies of the early 1950s on the island. A prominent feature of their study was their report on the differences in vegetation observed between 1914 and 1952, and they also noted other features including the occurrence of arctoalpine plants, steppe communities, and the bottleform larch and other endemic tree forms. During the period of 1950 to 1952 the botanist M. G. Popov made several collecting expeditions to the Ushkanii Islands with associates, though the results were not published separately (Галазий и Моложников 1982). L. V. Bardunov made a few bryological collections at Kruglii

Island in 1956, which added the first bryophyte records for the islands (Бардунов 1961). The Limnological Institute (LIN) studies on the Ushkani Islands remain the most comprehensive published account of the flora and phytogeography of the islands. The majority of the floristic studies in that project took place in 1959 and 1960 under the supervision of M. M. Ivanova and M. K. Shimaraeva, and are reported in Ivanova (Иванова 1969). For several years during the 1980s the geobotanist V. N. Molozhnikov resided on Bolshoi Ushkani Island (personal conversation with G. V. Matyashenko in July 1993), presumably making botanical studies; however, I was unable to contact Dr. Molozhnikov, and was unsuccessful in finding references, collections, or other records of his studies of the islands' flora. Such records, if they exist, would certainly be a valued addition to the floristic knowledge of the islands. Other studies and collections may have been made at the Ushkaniis as well. I visited the Ushkani Islands from July 4 to July 31 1995 to conduct field study; details of this study are given in the methodology section of this thesis.

There has been a large amount of other scientific research conducted on or relating to the Ushkani Islands important to this study. Addressing the climatic parameters of the island are those conducted by Vuikhristyuk (Вьхристюк 1966a, 1966b, 1969a, 1969b, 1980) and Ladeischikov (Ладейщиков 1977, 1982). In particular, the complex microclimatological studies undertaken by LIN during the multidisciplinary work on the Ushkani Islands starting in 1959 (Вьхристюк 1969a, 1969b) are valuable in assessing the effects of topography and proximity to lakeshore on climate and vegetation. The climate station on the southwest side of Bolshoi Ushkani Island allows continued monitoring of the climate and weather of the island, and makes continued long-term comparison with other shoreline and inland areas possible. Clima-

tograms published in various sources (Байкал атлас 1993, Выхристюк 1980, Ладейщиков 1982) are the most convenient method for this, and more complete data on temperature variation, snow cover, evapotranspiration, wind, and other factors give very useful insight for the interpretation of plant distribution on the islands (Мизандронцева 1985, Выхристюк 1966а, 1966б, 1980).

Extensive study of the soils of Bolshoi Ushkanii Island were undertaken during the LIN investigations, and were particularly well related to the vegetation of the island (Шимараева 1969). Their detail exceeds the scope of this thesis, and will likely remain for some time as a definitive study of the soils. However, it is possible that there has been some change in soil quality and distribution related to fires which have burned areas of the island since the studies.

#### Studies at the Caribou Islands

Limited studies have been undertaken at Caribou Island, though the majority of the information that is available concerns the flora. In 1931 the island was visited by Carl Grassl and Walter Koetz, and some plant collections were made (Morton and Venn 1996). Though there was no report for their work and collections, some herbarium specimens from their visit were deposited, including *Empetrum nigrum* (Soper and Voss 1964). Morton and Venn visited the island and made collections in 1976 (Morton 1976), though their collections and observations were not published until recently (Morton and Venn 1996). Their report was the first comprehensive treatment of the island's flora, listing 223 species to Caribou, Gull, and Lighthouse Islands, and subsequent investigations have added to that list. Comparison of Morton and Venn's observations with those of more recent investigators may be used to deter-

mine potential vegetation change; this will be discussed later in this thesis.

Brown (1981) made a brief visit to the island in 1981 and prepared an unpublished report on his findings. Unfortunately, Brown's report contains many questionable species reports, no voucher specimens are known, and habitat and location data of his records are minimal. It is doubtful, therefore, that Brown's report can be taken as valid documentation, and that component of his list which has subsequently been shown to be present at Caribou does not always match his habitat notes. Later collections at Caribou Island have revealed many of Brown's reported species, but many of the plants—including subtaxa—Brown reported are so unusual for the area that their presence at Caribou is unlikely (see comments in Morton and Venn 1996, White 1995). Other species he reported would, if confirmed, be important phylogeographical indicators (e.g., *Vaccinium vitus-idaea*, *Lycopodium alpinum*, *Betula aleghaniensis*, *Primula intercedens*, *Lycopodium alpinum*, etc.). It seems almost as though Brown made legitimate observations and reasonably comprehensive field studies, and then mixed a number of random species names to the list. To be fair, though, Brown's report seems to be of a somewhat provisional nature and not intended for the subsequent scrutiny given it by so staid a group of investigators! The end result, however, is that Brown's report causes more confusion (at least for the present author) than contribution.

Several studies and inventories have been more recently coordinated at Caribou Island by the Ontario Ministry of Natural Resources (OMNR). Noble (1982) and Kor (1993) made small OMNR site assessments at Caribou in accordance with management plans, and a systematic OMNR checklist of potential human impacts and values was completed in the early 1990s (OMNR undated). David White, a private

consultant working for the Ontario Ministry of Natural Resources, visited the island in 1994 as part of an investigative team assessing the island as an area of natural and scientific interest (ANSI) (White 1995). White's report for the island was finished a year before Morton and Venn's as an Ontario Government internal document, though his field work was done 18 years after Morton and Venn's. White reported a total of 246 species of vascular plants for the islands, including 21 unreported by Morton and Venn (1996), whose monograph—including species list and distribution—he had in draft form before his study. White also filled in abundant further detail on the ecological conditions of the island.

A comprehensive history of the island is given by Carter (1979), and it supplies much of the human activity record for the islands which is important in assessing the recent phytogeographical history, possible anthropogenic influence, and the conservation record and potential. Wormington et al. (1986) give an account mainly of the birds, but additional details are quite useful for assessing the general ecology as well. One note is that it was Wormington—only—who has reported seeing *Symplocarpus foetidus* on Caribou Island; the significance of this plant will be discussed further in this thesis. Kor (1995a) studied the geology of Caribou Island during the same expedition as White (1995), and his report helps in understanding the vegetational history of the island, particularly through his ideas on the geological history and age of the island.

## STUDY METHODOLOGY

The islands in this project have drawn my attention for some years previous to the field work, and during that time a reasonably complete search has been made for all pertinent sources of information. Additionally, I have continued my search of the literature and other relevant data after the field work and during thesis preparation. This has consisted of literature review using English and Russian language materials, consultation with experts familiar with the topics concerned, review of governmental and other non published materials, and aerial photographs (for Caribou Island only).

### Field Investigations

Field study was conducted at Ushkanii and Caribou Islands in 1995 and 1996 respectively. In 1995, I was on Bolshoi Ushkanii and Tonkii Islands of the Ushkanii Islands group continually July 4 through July 31. In 1996, I was on Caribou and Gull Islands of the Caribou Islands group continually June 14 through July 19. During that time on the islands, extensive field reconnaissance was made to examine vegetation and ecology, to look for indicative phenomena (such as plants or communities), and to inventory plants and habitats. Most days consisted of curation of collections and general duties in the morning, and site study in the afternoon and evenings. Weather was suitable for field botany during most of the time on both islands, and fewer than 5 "rain days" were sufficient during each island expedition to cancel field work.

The most important activities in field work were identification of plant species (and, where appropriate, subspecies) and community composition, delineation of plant

and community locations, field photography, general observation notes, and comparison with previous reports available for the islands. Plant communities and habitats were investigated individually for site conditions and composition. Straight-line transects were walked across many areas of the islands (generally from one side of the island to the other), regardless of obstacles (with the exception of open water on Caribou), to obtain a relatively unbiased familiarity with the vegetation diversity of the islands. A deliberate effort was made to visit all plant communities one or more times during the field study. Emphasis was placed on the community level and on indicator species, and the extent and composition of communities were compared with available data. An effort was made to find species or ecological conditions which were different from those previously reported, and which are important to the biogeography of the islands, rather than confirmation of all species previously reported. I did, however, try to confirm as many species as practical, particularly those at the Caribou Islands not documented there by previous investigators. Comprehensive photographic surveys were made for post-field study, and field notes facilitated later analysis of the islands.

Collections of previously unrepresented plants at the Caribou Islands were made, as well as many plants at the Ushkanii Islands, and are retained by the author. I expect to deposit duplicates of these collections in the future (the Caribou Island plants will be most likely at CAN). Extensive bryophyte collections were made for most habitats and areas of the islands during the field work at both sites, but the inclusion of these is beyond the scope of this thesis, and are not included here. It is expected that they will be covered in one or more separate reports later, and will add significantly to the understanding of the islands' physical environment and phyto-

ography.

Investigations on the Ushkani Islands differed from those on the Caribou Islands mainly because I had no manual of plants of the area available for use while on the Ushkaniis, and so checking of unknown plants was less convenient. (It should be noted here that, especially during the period of my study at Baikal, it was often very difficult or even impossible in the former USSR to obtain many resources taken for granted in the West.) A checklist was used (Бойков et al. 1991), and familiarity with the Baikal area flora facilitated recording of general notes on the abundance and distribution of plants. Some collecting was done of unknown plants for later determination in Listvyanka and in Irkutsk. There were few discrepancies found between the flora observed on the Ushkaniis and that information which was previously available, with the exception of two species new to the islands which I found. Post-island plant verification was made mainly using the *Flora of Central Siberia* by Malyshev and Peshkova (Мальшев и Пешкова 1979).

Field botany studies were more easily accomplished on Caribou Island, having had several botanical manuals on-site. The main botanical manual used in the field was *Spring Flora of Wisconsin* (Fassett, 1976), which proved most useful for the plants flowering on the island during my study, with the exception of a few easily recognized species not included (e.g., *Rubus chamaemorus*). It is interesting to note that *Spring Flora* was ideal for the period of my visit on Caribou (June 14-July 19), even though *Spring Flora's* emphasis is on plants flowering in Wisconsin *before* June 13. This reflects the colder climate and later spring flowering on Caribou Island compared to even Wisconsin. Gleason and Cronquist's *Manual of Vascular Plants*



(1991) was used as a second manual at my base camp.

### Limitations of the Project

This study has several limitations. First, the floræ of the islands presented here are only those plants which are known to have existed on the islands at the time of the various investigations which have been made. For example, *Symplocarpus foetidus* was reported by Wormington in 1979 (Morton and Venn 1996), although I was unable to locate it in 1996. In fact, no collections of this plant have been made at the island, and no other researcher has reported it. Does this indicate that it is or is not part of the flora? Perhaps it no longer grows there, or maybe never *did* grow there, since there is no herbarium record. Perhaps it will be established or reestablished there sometime in the future. Has *Iris ruthenica* grown on Ushkanii Island for the last several years, or for centuries? Some plants doubtless are established for only a period of time, then vanish from the islands. Others may reappear periodically. The floræ I give of the islands are not necessarily the plants *of* the islands, but only the plants *found on* the islands. Such reported floræ tend to become larger proportional to the number of field investigations undertaken, as noted by Hazlett (1988). For this reason, any analysis of the vegetation is simply an analysis of the plants that have been found and reliably reported.

Although I visited the islands, I did not attempt a comprehensive inventory of the flora at either site. I did, however, attempt to record any species which were previously not noted for the islands, or those with distributions which differed from previous reports. The field study instead focused on the differences and changes in the phytogeography and floræ from the information already available, i.e., the further

elaboration of the phytogeography of the islands. There may well be more taxa of plants "undiscovered" at Caribou than Ushkanii. Therefore, the floræ given represent at best the majority of the plants present during the various surveys. It is important to note, however, that since this thesis addresses that community level as well as indicator species, a good amount can indeed be determined from available data.

Another limitation of the data is that they are not equal for each site, and indeed not even for each island at each site. Research methods, support, and objectives have historically been different in Canada and Russia (and the USSR). Investigations have been more thorough at the Ushkanii Islands than at Caribou Island, although there is much more recent data available for Caribou than Ushkanii. The previous research at Caribou has been more conservation oriented, while at the Ushkaniiis it has focused more on landscape geography. Finally, greater detail (and variability) is available for the main islands—Bolshoi Ushkanii and Caribou—than their outlying islands.

A number of investigations over longer periods is superior to those during a shorter time, since plant populations undergo demographic fluctuations and may be more common during some years than others (Weaver and Clements 1938). Likewise, as will be discussed further, some plants may be established for a short time only, and therefore not noticed if field surveying takes place during a shorter period. The investigations by researchers of the USSR Academy of Sciences, Irkutsk State University, and others at the Ushkanii Islands have been comprehensive, addressing not only botany and plant ecology, but climate, geology, pedology, ornithology, zoology, and others. Also, the more extensive physical environment and landscape studies at Ushkanii allow a better interpretation of the phytogeography. The Caribou Is-

lands have been studied only briefly by comparison, and only in a few disciplines, although it should be noted that for such small (though important) areas they have, overall, received more scientific attention than most areas.

## STUDY SITE 1: THE USHKANII ISLANDS, LAKE BAIKAL

Baikal and its climate, animal, and plant worlds—it's a phenomenon; there's nothing in the world like it. But the Ushkanii Islands with their natural and climatic conditions; this is an exceptional wonder for Baikal. One may say that here is uniqueness within the unique.

—Nikolai Ladeischikov, 1975 (in Потемкин 1975)

### Location

The Ushkanii Islands, also known as the Ushkanii Archipelago or simply Ushkanii or the Ushkaniis, are situated at 53°50'N, 108°40'E, near the center of Lake Baikal and approximately 10 kilometers northwest from the east-central lakeshore at Svyatoi Nos Peninsula (полуостров Святой Нос). Though not as far from the shore as Caribou Island on Lake Superior, they nonetheless represent the most remote islands in Lake Baikal (Figure 1). The shortest land to land distance between the eastern most of the Ushkanii Islands (Dolgii and Kruglii) to the mainland at Svyatoi Nos Peninsula is approximately 6 km—the shortest possible migration route between the mainland and the Ushkaniis. The minimum distance to the western shore of Baikal is 27 km between Bolshoi Ushkanii Island and Cape Sharmla (мыс Шармла). The Ushkanii Islands are at the northern end of the submerged ridge of small mountains known as the Academic Ridge (Академийеский хребет), which stretches about 100 kilometers northeast from Olkhon Island to the Ushkaniis. The ridge rises a maximum of 1360 meters from the bottom of Baikal in the area (Галазий 1988), and the four Ushkanii Islands represent the tops of these submerged mountains.

The largest island of the group is Bolshoi Ushkanii (Большой Ушканий),

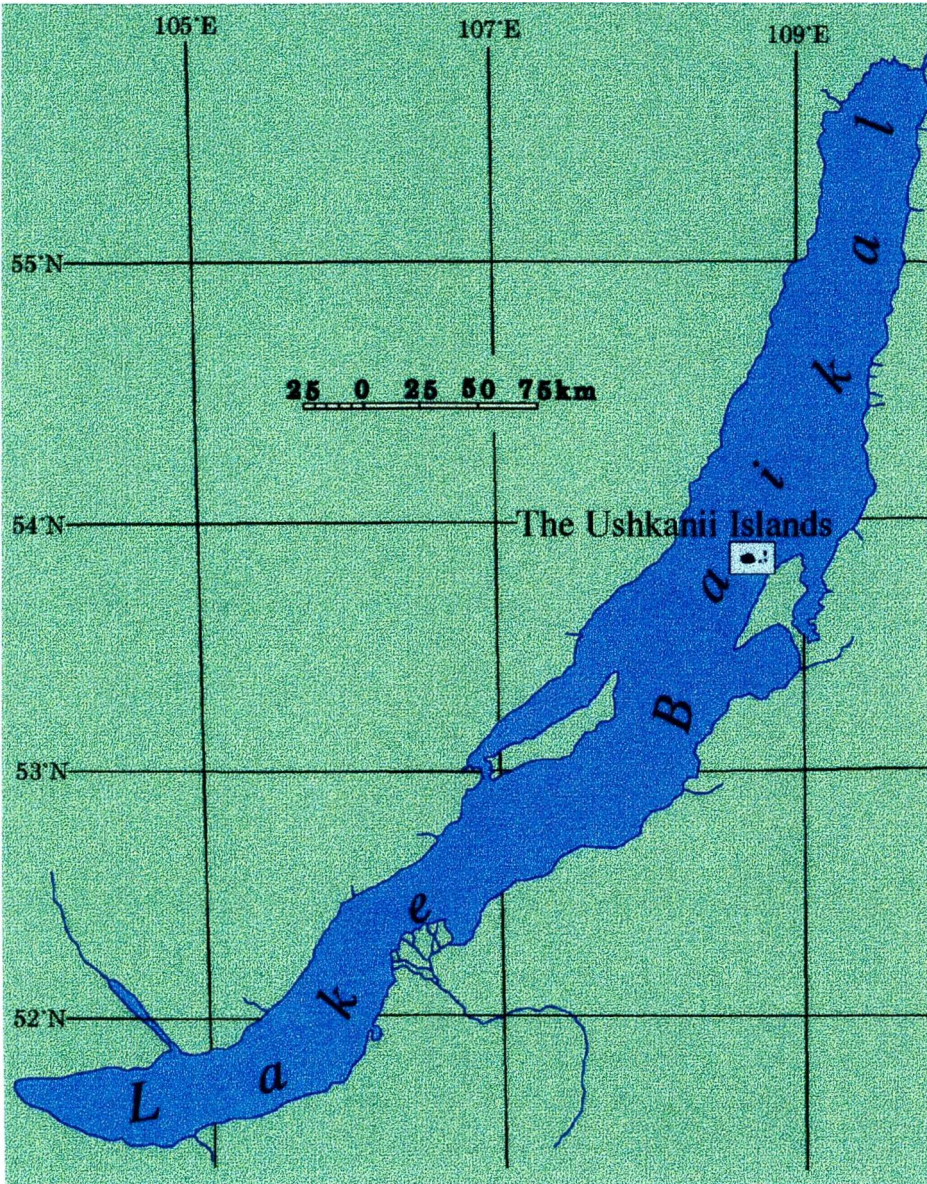


Figure 1. Location Map of the Ushkanii Islands.

which means “Big Ushkanii”, and there are three smaller islands nearby to the east: Tonkii, Kruglii, and Dolgii (Тонкий, Круглый, Долгий); which mean “tiny”, “round”, and “long”, respectively. Bolshoi Ushkanii Island is also called “Ushkanii Island” in this document and elsewhere. The name Ushkanii comes from a local Siberian word, “ushkan” (ушкан) for “hare” (заяц), taken from the Russian word for ear (ухо, pl. уши), in reference to the large ears of hares. On a 1701 map of the Baikal region by the historian, geographer, and cartographer S. U. Remezov, the islands were named the “Hares” (Заячьи) (Галазий 1988, Ламакин 1952). This may refer either to hares (*Lepus* sp.) or the Baikal nerpa (seal) (*Phoca sibirica*), which has also historically been given the name “ushkan” in local speech (Гурулев 1992). Incidentally, a species of White Sea seal is also sometimes called ushkan (Атлас Байкала 1969, Галазий 1988, Гурулев 1992, Байкал атлас 1993). The islands have also occasionally been referred to as the Marble Islands (Мраморные острова) (Галазий 1988). A general map of the Ushkanii Islands, showing place names referred to in this study, is given in Figure 2.

The Ushkanii Islands are comprised of four islands within an archipelago of one large island and three smaller islands arranged in an arc to the east of the main island (see Figure 2). The largest island, Bolshoi Ushkanii Island, is approximately 7 km<sup>2</sup> in area, and shaped somewhat like an east-west oriented oval. It is in longest dimension approximately 4.9 kilometers wide from east to west, and 2.7 km from north to south. Its longest continuous dimension is about 5 km in a east-northeast direction from the southwest tip near the meteorological station to the northeast tip. The maximum elevation above Lake Baikal is 216 meters (Ламакин 1952), although Galazii

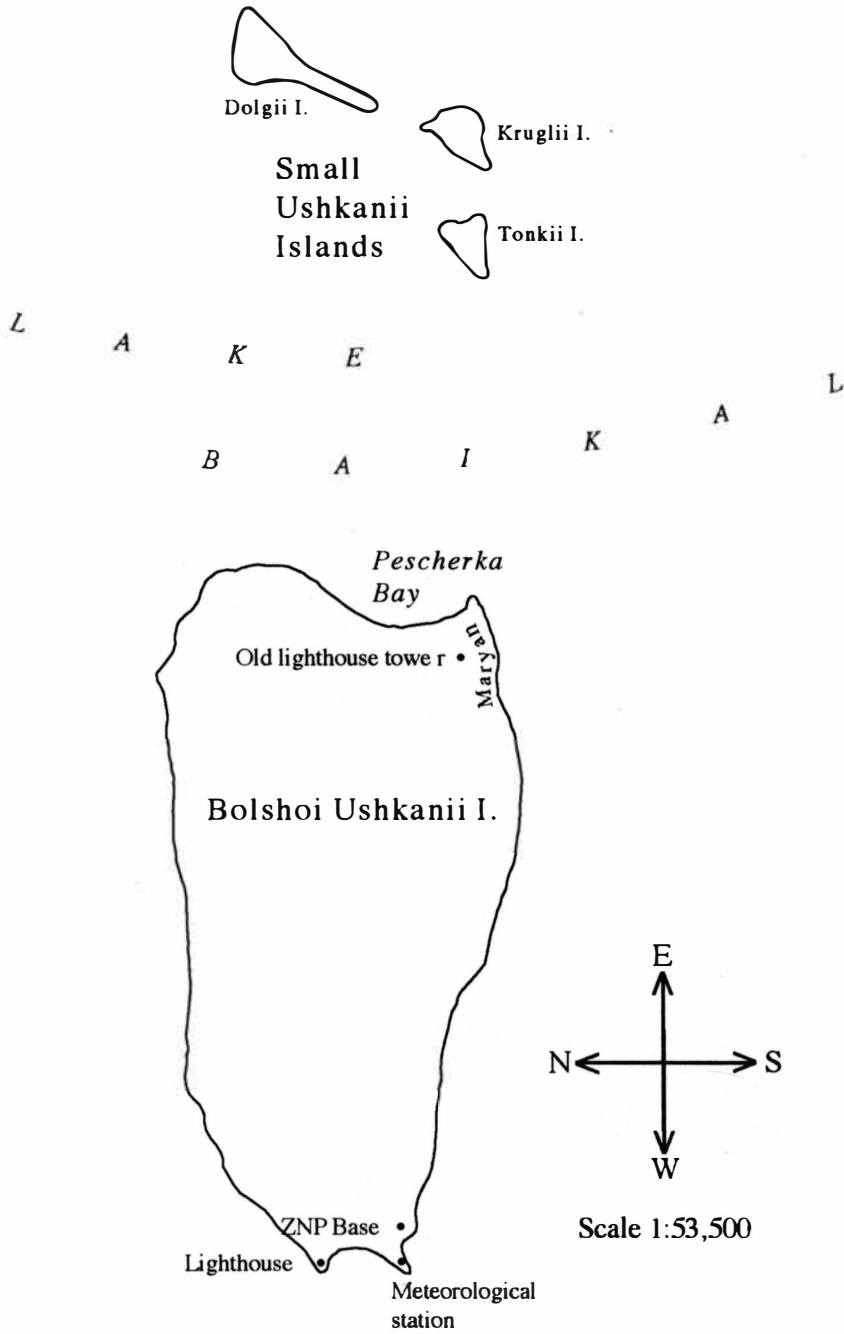


Figure 2. General Map of the Ushkanii Islands.

(Галазий 1988) gives a figure of 211 meters.

There are an additional three islands located to the east of Bolshoi Ushkanii Island, which are known collectively as the Small Ushkanii Islands, and all are much smaller than the main island. The largest of the Small Ushkaniis, Dolgii Island, is located about 3.4 km east of the northeast tip of Bolshoi Ushkanii Island. It is oriented SSW-NNE, is approximately 1250 meters long and 500 meters wide at maximum dimension, and its area is approximately 32 ha. It rises to an elevation of 21 meters above lake level. Tonkii Island is the smallest to the group, and is located approximately 2.3 km east of the southeast corner of Bolshoi Ushkanii Island. Its area is approximately 14 ha, and its maximum height is 17 meters. The island is shaped approximately like a triangle with rounded corners, and is about 400 meters in "diameter". Kruglii Island is the middle-sized island of the small group, and is positioned approximately between Dolgii Island and Tonkii Island, 2.5 km east of the southeast side of Bolshoi Ushkanii Island, 400 meters south of Dolgii Island, and about 300 meters from the east shore of Tonkii Island. It is, like Tonkii, approximately a triangle, and about 500 meters in diameter. Its area is 20 ha, and its elevation is 22 meters above the Lake Baikal mean.

The topography of the Ushkanii Islands is quite rugged, especially for its small surface area, and Bolshoi Ushkanii Island's highest elevations are near the southeast side of the island, as are the steepest slope areas. Former beach ridges, described best by Lamakin (Ламакин 1952), are a dominant topographical feature on many areas of the islands. Figure 3 clearly shows several former beach ridges and the difference in slope between the north and south sides of Bolshoi Ushkanii Island. On the north and east sides, for example, there is a steep slope from the higher areas





Figure 3. View of Bolshoi Ushkaniy Island From Tonkii Island.

of the island to a wide beach ridge, and then another steep slope to the lake level. On the west side of the island, there is a larger lower elevation than elsewhere on the island, and the steepest slope is further inland than on the east and north sides. Lama-kin and others (Ламакин 1952, Ескин et al. 1959) have differentiated approximately 9 or 10 different terrace levels on Bolshoi Ushkaniy and three on the Small Ushkaniis (Иванова 1969). The south-facing slope is perhaps the most dramatic topographic feature of Bolshoi Ushkaniy Island. The combination of climatic exposure and edaphic-geological conditions combine to create a landscape suitable for a type of steppe known as a "maryan" (марьян); a Buryat term for a grassy area found on south-facing slopes between forested areas.

The Small Ushkaniis have minor differentiation of former shorelines due to

their low elevations, although they do have steep enough south slopes to permit some steppe microhabitats. They have landscapes resembling in many ways miniatures of Bolshoi Ushkanii; for example, there are smaller areas with similar proportions of rocky and gravelly shorelines, lower relief, small steppe areas, and small, relatively simple larch forests.

### Geology

Much of the landscape of the Ushkanii Islands is dominated by outcrops of metamorphosed sedimentary rock of lower Proterozoic age (Ескин et al. 1959). There are several alternating layers of marble, but there is also a large area of much more resilient darker, non carbonitic rock consisting mainly of amphibole, plagioclase, and quartz. Near the southern shore of Bolshoi Ushkanii there is also an outcrop of hornblende-plagiogneissic and crystalline slate, and in areas near the north shore there are also exposures of hornblende and slates. According to Lamakin (Ламакин 1952) and Ivanova (Иванова 1969), the same rock strata are also encountered on the Small Ushkaniis.

Lamakin (Ламакин 1952) postulated that Bolshoi Ushkanii rose above the lake level in the early Quaternary (about 2.4 million years old), and the Small Ushkaniis during the middle Quaternary. He estimated the present average rate of rise of the Ushkaniis at 20 centimeters per 100 years. Later, Palshin (Пальшин 1959) suggested that the Ushkaniis may be somewhat older. He estimated their origin as closer to the late Tertiary (approximately 2.6 million years old).

The shallow and often outcropping bedrock is strongly expressed in the topography, soils, and vegetation of the islands. Much of the island has a rocky character,

and there are many rocky slopes, even cliffs, especially along the south slope and several of the terrace rises. The well weathered rock in these areas allows continued erosion and accumulation of young talus slopes.

The shorelines of the Ushkaniis are very rocky, and there are no appreciable areas of sand deposition. The total shoreline length of Bolshoi Ushkanii Island is approximately 13 kilometers; approximately 40% of this is gravel beach, and 60% is rocky or bouldery. Many areas of the shoreline are composed of steep rock outcrops, punctuated by gravelly or rocky beaches. This is particularly evident along the west and southwest sides of Bolshoi Ushkanii, and on areas of the Small Ushkaniis. More shallow shoreline topographies are typical of the west and northern shores of Bolshoi Ushkanii, with smaller areas of bedrock punctuated by gravel and rocky beaches. Ivanova (Иванова 1969) states that the beaches were considerably wider before the rise in Baikal's level following the construction of the Irkutsk Hydroelectric Station (GES). Other than the Baikal shoreline, there are no water features of any kind on the Ushkanii Islands. A map of the topography and geology of the Ushkanii Islands is given in Figure 4.

### Soils

The soils of the Ushkanii Islands are strongly governed by their parent materials, primarily marble, and are thus usually quite basic in reaction. There are no depositional landforms on the Ushkanii Islands other than the talus slopes, and parent materials for the soils of the island are mainly locally derived from the bedrock. Information on soils is primarily from Shimaraeva (Шимараева, 1969), who gives an extensive inventory of the composition of the soils of Bolshoi Ushkanii Island. Shi-

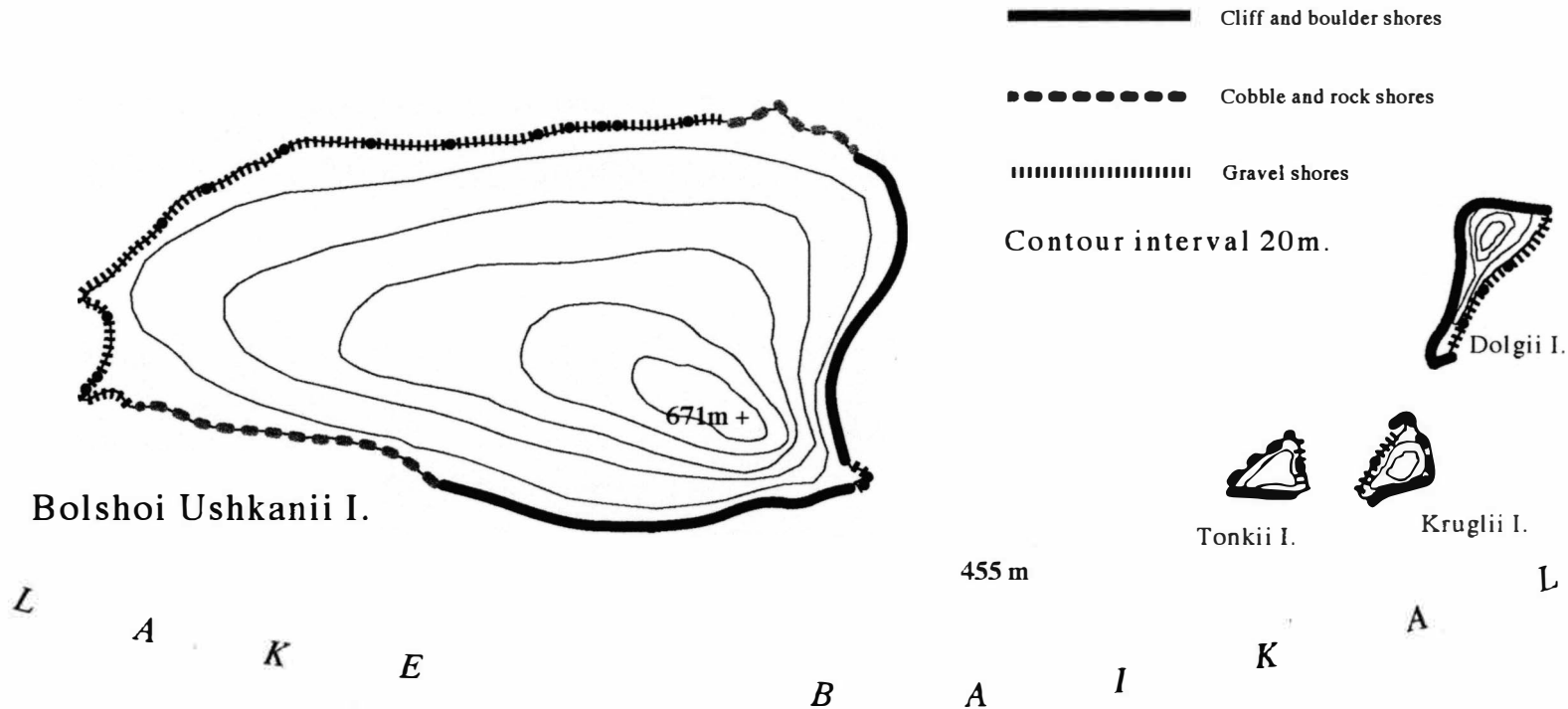


Figure 4. Geology and Topography Map of the Ushkani Islands.  
 Source: Ламакин (1952) and Атлас Озера Байкал (1942).

maraeva conducted the investigation of the soils, noting its strength was to give characteristics of the soils cover in association with the geobotanical investigations. A summary, slightly modified from Shimaraeva's, of the soils of Bolshoi Ushkanii Island follows here. Terminology and horizon designations have been changed in this thesis to follow the US SCS (NRCS) designations of 1981 (Miller and Donahue 1990). A map of the soils of Bolshoi Ushkanii Island is shown in Figure 5.

Alluvial mineral-organic humic Spodosols occupy nearly one third of the island, from the upper areas of the island to the bases of the northern and western slopes. They are formed from the weathering of hornblende-plagioclase slates and paraamphibolites, are unconsolidated, and strongly leached into spodic horizons ("podzolic"). Their pH is between 4.5-6.5. Shimaraeva postulates that these soils developed as "podzols", but following fire, their vegetation cover changed and the soils acquired a higher sod content. The sod horizon of this soil has coarse humus, is rather well aerated, and contains a large amount of carbon deposits indicative of fire. The O horizon is mainly composed of fallen needles of larch, though these soils support a variety of forest associations on the island.

Mineral organic forest Spodosols occupy small areas of the island on the northern and western slopes and talus areas. They are developed from the talus of non carbonitic rocks, are humus-rich, and have a variety of grain and particle sizes. They are somewhat ferric, and their pH is approximately 6.3, and their texture ranges from sandy loam to loamy. These soils occur in larch-rhododendron forests, and the O horizon is composed mainly of larch needles, herbaceous litter, and rhododendron leaf humus.

Mineral organic-carbonate Spodosols are distributed on middle and lower ar-

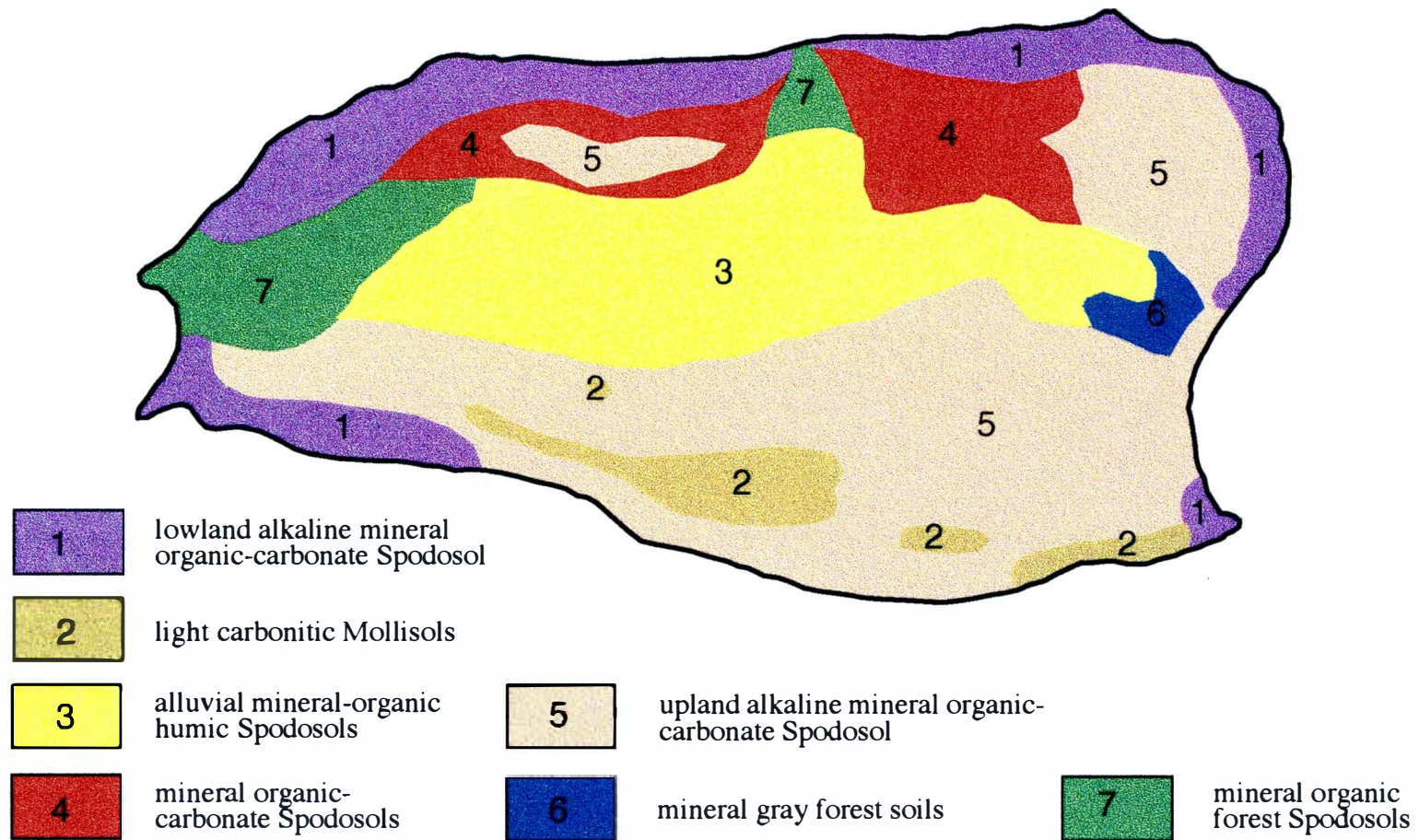


Figure 5. Soil Map of Bolshoi Ushkanii Island.

Source: Шумраева 1969, and field investigations by the author 1995.

eas of the northern slopes. They are often distinctly leached ("podzolic"), though less so than the above, and moderately loamy. They are developed over a marble talus substrate and are, therefore, quite basic, and leaching ("podzolization") is usually quite distinct. The pH ranges from 6 to 8. This soil is found in the larch-rhododendron-lingonberry herbaceous forest.

A highly alkaline mineral-organic Spodosol occupies the largest area of the island. Shimaraeva differentiated between this soil when found on nearshore gravel substrate and when found on slope talus. They are strongly structured (especially on steep slopes), and highly alkaline. Their pH ranges from approximately 6 to 8.5. The first variant is found on the lower coastal area of the northern, southeastern, and southeastern shoreline areas, including the steppe areas. The vegetation associated with the first group is a larch-lingonberry-herbaceous woods, with occasional patches of crowberry and mosses. They occasionally resemble a Mollisol, especially in the steppe areas with a more open, graminoid vegetation cover. The second variant occurs on large areas of the south and east slopes and the upper level peak of the island, as well as a smaller area on the north slope. They are associated with a herbaceous *Brachypodium* larch woods.

Mineral gray forest soils, which could possibly be termed as a Spodosol, are distributed on various locations of the east slope, and occupy a smaller area than the preceding soil. They are formed over a variety of weathered non-carbonate substrates, and are of mixed particle size. They are distinguished by a high content of humus, and range in pH from 6.5-7.5. The upper humus horizons increase in depth near slopes, from 8 to 23 centimeters. They occur in a pine-*Astragalus membranaceus* steppe open woodland.

Light carbonitic Mollisols are distributed only on the southern slope, and occupy small talus slide areas directly under cliff slopes. They are formed from carbonitic parent material, and occur in discontinuous, scattered areas within areas of the highly alkaline mineral-organic Spodosol type described above. Generally, they are strongly structured, moderately loamy, and very rich in humus in upper horizons. The O horizon varies from 20 to 50 centimeters, and their pH is slightly higher than the other soils of the island on average, being approximately 7.5 to 8.8. Typical vegetation on these soils is a slope steppe-pine-*Calamagrostis epigeios*-*Artemisia sericea* open woodland.

### Climate

The climate of the Ushkanii Islands is, as on Caribou and other large lake islands, strongly influenced by the waters of the lake. The limnoclimate of islands is stronger than most shoreline areas due to the lack of a suitable "buffer" of land climate, such as exists slightly inland at the mainland shore. This phenomena of limnoclimate, microclimate, and bioclimate has been extensively investigated at the Ushkanii Islands, and Vuikhristyuk (Вухристюк, 1969a, 1969b, 1980) presented a good synthesis of the conditions present. Since the late 1950s, a meteorological station at the southwest end of Bolshoi Ushkanii has recorded comprehensive climatic data. This enables direct long-term comparison with areas of the mainland and a better delineation of the differences between mainland and lake climate of the area. A climatic summary showing basic data is presented in Table 1.



Table 1  
Climatic Summary for the Ushkanii Islands

Data	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec
Temp absolute min.	-36	-35	-35.5	-29	-15	-5	0	0	-6	-20	-22	-30
Temp avg.	-18	-18.5	-13	-4.5	2	7.5	10	12	8	1.5	-4.5	-9
Temp abs. max.	3	0	9	17	21	25.5	29	25.5	20	17	16	8
Precip, mm	10	4	3	10	16	34	65	53	24	11	44	28

Source: Выхристюк 1969a and 1980, and Байкал атлас 1993.

## Temperature

The temperature extremes of the Ushkanii Islands are strongly ameliorated by the lake waters, and this influence is clearly observable in the temperature differences between island, lake, and mainland. Compared to the temperatures on the mainland, the islands are warmer in the winter and colder in the summer. These temperature differences are the result of the slowly changing lake water temperature compared to the air temperatures. The result is that the island seasonal temperatures lag somewhat behind those of the mainland and do not change as fast, nor as much, as the areas away from the lake. The waters of Baikal in the region of the Ushkanii Islands reach their highest temperatures in late August, and their coldest, of course, during freeze-over period between January and May (Байкал атлас 1993).

In the spring and early summer months, the average temperatures are lower than the mainland, while in the later summer and fall months they are somewhat higher. In addition to the seasonal differences, the diurnal temperature differences are smaller on the islands than on mainland areas, with the island during the warm months never reaching as high a temperature in the daytime, nor as cold at night, as the mainland. In the winter, the islands remain somewhat warmer during the daytime and nighttime relative to the mainland until freeze up, when they more closely follow the temperature patterns on the mainland, though the winter temperatures still do not fall as low as mainland areas (Выхристюк 1969а).

For example, the average temperature of Bolshoi Ushkanii Island is, compared to Davsha (Давша; a shoreline meteorological station to the northeast), 1.1°c colder in July, and 6.1°c warmer in December. The difference in maximum and minimum temperatures is much greater; the minimum temperature in Davsha may reach -50°c

in December, while it will only reach  $-36^{\circ}\text{C}$  on Ushkanii. Summer high temperatures are typically  $4-5^{\circ}\text{C}$  lower on Ushkanii than at Davsha (Вьхристюк 1969б, 1980, Байкал атлас 1993).

On the islands themselves, the temperature regime shows great variability. The most strongly moderated areas of the island are directly related to shoreline proximity; in winter the coldest areas are near the interior and upper areas of the island, and during the summer near the shorelines. In addition, there is a tendency for the south slope areas to be slightly warmer than the northern areas because of their aspect and, possibly, the decreased windiness on the south side (Вьхристюк 1980).

## Precipitation

### Rain

Precipitation at the Ushkanii Islands is somewhat lower than mainland areas. To compare with Davsha and Pokoiniki (Покойники, a shoreline weather station to the west), the precipitation is greatest at Davsha (488 mm/year), second at Pokoiniki (326 mm/year), and lowest at Ushkanii (306 mm/year). The greatest amount of precipitation falls in the summer months, with a second peak in November and December, when snowfall is greatest (Вьхристюк 1969а).

### Snow

Snowfall and snow cover, like rain, is lower on the island than on the eastern Baikal shore (Davsha), and slightly lower than the west (Pokoiniki). During the winter of 1961-1962, Vuikhristyuk (Вьхристюк 1980) measured snow at various areas

on the island, producing a series of maps from which several facts are noteworthy. The number of days with continuous snow cover is greatest on the upper regions of the island, and lowest on the south and southeast shores. Snow cover was lowest on the shoreline areas, and greatest on the upper areas, with a marginally greater depth on the north slope compared to the east and west slopes. Snow cover is also low on the south slope, with the cover being shallower and persisting for a shorter period, than the north slope and central areas. The southwest and east shoreline areas had snow covers intermediate of those of the south slope and north and central areas. The melting of snow cover also reflects this distribution pattern, with the last snow remaining on average until the beginning of May on the upper areas of the island

### Wind

The Ushkanii Islands do not have as pronounced a lake-breeze and land-breeze as the mainland Baikal shores, since the land area to heat or cool on the islands is quite small compared to the lake area. The islands, however, due to their position in the lake and the large open waters surrounding them (resulting in a maximum wind fetch) are quite susceptible to high winds. They are most frequently from the north (50%), and from the south (40%). Winds from the east and west are uncommon. Wind speeds are generally higher on Ushkanii than at the station Davsha, and similar to those of Pokoiniki, though with less seasonal speed variation than at Pokoiniki (Байкал атлас 1993, Выхристюк 1980).

## Visibility

### Clouds

The skies over the Ushkanii Islands—as over most of Lakes Baikal and Superior—are often clear during the spring and summer, and cloudy during the fall and winter (Ладейщиков 1982, Байкал атлас 1993, Eichenlaub 1979, Phillips and McCullough 1972). This is due to the colder lake water compared to the air during the spring and summer, and the warmer water compared to air in the fall and winter. The result is a larger amount of sunlight available for plant growth than that of most mainland areas, especially during the growing season. This is tempered somewhat by an increased amount of fog on the islands compared to mainland areas.

### Fog

Ladeischikov (Ладейщиков 1982) had discussed the fogs of the Ushkanii Islands in detail. Ushkanii has one of the largest incidences of fog on Baikal, second only to Listvyanka, where the Angara River and its valley have an unusually strong effect on the frequency and intensity of local fogs. He reported the majority of fogs on Baikal occur between the hours of 0700 and 1300 solar time. On all shoreline and open waters of Baikal (including the Ushkaniis), the foggiest month is July. On the Ushkanii Islands, the least foggy period is November to March. Bolshoi has an average of 9 days of fog in July and less than one in each of the winter months. During my stay on the Ushkaniis in July 1995, there were a number of very foggy days, with the fog confined largely to the lower areas of the island, near the shore and in the lower west side forest; they were less intense toward the interior of the island. The ma-

majority of the fogs dissipated by mid afternoon, though some lasted into the evening.

### Lake Ice

Most of the surface of Lake Baikal freezes completely each winter, including around the Ushkani Islands, resulting in a lower temperature at the islands after freeze-up than before. The average freeze-up date in the area of the Ushkani Islands is January 3, and average break-up is May 29, though the ice may be somewhat thin, especially to the northwest of the island (Байкал атлас 1993). It is reasonably solid, however, elsewhere around the islands, and the chief means of transportation for the ranger (or others) to the islands during the winter is via snowmobile over the ice. The implications of ice bridges for biogeography of the island will be discussed further in this thesis.

### Topographic Influence on the Climate

A significant climatic phenomenon is related to the topography of Bolshoi Ushkani Island, and facilitates perhaps the most unusual plant community there. The steep south slope of Bolshoi Ushkani combined with the east-west orientation of the island and the more northern latitude with its longer summer days causes an unusually high insolation during the summer period. The temperature, evapotranspiration, and sunlight create a harsh environment unsuitable for the boreal forest and shoreline species common to other areas of the island, and which is optimal for the steppe vegetation found in this area. Temperatures, as mentioned above, are influenced by the slope aspect. Vuikhristyuk shows the average annual air temperature to be slightly higher on the south slope and east steppe areas than the remainder of the

island. During my field work on the island in 1995 the area was by far the warmest on the island, as well as the driest of the areas explored on the islands.

Other topographic influences on the climate have been addressed in the investigations of Vuikhristyuk (Вухристюк 1980). The main differences he found relate to slope and orientation, though distance from the lakeshore is also an important variable in these topographic effects. Since the predominant wind directions are from the north and south, the island's topography—being arranged latitudinally—can effectively block much of the wind from one side to the other, and this likely has significant effect on the plant distribution. Humidity is generally greater on the higher elevations than the lower, and greater on the north slope than the south. Snow conditions, as mentioned previously, are also correlated with topography of the island.

### Animals

Litvinov (Литвинов 1982), Matveichuk (Матвейчук 1990), and others have studied and reported the zoogeography of the Ushkani Islands. The fauna of the Ushkani Islands is relatively poor, especially in mammals. There are essentially two mammals permanent to the Ushkaniis; the Baikal nerpa and the red polëvka, and only a few other wild mammals have been recorded for the islands. Two factors exist at the Ushkani Islands which greatly enhance the possibility of other mammals; the close proximity to undisturbed wilderness of the Svyatoi Nos Peninsula and the consistent, solid ice cover of Baikal during the period from early January to late May. This sometimes results in transient animals during the winter, and occasionally for longer periods. It also allows a relatively easy natural restocking of several mammals known periodically to the islands, such as hare. In addition, another mammal

which clearly has influenced the vegetation of the Ushkanii Islands finds easy passage at this time: man, as snowmobile access provides the easiest access of the year to the islands. The following accounts apply to Bolshoi Ushkanii Island only (as the literature and other sources largely did not address the Small Ushkaniis), except where noted for the nerpa and red polëvka.

## Mammals

### Nerpa

The predominate Ushkanii Islands mammal is the *nerpa*, or Baikal seal (*Phoca sibirica* Gmel.). This small seal ranges throughout Baikal, but large numbers of them gather at the Ushkanii Islands during the spring and summer months. They are most commonly seen on the offshore rocks and adjacent waters near the Small Ushkanii Islands, and are rarely seen at Bolshoi Ushkanii. This is likely due to human and domestic animal presence at the island, as will be discussed later. The seals are not rare at Baikal, and the total population of Baikal seal is estimated at approximately 80,000 animals (Alexander Timonin, personal conversation June 1995)

### Red polëvka

The Zabaikalskii National Park ranger stationed on the island stated in July 1995 that the only wild mammal other than seals that inhabited the islands at the time was the "red polëvka" (*Clethrionomys rutilus* Pall.), a species of vole. One specimen of this small mammal was seen, having been killed by the cat near the ranger station, and these small animals apparently exist in moderate numbers on Ushkanii. Litvinov (Литвинов 1982) estimated the population on Bolshoi Ushkanii to be over one



hundred.

### Transient Mammals

Other mammals have been reported for the islands at various earlier times, though they have not been observed to be permanently established there. Previously mentioned was the hare (*Lepus timidus* L.), which has been found on the island in populations of various size. In 1977 a population was estimated by counting tracks in the snow; it was estimated to be between 2 and 3 dozen individuals. In the 1920s the population was reported to have been much higher; indeed, the annual hunting kills amounted to about three dozen animals. The decline in population of the hares is attributed mainly to the dogs of the island research staff (ЛИТВИНОВ, 1982). Although a ZNP official stated in 1995 that the only mammals present at the time were nerpa and polëvka, rounded pellets were seen numerous times on the upper areas of the south slope; it is probable that they were of *L. timidus*.

The tracks of foxes (*Vulpes vulpes* L.) have been noted on Bolshoi Ushkanii Island during all times of the year, though their numbers are low. The "Ushan" (УШАН, *Plecotus auritus*, a bat) has been reported once from the eastern side of Bolshoi Ushkanii Island. Otters (*Lutra lutra* L.) occasionally swim to the islands, and wolverines (*Gulo gulo* L.) and lynx (*Felis lynx* L.) sometimes arrive at the island over the ice. Bears (*Ursus arctos* L.) are quite numerous on the Svyatoi Nos Peninsula, and rarely cross the ice to the Ushkanii Islands in the winter and spring. Sables (*Mustela zibellina* L.), the famous fur-bearer which gave Siberia much of its economic growth in centuries past, have been seen on the islands several times in the past, but

are generally known from a darker spruce-fir forest than the lighter larch-pine forests common on the Ushkaniis (Флинт et al. 1970).

### Other Animal Life

A prominent feature of the Ushkani Islands are the large numbers of ants. This is one of the main features for which the islands have been protected as a natural monument. Oleg Gusev, a prominent Baikal naturalist discusses these ant colonies, noting “in density the ants of Bolshoi Ushkani Island, it is likely, have no equivalent in the (Soviet) Union” (Гусев 1990, 147).

Birds of the Ushkani Islands have been surveyed by Oleg Gusev (Гусев 1960), Litvinov and Molozhnikov (Литвинов и Моложников 1969), Litvinov and Matveichuk (Литвинов и Матвейчук, 1977) and a summary of avifaunal conditions of the islands is also included in Imetkhenov et al. (Иметхенов et al. 1990). According to Imetkhenov et al., a total of 113 bird species in 11 orders have been recorded at the islands.

## Vegetation of the Ushkani Islands

### Overview

By far the most comprehensive vegetation survey of the Ushkani Islands is that of Ivanova (Иванова 1969). Her report incorporates the findings of research done prior to that time, and few vegetation data of consequence have been found from the period between Ivanova's early 1960s study and my 1995 study on the islands. She classified the forests, steppes, and other communities of the islands into several

main types and numerous smaller associations. Though there have been some changes to the vegetation in the last 30 years, the vegetation descriptions and community associations on the Ushkaniis still generally follow those of Ivanova, despite several fires and other impacts. When my 1995 observations matched Ivanova's descriptions, what is presented in this thesis follows her designations; when my findings were different, some additions and changes have been made to Ivanova's classifications to match what I observed during my 1995 field work. The only plant community I have added to Ivanova's designations, however, is the poplar thicket of the south shore. A vegetation map of the Ushkani Islands is shown in Figure 6.

Bolshoi Ushkani Island is covered largely with a variation of the low mountain forests which surround much of Baikal. Larch and pine forests, with admixture of birch, poplar, willow, and mountain ash, are the main forest tree species, with the forests of Ushkani being differentiated into two main types with either larch or pine dominant. Several common taiga trees of the region, such as spruce (*Picea obovata*), fir (*Abies sibirica*), and two other species of pine (*Pinus sibirica*, *P. pumila*) are rare on the islands, and are not significant components of the forests. Other areas of the Ushkani support several unique communities. Steppe vegetation is a characteristic feature on the southeast and east slopes, as well as a small area of the west side. On areas of the south slope there are rocky cliffs and talus slopes which, while having many species in common with the steppe areas, have a suitably distinct flora and microlandscape to be differentiated. Shoreline communities are well developed in various areas along the perimeter of the island, with some small areas of emergent aquatic vegetation on the northwest and south-central shores. Transition zones are also significant phytogeographical features on the island, particularly the forest edge at



steppe and shoreline areas. The broadest transitions are from the pine forest to the steppe areas, while those of the forest-shore are often quite abrupt. Other noteworthy transition zones are the larch forest-pine forest transition (particularly on the southeastern side of the island), and the south slope-pine forest transition. There are no permanent or intermittent wetlands of any kind on the Ushkanii Islands, save for the Baikal shoreline, and hence few species associated with such habitats.

Human activities on the islands have affected the vegetation. In addition to the "natural" communities, the area of the island near the meteorological and ranger station maintain some "weedy" species, and there are also several introduced species close to an old dwelling near Pescherka Bay. Many of these species may have been directly introduced by man, and all have found a suitable habitat among the disturbed and deforested areas.

Vegetation of the island has also been affected by the fires which have burned large areas of the island in this century (and perhaps past centuries). Later in this thesis an overview will be given of the fire history of the Ushkanii Islands in this century, and their possible influences on the islands' flora.

The Small Ushkanii Islands are too small to have vegetation zones as well defined as Bolshoi Ushkanii, though there is a definite steppe-xerophyte association on the southern slopes of the islands, a narrow forest-shore transition, and shoreline vegetation similar to that of Bolshoi Ushkanii Island. The forest areas are dominated by *Larix x czekanowskii*, as on the lower areas of the west side of Bolshoi Ushkanii Island. The wooded areas of the Small Ushkaniis have a relatively open larch-dominant forest with small additions of *Pinus sibirica*, *Sorbus sibirica*, *Pinus sylvestris*, *Picea obovata*, *Abies sibirica*, *Betula hippolyti*, and *Duschekia fruticosa*. Notable is

the thick ground cover in most forest areas of the Small Ushkaniis of *Empetrum sibiricum*. Several species are exclusive to the small Ushkaniis and are not known from Bolshoi Ushkani; including *Carex amgunensis*, *Salix stenolivida*, *Betula rotundifolia*, *Betula divaricata*, the hybrid *Betula divaricata* x *B. exilis*, *Astragalus sericeocanus*, *Conioselinium longifolium*, *Carex krausei*, and *Ribes paciflorum*. The Small Ushkaniis have a thinner forest—more closely approximating the shore-larch forest transition on Bolshoi Ushkani, attesting to a strong limnoclimatic influence on these islands. Ivanova (Иванова 1969) notes this pronounced limnoclimatic influence on the vegetation of the islands, particularly on the northern shores of the islands. There are several arctoalpine species on the Small Ushkaniis, including *Pinus pumila*, *Betula divaricata*, *B. rotundifolia*, *Salix divaricata*, *Sorbaria palassi*, and *Epilobium latifolium*. The arctoalpine flora of the Small Ushkaniis includes all arctoalpine species from Bolshoi Ushkani Island with the exception of *Polemonium boreale* and, therefore, shows the suitability of these smaller islands—with their strong limnoclimates—to arctoalpine species.

### Shoreline Vegetation

The shoreline topography of the Ushkani Islands is governed by the bedrock, which provides a variety of microlandscapes. The islands' shorelines are largely characterized by rugged bedrock exposures interspersed with rocky and gravel beaches, and there are no significant areas of sand beach on the islands. Most "true" beaches have a moderately wide gravel beach zone free of vegetation, and signs of continual reworking via wave action can clearly be seen. In small areas of the shore-

lines there are relatively calm shallow water areas with emergent aquatic plants. In these shallow waters of gently sloping shorelines, *Carex cespitosa* is common (Figure 7). The floristic composition of the shoreline areas is rather variable, and the only species appearing in all shoreline areas is *Carex cespitosa*. Additional species commonly found, to varying degrees, are *Allium schaeoprasum*, *Calamagrostis neglecta*, *Caltha palustris*, *Carex sajanensis*, *Potentilla palustris*, *Dactylorhiza majalis*, *Parnassia palustris*, *Ranunculus propinquus*, and *Vicia cracca*.



Figure 7. Shallow Water on South-Central Shoreline of Bolshoi Ushkanii Island.

### Emergent Vegetation

Emergent plants along the shorelines are more common along the west and, occasionally, the south shores. There is only one species of true aquatic plant (perhaps better termed as semi-aquatic) present on the Ushkaniis, *Caltha palustris*, which is found on Bolshoi and Kruglii Islands. Figure 8 shows one such shallow water area on the northwest tip of Bolshoi Ushkanii Island with *Carex cespitosa*, *Caltha palustris*, and *Allium schaenoprasum*. It was found growing on Bolshoi Ushkanii Island in 1995 only on a small area of the northwest side, among rocks and shallow water to approximately 1 dm deep, and in association with *Allium schaenoprasum* and *Carex cespitosa*. Ivanova (Иванова 1969) reported it for a possibly wider distribution ("at water edge"), as well as in a similar habitat on Kruglii Island. *Carex cespitosa* is common on the shorelines, especially on the west, northwest, and southeast-central areas. The beaches in such areas are characterized by gravel to large rocks, with little soil, and is frequently, though not exclusively, somewhat protected from extreme wave action.

### Beach Vegetation

Most areas of the shoreline appear to be well stabilized, though the small gravel spit at the southeast tip of Bolshoi Ushkanii Island is somewhat dynamic and largely unvegetated. Some areas of the shoreline have significant deposits of washed up debris, most notably the west side of Bolshoi Ushkanii Island. Figure 9 shows the northwest shoreline-forest transition of Bolshoi Ushkanii Island, with robust growth of *Atragene sibirica* and *Vicia cracca* and large amounts of wave-carried debris.





Figure 8. Shallow Water on Northwest Shore of Bolshoi Ushkanii Island.

These areas are often populated with a variety of plants which take advantage of the shelter, small areas of soil and sand, and decaying humus of debris provided. The actual species composition in the driftwood areas is variable, but *Dactylorhiza majalis*, *Aquilegia sibirica*, *Vicia cracca*, *Linnaea borealis*, and *Atragene sibirica* are common. Although Ivanova (Иванова 1969) reported that the best developed shoreline communities were on the west and north sides and the least developed were on the south shore, I found several well-developed shoreline communities along the south central shore. However, the best examples are to be found on the northwest areas. Most shorelines which are without large rocks have a gravel beach several meters wide free of vegetation, due to continual reworking by wave action, though areas with

boulders or other protections typically have some vegetation nearby.



Figure 9. Northwest Shoreline Forest Edge of Bolshoi Ushkanii Island.

### Forests

Two main forest types occur on the Ushkanii Islands, and are well organized according to topography, slope aspect, and related microclimatic variables, such as moisture and wind exposure. They are rather well differentiated, not mixing to a great extent, and occupy separate physiographic areas.

#### Larch Forest

The predominant forest type is a larch (*Larix x czekanowskii*) dominant forest with admixture of birch (*Betula pendula* and, less frequently, *B. hippolytii*), willow

(*Salix* spp.), and poplar (*Populus tremula*). It is the predominant forest type of the northern slopes and lower terraces of the island, save for the southeast side. The forest composition varies depending on proximity to lake, soil, aspect, and relief. Most of the areas of larch forest have a relatively open character, as *L. x czekanowskii* is a rather shade intolerant species (ИВАНОВА 1969). The frequent sunshine during the warmer months may also be a reason for the preponderance of larch and pine, and paucity of the darker conifers, such as *Picea* and *Abies*.

An open larch crowberry wood is typical of the Small Ushkanii Islands, and a similar, though perhaps somewhat less complex forest type occurs in the very northwest tip of Bolshoi Ushkanii Island, where the forests are exposed to possibly the strongest, coldest lake winds. Figure 10 shows an open larch-crowberry woods on the northwestern side of Bolshoi Ushkanii Island, and the larch at the center of the photograph shows clearly the bottleform trunk typical of the larches on the Ushkanii Islands.

The larch-lingonberry (*Vaccinium vitus-idaea*) herbaceous forest association is common to the lower areas of the island, particularly in the outer forests bordering the shore areas, with the exception of the south shore. Larch is dominant, in association with lingonberry (*Vaccinium vitus-idaea*), *Festuca ovina*, crowberry (*Empetrum sibiricum*), *Vicia multicaulis*, *Bromopsis pumPELLIANA*, *Linnaea borealis*, *Dendranthema zawadskii*, and the moss *Rhytidium rugosum*. The Russian term *raznotrav'ye* (разнотравье) is introduced here; it means literally "diverse herbs" or "various herbs", and refers to herbaceous plant cover other than graminoids and the Fabaceae. It is difficult to translate concisely, but I have used the term "herbaceous" in place of

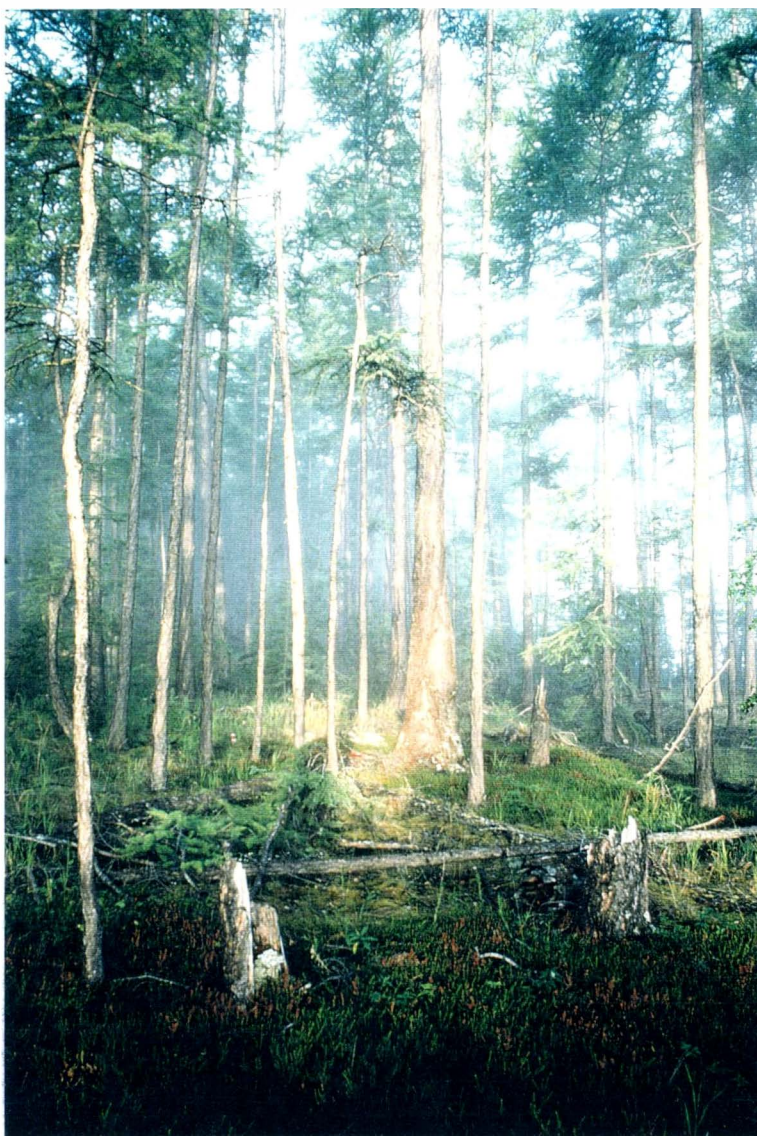


Figure 10. Open Larch-Crowberry Woods on Bolshoi Ushkanii Island.

the Russian *raznotravye* throughout this thesis.

A small area of larch-steppe transition exists in the southwest slope of the interior of the island, to the northeast of the ZNP ranger station. It is characterized by rocky slopes with scattered larch trees, and an undergrowth of *Festuca ovina*, *Vicia multicaulis*, *Artemisia sericea*, *A. tanacetifolia*, *Dendranthema zawadskii*, *Crepis si-*

*birica*, *Youngia tenuifolia*, *Carex pediformis*, and *Bromopsis pumpehiana*.

A larch-*Brachypodium* herbaceous forest type grows on two small areas of the island; one near the east side slope toward Pescherka Bay, and another near the southeast lower slope. It is characterized by a thin secondary (shrub) layer, consisting of occasional *Spirea media* and *Rosa acicularis*, and a rather thick herbaceous layer. Important species in this association include *Brachypodium pinnatum*, *Lathyrus humilis*, *Poa sibirica*, and *Geranium pseudosibiricum*.

The larch-fescue-sedge herbaceous forest association occurs on terraces of the north slope. Common species here include larch, *Betula pendula*, and a very diverse herbaceous layer including *Acontium septentrionale*, *Vaccinium vitus-idaea*, *Carex macroura*, *Linnaea borealis*, *Equisetum pratense*, *E. scirpoides*, and *Maianthemum bifolium*.

The larch-sedge herbaceous tallgrass forest association consists of an exclusively larch tree cover and few shrubs. The herbaceous layer is much more diverse, and dominant and important species include *Carex macroura*, *Lathyrus humilis*, *Linnaea borealis*, *Equisetum pratense*, *Calamagrostis obtusata*, *Poa sibirica*, *Geranium pseudosibiricum*, *Acontium septentrionale*, *Aegopodium alpestre*, *Heracleum dissectum*, and *Thalictrum minus*. This forest type occurs on medium slopes near the northeast side of the island, as well as in a slightly smaller area near the southwest side.

Larch-shrub associations are found on several areas of the north side forest, on acidic Spodosols on the north and northeast lower terrace slopes, in areas which Ivanova has noted are the coldest microclimates of the island. Figure 11 shows one



Figure 11. Larch Forest on Bolshoi Ushkanii Island.

such larch forest, with rhododendron and *Duschekia*, near the shoreline on Bolshoi Ushkanii Island's west side. This association is restricted to small areas, and is not shown on the map. Species composition is of an exclusively larch tree cover with understory of *Ledum palustre*, *Vaccinium vitis-idaea*, *Equisetum scirpoides*, and in more eastern areas, *Festuca ovina*, and *Pyrola incarnata*. There is a continuous rich moss cover of *Pleurozium schreberi*, *Aulacomnium turgidum*, *Hylocomnium splendens*, and *Ptilium crista-castrensis*. The leathery lichen *Peltigera apathosa* is also a common feature.

The larch rhododendron forest association occurs on Spodosols of the north lower terraces. Predominant species are *Rhododendron dahuricum*, and *Vaccinium*

*vitus-idaea*, with occasionally *Salix livida*, *Duschekia fruticosa*, *Bergenia crassifolia*, *Rosa acicularis*, *Spirea media*, *Festuca ovina*, *Linnaea borealis*, with the moss *Pleurozium schreberi*.

The larch-*Duschekia*-rhododendron forest is found at the upper side of the northern slope, between the pine forests of the upper areas and the larch-rhododendron forests of the northern slope. In 1995 they were extremely robust and, especially on the east-central upper slope, very difficult to walk through, although occasional more open areas were found throughout. It is possible that this predominance of secondary layer growth is because of increased light resulting from fires in recent decades. Important species are larch, *Vaccinium vitus-idaea*, *Festuca ovina*, *Linnaea borealis*, *Bergenia crassifolia*, *Ledum palustre*, *Duschekia fruticosa*, *Betula pendula*, *Populus tremula*, *Rhododendron dahuricum*, *Vaccinium uliginosum*, *Pedicularis labradorica*, and the moss *Pleurozium schreberi*.

### Pine Forest

The second main forest type is pine dominant with admixture of larch, birch, and various herbaceous species. Pine forests are distributed on the southern slopes and on the upper areas of the island, but are largely absent on the northern slopes and lower terraces of the west side. Ivanova's classifications include the main associations which follow.

The pine-rhododendron-*Duschekia* forest is quite similar to the larch-rhododendron forest described above, with the main difference being the replacement of primary tree species (pine for larch) and addition of *Duschekia fruticosa* as a primary

woody species. It is distributed in a compact area on the northern side of the upper forest, bordering the larch-duschekia-rhododendron forest. Other important species include *Vaccinium vitus-idaea*, *Arctostaphylos uva-ursi*, *Thesium repens*, *Festuca ovina*, *Vicia multicaulis*, *Bromopsis pumpelliana*, *Pulsatilla multifida*, *Linnaea borealis*, and *Carex macroura*. The mosses *Pleurozium schreberi* and *Ptilium crista-castrensis* are sporadic throughout. Near the northeastern border of this association, on the edge of the upper north slope, larch becomes an important tree species, and the forest here might be best termed a larch-pine rhododendron *Duschekia* forest.

A pine-rhododendron-lingonberry forest is found on the central upper area of the island. Important species are *Pinus sylvestris* as the main tree cover, and *Rhododendron dahuricum*, *Vaccinium vitus-idaea*, *Festuca ovina*, *Bromopsis pumpelliana*, *Pulsatilla multifida*, *Dendranthema zawadskii*, and *Linnaea borealis*.

The pine-herbaceous lingonberry forest association is distributed in the upper level forest of the island and on areas of the east and south slopes, as well as in a narrower zone on the lower terrace of the southern slope on rocky highly alkaline, loamy soils. Figure 12 shows the pine forest on the central upper area of Bolshoi Ushkanii Island. On the areas of this forest on the east slope, the soils are shallower, with bedrock often close to the surface. Common species include *Pinus sylvestris*, *Vaccinium vitus-idaea*, *Festuca ovina*, *Vicia multicaulis*, *Bromopsis pumpelliana*, *Pulsatilla multifida*, *Geranium pseudosibiricum*, *Dendranthema zawadskii*, the moss *Pleurozium schreberi*, with additional species distributed occasionally throughout. In areas where the forest is in transition with larch-dominant forests, the characteristic species are similar, but with the addition of larch as a primary tree species and some slight



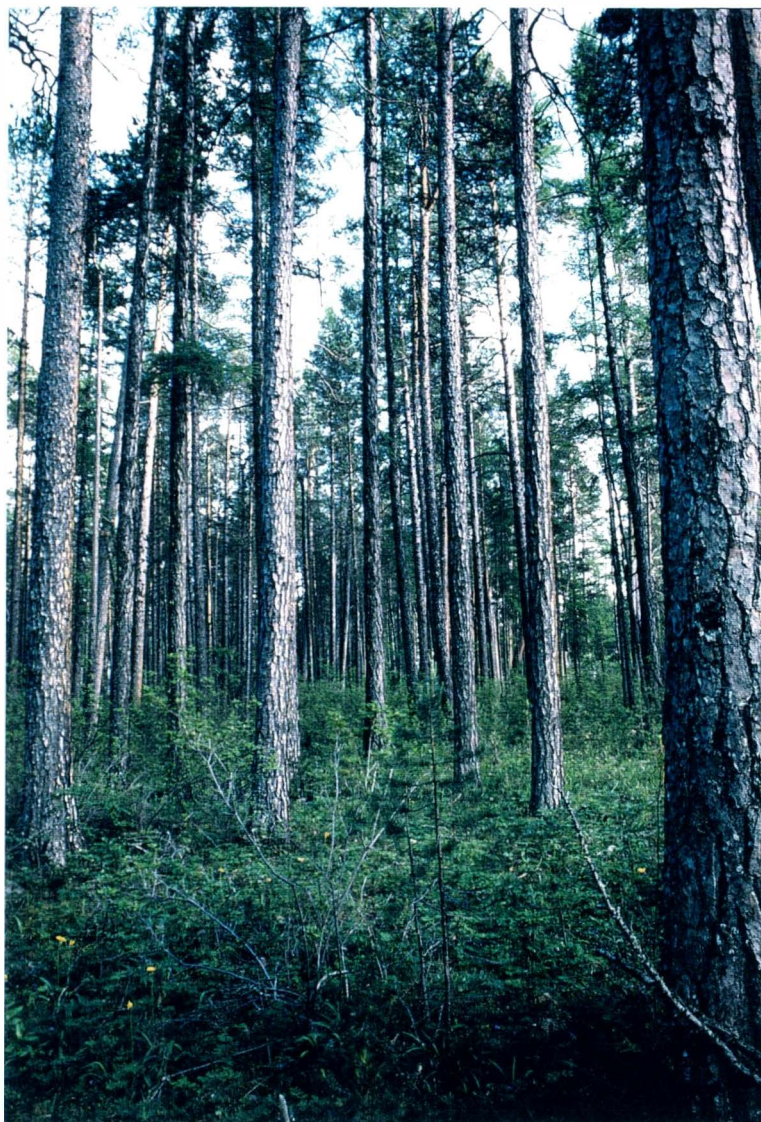


Figure 12. Pine Forest on Central Upper Area of Bolshoi Ushkanii Island.

changes in species of herbaceous plants.

Where the land has a more variable and xeric character, there is a broad pine-lingonberry steppe transition association. This is rather variable, ranging from a complete forest canopy to open areas of scattered trees merging with the steppe associations. Local variations are likely caused by microclimatic (evapotranspiration,

soil moisture, runoff, snow cover), as well as soil (particularly erosion and deposition) factors. The pine-steppe edge forest association is distributed on larger areas of the middle slope forests of the south side and of the east side near Pescherka Bay. It is composed of a relatively open pine canopy, with many understory species in common with the more open steppe areas nearby. Figure 13 shows one of the pine forest-steppe transition areas on the upper southeast slope of Bolshoi Ushkanii Island; the view is toward the southwest. Common herbaceous species in this forest association include *Pulsatilla multifida*, *Scozonera austriaca*, *Vicia multicaulis*, *Bromo-*

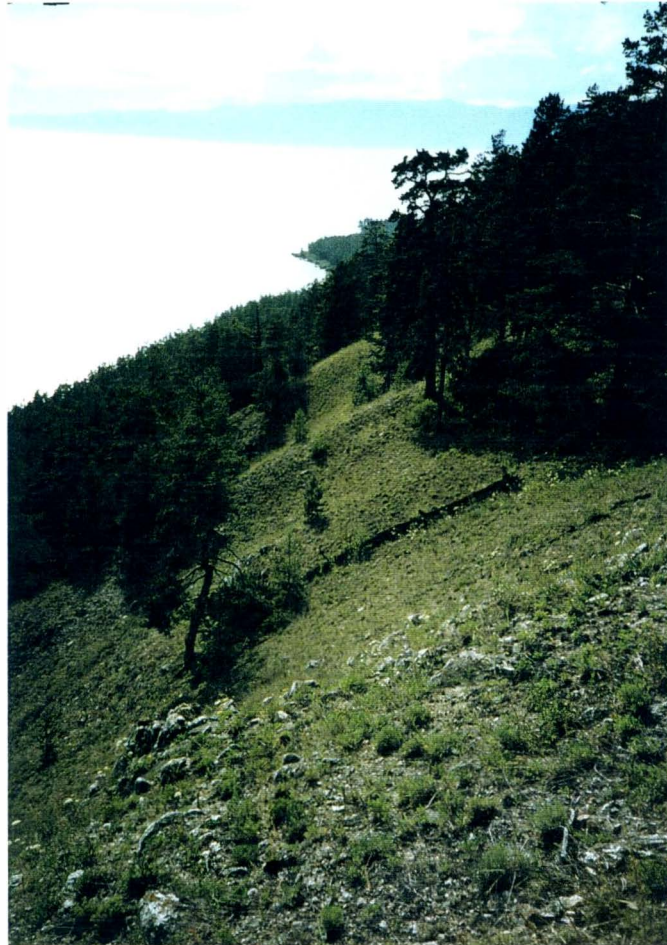


Figure 13. Pine Forest-Steppe Transition on Bolshoi Ushkanii Island.

*sis pumpelliana*, *Festuca ovina*, *Artemesia sericea*, *Astragalus membranaceous*, and various other species distributed sporadically throughout.

### Poplar Thicket

According to Ivanova, pine and larch forests were the only major associations on Bolshoi Ushkanii Island at the time of her investigations. However, in 1995 there was a definite, if not extensive, poplar (*Populus tremula*) thicket on the south-central side of the island. This small poplar forest (Figure 14), approximately several dozen meters across and extending partially up the slope, appeared to be of even-aged trees, with a smaller understory component, and approximately 10-20 years old. This forest area is quite likely a clone growth which was established (or at least predominated) after one of the fires. It is situated in a slight ravine area, where there may have been factors (such as erosion or deposition of soil) which favored *Populus* over other tree species. There is a minimal component of small larch trees, and herbaceous species include various graminoids, *Pulsatilla patens*, *Trollius asiaticus*, and several leguminous species.

### Steppes and Cliff Vegetation

Steppe communities are a conspicuous feature of the Ushkanii Islands, and represent the northernmost steppe communities at Baikal, with the exception of some small areas in the Barguzin Valley to the east of Baikal. These steppe communities in the Baikal region represent the most northern extension of the central Asian steppes (Пешкова 1972 & 1984, Байкал атлас 1993, Гагарин 1974). Steppes on Bolshoi Ushkanii Island are distributed on steep slopes of the south side, the upper ar-



Figure 14. Poplar Thicket on Bolshoi Ushkanii Island.

east of the south slope, and ledges of the lower beach-edge terraces. They are present where southern exposure, rocky soil, and xeric conditions prevail. They are best developed on Bolshoi Ushkanii, due to the steeper and more extensive slopes. Figure 15 shows the upper steppe slope of the *maryan* on the southeast side of Bolshoi Ushkanii Island. There is a transition from this steppe to pine forests (and occasionally



Figure 15. Upper Slope of the Maryan on Bolshoi Ushkaniy Island.

larch) in their upper areas, and on the lowest areas they either grade into open larch or pine woodland or shorelines. Near the shores it may either abruptly stop near a gravel beach, bouldery or rocky shore, or at the upper limit of a steep rocky slope leading to the water's edge (the latter condition is typical of the extreme southeast slope and near the northeast steppe). There are steppe associations on the south slopes of the Small Ushkaniy Islands as well, though they are represented in a less dramatic form on the Small Ushkaniis because of the much smaller areas. The following steppe associations have been identified by Ivanova, although they occur in such variability and intermittent and small areas that the steppes are mapped in the vegetation map of this thesis (see Figure 6) as one unit.

*Agropyron* steppes are found in the drier, more harsh microclimates; there are two identified associations. The *Artemesia-Agropyron* steppe is the largest steppe association on the islands. It occurs on the most xeric areas of the island on prominent dry, rocky slopes on fine carbonate Mollisol soils. It is an open steppe, with mainly graminoids and some forb plants. Important species are *Agropyron cristatum*, *Kitagawia baicalensis*, *Carex pediformis*, *Artemesia commutata*, and *Poa botryoides*.

A *Koeleria-Agropyron* steppe is similar to the above association with slight differences in species composition related to the more mesic microclimate of the area of the maryan where they are found. Dominant species include *Koeleria altaica*, *Agropyron cristatum*, *Helictotrichon schellianum*, *Dianthus versicolor*, *Scorzonera austriaca*, *Artemesia commutata*, *Vicia multicaulis*, and *Astragalus austrosibiricus*.

Steppes with a prominent *Stipa* presence are distributed on the shallower, generally less rocky, more mesic conditions than the *Agropyron* dominant steppe. On fine, carbonate Mollisols of the shallower south slopes, a *Stipa capillata* dominant steppe occurs. These areas are less rocky and more mesic than the *Agropyron* steppes, and are distributed on the maryan and on the south slope in a narrow band near Pescherka Bay. Other key species include *Helictotrichon schellianum*, *Koeleria altaica*, and *Carex pediformis*.

An *Artemesia-Koeleria-Stipa* steppe association is found on the more level areas of the maryan. The species association here is *Artemesia commutata*, *Koeleria commutata*, *Stipa capillata*, *Kitagawia baicalensis*, *Agropyron cristatum*, *Scorzonera*

*austriaca*, *Helictotrichon schellianum*, *Artemesia* and *frigida*, and *Kochia prostrata*.

A *Helictotrichon-Stipa* steppe association is located on an area gently sloping toward the beach at Pescherka Bay. Species associated with this community are *Stipa capillata*, *Helictotrichon desertorum*, *H. schellianum*, and *Scorzonera austriaca*.

A *Agropyron-Stipa* herbaceous steppe association is distributed widely on the south slope, in patches between the *Stipa* and *Agropyron* associations. Dominant species are *Stipa capillata*, *Agropyron cristatum*, *Carex pediformis*, and occasionally *Helictotrichon schellianum*.

An *Agropyron-Stipa-Kochia* steppe association occurs only on the more rocky slope areas of the maryan than the above association. Dominant species include *Stipa capillata*, *Agropyron cristatum*, *Kochia prostrata*, *Artemesia frigida*, *Koeleria altaica*, *Scorzonera austriaca*, and *Alyssum lenense*.

An *Agropyron-Stipa* steppe association occurs at the upper rocky areas of the south slope. It is, according to Ivanova (Иванова 1969), an area of abundant spring snow melt, which causes erosion and soil transport. The dominant species are *Stipa sibirica*, *Agropyron cristatum*, *Kitagawia baicalensis*, *Artemesia commutata*, *Alyssum lenense*, and *Orostachys spinosa*.

Finally, an *Agropyron-Stipa-Artemesia* steppe association occurs on areas of the maryan. The dominant species in this association are *Artemesia frigida*, *Stipa sibirica*, *Agropyron cristatum*, *Stipa capillata*, *Artemesia frigida*, *Kochia prostrata*, and *Carex pediformis*.

Cliff vegetation is characteristic of the upper areas of the south slope where

bedrock outcrops form cliffs or very steep, rocky slopes with dry, poorly developed soils which are continually eroding from frost, wind, and water action. Exposure, poor soils, high alkalinity, and the close bedrock combine to create a microenvironment suitable to few but the hardiest and most xerophytic species. Species common here are *Alyssum lenense*, *A. obovatum*, *Veronica incana*, *Potentilla acaulis*, *Thymus serphyllum*, *Polygala sibirica*, *Androsace incana*, *Patrina sibirica*, *P. rupestris*, *Kitagawia baicalensis*, *Chamaerhodos grandiflora*, *Saxifraga spinulosa*, *Orostachys spinosa*, and *Sedum aizoon*. *Ephedra monosperma* is also an occasional, though indicative, species here.

### Disturbed Areas

There has been moderate human disturbance at the Ushkanii Islands, and disturbed "lawn" areas are a distinctive vegetation type near the ZNP ranger station and, though apparently largely regrown, in a small area near Pescherka Bay. Lighthouse keepers, fishermen, seal hunters, scientific researchers, and tourists have all contributed to vegetation and landscape changes to the islands, and the greatest change is near their main areas of activity. There have been small areas of habitation on the island in at least two places; one of these is the base (ZNP ranger station) at the southwest side of the island, which is still used as a residence for the ZNP ranger and a scientific and meteorological station. The areas are probably largely artificially maintained, since in such areas near the east side there are but few remnant weedy species left.



## STUDY SITE 2: THE CARIBOU ISLANDS, LAKE SUPERIOR

...my curiosity was raised anew, by the account given me by my companions, of another island, almost as large as the one on which I was...

—Alexander Henry (1809, 223-224)

### Location

The Caribou Islands, also known as the Caribou Archipelago or Caribou or the Caribous, are situated near the east-center of Lake Superior, approximately 55 kilometers west of the shoreline at Agawa Bay, near 47°22'N and 85°49'W (figure 16). One of the most significant aspects of their location is that the Caribou Islands represent the most remote lake islands in the world. The shortest distance between land points is between the north tip of Caribou Island to the south shore of Davieaux Island (a small island about 1 km south of Michipicoten Island). This distance is over 33 kilometers, and represents the shortest possible migration route from land for plants and animals. (Michipicoten Island itself is located about 15 km south of the mainland, which is the Pukaskwa coast.) Caribou Island is positioned close to the USA-Canada border, just about 5 km inside Ontario from Michigan. The islands are situated on the North Bank, a north-south trending bedrock ridge which is approximately 15 km long and 7 km wide. Because of this ridge, the waters around Caribou Island are relatively shallow and rocky; in this area there is good fishing for lake trout and other fish and it is in this area where the noted freight ship *Edmund Fitzgerald*—possibly after striking the rocky bottom—began to take on water before sinking in 1975.

The name Caribou Island was first assigned to this island on maps in 1796,

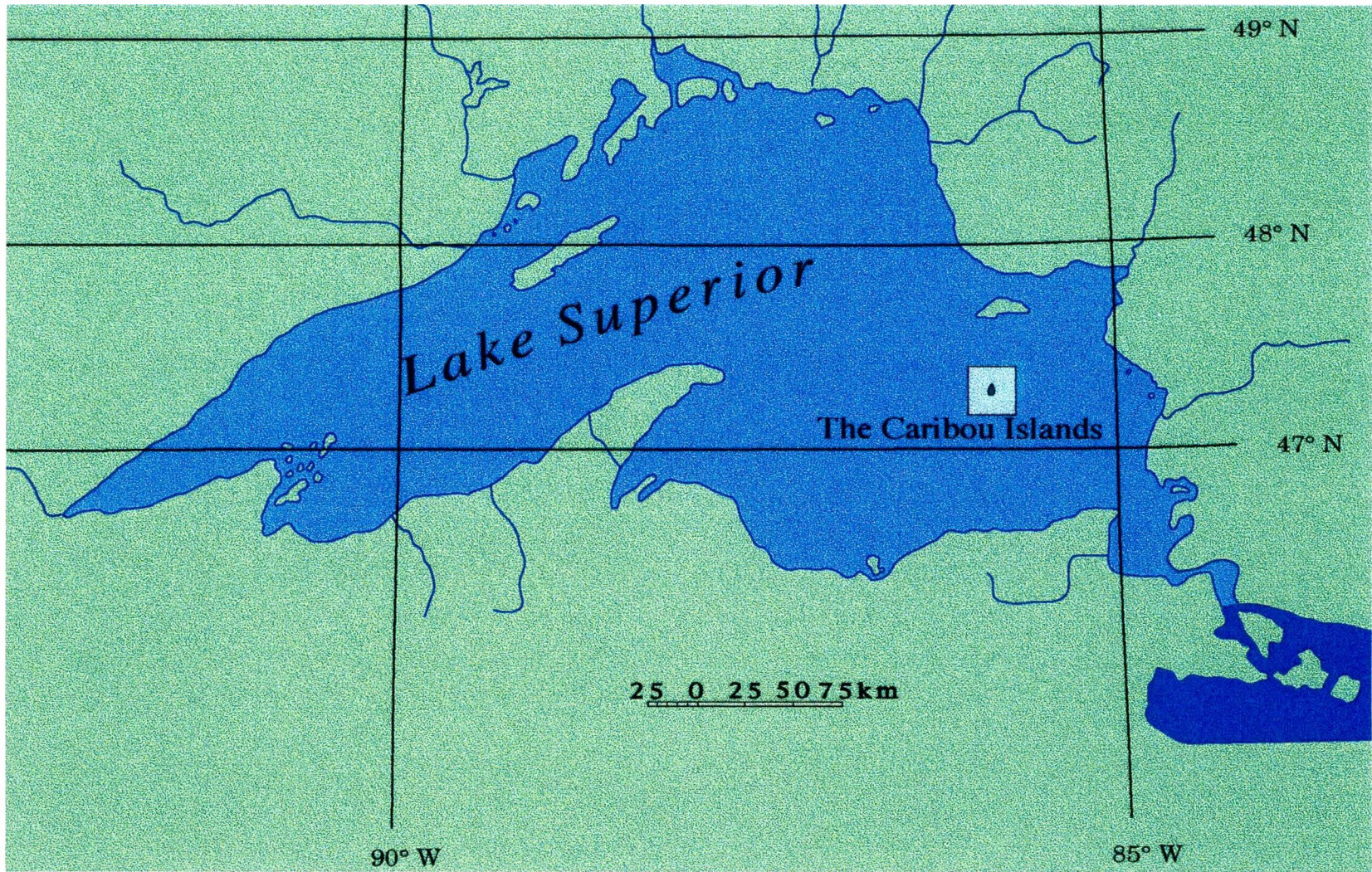


Figure 16. Location Map of the Caribou Islands.

and was probably in response to the information of Alexander Henry, who reported caribou on the islands (which is discussed further in this thesis), or another such report. Prior to this, the island had been known as Isle Ste. Anne on European maps, Isle of the Golden Sands, Round Island (Carter 1979), and, to natives, Adikiminis (Graham 1995). Because of the relative size difference—the outlying islands are nearly insignificant in comparison—the site is usually referred to as simply Caribou Island. In this thesis, however, Caribou Island will refer only to the main island.

The name of Lighthouse Island is most certainly the first “official” name of the small islet to the south of Caribou, and it was probably named by default about the same time as the construction of the first lighthouse there in 1886, or possibly upon publication of the first Canadian topographic map of the area (named “Lighthouse Island”). Gull Island, just off the northwest tip of the island, was probably named by Captain Roys Ellis, the owner of most of Caribou Island until his death in 1982. Other toponyms shown on the map in Figure 17 are those which, according to Morton and Venn (1996), were used by Ellis and his family in 1976, and those used by myself (for unnamed features) in 1996.

The Caribou Islands are comprised of the larger Caribou Island and the very small nearby Lighthouse Island and Gull Island. The size of Caribou Island is approximately 6.2 km<sup>2</sup>, or, given variously by different authors, 1300 acres (Brown 1982), 1520 acres (Ontario land transfer records of 1902, Carter 1979, Morton and Venn 1996), 700 ha (Noble 1982), and 1600 acres (Nisbet 1981). It is somewhat diamond-shaped, longest in a SSE-NNW orientation and shortest in the ENE-SSW. The maximum length is 5.5 km; the maximum width about 2.25 km. The maximum height of Caribou above Lake Superior level is not great; approximately several dozen

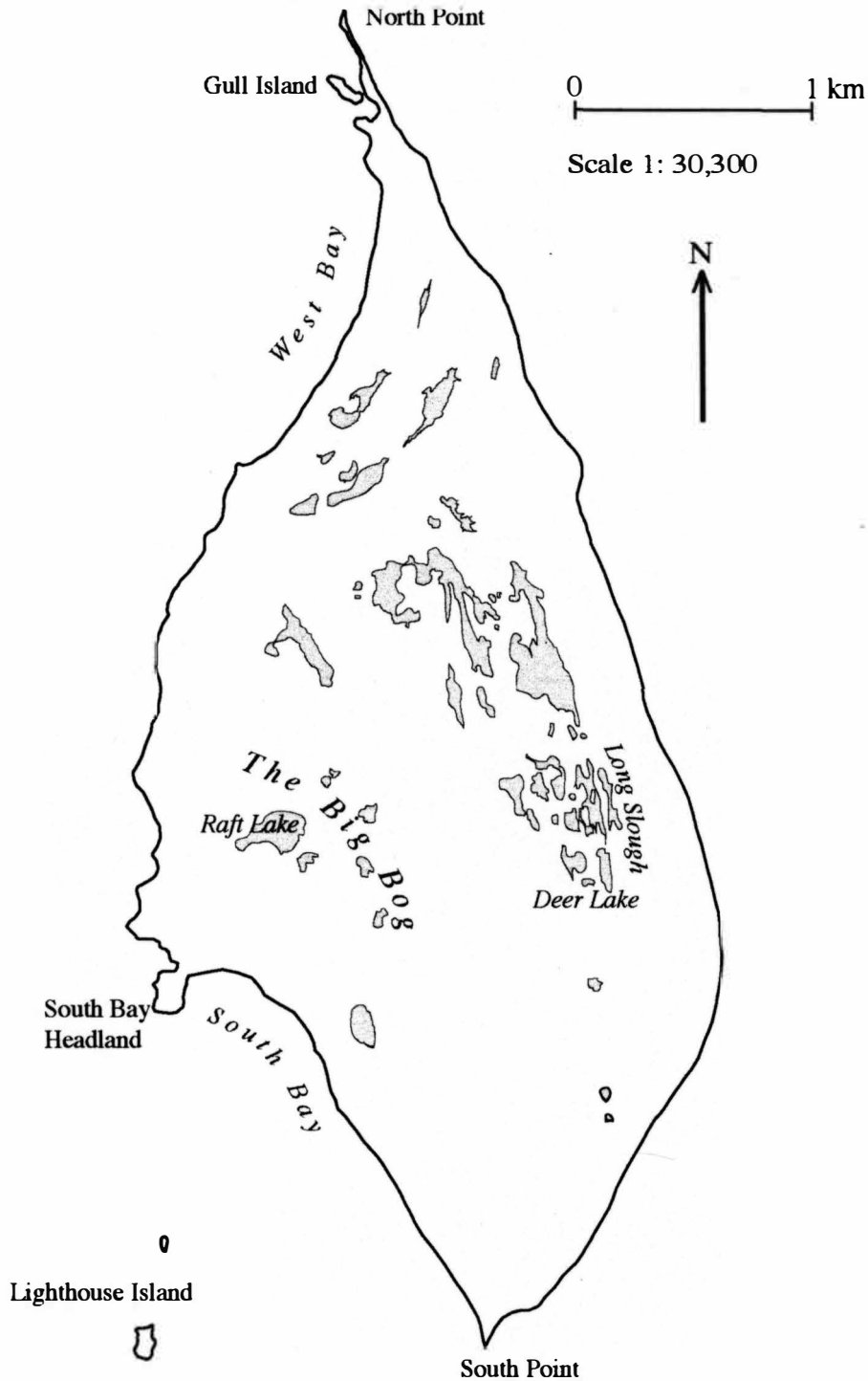


Figure 17. General Map of the Caribou Islands.

meters. This figure has been variously given as 120 feet (37 meters) to tree tops (Canadian Hydrographic Service 1976), 120 feet (Carter 1979), and less than 20 meters (Kor 1995a). It is my observation that Kor's estimate is closest to the true relief.

The east and west sides are markedly different topographically, and Caribou Island can be approximately differentiated into two main physiogeographic regions based on relief and vegetation. Figure 18 is an oblique aerial photograph of Caribou Island showing the difference in vegetation and topography between the east and west sides as well as remnant shoreline features. The view faces southwest, and Lighthouse Island can be seen in the upper center of the photo. A Canadian Coast Guard maintenance ship is arriving to the left.



Figure 18. Aerial Photograph of Caribou Island.

The east side of Caribou Island is mainly a forested dune and moraine complex with scattered wetlands including vernal ponds, fens, and bogs between forested dune ridges. It features the most varied relief of the island, and the highest areas are along the ridge of forested dunes which run approximately north-south close to the east-central region of the island (Figure 19). The slopes here are quite steep, and the individual ridges are as high as approximately 10 meters, peak to trough. The tallest and steepest ones I encountered during my 1996 surveys are near the southeast center of the island; this was especially noticeable with the aid of airphoto stereopairs.

The west side of Caribou Island is characterized by large open or forested bogs and muskeg, and is rather level compared to the east. There are only a few small hills on the west side, with the exception of very small vegetated dune areas near the northwest side and, to a lesser extent, near the South Bay.

Lighthouse Island, located about 1.2 km southwest of the southwest shore of Caribou, is little more than a rock, and is about 1 acre (.405ha) according to Kor (1995a). It has been heavily modified from its prehabitation condition by the lighthouse facilities.

Gull Island is barely an island at all, being separated from the northwest shore area of Caribou Island only by a small channel which is at its narrowest about 4 meters wide and one meter deep. Its area is, like Lighthouse Island, very small (about .4ha), and although it is situated very close to Caribou Island, it nonetheless is a distinct island. Its maximum height above lake level is about one meter, and it is highest at the south side, sloping downward toward the north. It is probable that this small island has been in the past, or will be in the future, a part of Caribou Island.

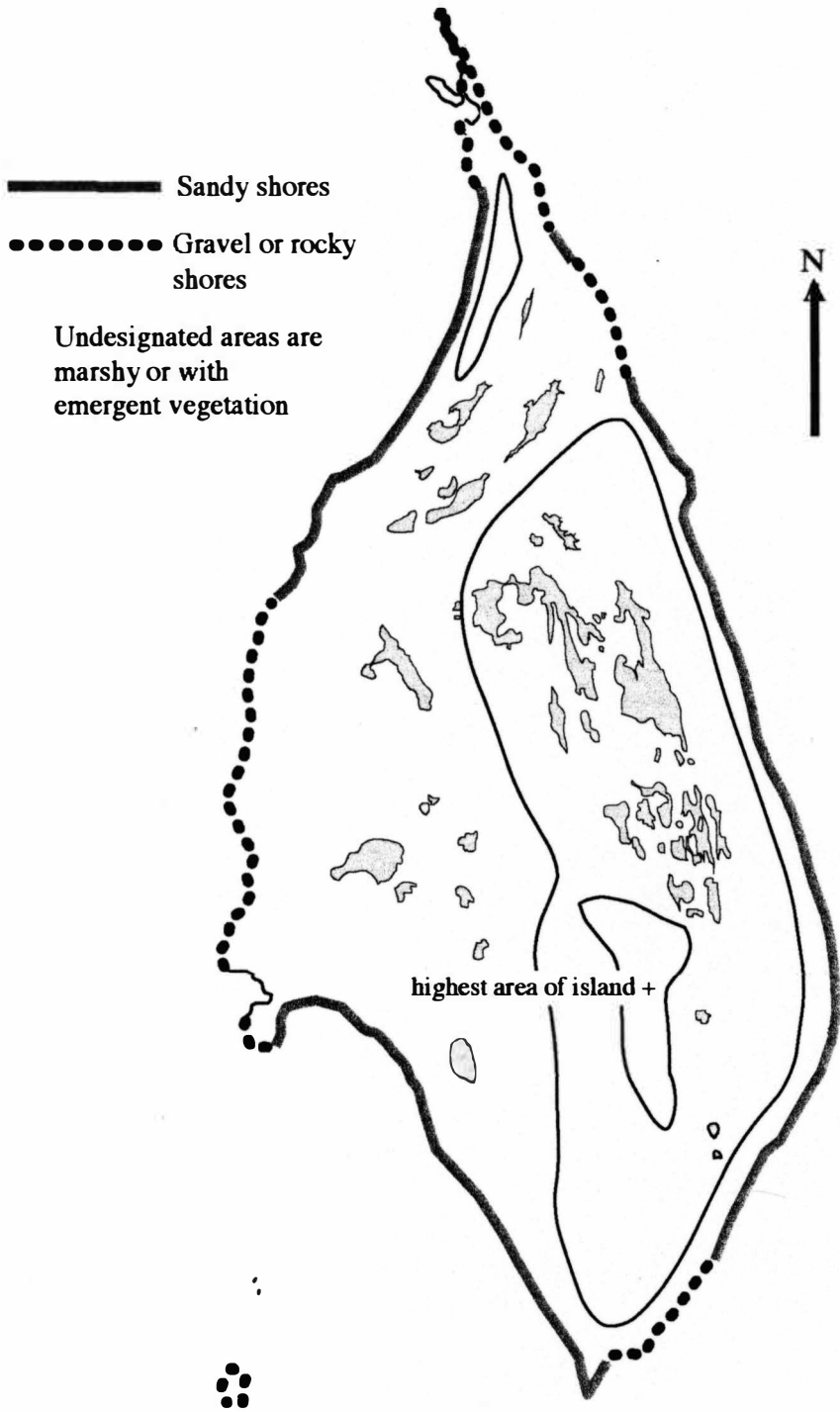


Figure 19. Topography and Geology Map of the Caribou Islands.

## Geology

Kor's (1995a) was the only geological investigation at Caribou for which I was able to locate documentation; though it is assumed that some type of cursory geological investigations were undertaken in the time during which Caribou Island was being considered as a potential runway construction site of an emergency landing site for commercial airline flights over Lake Superior (this event is mentioned by Carter [1979]). In addition to information from the report by Kor, I provide here some details on the general physical geography of the island from my 1996 field study.

Caribou Island is composed of a sandy moraine resting upon a large bedrock shoal (the North Bank), which extends considerably beyond the shores of the islands. The geology of the Caribou Islands is dominated by these two main features of the island.

The late Precambrian age Jacobsville Sandstone forms the "platform" on which the islands are situated, although Kor discusses the question of the age of the Jacobsville Sandstone, noting the disagreement in age among various geologists. The Jacobsville Sandstone is exposed elsewhere in the region on Leach and Montreal Islands and Grindstone Point to the east; and interruptedly along the south shore of Lake Superior from the Keweenaw Peninsula to Sault Ste. Marie and north to the Batchawana Bay, including the spectacular high cliffs of the Pictured Rocks and Grand Island (Ayres 1969, Pye 1969, Hamblin 1958).

The sandstone bedrock at the Caribou Islands remains mainly hidden beneath the sands of the island and offshore waters. The only areas where it is directly observed are several very small outcroppings several inches above the sand along the



west side wave zone, and a slightly larger outcrop just onshore at the south side. Kor (telephone conversation April 1996) precisely describes this outcrop as being "about as big as a bus". Other areas have indications of near-surface bedrock, exemplified by large, platy fragments of rock or coarse cobbles in the nearshore waters. From a plane, there is also evidence of near surface bedrock in several offshore areas, including to the east of the island. Lighthouse Island has surface bedrock, as does the small islet which is just to the north of Lighthouse. Additionally, during my 1996 field study on Caribou Island I was able to detect a continuous bedrock presence approximately 2 meters below the surface over a large area of the west side bog. This I determined by probing through the peat deposits with a sharpened stick; there appeared to be little more than peat over a thin (less than 10 centimeters) sandy layer over solid bedrock.

A reworked moraine of glacial deposits make up most of Caribou's land mass above the Lake Superior level, and this aspect is very important to the vegetation. These sand deposits, while primarily a moraine, have been somewhat reworked by wind action, most notably in the dune areas. They have also been considerably altered by wave and water action between the time of their deposition and the emergence of Caribou Island from the waters of Lake Superior. They appear to be of at least partially distant origin, since there are small rocks and gravel in the deposits, including granite and other types not found in the bedrock of the area. Active and vegetated dunes are a prominent feature of the island, especially on the east, northwest, and south sides. It is possible that some of the forested areas of the east side are also sand dunes, though in a number of areas where wind thrown trees gave a chance to examine the soil and subsoil, gravel and rocks could be seen, indicating a morainal

deposit rather than wind-formed dunes at least in those areas.

The shorelines of Caribou Island are primarily sandy and gently sloping, though there are some gravelly areas on the southwest side and elsewhere. The total shoreline length of Caribou Island is approximately 13 kilometers, and of this length, approximately 8.4 km is sandy beach, and 4.5 km is gravel or rocky shoreline. Small areas near the southwest and northwest shores, totalling approximately 100 meters, are marshy. There is an area which very clearly shows abandoned beach ridges on the south bay dune area, and a much smaller area near the northwest dune area. Figure 20 is an oblique aerial photograph, looking ENE, showing features of southwestern Caribou Island, including the former beach ridges. The most geologically dynamic areas of the island's shoreline are the southeast tip and the west center shore, due to their exposure of gravel and sands to wave and current action.

Hydrological features are a prominent feature of the Caribou Island landscape. Wetlands of the island range from shoreline marsh to fen, to bog and muskeg, vernal pond, beaver pond, and small lake. Swamps can be found in small areas, such as the central east side and southwest deciduous transition. Two semipermanent "rivulets" can be seen on the island; one at the southeast side of the South Bay Dunes, and one near the south end of the northwest shore dunes. These small streams always had some water flowing in them during my time there in 1996.

Kor theorizes that Caribou Island's age is very approximately 2200 years, which he estimated using the island's elevation and isostatic rebound rates. This would place the emergence of the island during the Algoma and Sault levels of Lake Superior. The east side is most probably the oldest area of the island, having emerged much earlier than the west side. If Kor's estimate is correct about the iso-



Figure 20. Aerial Photograph of Features of Southwestern Caribou Island.

static rebound of the island, the island would likely be “growing” fastest westward, as indicated by the higher relief on the east side of the island. Also, the large amount of debris (logs, wave debris, etc.) on the west side indicates a greater tendency for deposition there, and might be a significant source of material for the westward expansion of the island.

### Soils

Comprehensive information on the soils of the Caribou Islands is nonexistent, and further work is desirable to understand the relationships of climate and vegetation upon soil development there. Morton and Venn (1996) mention some characteristics

of the soils of Caribou Island, including a few pH levels. White (1995) adds a few more details, mostly in the context of site records (Life Science Inventory Site Records). During my 1996 field study on Caribou Island, I made general notes on some aspects of the islands' soils, though much remains to be understood of them. Terminology given in this thesis follows the US SCS (Miller and Donahue 1990). A preliminary soil map, compiled by the present author from airphoto vegetation patterns and ground observations, is shown in Figure 21.

Because of the geological nature of the island, i.e., moraine and dunes over a flat "shelf" of Jacobsville Sandstone, most of the island has a sandy or stony beach, and the simplest soils of the island are the areas directly adjacent to the lakeshores. These areas have soils which are very poorly developed or non developed. Morton and Venn (1996) report the pH of the dune soils at 6 to 7. In general, the upland soils are dominated by the sandy nature of the islands, and, less frequently, the Jacobsville Sandstone. On the lower areas, particularly of the large wetlands of the west side, however, they are composed of extensive areas of peatland deposits. On the southwest corner of the island, a much richer organic soil has developed in the areas of deciduous forest.

Boreal forest Spodosols, found on well-drained (upland) areas of the island, are the main forest soils of the island. They are composed of thin spodic horizons developed over a sandy, moderately well-drained depositional (morainal, lacustrine, or *Æolian* dune) quartz sand substrate. O horizons are differentiated by little more than a thin (average of approximately 1-5 centimeters) layer of plant litter (mainly leaf litter of birch, spruce, and fir). The soils were observed to be thinner on the peaks and slopes than on lower interdune areas (former swales). This thin soil over unconsoli-

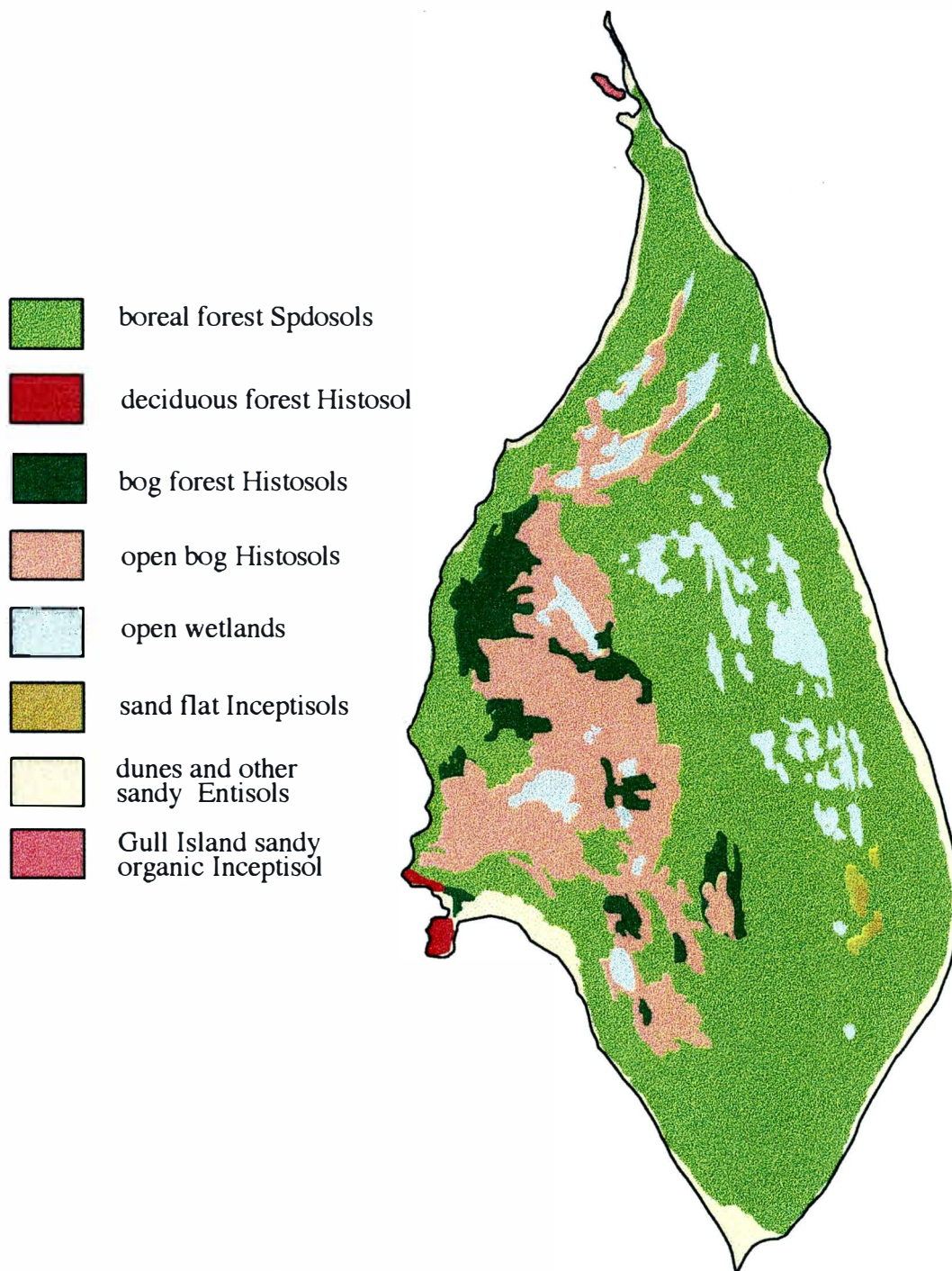


Figure 21. Soil map of the Caribou Islands.

Source: 1996 field investigations and airphoto interpretation by the author.

dated sand provides a minimal strength "foothold" for the forest trees, allowing significant windthrow and contributing to a "pit-and-hummock" topography of the forest. This high incidence of windthrow on the island, interestingly, gave frequent opportunity to observe the depth of soil and underlying material. In such areas it was noted that soil development is very thin, and below the soil (occasionally with an admixture of stones or gravel) bare sand may be observed. Figure 22 shows a wind thrown tree in the east-central boreal forest, exposing thin soil underlain by moraine (?) sand with stones. The soil is mesic, well aerated, and of a medium gray color; the sand below (E horizon) is yellowish-gray. In some areas where the forest is wetter, such as low depressions, a higher organic content is found, and the soils resemble those of the bog forest soils (below). Dominant species typical of this soil include *Picea glauca*, *Abies balsamea*, *Betula papyrifera*, and, occasionally, *Sorbus decora*, and *Sphagnum* spp. mosses are common near saturated ground or standing water.

A deciduous forest Histosol is found in the small areas of the southwest deciduous forests. It is the only area where a deliberate effort was made to examine the soil, with interesting results. A soil profile diagram from near the center of the southernmost deciduous forest area is shown in Figure 23.

An Oi horizon, approximately 1 centimeter thick, of undecomposed organic matter (leaves and other plant detritus, etc.) forms the upper layer of the soil. An Oa horizon, approximately 10-12 centimeters thick, is beneath. This horizon is quite fine, sticky, and is dark in color. It is nearly entirely organic (possibly with some clay), and a "teeth test" for mineral matter revealed very minimal sand content, probably from sand blown from nearby dunes or over ice. Below this Oa horizon a layer abruptly begins, approximately 15 centimeters thick, where the organic soil is mixed



Figure 22. Windthrown Tree and Soil Exposure in Boreal Forest on Caribou Island.

with rounded stones and gravel, from 1-10 centimeters in diameter. This is obviously a former beach layer. Below this, the soil rapidly diminishes, and “naked” gravel continues. The underlying material here is large (2-10 centimeters) stones of the former shoreline. This provides a somewhat well-drained basement to the soils, though the water level of Lake Superior is only slightly more than a meter below.

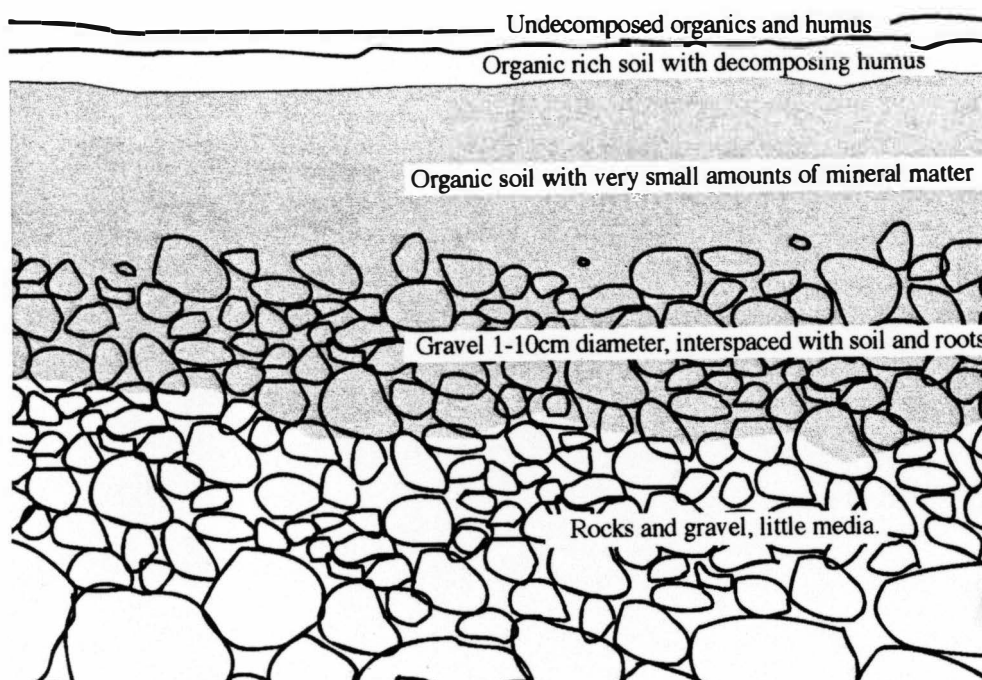


Figure 23. Soil Profile From Deciduous Forest on Caribou Island.

This thick and fine-textured organic soil was always found to be somewhat moist. Several small depressions in the forest area were found with surface water and water-logged soil. The origin of this soil is most likely from the leaf and other litter of the deciduous forest, with the possible addition of windblown materials due to the proximity to the lake. Dominant species in this area are *Sorbus decora*, *Betula papyrifera*, and a shrub layer of *Taxus canadensis*.

A sandy organic Inceptisol occurs on the wet and low Gull Island and small areas of adjacent Caribou Island, where the vegetation is mainly of graminoids and many r-selective species adapted to conditions of high water level, frequent washings, and heavy influence of bird activity. It is composed of wet gravel and sand, which are probably rarely dry, due to the low elevation of the island. It is very thin, with an



O horizon of humus and other organic matter, including waste from the large numbers of gulls and geese who frequent the island. They are also very likely highly potassium and nitrogen rich for the same reason (Hogg and Morton 1983). In the center of the island, where there is a small wooded area, the soil is somewhat drier and contains a lighter, better aerated humus content as a the O horizon. The soils have a deep gray color.

Open bog Histosols are predominant on the large areas of open and closed bogs of Caribou Island. They are similar to those found in muskeg and kettlehole bogs on the mainland. They are of a dark gray to black color, water saturated and poorly aerated, and include little mineral material. These soils are poorly drained, though there is, apparently, some subsurface drainage to the west, over the sandstone bedrock basement. Though the soils were not examined, it is possible, due to their unique hydrology and morphology (see the section on geology), that there may be some critical differences based on drainage and subsurface flow from other bog histosols of the region. The acidophilic mosses of the genus *Sphagnum* are the dominant plant on these areas, and a number of ericaceous shrubs are the main "canopy".

Bog forest Histosols are found in forested areas adjacent to the open bogs, mostly to the west of the large west side bog. They have a somewhat lower organic content than the bogs, and, apparently, are developed over a sand and gravel former shoreline which is in many areas as close as 2 meters below the surface. Mineral content is higher in open, drier areas, and lower in the wet forested bog and swamp areas. There is a very thick O horizon of organic matter in all areas compared to the boreal forest soils. These soils are of a very dark black color. The primary vegetation cover is *Picea mariana*, *P. glauca*, *Abies balsamea*, and several ericaceous

shrubs.

Sand flat Inceptisols are a minor though distinctive soil found in several small areas of the interior east side. These areas have a very poorly developed soil profile, with a very small organic content. They are poorly aerated, and somewhat compacted. The soil is of a light gray color, somewhat well-drained, though close to the water table and covered with vernal ponds in the spring. Vegetation is scant, consisting of smaller than normal individuals of *Cornus canadensis*, *Maianthemum canadense*, *Viola lanceolata*, and occasional shrubs of *Spiraea alba* and *Chamaedaphne calyculata*. Some areas have little more than an intermittent colony of the moss *Polytrichum commune* interspersed with bare sand.

Dry bog edge Inceptisols are locally found near wetlands on the eastern side of the island. They occur as small (usually less than 10 meters at widest dimension) well-drained and dry, sandy areas of open or thinly vegetated ground which at times resemble miniature dune blowouts. The areas, comprising small ridges and water-side openings, provide a striking contrast to the bogs so close by. The soil is very poorly developed and resembles the sand of the dunes, but with a somewhat grayer color and small amounts of coarse organic materials. Vegetation on these soils include a admixture of stunted species found on dunes and in the boreal forest.

### Climate

As with other aspects of the islands in this study, the climate of Caribou Island has been less thoroughly investigated than that of the Ushkanii Islands. There is no comprehensive climate station on the islands, although some data has been recorded by lighthouse keepers, and several measurements are collected automatically, appar-

ently at the lighthouse, including temperature, humidity, wind speed and direction, and atmospheric pressure. Some climatic data can be extrapolated from a scattered variety of sources, including records kept by the lighthouse keepers stationed at the island; Morton and Venn (1996) give a good summary of this data. Other sources of information include climatic data from meteorological stations at other areas of the lakes. Some meteorological information was available as a current weather report for "Caribou Island, Ontario" via internet on *The Weather Underground* (<http://www.wunderground.com/global/stations/71433.html>) as of June 1998, though I was unable to find compiled or statistical data for the islands from these observations via *The Weather Underground* or other sources, and so have not been included in this thesis. The main sources of data used in this thesis are Phillips and McCullough (1972), Phillips (1978), Morton and Venn (1996), and Saulesleja (1986). Saulesleja's data used for Caribou Island consist mainly of maps of the "Lake Superior shipping route east", which can be described approximately as the area from the tip of the Keweenaw Peninsula north to the 43°N, east to Mamainse Point, all of Whitefish Bay, and Whitefish Point to the tip of the Keweenaw. Since these areas are primarily open water, some data may be less applicable to the land area of the islands.

As on the Ushkanii Islands, most limnoclimatic effects (temperature, fog, wind, precipitation) are strongest near the shores and weaker inland, although such islands are too small to have much influence on cloud development (Ладейщиков 1982). A climatic summary for the Caribou Islands is shown in Table 2.

### Temperature

Temperatures on the Caribou Islands are greatly influenced by the surface

Table 2

## Climatic Summary for the Caribou Islands

Data	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temp. min.	-	-	-	-6.1	-4.4	-1.1	1.7	4.5	-0.6	0	-18	-17
Temp. avg.	-6.6	-	-	1.7	5.3	7.7	11.5	14.1	11.6	6.8	1.7	-
Temp. max.	-	-	-	15.5	22.8	20.5	25.6	25.6	24.5	27.8	12.8	8.9
Mean air temp. over lake												
Superior	-9	-10	-4	-4	7.5	10	12.5	15	12.5	7.5	2	-3
Precip., mm	76.2	-	-	50.8	64.7	68.7	66.6	78.3	75.3	68.7	65.8	-

A dash (-) denotes data unavailable for month.

Source: Morton and Venn 1996 and Saulesleja 1986.

temperatures of the waters on Lake Superior near Caribou Island, which are their highest near the Caribous in August and September; about 12°C (Saulesleja 1986). Because of the mixing of the water layers during winter months on open water, the lowest surface temperatures of Lake Superior near the Caribous are between approximately 0°C and 4°C, unless there is ice cover, in which case the temperatures can be much lower (Wetzel 1983, Ладейщиков 1982).

Caribou is colder in the summer, warmer in the winter, and of similar temperature in fall and spring compared to mainland areas nearby. Examples are given by Morton and Venn (1996) for several climate stations compared to Caribou. In January, the daily mean temperature of Caribou is -6.6°C, while at Wawa (northeast of Caribou close to the east-central Superior shore) it is 6.7°C colder: -13.3°C. In July this temperature difference is reversed, with the daily mean at Caribou 11.5°C on Caribou and 5.1°C warmer at Wawa; 16.6°C. During my stay on the island in 1996, I informally compared temperatures on Caribou Island with those given on Environment Canada and CBC Radio broadcasts for Sault Ste. Marie, Wawa, Chapleau, and other areas on the Canadian mainland east of Lake Superior, and noted that—without exception—they were higher than the temperatures which I measured on Caribou Island. Chapleau and areas further inland had higher temperatures than Wawa and areas closer to the shore, though all were higher than my readings on Caribou. Morton and Venn (1996) show the highest temperatures for the island to be in August, with one outlying extreme high temperature (27.8°C!) in October.

Though there have been no detailed studies made of the microclimatic variations at Caribou, I was able to note a few trends during my field work on Caribou in 1996. The temperatures in the interior of the island, particularly the large west side

open peatlands, had daytime highs considerably above than the shoreline areas. Readings with a hand-held thermometer revealed the temperature in the interior to be consistently warmer, by as much as 8°C, than the shoreline. This difference is probably reversed during the winter months (when the lake is not frozen over), with the higher temperatures near the shoreline. The areas of the boreal forest were generally warmer than the open shorelines, but cooler than the open bogs, which I found to be the warmest areas of the island, and the south shores were warmer than the north.

### Clouds and Fog

The cloudiness over the Caribou Islands follows the general rule of open waters over large lakes, i.e., usually clear during the warm season and usually cloudy during the cold season. Saulesleja (1986) reports the visibility of the area as lowest in June and July (due to fog), and highest in October and April (the intervening winter months include snow visibility limitations). He reports the least cloudiness during June and July, and the greatest in November and December, though data are not given for January to April. It is likely that cloud cover significantly decreases when the lake cover freezes over, though this is rare in the area of Caribou Island.

### Precipitation

Annual precipitation on Caribou Island is slightly lower than mainland areas (Phillips and McCulloch 1972, Morton and Venn 1996). The total annual precipitation for the area of Lake Superior near the Caribou Islands has been estimated by Phillips and McCulloch as 813 millimeters, of which slightly less than half falls as snow. This total is slightly lower than that for Wawa and other areas on the east mainland of Lake Superior (Wawa-940 mm/yr.; Sault Ste. Marie-906 mm/yr.), though

still slightly higher than for Grand Marais (762 mm/yr.), due south of Caribou in Michigan. It is also significantly higher than that of the Ushkani Islands (306 mm/year). During my time on the island, rain was less frequent than on the mainland, which I noted by comparison to weather reports for nearby mainland areas. Though there are no data available to confirm it, there may be a lower proportion of snowfall on the Caribou Islands compared to mainland areas because of the lack of a large land mass to cool the air masses and effect precipitation. Although the mainland area to the east of the islands is one of the greatest snowbelt areas on the Great Lakes, it is unlikely that the Caribous have nearly such a significant snowfall, due to their size and position in the lake. Snow cover is probably very low near the shores (because of wind), and highest in the interior forest and bog areas. Snow is also apparently very significant in forest edge blowdown areas, and on June 21 I found the only remaining snow on the island in these areas.

### Wind

Phillips (1978) reported that the winds at the Caribou Islands are less unidirectional than other areas on the lake, and that maximum wind speeds are higher there in general than other areas. He wrote that an averaged one hour extreme wind speed was reported at 31 m/s. The wind speeds at the open water areas near the Caribou Islands have a somewhat lower speed during the summer months than the winter, with a speed 50% of the time of 20-30 knots ( $\approx 10-15$  m/s), according to Saulesleja (1986). As on the Ushkaniis, the lake-breeze and land-breezes are not strong compared to those of the mainland shore because of the small land mass of the islands (Phillips 1978). Judging from the deposition of debris on the shoreline, it appears that the prevailing wind direction to Caribou Island is from the northwest and west, especially

during the storm season (late autumn), when most debris is deposited along the shorelines. Wind was more common on the northwest shoreline during my time on the island in 1996, and least common on the interior of Caribou Island. It appears that the strongest deposition of wind carried (and rafted) materials is along the west shore of the island.

### Lake Ice

An important aspect of the Caribou Islands' climate—and one which is quite different from the Ushkanii Islands—is that ice cover is rare in the central area of Lake Superior where they are located (Rondy 1976). This has two major implications for the biogeography of the Caribous. First, it keeps the winter temperatures at the island considerably warmer than areas where the lake freezes since the open water stays above zero degrees centigrade. Second, it effectively prevents the ice-bridge crossing of animals and the over-ice wind transport of plant propagules. That animals can, and will, cross during those times when ice cover is present is established by Kor's (1995a, and telephone conversation, April 1996) reports of the deer and fox who were sighted on the island in 1994. Lake Superior froze completely for the first time in over 2 decades during the winter of 1993-1994. The situation of animals crossing ice to islands may also, apparently, occur in the opposite direction, as the caribou herd established on Caribou Island in the 20th century is reported to have left, then returned in part to the island during time of ice bridge connections to the mainland (Osborn and Osborn 1949). Moose and wolves at Isle Royale (Peterson 1995) and Caribou on Montreal Island in Lake Superior Provincial Park (personal conversation with Carol Dersch, May 1996) have likewise moved from their respective islands to the main-



land.

## Animals

### Birds

Several brief surveys have been made by other researchers of the avifauna of Caribou Island. The most extensive was that of Wormington, Nisbet, and Finlayson (1986). They spent a total of 58 days on three visits to Caribou in 1979, 1981, and 1984, and recorded a total of 192 species. They note that several birds common to the mainland have not been reported to the island, despite the apparently suitable habitat. These include spruce grouse, ruffed grouse, gray jay, and boreal chickadee. Additionally, they discuss other significant findings, such as a number of birds seen on the island which are not normally known to cross bodies of water as large as Lake Superior. The absence of certain bird species may have an effect on those plants which are assisted by them (such as those with fruit favored by a particular bird species).

### Mammals

Most mammals are effectively prevented from reaching the islands by the open lake water, though as noted above, during those rare occasions when the lake does freeze at least some animals appear ready to cross very quickly. Animals which swim or fly the distance from the mainland or Michipicoten Island apparently have been somewhat more successful (with the exception of caribou), though it is certainly a long journey from the mainland.

## Beaver

The mammal fauna of the island is poor, and no mammals other than beavers (*Castor canadensis* Kuhl) were seen inhabiting the island in 1996. Large beaver lodges are found throughout the island on and near the open water areas of the wetlands, as well as the alder thicket along the Lake Superior shore on the southwest side of the island. Beaver trails lead between various areas of the interior of the island, and many of them are quite well-worn and easily followed, resembling at times a deer trail. Beavers were encountered on several occasions; their reactions to what must have been an unusual meeting for them seemed more of irritation than fright, defense, or surprise; one repeatedly slapped his tail and swam back and forth in the water near me until I left the area.

Noble (1984) reported that the population of beavers on Michipicoten Island is among the most densely populated areas of beavers in the Wawa forestry district, with approximately one lodge per square kilometer. Though lodges were not counted on Caribou Island, I noted approximately ten different lodges during field reconnaissance, which would make the density at least as high, on a per kilometer basis, as that of Michipicoten. The population dynamics of the Caribou Island beaver population, in light of their predator-free status, small and isolated population, and lack of significant genetic input might present an excellent prospect for future research of Caribou Island and Lake Island biogeography.

Interestingly, Alexander Henry theorized on the population dynamics of beavers and caribou on Caribou Island nearly two hundred years ago, giving some early thought to a key research interest on islands of Lake Superior in our time:

...It is very low, and contains many small lakes. These later I conjecture to have been produced by the damming up of the streams by beaver, though those animals must have left the island, or perished, after destroying the wood. The only four-footed animal was the *caribou*, and this, it is probable, was first conveyed to the island on some mass of drifting ice. It was however no new inhabitant; for, in numerous instances, I found the bones of *cariboux* [*sic*], apparently in entire skeletons, with only the tops of their horns projecting from the surface, while moss or vegetable earth concealed the rest. Skeletons were so frequent, as to suggest a belief, that for want of food, in this confined situation, had been the destruction of many; nor is any thing more probable: and yet the absence of beasts of prey might be the real cause. In forests more ordinarily circumstanced, the graminivorous animals must usually fall a prey to the carnivorous, long before the arrival of old age; but, in an asylum such as this, they may await the decay of nature. (Henry 1809, 228-229)

### Caribou

Henry reported seeing (and shooting) a surprisingly large number of caribou (*Rangifer caribou caribou* Gmelin) on the island during his three day visit in there 1771. He reported seeing tracks of this animal immediately upon landing on the island, and during a stay of three days, killed 13, the meat of which his party apparently smoked and took away. There were no caribou left on the island when Chase Osborn and company decided to restock the island from Newfoundland stock and make the island a private hunting preserve (Osborn and Osborn 1949). Despite population fluctuations the herd apparently did well, and Carter (1979) reports that lighthouse keepers hunted game on the island, and that one, G. W. Johnston, took care to kill only one caribou per season. The last of this herd was killed in the mid 20th century. None are known to have been seen on the island since that time, and they are now rare on the nearby mainland.

### Other Mammals

Two old fox (*Vulpes vulpes* L.) dens dug into sand were found in 1996; one along the "Long Slough" of the east center of the island, and the other in the south center forest. Both had been abandoned for at least several months (and presumably the season), and no tracks, droppings, etc. were seen nearby. These dens were probably dug by the fox that Kor reported (see below).

Kor (1995a and personal communication April 1996) reports seeing tracks from two white tailed deer (*Odocoileus virginianus* Miller), small and medium sized, on the island in 1994. He postulates that a pregnant female deer crossed the ice to the island in the winter of 1993-1994, the first time in over a decade that Lake Superior froze completely. No signs of deer of any kind were observed on the island during field study in 1996. Kor also documented sighting one deer during a flyover in late 1994

Although I saw no signs of bats on the islands in 1996, there is reason to believe that bats may have been present there in the past, and it is not hard to imagine them crossing from the mainland. The small cabin built by Roys Ellis on the east side of the island had a whimsical sign painted on the door: "Margie's Bat House" (Marjorie was Captain Ellis' wife). Whether this was a joke or in reference to a real situation is unknown, and no signs of bats (skeletons, droppings, etc.) were found anywhere in the cabin.

Osborn and Osborn (1949) report that the lighthouse keeper G. W. Johnston, in addition to his careful stewardship of the caribou, also shot "rabbits" on Caribou Island. "Rabbit" could mean either rabbit (*Sylvilagus*) or hare (*Lepus*). No further information on their possible presence on the islands could be ascertained and no signs

were seen in 1995.

No sign of other wild mammals could be found with one possible exception. A set of tracks with a pronounced dragging (of a tail or a low belly?) was found leading from the water on the east beach up to a stabilized dune area (where the tracks were lost) and, presumably, beyond. Despite photographs, the tracks could not be identified. It is possible that they are beaver tracks, or perhaps otter tracks. This type of tracks was never noted again and, with the exception of rare beaver tracks and bird tracks, no other wildlife tracks were seen in any areas of the island, including shoreline sand, and muddy areas of the bogs and fens. Small mammals are probably also absent on the islands, and small mammal live traps placed at several locations on Caribou Island (the open west side bog, near the southeast shoreline, and near the northern tip) failed to catch anything.

#### Other Animal Life

Salamanders (*Ambystonia* sp.) were seen several times under wood on the backdunes, and White's 1995 report also mentions these. Likewise, I saw several toads (*Bufo americanus americanus*) in the area near my base camp, which White also reports. He further reported, though I did not see, the boreal chorus frog (*Pseudacris triseriata maculata*), though I did see tadpoles of an unidentified species in the vernal ponds of the east side.

Few ants were seen on the island (unlike Ushkanii Island), but the presence of several ant-dispersed species such as *Claytonia caroliniana* and *Viola* spp. raises questions of their influence on plant dispersal on the island. They were, however, common in small numbers on sandy and hummocky areas of the island, especially on

bogs. Sand spiders are common on the dune areas of Caribou Island, and were a frequent problem in my tent.

## Vegetation of the Caribou Islands

### Overview

The vegetation of each of the three Caribou Islands is markedly different from the others. Caribou Island will be described in greatest detail here, and it has the most floristic complexity. It has broad areas of boreal forest, bogs, and dunes, as well as several smaller and more unusual habitats. Gull Island is so small, low, and heavily influenced by the birds who rest and feed there that its vegetation is severely limited. Lighthouse Island is likewise limited in its vegetation, though on that island it is primarily because of the extensive modification and human utility use of the lighthouse facilities, rather than bird activity (though this may also play some part). Its vegetation consists of a small flora somewhat reminiscent of many utility areas on the Great Lakes—severely modified, culled, and with a high proportion of introduced and other weedy r-selective species. There are few trees, and no wooded area. The island is low, rocky, and gravelly, and very modified by the lighthouse facilities, and the vegetation reflect this state. A map of the vegetation is given in Figure 24.

### Shorelines

The sand and gravel beaches of Caribou Island represent one of the few areas on the Great Lakes where a pristine sandy shoreline environment still exists. There are no homes, no docks, and no "improvements" to the shoreline of Caribou Island, and therefore natural processes may take precedence over those anthropogenic. This

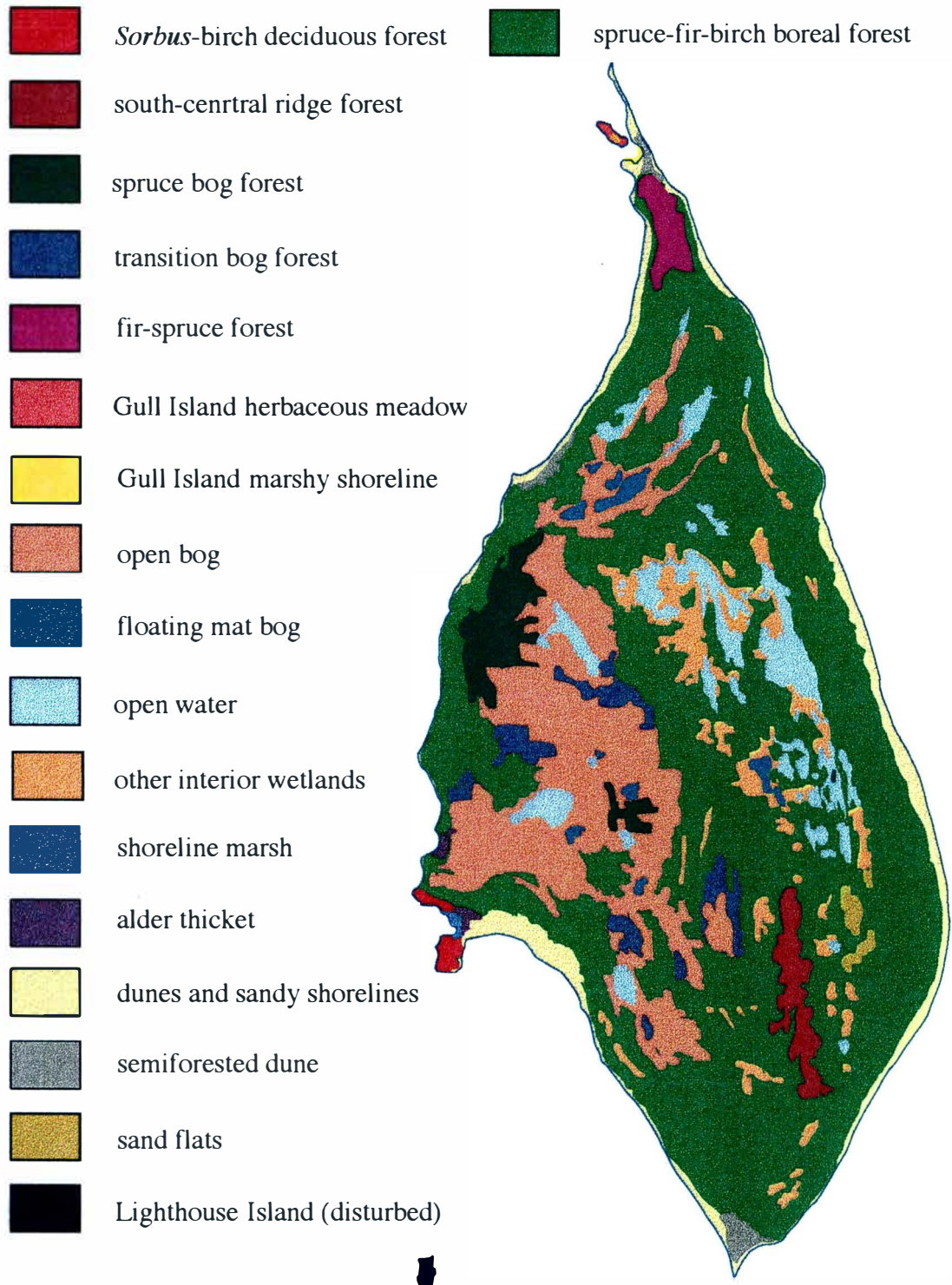


Figure 24. Vegetation of the Caribou Islands.

Source: Field work and airphoto interpretation by R. Liebermann (1996).

is an important aspect of the biogeography of the island, since many of the propagules introduced to the islands enter via this corridor, and the natural state allows continued evolution of the island's ecology. However, the shorelines also present difficulties to the establishment of plants on the islands, as will be discussed later.

The sand beaches and dunes are a rather harsh environment for most plants, and only a relatively few can survive the temperature extremes, poor xeric soil, shifting sands, and wind abrasion. Of the plants that are able to survive there, many are noticeably more robust as the backdune and forest edge are approached (*Maianthemum canadense* and *Cornus canadensis* are typical examples).

### Sand Beach

A wide sand beach surrounds the entire island save for the southern west side and small areas on the northern end (see Figure 19). The majority of the island's sandy shorelines have a well-developed beach-dune-forest zonation. Areas such as the southeast, northeast, extreme northwest, and central west shores have relatively short zones of mostly unvegetated sand which is often subject to wave action before the forest edge. These areas are probably more subject to wave erosion than the gravel shores. Along the south and east sides, the northwest side, the south bay shore, and the south point, sand beaches are a conspicuous feature of the island perimeter. The vegetation of sandy beaches is very limited (because of the dynamic, constantly shifting sands), and similar to that of the mainland in the region, albeit with a smaller flora. The vegetation is sparse, consisting of mainly of *Ammophila breviligulata* and other species sporadically.

The vegetation of the sand beaches merges into the adjacent community. In



most cases this results in a dune area of varying width, as on the northwest and east-central sides. Figure 25 shows the shoreline on the northwest side of Caribou Island, with a wide sand beach, a small dune area dominated by *Ammophila breviligulata*, and the boreal forest edge. In other areas, such as near the northeast and southeast sides, a small (sometimes less than several meters wide) beach is directly adjacent to a forest edge, with little or no transition. In such cases, there is practically no shoreline vegetation associated with the sand beaches. These areas represent an erosional transition.



Figure 25. Shoreline on Northwest Side of Caribou Island.

### Gravel Shore

Some areas of the island have gravelly shores, and there are several shallow outcrops of bedrock along the south side which are associated with the gravel beaches, probably because of the availability of weathered bedrock as components of the gravel. Gravel shore is most typical of the southwest and extreme northern tip shores. In 1994 White (1995) located *Sagina nodosa*, an arctoalpine known from other areas of the north shore of Lake Superior, on cobbles of the southwest shoreline, although I was unable to relocate this species on the island in 1996. There are few species common in these areas, since the gravel is usually well tilled by waves and ice.

### Bedrock

Bedrock outcrops on the islands are minimal, and hence Caribou Island does not have the rocky shoreline plant communities which are so celebrated along the northern and eastern shores of Lake Superior, the Keweenaw Peninsula, and Michipicoten Island. The outcrops, all of which are situated along the shoreline of the island, are too small to support much of a distinctive flora, though a number of mosses and liverworts grow on the wave-washed bedrock on the south shore (generally members of the Bryaceae and *Marchantia polymorpha*). Additionally, the proximity of the bedrock very near to the surface in several areas likely affects the vegetation. For example, cranberry, *Oxycoccus palustris*, grows on sandy soil on several locations along the west-central shoreline in such situations. It is unusual to see this species growing on a sandy beach two meters from the lake's edge; this probably is at least partially a result of the very poor drainage on these sites, which simulates the bog habitats more

commonly associated with *O. palustris*.

### Dunes

The sandy beaches are often replaced further inland by areas of active or vegetated dunes. The best examples of sandy beach-dune complex are along the east and northwest sides, and the vegetated beach ridges of the South Bay shore, opposite Lighthouse Island. All of the sandy beach-dune complex areas have well defined wash-, fore-, mid-, and backdune zones (Figure 26). Many areas of the dunes are active, while there are some in initial to advanced stages of stabilization. The dunes on the South Point are a good example of dunes which are largely stabilized by a cover



Figure 26. Dune Zonation on the East Side of Caribou Island.

of vegetation. A more extreme example is the forested areas which cover most of the east side, which have been completely vegetated with the boreal forest. The common dune grass *Ammophila breviligulata* is the predominant species here, though the dunes are more noteworthy for their pristine ecological condition and a number of species such as *Empetrum nigrum* and *Hudsonia tomentosa*, the presence of which Morton and Venn (1996) attribute to the "severity of the climate".

The foredune areas are vegetated primarily with *Ammophila breviligulata*, and *Juniperus communis*, *Arctostaphylos uva-ursi*, *Potentilla tridentata*, *Geocaulon lividum*, *Melampyrum lineare*, *Hudsonia tomentosa*, *Prunus pumila*, and *Chimaphila umbellata* are found to varying degrees as well. There is a well-defined mid- and back-dune area in many areas, most notably the west side and northwest side, and these areas are increasingly vegetated toward the forest edge. Mid dune areas have a cover of *Ammophila breviligulata*, *Lathyrus japonicus*, *Hudsonia tomentosa*, *Empetrum nigrum* (on the northern end of the island), *Arctostaphylos uva-ursi*, *Vaccinium angustifolium*, *Cypripedium acaule*, *Maianthemum canadense*, *Chimaphila umbellata*, *Melampyrum lineare*, and *Potentilla tridentata*. Species increasingly more common toward the forest edge include *Maianthemum canadense*, *Vaccinium angustifolium*, *Cornus canadensis*, *Polygala paucifolia*, *Linnaea borealis*, and *Lycopodium clavatum*. *Cladina* spp. lichens are common on the mid dunes, especially in lower vegetated blowout areas. They decrease near the forest edge, but several species of mosses, including *Dicranum* spp., *Ceratodon purpureus*, and *Polytrichum commune* increase in frequency toward the forest.

## Forest

### Forest Edge

The forest of the interior of the island usually has a rather abrupt transition to the shorelines and dune vegetation, with some exceptions. In a very few shoreline areas, e.g., on the northeast and southeast shores, there is an almost nonexistent transition from forest to water. The edge forests are usually quite robust, due probably in large part to the extra light available. Also, windthrow is a prominent feature of these areas. Windthrow clearings often provided an easier access to the interior of the island than attempting to crawl through the thick growth of trees at the forest edge. It is possible that these forest edge blowdowns provide an opportunity for new species to become established on the island, although no unusual species were found in the areas. It was in such windthrows, on the center-east side of Caribou Island, where the last winter snow was noted on Caribou Island on July 21 1996. therefore, it seems that there is significant wind directed into these areas where seeds might also be deposited, along with leaves and other detritus which could serve as a rich humus. The island supports two main types of forest and several smaller varieties, as described below.

### Boreal Forest

The boreal forest is the predominant forest, indeed the predominant vegetation type of the island, and covers about 70% of Caribou Island, but does not occur on Lighthouse or Gull Islands. The composition of the forest is somewhat plastic, and changes according to topographic variables of the island such as slope and aspect, proximity to shore or bog, water table, etc. Along the forest edge near the shoreline

there is an increase of *Abies balsamea*, which take advantage of the higher light levels. In wetter areas there is a presence of *Picea mariana* and some typical bog species, including ericaceous shrubs and *Sphagnum* mosses.

The boreal spruce-fir-birch forest is the largest vegetation association on Caribou Island, covering most of the east side of the island, as well as areas on the south and west sides. It resembles the boreal forest of the mainland, with a few differences, most notably the larger tree sizes (probably due to long period since last disturbance) and extensive covering of epiphytic lichens on the trees. It occurs mainly on the well-drained sandy soils of upland areas, though it also occupies some of the lower areas of the island near the west side wetlands. Predominate tree species are *Abies balsamea*, *Picea glauca*, and *Betula papyrifera*, with admixture of *Sorbus decora* and *Picea mariana*. Common herbaceous species include *Maianthemum canadense*, *Cornus canadensis*, *Clintonia borealis*, *Linnaea borealis*, *Gaultheria hispidula*, *Trientalis borealis*, *Galium triflorum*, *Vaccinium* spp., *Coptis trifolia*, *Lycopodium lucidulum*, and *Dryopteris intermedia*. *Pleurozium schreberi* is the most common bryophyte species in the boreal forest, and other common forest species are *Hylocomnium splendens*, *Dicranum* spp, *Ptilium crista-castrensis*, *Tetraphis pellucida*, *Polytrichum* spp, *Sphagnum girgensohnii*, *Leucobryum glaucum*, *Thuidium* spp., *Ptilidium pulcherrimum*, and *Lepidozia* sp. Lichens are common due to the high moisture of the air and soil in the forest, and include the epiphytic *Usnea* spp. and *Bryoria* spp. Ground lichens include *Cladina* spp., *Peltigera apathosa*, and an uneven distribution of numerous others.

Small areas adjacent to the west side bogs have a black spruce (*Picea maria-*

na) dominant bog forest, and other trees such as *Abies balsamea* and *Picea glauca* are absent or minimal here. The ground is water saturated, with a peaty soil, and covered with *Sphagnum* spp. mosses and growth of such herbaceous species as *Maianthemum canadense*, *Coptis trifolia*, *Linnaea borealis*, and *Oxycoccus palustris*. Various ericaceous shrubs, including *Ledum groenlandicum*, *Chamaedaphne calyculata*, *Andromeda polifolia*, and *Kalmia angustifolia* are also important species here.

Areas that have a moderately wide transition from bog to boreal forest might best be classified as a transition bog forest. The areas, generally west of the large west side bog, have a variable character with small open bogs and swampy areas contrasting with forest areas which often contain standing water. Tree species typical on these soils are *Picea mariana*, *Picea glauca*, and *Abies balsamea*. Common shrubs include *Ledum groenlandicum*, *Chamaedaphne calyculata*, *Kalmia polifolia*, and *Andromeda polifolia*. *Sphagnum* is common most everywhere in these areas, and herbaceous species are similar to the spruce bog forest, above.

Near the north central area of the island there is a slightly different boreal forest species composition, with the main distinction being the low frequency of *Picea glauca*. This fir-birch forest is generally more open, wetter (although not boggy), and there may possibly be some differences in soil which are important factors as well. Windthrow was common, and the forest has a very "hill and hollow" appearance. It was also in the driest areas of this forest where the only occurrences of *Pteridium aquilinum* were seen on Caribou.

On the ridge tops of what is likely a dune-modified moraine, in the south-central forest, there is a character of the vegetation worth differentiating, and which I

term the south-central ridge forest. Here, on the highest elevations of the island, there are very large *Betula papyrifera*, and an extremely dense undergrowth of small *Abies balsamea*. This cover is so thick that foot travel through was difficult. There is very little ground vegetation, probably related somewhat to light availability and perhaps other microclimatic factors such as a moisture deficit. No logs or stumps were found, which probably excludes the likelihood of a large insect destruction of trees, or other factors which might better explain such a thick growth of small fir trees.

### Deciduous Forest

There are two small areas near the southwest shore of Caribou Island that support a deciduous forest type, and a very small deciduous area on Gull Island. On the southwest areas there is a well developed *Sorbus-Betula* deciduous forest community dominated by *Sorbus decora* and *Betula papyrifera*, with an often dense understory of *Taxus canadensis*. Figure 27 shows the general character of this southwest deciduous forest. *Alnus viridis* occurs at the edges of this community type where wetter soil conditions prevail, such as along the shore and at the edge of the fen. Herbaceous vegetation is likewise distinct in this area and consists of *Streptopus amplexifolius*, *Clintonia borealis*, *Oxalis acetosella*, *Dryopteris intermedia*, *Heracleum lanatum*, and *Cornus canadensis*. Spring beauty, *Claytonia caroliniana*, was found throughout the central portion of this area in late June, and was found nowhere else on the islands.

It is possible that the reason for the deciduous forest at these locations is the relatively thick and fertile soil, combined with a well aerated and drained gravel zone





Figure 27. Character of the Southwest Deciduous Forest on Caribou Island.

beneath. It is also possible that evergreen trees such as spruce and fir are more susceptible to windthrow in this area, while deciduous trees (without their leaves in the autumn and winter) are better able to withstand autumn storms and their associated high winds.

On Gull Island there is a much smaller area of deciduous forest (little more

than a thicket) consisting of *Sorbus decora* with admixture of *Cornus stolonifera*, *Sambucus racemosa*, and others. The understory is composed of *Ribes glandulosa*, *Diervilla lonicera*, and others including several weedy species.

## Wetlands

### Bogs

Caribou Island is noteworthy for its large expanse of peatlands. As discussed previously, the west side is composed largely of open peat bogs, interspersed with somewhat drier areas (Figure 28). The bogs are typical in their species composition compared with those of the mainland, although their hydrology may be unique, as



Figure 28. Character of the Open West Side Bog on Caribou Island.

discussed previously. Additionally, there are few floating mat bogs, and most of the large peatlands are very easily traversed on foot.

*Sphagnum* is the dominant genus on the open bogs, with trees and shrubs including *Chamaedaphne calyculata*, *Andromeda polifolia*, *Kalmia polifolia*, *Ledum groenlandicum*, *Larix laricina*, and *Picea mariana*. Herbaceous species include *Eriophorum* spp., *Drosera* spp., *Sarracenia purpurea*, *Carex oligosperma*, *C. magellanica*, and *Maianthemum trifolium*. *Pleurozium schreberi*, *Polytrichum* spp., and *Mylia anomala* are other common bryophytes on the bogs. In a small area on the northeast of the big bog, there are small, ragged-looking Arborvitæ trees (*Thuja occidentalis*), which might be the remnants of a once larger population (Figure 29). This problem is discussed further in the floristic discussion section of this thesis.

### Fens

Morton and Venn (1996) described the vegetation of several areas of Caribou Island as "fen-like" because of their typically fen species and hydrology. These areas include small associations near east side interior wetlands, as well as a larger area near the South Bay Headland, between the two areas of southwest deciduous forest. It is possible that these fen areas have developed where there is suitable porosity of the substrate (sand on the west side and, perhaps, gravel or cobbles on the southwest side), where there is enough water exchange to limit the acidity. Actual species composition is variable, but certain species are common to all fen areas, notably *Chama-*



Figure 29. Possible Remnant Population of Arborvitæ on Caribou Island

*edaphne calyculata*. Morton and Venn (1996) describe in more detail their species findings in several different fen areas of the island.

#### Shoreline Marsh

The shoreline marsh is a minor but important plant community on Caribou Island, restricted to a small area of the southwest shoreline between the two areas of deciduous forest, and bordering in the middle of the alder thicket (this area can be seen well in Figure 20). This is likely a very nutrient rich area, indicated by the large presence of emergent graminoids present and a significant amount of gull droppings which frequently give a brown opaqueness to the water. Common species here include *Alnus viridis* (at the forested edges), *Calamagrostis canadensis*, *Carex aquati-*

*lis*, *Iris versicolor*, *Primula mistassinica*, *Lathyrus palustris*, and *Platanthera hyperborea*. It is interesting that this is the only site on the island where I found *Lathyrus palustris*; Morton and Venn report it only in the area near Gull Island for 1976, and White did not note it at all.

#### Small Interior Wetlands

In areas of the boreal forest where there is poor drainage, small swampy areas have formed. These are apparently often former swale areas and interdunal low spots, which reach the level of the water table where they occur. They generally appear to have some hydrological interaction with the water table, and do not have peat deposits as thick as the west side bogs. Their acidity is probably lower than that of the bogs as well, because of the likelihood of water exchange with the groundwater. They are most common in the southeast interior forest and north-central forest. Common species in these areas differ slightly from the boreal forest. *Picea mariana* is found in many such areas, and with the shrubs *Potentilla palustris*, *Spiraea alba*, *Ledum groenlandicum*, and the herbaceous species *Iris versicolor*, *Lysimachia terrestris*, *Oxycoccus palustris*, and others.

#### Gull Island

Gull Island has a habitat which differs from the other areas of the Caribou Islands. It is composed mainly of an open wet meadow-type vegetation, and has a small wooded area at the center, buffered on the west side by a robust growth of *Cornus stolonifera* shrubs. Species common include *Sorbus decora*, *Alnus viridis*, *Bo-*

*trychium* spp., *Equisetum* spp., *Stellaria borealis*, *Cirsium arvense*, *Cornus stolonifera*, *Calamagrostis stricta*, *Phalaris arundinacea*, *Sisyrinchium montanum*, *Polygonum* spp., *Primula mistassinica*, *Potentilla anserina*, *Prunella vulgaris*, and *Hieracium canadense*.

### Alder Thicket

This community occupies a small series of areas along the southwest shore, most notably near the deciduous forest areas, and decreases to the north. In some areas it borders the shoreline, such as at the marsh areas (described above), and to the north of the deciduous forest areas. This is also the area where Wormington reported finding *Symplocarpus foetidus* in 1979 (Morton and Venn 1996). The soil in these areas is damp, from sandy to organic or mucky, and the areas nearer the Lake Superior shore most likely get frequent wave "flooding" during autumn storms, as evidenced by the large amount of logs, stumps, and other lake debris washed well into the thickets. This also probably has some effect in discouraging competitive species from becoming established and thereby maintaining the dominance of alder in the community. Important species are *Alnus viridis*, *Cinna latifolia*, *Galium asprellum*, *Potentilla palustris*, and few others.

### Sand Flats

There are several small areas on the mid-east interior, which White (1995) termed "sand flats". Figure 30 shows one of these sand flat areas, with vegetation including *Polytrichum commune*, *Cladina* spp., and *Spiraea alba*. These small, sandy openings occur south of the mid-east side wetlands. There are approximately five



Figure 30. Sand Flat on Caribou Island.

such areas in close proximity to each other, with the largest approximately 25 meters long and 15 meters wide. They are shallowly valley-like, and most have an open canopy, though the southernmost one is under the shade of large birch trees. This shaded, open area resembles an almost park like environment, with little ground cover other than mosses and small herbs. Plant species common include the moss *Polytrichum commune*, *Cladina* spp. lichens, small-sized individuals of *Maianthemum canadense* and *Cornus canadensis*, *Spiraea alba*, and *Viola lanceolata* Morton and Venn (1996) and White (1995) have offered theories on the reason for the sandy openings. Morton and Venn suggest that windblown sand deposition might be responsible, while White theorized that the reason is due to seasonal inundation, which effectively prev-

ents the establishment of most plants in the area. My opinion is that the second variant is more probable. The sand flats are probably inundated most springtimes, and in 1996, I observed several of the areas to be apparently in the drying stage, with some areas still having standing water and others in stages of drying, including dry. I saw many tadpoles in several of them, indicating their importance to the animal life of the island as well.

### Dry Bog Openings

Local wetlands on the eastern side of the island are interspersed with small openings of well-drained and dry, sandy soil. The areas, comprised of small ridges and water-side openings, provide a striking contrast so close to the bogs. These dry areas are open, with only a few generally very small trees such as *Picea glauca*, *Abies balsamea*, and, occasionally, *Betula papyrifera*. In contrast to such diminutive trees, all three of the very large *Pinus strobus* noted on the island were also in these areas. Ground cover consists of many backdune and mid-dune species such as *Maianthemum canadense*, *Cladina* spp. lichens, *Dicranum* spp. mosses, *Cypripedium acaule*, *Arctostaphylos uva-ursi*, *Cornus canadensis*, *Melampyrum lineare*, *Polygala paucifolia*, *Potentilla tridentata*, *Geocaulon lividum*, and *Vaccinium angustifolium*.

### Disturbed Areas

The only area of the Caribou Islands which shows extensive influence of human activity is Lighthouse Island, which is addressed more thoroughly later in this thesis. Other areas of the Caribou Islands show little or no human disturbance. Small areas of the interior forest are regularly opened by windthrow of trees, but few



differences in species composition were seen in these areas.

## FLORISTIC COMPARISON OF THE OF THE USHKANII AND CARIBOU ISLANDS

It is now universally known that living beings, animals and plants, are not scattered at random over the surface of the whole globe.

—Louis Agassiz (1850, 137)

### Similarities and Differences

The primary difference between the phytogeography of the Ushkaniis Islands and Caribou Islands is their surrounding vegetation. Although both groups are in the circumboreal realm, the Caribous are in the spruce-fir-birch low boreal North American taiga, while the Ushkaniis are in the eastern Siberian larch-pine taiga. These forest types reflect their climatic conditions; greater moisture and warmer winter temperatures favor the vegetation near Lake Superior, and the colder winters and drier climate favors the larch and pine forests of the Baikal area. The topography of the islands is another major factor, and perhaps the most immediately visible; the vegetated and active dunes and vast open bogs at Caribou Island contrast strongly to the steep, rocky terrain of the Ushkaniis Islands. Though both groups have large forested areas, the steppes at the Ushkaniis are strikingly correlated with the topography, as are the wetlands at Caribou.

The floræ of the Caribou and Ushkaniis Islands express the response of climate, geology, topography, soils, disturbance, and time, as well as the interactions of other plants, humans, and animals. All of these factors interact to affect the immigration, persistence, and extinction of individual plants and plant communities on the islands. Though it is difficult to isolate all of the variables, it is nonetheless possible to make conclusions based on recurring patterns, such as endemic and disjunct spe-

cies presence, patterns of plant communities on the islands, absent species, and the ecological and phytogeographical characteristics of those present.

As has been found in other areas of the Great Lakes and Baikal (see Given and Soper 1981 and Попов и Бусик 1966, for example), there are floristic phenomena on the islands in this study which are similar to those of other large lake islands. Furthermore, unlike most mainland shoreline areas on the lakes, there exists on the Caribou and Ushkani Islands the possibility to compare, in a compact area, differences of exposure (north vs. south, etc.) and prevailing wind and wave direction on their associated vegetation conditions.

The floræ of the islands immediately show some superficial floristic similarities:

1. Both are forested with a coniferous-dominant forest with admixture of broadleaved tree species; the taiga of their respective regions.
2. Both have a smaller flora than might be expected for equivalent mainland areas.
3. Both have rare species present, and they are disproportionately situated closer to the shorelines.
4. Both have several "conspicuously absent" species.
5. There are some plant taxa common to both locations, including several species, a few more "analogous" species, and many families.
6. There are more weedy species on the islands with human activity than those without.

At the same time, they show some major differences:

1. The topography of Ushkani is much more rugged than Caribou, and the vegetation is more strongly affected by the topography at Ushkani than at Caribou.

2. The shorelines of the Caribou Islands are mainly sandy or gravel beaches, while the shorelines of Ushkanii are very rocky or gravelly, and these differences in shoreline morphology effect differences in their associated floræ.

3. Caribou is forested with a spruce-fir-birch dominant forest, and has a very small presence of pine, larch, and poplar, while Ushkanii Island is forested with a pine-larch-poplar forest with some birch, and very rare spruce and fir.

4. Caribou is well-endowed with a variety of wetlands and associated plant communities, while Ushkanii has no water features of any kind, other than the Baikal shoreline.

5. Ushkanii clearly shows the effects of fire in the recent past, while no signs of fire were found at Caribou.

6. Ushkanii has endemic taxa, while Caribou has none.

There are several clearly visible patterns of the islands' floræ, including:

1. Disjunct and other "unusual" plants are present at both sites, and most common near the shorelines, and, on the Ushkanii Islands, on the south-facing slopes.

2. Certain plants, otherwise common in the regions, are absent or rare on the islands.

3. Non-native plants are present at both sites, and largely follow patterns of human disturbance.

4. Areas near the shorelines show the strongest limnoclimate and resultant influence on the vegetation.

5. Certain shoreline areas receive more deposition of wave-carried debris (and therefore propagules?); i.e., the east shore at Caribou and the north and east shores at Bolshoi Ushkanii.

6. The Ushkanii Islands, closer to the mainland and older, have a larger flora than the Caribou Islands, which are younger and farther from the mainland.

7. Dolgii, Tonkii, Kruglii, Gull, and Lighthouse Islands all have species which are not found on the other islands of their archipelagos as do their main islands (Bolshoi Ushkanii and Caribou).

8. Both archipelagoes appear to be somewhat free of natural fires, as indicated by the old trees of Caribou Island and Ushkanii Island (the situation has changed in the 20th century at Ushkanii due to human-caused fires).

With the influences recognized, the floræ of the islands and their phytogeography can be examined to gain some understanding of the forces responsible, and which ones are perhaps most important. By noting the differences and similarities between the islands, general observations on the floræ can be made which might serve to better delineate the principles of lake island biogeography.

#### Numerical Characteristics of the Vascular Floræ

There are few vascular plant species in common between the island groups (15), although the families are divided approximately equally; 22 exclusive to Ushkanii; 31 exclusive to Caribou; 33 in common. Figure 31 shows comparison the numbers of vascular plant families of the Ushkanii and Caribou Islands. The Ushkanii Islands have 283 species (Bolshoi Ushkanii 276, Dolgii 79, Tonkii 78, Kruglii 93). 155 species are exclusive to Bolshoi Ushkanii, two to Tonkii, one to Kruglii, and four to Dolgii. Figure 32 shows the numbers of species on the Ushkanii Islands. The Caribou Islands have 257 species (Caribou 237, Lighthouse 37, Gull 46). 177 species are found on only Caribou Island, and three species (all *Potamogeton* spp.)

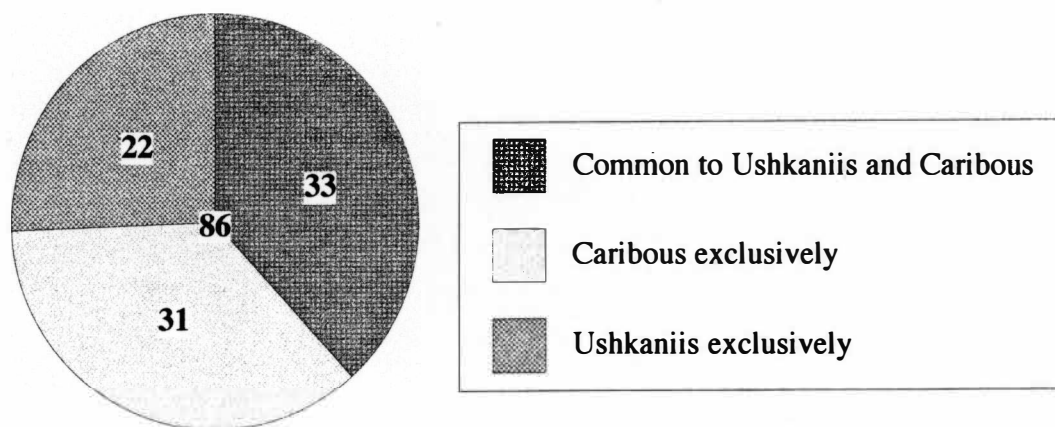


Figure 31. Numbers of Plant Families of the Ushkaniis and Caribou Islands.

are found only in the waters between Gull and Caribou Islands. Nine species are exclusive to Lighthouse Island, and eight species are exclusive to Gull Island in the group. Figure 33 shows the numbers of species on the Caribou Islands.

These species numbers represent those observed and reported in the literature for each site, and it should be noted that the main islands have been examined much more carefully than the smaller islands. Nonetheless, the numbers are reasonably accurate and may be at least partially explained according to (a) the island size, (b) the diversity of habitats, and (c) in the case of Lighthouse Island, the complete human caused modification of the island.

There are fewer taxa in certain habitats of the Ushkaniis and Caribou Islands, apparently, than that of similar areas on the nearby mainlands. This is somewhat difficult to quantify, however, as the habitats of the Caribou Islands do not exactly match those of the nearby shoreline areas, and the habitats of the of the Ushkaniis Is-

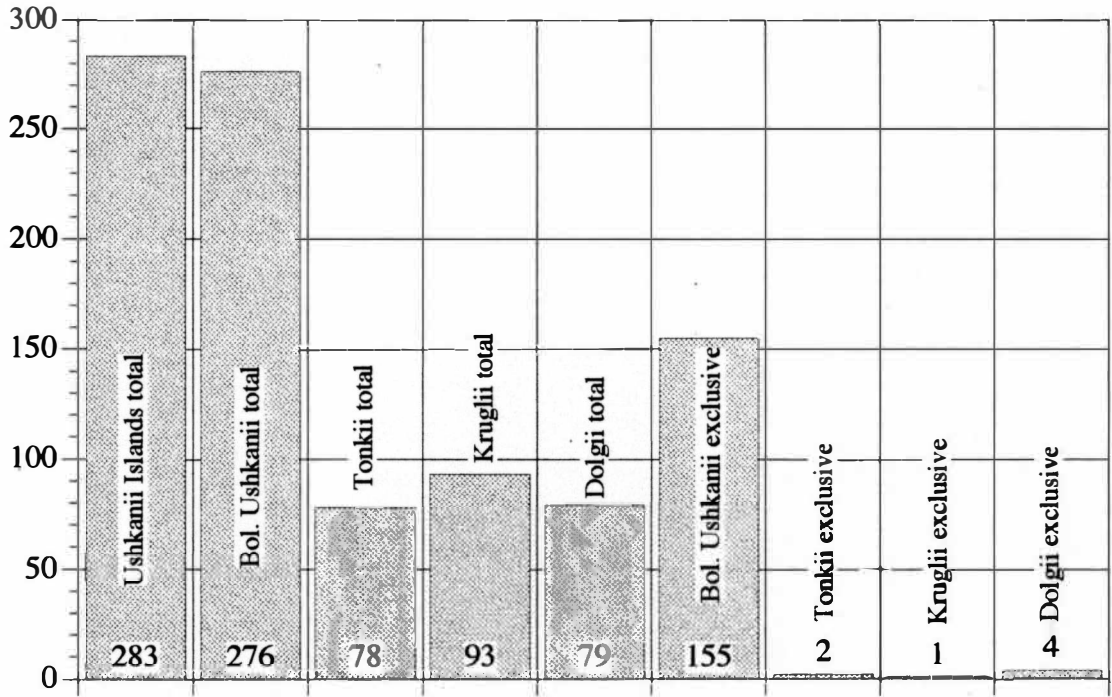


Figure 32. Numbers of Species of the Ushkani Islands Flora.

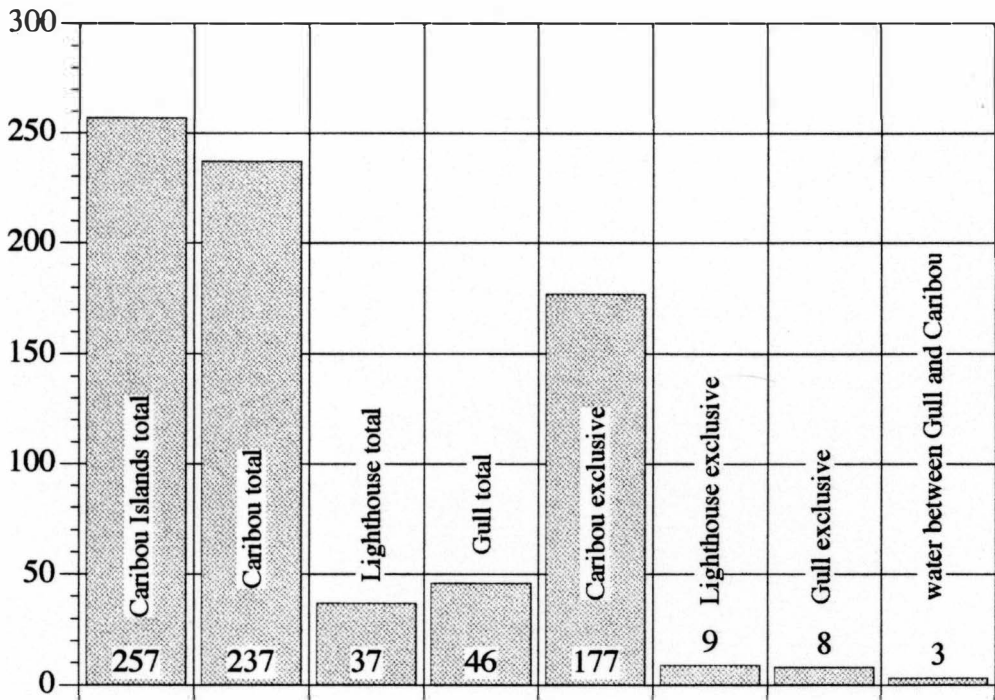


Figure 33. Numbers of Species of the Caribou Islands Flora.

lands even less so than those of the Svyatoi Nos or areas of the west Baikal shore. Comparing the flora the Ushkanii Islands with that of the Svyatoi Nos Isthmus (Mlikovsky and Styblo 1992) or the Barguzin Zapovednik (Тройцкая и Федорова 1989) or of Caribou Island with that of Lake Superior Provincial Park (Brunton 1991), in the Batchawana Bay area (Hosie 1938), or on Michipicoten Island (Noble 1984) consistently shows a larger flora on the mainland than for similar environments on the islands.

### Influences on the Phytogeography

To understand how the islands are different from the mainland, it is important to know which factors are influential on the floræ and phytogeography of the islands and which are related to their insular nature. Islands at “equilibrium” theoretically have relationships between number of species and size, age, and distance from mainland (Mac Arthur and Wilson 1967). Other important variables are diversity of habitats on the island suitable for colonization, the composition of the nearby mainland flora, the similarity of the island to nearby mainland areas, disturbance history, and plant dispersal methods. Since there are a number of variables, it is difficult to postulate which are the dominant, or even more important ones. If one follows the strict theorem concerning number of taxa, island size, distance from mainland, and island age, the Ushkanii Islands should have a larger flora, which indeed they have. Conversely, the Caribou Islands, apparently, have a greater variety of habitats, although the number of taxa is smaller. It is not, therefore, readily possible to tell which of these factors are responsible, nor in which order of importance. It is most likely a combination of them, and perhaps others even less isolatable.



### Island Size

According to island biogeography theory, larger islands, if other variables are similar, should have more species than smaller ones. This generally holds true for the islands in this study relative to others, with some exceptions. Figure 34 shows a species-area relationship for a number of Great Lakes and Lake Baikal Islands, showing the position of the Ushkanii and Caribou Islands, and Figure 35 shows a species-area relationship for only the islands in this study.

A problem of the size of islands is that it may occasionally be variable. An example is drawn from Caribou, which most likely has been “growing” westward (Kor 1995a), and at the same time probably undergoing changes in environment that might affect the suitability for various plants. As will be discussed further below, *Thuja occidentalis* and, possibly, *Pinus strobus* may have once had a more robust presence on Caribou. If this is the case it follows that other species may have likewise found more suitable habitat at that time.

### Distance to Mainland

The farther an island is from the mainland, the more difficult it will be for propagules to be transported successfully to the island, whatever their method. However, this is not as simple a problem as it might appear, for several reasons. First, the mainland might not be the closest area of land. If there are islands closer to the island in question, it becomes a more difficult question as to what the source area is. Caribou Island, for example, is closer to Michipicoten Island than it is to any mainland areas, and beyond that, it is closer to the Pukaskwa Peninsula, north of Caribou Island. To the east, it is only slightly farther than this to Leach Island and to Cape

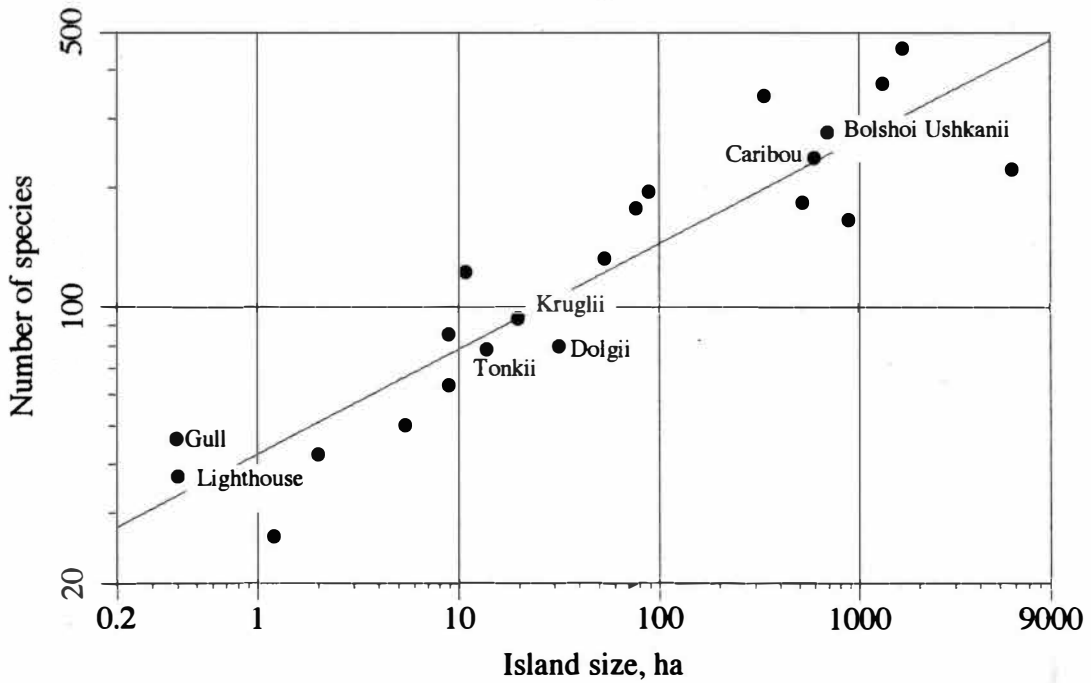


Figure 34. Species-Area Relationship for Islands in the Great Lakes and Baikal, Showing Positions of the Ushkanii and Caribou Islands.

Source: Иванова 1969, White 1995, Morton and Venn 1996, СкрЯбин 1987, Hazlett 1988, Forzley et al. 1993, and field investigations by the author in 1995 and 1996.

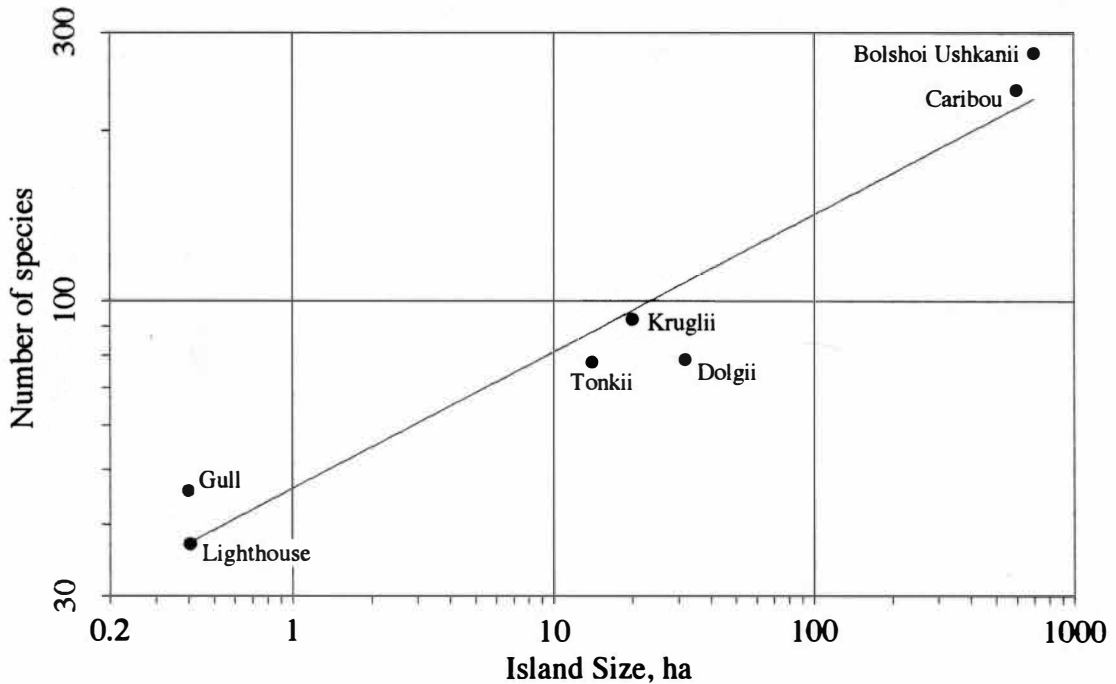


Figure 35. Species-Area Relationship for Islands of the Ushkanii and Caribou Archipelagos.

Gargantua on the mainland. Did some plants therefore "island hop" to make it to Caribou? Hultén (1927, 1960) discussed this question in relation to the Aleutian Islands and the islands near Kamchatka, Thornton (1967) to various other areas, and Mac Arthur and Wilson (1967) have addressed the problem theoretically as well as empirically. In an extreme example, the difficulty for plants to immigrate to Gull Island from Caribou or vice versa is probably negligible, and the main reasons for vegetation differences between the two are likely climatic and edaphic. Morton and Venn (1983), for instance, found that the nesting and activities of gulls on islands in Lake Huron had a severe influence on the vegetation of the islands. Nutrient levels were extremely high because of the bird droppings, particularly nitrates and phosphorus. The constant activity of the gulls, and the related disturbance of the plant habitats also contributed to a hostile environment to many species.

It is convenient for the phytogeographer that the Caribou and Ushkanii Islands are so discretely located far from land in their lakes, with a relatively uncluttered path to the mainland. However, it seems almost certain that some of the plants on these islands have not come directly from the mainland. Many of the plants of the small Ushkanii Islands, for example, must have come via Bolshoi Ushkanii, and likewise those on Gull Island (especially) and Lighthouse from Caribou. The distance from Caribou to Gull Island is, after all, only several meters. However, even Gull Island has species which are not found on Caribou Island, and one wonders if these have found their first (and perhaps to be their only) habitat on that island of the Ushkanii Archipelago. Anecdotal evidence shows that this is also possible in reverse: near the end of my visit to Caribou Island, Canadian Coast Guard crews were performing some maintenance at Lighthouse Island, which included cutting of excess vegetation.

Many of these cuttings, principally of *Heracleum lanatum*, had washed up on the shores of Caribou Island within a day.

A second complication of the distance to mainland theory is that the distance from even the most distant shores to the Ushkanii and Caribou Islands is not great compared to the possible dispersal range of many plants, and even though plants may have a somewhat enhanced probability of immigration from the nearer areas of the mainland, this is by no means certain. Plants may not necessarily take the shortest path to islands, but often a more lengthy path with easier (or even "accidental") transport. This is particularly likely when there are no known locations of the plants close to the islands, although further study might reveal whether the closest stations are indeed the most common sources.

The example of *Rubus chamaemorus* (cloudberry) on Caribou Island is a noteworthy example; the steppe plants on the Ushkanii Islands are another. *R. chamaemorus* was surely transported by a bird migrating from the north—the distance is impossible to know—within the distribution area of the plant. It is not known from any areas on the east or south shores of Lake Superior, nor from Isle Royale or Michipicoten Island. The example of *Thalictrum revolutum* on Caribou Island, which has apparently traveled a much greater distance than the closest shoreline to become established on the island, is another indication of the problem of long-distance immigration.

Winter winds may occasionally carry seeds and other propagules over ice directly to the Ushkanii Islands, and favorable currents may carry them on water in the warmer months. Birds may also be an important form of transport for some of the species from steppe areas. On the Ushkanii Islands, the steppe plants have probably

taken a slightly longer route to the islands. It is likely that the source of many of these steppe plants on the Ushkani Islands is from the southwest—from steppe areas such as those on Olkhon Island and the islands of the Maloye Morye (“Small Sea”) Strait, which is well known and studied for its steppe climate and vegetation (Гагарин 1974, Литвинов 1982, Пешкова 1972, Попов 1990, Скрыбин 1987).

Another example on the Ushkani Islands may be drawn from *Larix x czekanowskii*. Its parent species grow on opposite shores of Baikal—*L. gmelini* on the east and *L. sibirica* on the west (Мальшев и Пешкова 1979). Although the tree may have been established on the islands from populations on the mainland, it is also possible that it is the result of hybridization from pollen from both shores.

Additional factors on the distance-species relationship include such complications as nearby mainland habitat versus that of the island as well as air, water, and bird migration currents.

### Island Age

Older islands theoretically have had more time to develop a flora, and more time for species to become established (i.e., closer to equilibrium or the point at which the immigration of new species balances exactly the disappearance of established species). Thus, they should have a larger flora than younger islands if equilibrium has not been reached. A problem of equilibrium, as noted by Mac Arthur and Wilson (1967), is that “a perfect balance between immigration and extinction might never be reached, since it would be approached exponentially”. The Ushkani Islands indeed have a larger flora than the Caribou Islands, and are older. Is this evidence of Caribou being further from equilibrium than Ushkani, or further from the

mainland? It is difficult to say, although as the islands have nominally complete floræ (compared to their closest mainland areas), it is possible that they are at least close to equilibrium, since their floræ are not becoming larger to any great extent.

### Dispersal Method

The question of dispersal method on the phytogeography of insular ecosystems is of great importance. Morton and Hogg (1989) and Hazlett (1988) have done a good job addressing this question in their research on lake island phytogeographies, and found a greater incidence of sarcochores (those with a fleshy fruit), which are often bird-dispersed. This study does not incorporate analysis of dispersal methods, since reliable data were not available to me for many of the Siberian species. However, Morton and Venn (1996) mention the high proportion of bird or water-dispersed species at Caribou Island, and the lack of desmochores (bur-fruited species). Ivanova (ИВАНОВА 1969) makes no mention of dispersal methods, but a brief generalization for Ushkaniï can be drawn: (a) the steppe flora is largely wind dispersed, (b) there are a large number of sarcochores (fleshy-fruited species) which are likely bird transported, and (c) the desmochores are generally lacking.

### Topography

Plants on both island groups in this study reflect the topography to varying degrees. On Ushkaniï Island, for instance, the vegetation is well arranged by elevation, with the larch forests occupying the lower areas of the island and the pine forests on the higher areas. Exposure, slope steepness, and aspect are perhaps the most important elements of the topography on vegetation at the Ushkaniis. The aspect and steep-

ness of slopes affects the wind exposure, insolation, and other microclimatic elements strongly on the Ushkaniis, and the north slopes have a distinctly cooler microclimate than the south slopes, especially in the spring and summer (Вьхристюк 1980). Another important element of slopes on Ushkaniis which influences the vegetation is erosion. This is particularly evident on the south slope, and may be one reason for the lack of trees on many areas of the slope.

On Caribou Island the vegetation also follows topography, although the differences in vegetation appear to be more related to hydrology than exposure. Since the island is quite low in relief, the differences are often manifested more abruptly than at Ushkaniis. The bogs are a prominent landscape feature of the island, and are all at approximately the same level. The dune ridges of the east side of the island have well-differentiated "zones" of vegetation as well, with the tops of many ridges having larger than normal birches and small, dense thickets of fir. Lower areas between dune ridges have plants better suited to a moister or even swampy area.

### Animals

In addition to man, the effects of other animals can have a strong influence on the vegetation of a region; this is particularly manifested at Caribou, and very little at Ushkaniis. This is particularly evident where a plant is used as food by an animal when the plant is in short supply. It is also important when the plant's seeds are distributed by animals, such as *Rubus chamaemorus* on Caribou Island. The influence of migrating birds, of course, on the dispersal and introduction of plants at the islands is of primary importance, and geese and resident gulls on Gull Island and small areas of the immediate Caribou Island shoreline also have a severe influence on the vegeta-

tion in their proximity. The influence of animals other than birds on the islands in this study is probably minimal, with the exception of that caused by beavers on Caribou Island. No other animals appear to be important enough elements in the islands' ecosystems to cause significant impact or change, although the presence of a large number of caribou on Caribou Island might have once had an influence on the vegetation.

### Beaver

Beaver (*Castor canadensis* Kuhl) exert a strong influence on the flora and hydrology of the wetlands of Caribou Island from their engineering activities. Though there are few streams to dam, they nonetheless have put dams on the few that are suitable, to great effect. The most significant is probably the one near the northwest side, where the water level has been raised by approximately a meter, and the muddy dam and pond shores support large populations of *Viola lanceolata*, *Menyanthes trifoliata*, *Iris versicolor*, *Impatiens capensis*, and other plants well suited to such a situation. The pond created is not large; approximately 0.5 ha. In many other areas of the west side, the canals of beavers are common on the open wetlands; these canals probably alter the hydrology to some extent, as well as providing a habitat suited to such plants as *Utricularia* spp. and others. In the forested areas between wetlands, trails are a common evidence of beaver reworking the landscape to suit their needs (Figure 36). The preferred food available on Caribou Island is *Betula papyrifera* (white birch), and these trees are as a result rare near the wetlands. The lack of trembling aspen, *Populus tremuloides*, on Caribou Island might be attributed to some degree to the large beaver population on the island. The fact that the only individuals



of this tree, the preferred food of the beaver, on the islands are a few very young specimens on the east shoreline of Lake Superior is puzzling, unless one considers the large beaver population.



Figure 36. Beaver Trail in Boreal Forest of Caribou Island.

### Geese

Canada geese can often be found at the northwest end of Caribou Island, usually resting and feeding on herbaceous plants on the low shores of Gull Island. They were also frequently seen swimming in the waters on the southwest side of Caribou Island. The "grazing" by geese on Gull Island probably has a strong impact on the phytogeography of the site, and certainly does on the morphology of the plants. For example, most of the vegetation has been severely culled, with the exception of the most inaccessible areas such as under shrubs, near rocks, etc. This may account for the gap in distribution records for *Botrychium* spp. (moonwort) and *Onoclea sensibilis* (sensitive fern) on Gull Island between those of Brown (1981) and my collections of 1996. Indeed, most of the specimens of *Botrychium* found had suffered some degree of damage from biting geese, and all were found under the relative protection of shrubbery or other objects.

### Gulls

Gulls also influence the flora near their activities, though it is apparently less dramatic than that of the geese. Their influence is clearly seen near their nesting areas on Caribou Island at the North Point and several smaller areas along the southeast and northeast shores. There is also a significant presence of gulls on Gull Island and Lighthouse Island. On the Ushkanii Islands, gull nesting and activity is largest near Pescherka Bay. Hogg and Morton (1983) and Hogg, Morton, and Venn (1989) have shown that the nesting and activities of gulls on islands in Lake Huron had a strong influence on the number, species, and origin of plants, and that nutrient levels were extremely high because of the bird droppings, particularly nitrates and phosphorus.

They found that the constant activity of the gulls, and the related disturbance of the plant habitats also contributed to a hostile environment to many species. This may be the case (albeit to a lesser extent) on the Caribou and Ushkanii Islands.

### Barriers to Successful Colonization of Plants

The absence of competing species may, however, hinder species establishment by virtue of the harsh, unprotected environment. An example is the several seedlings of sunflowers, *Helianthus*, found on the west shore of Caribou Island. Although the seeds made the journey successfully to the island's shoreline and germinated, their location on the very edge of Lake Superior and a sand beach did not appear agreeable for their successful establishment on the more favorable areas of the island, even if the growing season and other climatic factors were sufficient for the plant's needs. Some plants may be prevented in colonization without the simultaneous introduction (or established presence) of a suitable symbiont. Others may be less robust, or less able to withstand edaphic conditions without a symbiont. To what extent symbiosis affects island phytogeography I could not determine from the literature, but this question could be an important one to the understanding of island ecosystems.

### Habitat Availability

Regardless of proximity to mainland, size, or disturbance, if there are not suitable habitats available in an area for plants, they will not be found. Therefore, habitat availability and suitability are prime factors on the biodiversity of the islands. Although a long discussion of succession is not necessary here, it is certain that the

habitat of the islands has changed with time, and so what follows here may apply only to the present state of the islands. Both the Caribous and the Ushkaniis have a limited number of habitats available for immigrant species as well as those already established. Any new species which might have successfully made it to the islands also have the obstacle to overcome of finding suitable habitats to grow and become successfully established.

As on new islands, plants find an easier situation in areas with low competition for some resources (water, light, germinating area), and the epitome of this is an area free of other plants. Besides the shorelines (and dunes on Caribou Island), there are few unvegetated areas on the islands. However, some disturbances such as fire, human disturbance, animal activity (such as beaver on Caribou Island), windthrow, slope erosion (on Ushkanii), and dune migration and blowout (on Caribou) create variable sized areas which can be colonized by new species or those already established. The weedy, r-selected species on Lighthouse Island and the ZNP station area of Bolshoi Ushkanii Island are examples of plants particularly well adapted to this. It also seems likely that plants are more likely to become established on the islands near disturbed shorelines.

The greater frequency of plants with limited presence on Caribou Island along the west shore may indicate this, although the east shore, with its more extensive sand beaches, is likely a more active shoreline. Perhaps more important in this case is the greater deposition of material—including plant propagules—on the west side. The presence of such species as *Thalictrum revolutum*, *Lathyrus palustris*, and others near the northwest and southwest shorelines may support this. On the Ushkanii Islands, likewise, a number of species have been reported only from disturbed shorelines, and

this might reasonably be attributed in large part to a similar cause.

Many mosses are especially well suited to colonization of shorelines and islands. Like other cryptogams, their spores are so small as to be easily transported very long distances by wind. Another factor, which I have seen empirically demonstrated repeatedly on several island shorelines, is that a "clump" of moss plants, often with some soil, can be easily dislodged from the shoreline and transported to another location by water currents. Mosses attached to pieces of wood (or other floatable debris) may stand a reduced danger of sinking, and therefore a greater success rate. Also, mosses are better able to withstand prolonged periods in water, especially the species common to shorelines. Both variants of living moss plant transport were seen on the shores of Caribou and Ushkanii Islands.

#### Shoreline Morphology

The minimal vegetation on many of the shorelines on the islands illustrate their inhospitability to plant survival. Shorelines present either a formidable barrier or an easy site for successful growth, depending on the nature of the shoreline. Such barriers are particularly important for water-carried propagules, though other sorts, such as wind-carried seeds, may also easily locate to the open dune or beach areas of Caribou Island only to wither in the hostile environment.

There is a greater tendency of plants that are "rare" to the islands (i.e., exist in very small populations relative to other species on the islands) to be found on the shorelines. This was found to be particularly obvious on the northwest side of Caribou Island near Gull Island, where a large number of species are restricted to only this shore area. It is possible that many of these plants are only transitory immigrants in such areas. If they are unsuccessful at expanding their range away from the shore-

lines, they are much more prone to stochastic disturbance and extirpation. An extreme example of this are the two *Helianthus* (sunflower) seedlings found on the west shoreline beaches of Caribou Island in 1996. Examples of plants which may have a better chance of establishment from shoreline areas are *Iris ruthenica* on Bolshoi Ushkani Island and *Pyrola asarifolia* on Caribou. Some plants are, of course, best suited to the climatic conditions of the shorelines, and are well established there.

The shorelines can be divided into 2 varieties; rocky and sandy. Rocky Shores are present on large areas of the Ushkani Islands and small areas of the Caribou Islands. They present a serious to nearly absolute barrier. The vertical and steep rocky shores on the Ushkani Islands effectively prevent plant introduction in these areas, while the gravelly shores of the Ushkaniis and the west side of Caribou allow a somewhat greater possibility to the water-carried propagule. On gravel shores, the lack of soil, as well as extremes of moisture and temperature (see Lindsay 1968) present difficulty to the establishment of plants. Some plants, however, are well adapted, and have become established in such areas. The Ushkani shoreline communities of *Allium schoenoprasum*, *Carex cespitosa*, and *Caltha palustris* are a good example of this.

Sandy Shores, present for all practical purposes only at Caribou Island in this study, present similar difficulties to plant immigration to islands. The often wide beaches, particularly on the east-central and northwest shores, give long expanses of sterile beach sand separating the more hospitable forests from the shoreline. The constant wave, wind, and ice action and dynamism of the shoreline areas are also inhibitors to survival of plants on the shorelines. White (1995) also noted this aspect of the shorelines.

## Origins of the Vegetation

It is difficult to speculate which source areas have been most important for the vegetation of the islands in this study for several reasons. The most likely areas are probably the closest—the west shore of Baikal, the east shore of Baikal and the Svyatoi Nos Peninsula (especially for wind and wave dispersed species), and areas to the north (for bird dispersed species, as southward migrating birds in autumn may easily deposit seeds on the Ushkaniis during their travel). Most components of the flora, particularly the steppe communities and arctoalpine plants, probably have their origins from similar Baikal area plant communities. The arctoalpine plants on the Ushkani Islands, if they migrated to the islands after the Pleistocene, probably came from either existing disjunct populations on shorelines or those of alpine areas, rather than more distant arctic areas. Areas to the south may be most important for wind dispersed steppe species, such as the of Olkhon Island steppes, and Popov (Попов 1957) discussed the probability that the Baikal steppe species may have migrated from the north (Yakutia), where there was a much greater distribution of steppe during the Pleistocene and early Holocene. Presumably, these steppe plants were first established on the nearby mainland, and then migrated to the Ushkaniis.

As the structure of the flora of the Ushkaniis in general resembles that of the mainland, it has probably evolved with that flora, and the source of the islands flora, as it exists at present, is probably from the nearby mainland. Since, as Galazii (Галазий 1988) shows, the climate has changed since the time of Bolshoi Ushkani's origin, it is very likely that the vegetation of the islands has changed likewise during the history of the islands. Galazii states that the climate of the region in the Tertiary Period was warmer than at present, and a forest type closer to the east Asian broad-

leaved forest predominated. If Bolshoi Ushkanii originated during the late Tertiary, a very different flora was probably first present on the island. During the Pleistocene, likewise, a more arctic flora may have predominated than on the mainland; Galazii reports that in the Pleistocene the climate of the Baikal region was somewhat colder, with considerably higher precipitation (especially as snow) than at present, and that the mainland vegetation was different in that it had a lower alpine treeline. Some of the plants common in the Pleistocene may have survived the ensuing warming trend and vegetation change, and survive to this day as part (or all) of the Ushkanii Islands' arctoalpine flora. Though impossible to ascertain, the islands may well have always supported a variety of "colder than mainland climate" plants, just as it does today, because of the limnoclimate. The Pleistocene also summoned the end of many warmer climate (broadleaved forest) plants which were common since the Tertiary, and it is therefore also likely that the islands may have lost many formerly common species (there are several areas near Baikal [e.g., the Khamar-Daban Range south of Baikal] which have a warmer microclimate and harbor populations of Tertiary relicts).

It may also be that part or all of the arctoalpine flora is of more recent arrival (or even continued immigration). The probability of this is increased by several conditions:

1. The close proximity of the islands to the shoreline (where some arctoalpines are found) and the nearby alpine areas of the Barguzin Range and Svyatoi Nos which allows a relatively easy crossing to the Ushkaniis.
2. The presence of arctoalpines on the Small Ushkaniis (which are considerably younger than Bolshoi Ushkanii).



3. The very tenacious and small presence of most arctoalpines on the Ushkaniis, which suggest that occasional stochastic events may be capable of extirpating the arctoalpine populations, which would then need to be reestablished.

If, as Kor (1995b) has suggested, Caribou Island is approximately 2000 years old, the vegetation would have had to have immigrated since that time. There was no great vegetation difference of the mainland areas at that time compared to now, as the arctic postglacial environments had already receded (Given and Soper 1981). There are fewer clues to the origin of the vegetation than at the Ushkaniis, but some clues are available. Morton and Venn (1996) show the currents of the east side of Lake Superior might favor water-carried propagules from the south shore, i.e., Whitefish Bay and Whitefish Point areas. Shoreline debris found in 1996, however, included a large proportion of twigs and branch tips of *Thuja occidentalis*, a tree much more common to shorelines along the east shores, the Pukaskwa Peninsula, and Michipicoten Island. This *may* indicate a significantly higher probability of propagules reaching Caribou from the east and northeastern areas, though *T. occidentalis* does occasionally occur near the south shore, and could also be carried from inland rivers. In addition, wind directions are frequently from the northwest or west at Caribou (Saulesleja 1986), and detritus rafted on the surface of Lake Superior by wind and currents might also come from those directions. There are few plants on the Caribous which have such a narrow distribution as to give evidence to their source. Several of the arctoalpines are found at disparate locations on Superior (Keweenaw Point, north shore, east shore, Michipicoten Island). The western disjuncts as described above (with the exception of *Amelanchier alnifolia*) have an even more general distribution in the northern Great Lakes region. The same is true of the more

southern species at Caribou. Thus, it is difficult to say for sure which area has been most important in supplying the first (and subsequent) plants to Caribou Island.

The Lake Superior shore is well known as a botanically interesting area, particularly in disjunct and relict plants (Soper 1963, Soper and Maycock 1963, Given and Soper 1981). The most well known are the arctoalpine plants disjunct at Superior, which often occur on the exposed rocky shorelines. Caribou Island has fewer such "unusual" plants than other areas of the lake, such as Isle Royale or Michipicoten Island, and the reason for this has been suggested by Morton and Venn (1996) as a combination of factors. First, the island is likely much younger than the other areas which are well-known for their arctoalpine plants. Kor (1995a) suggests the island is likely approximately 2 000 years old, while many of the rocky shores elsewhere on the lake have been ice-free and above the lake for much longer or have had a direct "migration" possible as shorelines receded. As a result, areas which were originally part of the much larger habitat of a postglacial arctic flora have since managed to retain some relics of this flora, due to microclimatic conditions (Given and Soper 1981). Caribou Island, on the other hand, emerged from the lake long after the flora of the region had changed from the arctic to one much more similar to that of the region today.

Therefore, Caribou Island was forming its early flora at the time when the postglacial tundra had already passed from the region, and there were few arctoalpine plants abundant enough in the region to colonize the new island. The variety of propagules reaching the island were (and are) much in favor of the "regular" flora rather than the "relict" flora. The second reason for the lack of rare plants is that the topography of Caribou Island is quite dissimilar to that of the areas of Lake Superior

noted for their arctoalpine plants (i.e., rocky). These rocky areas often have the suitable microclimates and are the main habitats of most of the arctoalpine plants at Lake Superior. It is in such inhospitable habitats that many other plants less able to withstand the lack of soil, colder summer temperatures, and extreme temperature and moisture conditions, that the remaining arctoalpine plants find their niche (Lindsay 1969). Any viable arctoalpine propagules reaching Caribou Island face the further obstacle of finding suitable habitat. With a mainly gently sloping sandy beach, areas immediately adjacent to the water, unlike in steeper rocky areas, are continually disturbed. Areas of the island farther, and safer, from the wave action are more easily vegetated with such "typical" beach and dune species as *Ammophila breviligulata*, *Cornus canadensis*, and *Linnaea borealis*.

### Vegetation Change

The islands in this study are exemplary areas for study of environmental change: concise, relatively free of disturbance, and with smaller floræ and faunæ than mainland areas. In addition to understanding the origins and present conditions of the vegetation on the Ushkanii and Caribou Islands, it is important to understand how this vegetation has changed and is changing according to natural and human factors. Such knowledge may aid in the conservation of the islands, and, in a broader context, add valuable data to the growing body of knowledge in conservation biology. In addition to the more recent changes (on a scale of years or decades), indicators on the islands from vegetation may be used to gauge environmental and climate change over a much larger time (from centuries to millennia), and how human activity contributes to this change.

### Human Influences on the Vegetation

Disturbance by man has caused a major change in the vegetation of Lighthouse Island, large areas of Bolshoi Ushkanii Island, and to a lesser extent on the other islands in this study. Human activity has impacted the vegetation on the Ushkanii Islands more than the Caribous, though probably the most severely influenced island in this study is Lighthouse Island. Changes to the vegetation of the Ushkanii Islands have been most intense in recent decades because of the fire, forest clearing, construction of the station facilities and lighthouses, and other influences of man. A more extensive investigation, such as review of original notes, older photographs, or herbarium specimens made prior to the human influence at Bolshoi Ushkanii Island might give important clues to the preexisting vegetation conditions—and by the same token additional data on the formation of the Ushkanii Islands flora. Such comparisons are not possible, however, at the Caribous, because of the lack of older data.

Judging by the distribution records of Sukachev and Lamakin (Сукачев и Ламакин 1952) and Ivanova (Иванова 1969) compared to my observation in 1995, several comments can be made regarding the changes in quality and extent of vegetation communities on the Ushkanii Islands. Because a full inventory of plant taxa was not undertaken during the field work, the exact nature of vegetation change cannot be discussed here at anything more than the community level, though the most intense vegetation changes—from fire and lake level rise—can be observed

### The Irkutsk GES and Baikal Water Level

Following the construction of the Irkutsk Hydroelectrical Station (GES) in the 1950s, Lake Baikal rose approximately 1 meter to a stable level of 456 meters above

sea level. The Ushkani Islands, with their shallow-grade shorelines in most areas, must have undergone significant change on such shores. For example, if the shoreline moved inland an average of just 15 meters around the perimeter of Bolshoi Ushkani Island, the island would have lost nearly 20 hectares of shoreline habitat in less than 2 decades. It is unlikely that the migration of species to the higher shorelines and their geomorphological development could have happened rapidly enough to avoid some vegetation changes. Ivanova (Иванова 1969) reports old, dried trunks of larch on the Small Ushkani shores, attributing them to raised water levels on Baikal, although I saw none in 1995. Other indications of shoreline change are supported by the fact that Ivanova's descriptions of shoreline communities, while matching approximately in composition to those I observed, did not always match in distribution (e.g., she notes that shoreline communities were least developed on the south shore of Bolshoi Ushkani, while I found several well-developed communities there).

Some plants may have become extirpated from the islands following the lake rise. *Betula divaricata*, for example, was noted in 1914 and 1952 (Сукачев и Ламакин 1952), but not subsequently. As its only known location on the islands was on the shoreline of Bolshoi Ushkani Island, the rise in lake levels may have had some influence on its disappearance. Since the floristic descriptions were less extensive for Sukachev and Lamakin than Ivanova, it is difficult to extrapolate further information which might show that a more extensive shoreline flora was affected at the Ushkaniis following the rise in lake level. Previous to the GES and lake level rise, however, the lake has undergone periodic temporal fluctuations in level; about 2 meters in the last century (Галазий 1988).

### Human Utility Activities

The clearing of forest areas near the ZNP station has created new openings in the forest suitable for invasion of species more suited to an open forest canopy, and the frequently disturbed ground gives opportunities for newly arrived species. These are primarily situated at the areas around the station, which have become inhabited with a variety of weedy species. In addition there are several introduced species also remaining near the northeast where there was a former human presence. Certain aggressive plants are likely to have become established with the help of human activity by transport of the seeds or other vegetative parts, while others might have come to Ushkanii via the more "natural" means of wind, water, or bird transport as the native flora.

One of the most visible influences on the vegetation of the Ushkanii Islands is from the human caused fires that have burned much of the island. It has changed the character of the forest on Bolshoi Ushkanii Island (and somewhat less dramatically on the Small Ushkaniis), and has possibly resulted in soil erosion and subsequent vegetation change, the loss of some species, and likely is responsible for a large poplar grove on Bolshoi Ushkanii. Fire may also have provided open habitat for some new species; the other major change to the vegetation of the islands in this study is the large proportion of "weedy" species in the human activity areas, such as the ranger station at Ushkanii Island and the Canadian Coast Guard facility on Lighthouse Island at the Caribous. The areas near the ZNP station (and to a lesser extent near Pescherka Bay) on Ushkanii Island also show definite signs of vegetation change from another no less severe form of vegetation change—forest clearing for habitation. Besides the fires and the disturbance near the ZNP station area on the southwest side,

there are few signs of human influence on the Ushkanii Islands. A foot trail circumnavigates the perimeter of the island, though it is an all areas very narrow and in many areas easy to lose. The remains of the old lighthouse still stand on the southeast side of the island, above the malyan. Old habitations referred to by previous authors were not relocated in 1995.

### Forest Cutting

Some areas of the forest of Bolshoi Ushkanii Island are used as sources of firewood by the ZNP and meteorological station staff. Areas of forest near the northeast and northwest of the ZNP ranger station have been cut for firewood, with larch being the preferred—or most frequently cut—wood. Though the areas are not yet extensive (approximately several hectares), regrowth does not equal cutting; and if it continues indefinitely, it could be a significant force upon the composition and ecology of the island's ecosystem (Figure 37).

### Introduced Plants

The human activity on Ushkanii Island has affected the immigration and establishment of some species, especially of the “weedy” species near the ranger station and the areas near Pescherka Bay. On the Caribou Islands, the main area of anthropogenic vegetation change is on Lighthouse Island, and other areas show very little lasting influence. On Lighthouse Island, the large number of non-native species, as well as r-selected species, indicate the disturbed nature of the site, due in large part to the human activity there.

There are 29 introduced plant species on the Ushkanii Islands according to



Figure 37. Forest Cutting on Bolshoi Ushkanii Island.

Ivanova (Иванова 1969). They are mainly aggressive r-selective annual "weeds" introduced by human activity—either intentional planting, accidental introduction, or by disturbance of the ground which allows such species conditions favorable to colonization and growth. Because of the small areas disturbed on the islands (other than by fire), they are a relatively small component of the islands' flora (though they comprise 10.5% of the flora of Bolshoi Ushkanii Island; 10.2% of the flora of the Ushkanii Islands). Their distribution is very closely related to human occupation or other activities, with the greatest number in the area around the ZNP station and near the northeast area of a former habitation. Because of their inability to successfully invade the other areas of the island (with the possible exception of the steppe areas),



they are of little ecological consequence. Ivanova notes that on the Small Ushkaniis where there has been no major disturbance, there were no introduced species found.

Introduced species are likewise a small but important component of the flora of the Caribou Islands, with a total of approximately 20 species of alien plants (7.7% of the flora). However, Lighthouse Island has 13 species, constituting a considerable 35% of its flora. Gull Island, by comparison, has 9 alien species (20%), still high, and indicative of its disturbed (by wave and bird action) state. Most all of these species have likely become established naturally on the islands, with the possible exception of some of the species on Lighthouse Island, which might have become established during lighthouse occupation or service. Alien species are widely distributed in the region, and could possibly have been spread through some mechanism related to the shipping traffic common near the Caribou Islands, such as drifting to the islands from a ship or port facility.

### Fire

On the Ushkaniis Islands, the frequent fires may hinder the persistence or immigration of some species, and it may enhance others. It is likely that certain species that are limited to a small area on the island might easily become extirpated, at least temporarily, if their habitats were destroyed by fire (as on Ushkaniis) or most individuals were killed. Likewise, other plants may find habitat following fire where it was formerly unsuitable for them.

Bolshoi Ushkaniis Island, as well as Kruglii and Dolgii have suffered the effects of fire in recent years. Bolshoi Ushkaniis Island is been reported to have burned in part or whole no less than four times in this century, and Galazii and Molozhnikov

(Галазий и Моложников 1982), using dendrochronology, have dated fires on Bolshoi Ushkanii Islands to 1812, 1857, 1907, and a particularly severe fire in 1937 which burned on all four islands. The 1937 fire is attributed to a particularly dry season, and burned all of Bolshoi Ushkanii with the possible exception of the extreme northwest tip. The years of the most recent fires are variously given as 1976 and 1979 (Иметхенов 1991), June 1977 (Литвинов 1982, Галазий и Моложников 1982), and approximately 1982 or 1983 (Alexander Timonin personal conversations June 1995).

Although fires have surely had an impact on the vegetation of the Ushkanii Islands, the plant communities delineated by Ivanova appear to be present today, with the exception of the addition of the poplar thicket, as described previously in this document. Signs of fire are evident in the forests of Bolshoi Ushkanii, particularly in the upper south slope pine forest and on the west side larch forest. The 1977 fire burned nearly the entire east half of Bolshoi Ushkanii Island (Галазий и Моложников 1982). Signs of fire are still quite obvious on several areas of the island, and the pine and larch forests of the southeast, southern, and central areas of Bolshoi Ushkanii Island currently (as of 1995) show the effects of a recent (1980s?) fire (Figure 38), while other areas of the island show less evidence of fires. The slowest recovery has been apparently on areas of the south slope above the maryan, where the burned wood still litters the ground, and herbaceous vegetation, young trees, and older tree canopy are thin. This may be due to the strength of the fire in this area, the difficulty of the vegetation to recover from fire because of the microenvironment, or both. In this area, the forest has the appearance of a very recent burn, with little ground cover compared to other areas. There appear to be fewer large

trees than reported by Sukachev and Lamakin and Ivanova; many of the larger, older trees were possibly killed during the fires, or perhaps by subsequent insect infestations. Further evidence of this lack of large trees is indicated by an extremely large, bottle-trunk larch pictured in Sukachev and Lamakin's (1952) article on the flora; I saw no such large trees on the islands in 1995.



Figure 38. Fire Traces in Larch Woods of South-Central Bolshoi Ushkanii Island.

Of the Small Ushkani Islands, it was reported to me that only Tonkii Island of the Ushkani Archipelago has not burned in recent memory (ZNP official; personal conversation July 1995); the last time was probably the 1937 fire there (Галазий и Моложников 1982). Though I did not visit Kruglii Island, signs of fire including older burned trees and robust even-aged tree regrowth could clearly be seen on Kruglii Island from Tonkii Island (Figure 39).

During the time that I was on Ushkani in 1995, a strong thunderstorm set a series of fires on the Svyatoi Nos Peninsula. It seems logical to assume that fire has been a periodic element of the ecology of the islands as well, though the increased fire on the Ushkaniis due to human error has obviously been more frequent than natu-



Figure 39. Signs of Fire on Kruglii Island.

ral causes in the past 100 years.

On Caribou Island the problem of fire has a completely different relevance than it does at Ushkanii. Caribou Island has no signs of fire in the recent past, and it is possible that there have been no major fires there in more than 100 years. Fires also enhance the suitability for some fire and disturbance dependent species such as *Populus tremuloides*, *Pinus banksiana*, and the moss *Funaria hygrometrica*. Of these, only *P. tremuloides* was found on the islands—and only a few, very small, very young specimens along the west shoreline. Another factor in the absence of *P. tremuloides* at the Caribous, as mentioned above, is the population of beavers on the island. Had fires burned on the island recently it might be expected that *P. tremuloides* would be found at least in the drier upland areas where beaver are unlikely, though I did not find it even there. The frequent fires of this century have in all likelihood extirpated species from the islands, although the determination of this was not undertaken in this study.

#### Natural Vegetation Change

Because of the human influence at the Ushkanii Islands, natural vegetation change is not evident, although some of the features such as new species which I found may indeed be evidence of “natural” vegetation change. At the Caribou Islands, there are some differences between the report of Morton and Venn's 1976 field study (published in 1996), the findings of White (1995), and My 1996 observations which may indicate vegetation change. Since there has been no large-scale human influence at Caribou and Gull Islands, these changes, if they have occurred, may be due to natural causes. Morton and Venn mention several features which were appar-

ently obvious at the time, but which I could not find in 1996. These include the presence of small white pine, *Pinus strobus*, trees in areas of the forest edge at the back of dunes and Labrador tea, *Ledum groenlandicum*, as a "conspicuous feature" in the west side dune-forest transition. Other reported distributions of Morton and Venn were different from those I encountered: bird's eye primrose, *Primula mistassinica*, at the northern shores only (but not along the southwest, where I found it common), and marsh wild pea, *Lathyrus palustris*, for Gull Island (I found it only along the southwest marshy shore; white did not note it at all). Morton and Venn do not report heart-leaved twayblade, *Listera cordata*, although White does, and I found it to be fairly common on the dune-forest edge and in scattered locales in the boreal forest. It is possible that this plant is rather newly established on the island, although the microscopic seeds are so easily disseminated by wind that this seems unlikely.

Likewise, balsam poplar, *Populus balsamifera*, was found on Caribou Island according to Morton and Venn (1996) as "a few stunted trees at the north end of the island". In 1996 I found that the *P. balsamifera* of Caribou were indeed at the north end of the island, but appeared quite healthy, forming a small thicket approximately 3 meters tall. Perhaps Morton and Venn's observations were made when these trees were newly established on the island (at least in that site), and they have strengthened their establishment in the ensuing 20 years. Whether this thicket will become a larger shoreline forest remains to be seen.

Some plants which only later workers found at the Caribous (especially on the Caribou Islands, due to their smaller history of botanical studies) are possibly due to more extensive searches rather than a new presence, e.g., *Listera cordata*, *Botrychium*

*lunaria*, *Onoclea sensibilis*, *Vaccinium macrocarpon*, *Claytonia caroliniana*. As discussed elsewhere in this thesis, the presence of *Symplocarpus foetidus* on the island has been reported only during 1979, and searches after have not located this species. Although it may have never existed there, it might also have become extirpated, or, conversely, still exists in such hidden or minor distribution as to have been repeatedly overlooked.

On a larger time scale, there is also some evidence of vegetation change on Caribou Island. Most visible are the "vanishing species" of Caribou: white cedar (*Thuja occidentalis*) and white pine (*Pinus strobus*). *T. occidentalis* may indicate a change in hydrology associated with the westward "expansion" of the island. To speculate, it is possible that when the island was smaller—for instance half of its present size—the area where the *T. occidentalis* trees are now might have nearer to the east shore. As the island's shore moved further away the drainage was impeded, and the large peatlands began to form, making the ground water more acidic. High acidity is not tolerated by *T. occidentalis* (Crum and Planisek 1988), and their extent and health are therefore minimal. It might provide an interesting clue to this mystery if dendrochronology testing were to be done on these trees to find their age—and determine if their growth rate has changed.

*Pinus strobus* is another tree which must have had a greater vitality on Caribou Island in times past. The wide distance between trees, as well as their great size (and apparent old age) indicate that they might be the last holdouts of a once larger population, perhaps when the islands were warmer and drier.

## Noteworthy Plants

There are a number of plants present on the islands which are rare or disjunct at areas of the nearby mainland, and are therefore useful as ecological and phytogeographical indicators. They may be placed into several arbitrary groups including: (a) endemic (at Ushkanii), (b) arctoalpine (at both Ushkanii and Caribou), (c) steppe (at Ushkanii), (d) southern (at Caribou), (e) western (at Caribou), and (f) eastern (at Caribou). A listing of these plants is given in appendix B.

### Endemic

Genetic drift and adaptation are one of the key reasons for endemic species evolution on oceanic islands (Darwin 1859 and 1859, Mac Arthur and Wilson 1967, Carlquist 1974). Lake islands such as Ushkanii and Caribou, however, are much younger than most oceanic islands, and generally younger than necessary for the evolutionary divergence leading to endemic species. This begs the question: to what extent does genetic drift play a role in the populations on Ushkanii and Caribou Islands?

The Ushkanii Islands show a definite, if small, degree of endemism (Иванова 1969, Сукачев и Ламакин 1952), unlike the Caribous; this is likely due to the relative age differences of the two. The wide-bottomed "bottleform" larch trunks, the black-barked birch (*Betula pendula*), and the acuminate leaved poplar are examples, most likely, of short evolutionary selections to conditions on the Ushkaniis. It is interesting that in addition to the terrestrial endemics at the Ushkanii Islands, there are several endemic aquatic species of fish and invertebrates which are restricted to the waters around the islands (Ламакин 1952).



The larch has been explained as a possible adaptation to withstand the frequent high winds sustained on the islands; trees with a broader base have been historically better able to survive such winds, and, therefore, influence the genetic pool of trees (see Figure 10 for a photograph of larch woods on Bolshoi Ushkanii Island showing a bottleform trunk). Indeed, the existence of *Larix x czekanowskii* on the islands, midway between the primary ranges of the parent species (*L. sibirica* and *L. gmelinii*), is a semi-endemic hybrid in itself. *L. x czekanowskii* also occurs along the shoreline areas of northern Baikal and occasionally in the Dahurian Mountains to the southeast of Baikal (Мальшев и Пешкова 1979). The species has been proposed as an endemic on the Ushkaniis, *L. ushkanensis* because of its unusual form (Попов и Бусик 1966).

The form of *Betula pendula* on the islands is another interesting semi endemic—or possibly endemic—species on the Ushkaniis. In addition to its much darker bark, the leaves of this species on the islands have a much deeper, sharper serrated margin on the leaves compared to the mainland form. The form has been proposed as a separate species, *B. uschkanensis* or *B. insularis*. In fact, Czerepanov lists *B. insularis* as the legitimate name of this species, as do Malyshev and Peshkova in *Flora of Central Siberia* (Мальшев и Пешкова 1979), who give its distribution as Bolshoi Ushkanii Island (with no mention of the Small Ushkaniis) and the Baikal Mountain Range (apparently at the upper limit of treeline there, which raises interesting questions on the status of this species as an arctoalpine plant). I was unable to find subsequent documentation, however, on its validity. Furthermore, the revision of the genus *Betula* in *Flora of Siberia* (Флора Сибири) has greatly reduced the number of

accepted species in the region. Therefore, I have opted to use the more conservative *B. pendula*, although the endemic species name may well prove to be the most appropriate.

*Geranium pseudosibiricum* has been named by Popov (Попов 1956) as an individual species (*G. uschkanense* M. Pop.; *G. coeruleum* v. *uschkanense* M. pop.) owing to its overall smaller size and longer peduncles and pedicels, though later authors appear to have ignored this name, and I have seen no further reference to it.

A fourth possible example of endemism on the Ushkaniis is the case of *Populus tremula*. This tree on the islands also has an unusual and characteristic leaf, though endemism, if it is occurring, is probably at an earlier stage than in the preceding species. The leaves of *P. tremula* on the islands are more acuminate at the tips than those of the species elsewhere. The tree has been proposed as an endemic form, *P. tremula* f. *uczkanensis*.

Regionally endemic species are present around both Lake Superior and Lake Baikal, however they have not been found on the Caribou Islands. On the Ushkani Islands, however, a number of regional endemics have been documented, and the most noteworthy of these is probably *Cotoneaster tjuliniae*. The species has been described as a new species from the rocky steppe slopes of Bolshoi Ushkani Island, and has also been found at several other areas on the northern shores of Baikal. *C. tjuliniae* was named in 1978, and so was not discussed in Ivanova's report. It is likely that she collected the plant as *C. uniflorus*, which it resembles with the distinction of its larger size and bluish-gray layering on the mature fruit (Флора Сибири 1988). No herbarium records were consulted in the present study, and so it remains

unclear whether both of these species exist on Ushkanii Island.

*Deschampsia turczaninowii* is another good example of a Baikal endemic plant which also occurs on Ushkanii. The distribution of this species, which is described as “on sands and gravels of the shores of Baikal” (Мальшиев и Пешкова 1990) is restricted only to the Baikal shores. On Bolshoi Ushkanii Island it has been reported from gravel beaches along waterline (Иванова 1969).

In addition to the terrestrial endemics present at the Ushkaniis, it is interesting to note that there are a number of aquatic endemic taxa of fish and invertebrates which are restricted to the waters around the Ushkanii Islands (Ламакин 1952).

### Arctoalpine

The arctoalpine (also known as arctic-alpine) plants are perhaps the most indicative—and interesting—phytogeographic feature of the islands in this study. Previous work on shoreline area vegetation at Lake Superior has often focused on arctoalpine plants, and they draw significant interest at Baikal as well. The areas around Lake Baikal and Lake Superior have different factors which might affect the immigration and persistence of arctoalpines, such as glacial and postglacial history, proximity to mountain and arctic areas, climate and limnoclimate, shoreline area landscape, topography, soils (or lack thereof), and geology.

The strongest factor in the persistence or occasionally immigration of arctoalpines is a suitable microenvironment where they have an advantage over other plants, while the most significant factor in the origin of arctoalpines is probably the glacial histories and proximity of mountain and arctic habitats to the lakes. Authors such as Given and Soper (1981), Lindsay (1969), and Popov (1957a), and others have noted

that unusual plants—arctoalpines, southern disjuncts, and others apparently dependent on peculiarities of microclimate—are very often found only near the shorelines. It is particularly striking on the islands in this study that all of the arctoalpine species listed for the Ushkanii Islands, and most for the Caribous are reported to the islands only from near the shorelines.

The Lake Superior region was covered by continental ice as recently as 8000 years ago (Dorr and Eschman 1970), and arctoalpine habitats were common in the area much later than this. At Lake Baikal there were no continental glaciations during the Pleistocene, but there were a number of alpine glacial advances from the mountains near Baikal (Галазий 1988), and tundra plants were doubtless found at lower elevations than at present. Another factor at Baikal is the fact that it is surrounded largely by mountains. These alpine areas are quite close, and can easily be modern sources of arctoalpine species, including those suitable to the cold shores of Baikal, and which may find interim habitat on other Baikal shores. Therefore, arctoalpines at the Ushkanii Islands may be relics of a colder climate at the islands, or more recent immigrants from other areas of the lake such as shorelines or alpine areas. It is probable that a combination of both are responsible.

A major question of arctoalpine relics is how long they survive, and what demographic problems they may encounter in the period between their establishment, abundance, and eventual extirpation (see Fernald 1935, Given and Soper 1981, and Lindsay 1969). Following the postglacial tundra environment, populations of arctoalpine plants were gradually replaced by those more suited to the increasingly warmer environment as the regional warmed. It is clear, however, that this did not occur at an identical rate among all taxa, as evidenced by the presence of arctoalpine

species to this day at both regions. The persistence of arctoalpine plants is a consequence of tolerance, adaptation, and, perhaps, precarious survival (and the harsh environments of the Baikal and Superior shorelines are not well suited to many plants). More specifically, plants may be best suited to an environment which has different temperature regimes, but persist in other areas because competition is low enough or there are suitable microenvironments in which they may find refuge to assure continued survival, or they may adapt either morphologically or physiologically to changing conditions. Plants disjunct at Lake Superior and Baikal are likely result of this last variant.

Plants such as *Vaccinium vitus-idaea* (lingonberry), *Pinguicula vulgaris* (butterwort), and *Empetrum nigrum* (black crowberry) are somewhat common arctoalpine plants along the shores of Lake Superior, and represent apparently a diminished though somewhat stable presence of their former populations in the area during the time of postglacial tundra and forest-tundra. Other more rare species, such as those mentioned by Wells and Thompson (1974) for the Keweenaw Peninsula and Given and Soper (1981) for the Lake Superior region in general, occupy only a few sites, and are likely to be tenaciously surviving in the region, and may be particularly susceptible to stochastic events.

Some arctoalpine species, however, are not relicts, but immigrants. The proximity of source regions is important to understanding their histories, and this is likely a much more important factor at Baikal than Superior in the post-Pleistocene period. All plants, including the arctoalpines, on the islands in this study are necessarily immigrants (since the islands have never been connected to their mainlands), and so provide examples of successful immigration to non-arctic or alpine areas.

This supplements the conventional "postglacial refugia" theory (which emphasizes persistence over immigration of arctoalpine flora), commonly accepted for the Lake Superior region (for a discussion of this see Fernald 1935, Given and Soper 1981, and Soper and Maycock 1963).

At Lake Superior, arctoalpines are believed to be largely the postglacial relicts (Given and Soper 1981). They are thought to have survived in isolated areas where the microclimate has been suitable since the Pleistocene for survival against more recent immigrants (Given and Soper 1981). Although the arctoalpines on Caribou Island are relatively few, they provide evidence that postglacial immigration is possible and does occur. In the case of *Rubus chamaemorus*, immigration was likely from a distant population. In the case of *Empetrum nigrum*, *Sagina nodosa*, *Leymus mollis*, *Calamagrostis stricta*, and *Festuca brachyphylla*, it is probable that initial propagules have come from populations of these plants along the east or other close shores.

Several arctoalpine plants are known from the Ushkani Islands. These plants are probably more easily able to establish themselves near the shores of Baikal than at Superior, since the lake is surrounded primarily by mountains and, therefore, a potential source of arctoalpines is very close. It is likely that an even closer source of arctoalpines is the alpine areas of the Svyatoi Nos Peninsula (with large areas of alpine and subalpine habitat), just a dozen or so miles east of the Ushkaniis. The highest mountains (and the largest areas of alpine and subalpine habitat) of the Baikal region are just slightly farther away, in the Barguzin Zapovednik to the northeast of the Ushkaniis. The rocky topography of the Ushkaniis also bears a close resemblance to the alpine areas.

Molozhnikov (Моложников 1969) discussed the occurrence of *Pinus pumila*,

a mountain species, on the Barguzin Range and its secondary distribution near the shorelines of Baikal. This shrubby pine also occurs occasionally along the shores on the Ushkani Islands. Sukachev and Lamakin found *Pachypleurum alpinum*, an alpine slope and meadow plant in the region, on the west shoreline at water edge (Сукачев и Ламакин 1952), though it has not been reported since to the Ushkani Islands. Two arctic species of birch, *Betula divaricata*, and *B. rotundifolia*, have been found on the northern shores of the Ushkaniis, and other arctic shrubs (*Salix divaricata*, *Sorbaria pallasii*) and herbaceous plants (*Polemonium pseudopulchellum* and *Chamenerium latifolium*) have also been found at the islands.

There are fewer arctoalpine plants at Caribou than at Ushkani. It appears that the climate on Caribou Island is suitable, however, for the variety of arctoalpines found elsewhere on Lake Superior. Caribou Island does have a few arctoalpines, including *Leymus mollis*, a nominally arctoalpine grass species which is found on dunes of the island. White (1995) found a small population of *Sagina nodosa*, knotty pearlwort, on the cobbly shore near the southwest end of the island. Perhaps most interesting, however, is the occurrence of cloudberry, *Rubus chamaemorus*, at an isolated site near the south center of the large western bog on Caribou Island. According to Soper and Heimbürger (1982), this is the farthest south occurrence of this plant in the region; it is known to occur slightly farther south only in the mountains of New England. *R. chamaemorus* is known in the region only from the north shore of Lake Superior, and at it closest is about 150 kilometers northwest of Caribou Island, near Pays Plat, near Neys Provincial Park, Ontario (Soper and Heimbürger 1982). It seems a perfectly safe example of island biogeography: a bird, migrating south in the autumn

eats the flavorful fruit of cloudberry perhaps 100 or more kilometers north of Caribou Island. Flying over the expanse of Lake Superior, he finds Caribou Island to be a convenient "rest area", and lands on the shrubby bog. Leaving the seeds there, he continues south. In the spring of the next year one or more of the seeds successfully germinate, find the bog habitat and microclimate suitable, and the plant is established

Arctoalpine plants of the Caribou Islands are found in other locations elsewhere at Lake Superior in several key areas, including the Keweenaw Peninsula, Isle Royale, the Lake Superior Provincial Park shoreline, the northern shorelines and islands, and several other concentrations (Given and Soper 1981). Other arctoalpines have somewhat closer locations. *Empetrum nigrum*, for instance, is found as far south in the area as Summerby Swamp, in the Upper Peninsula of Michigan, as well as at several locations along the south shore of Lake Superior and, more frequently, along the north shore (Barclay-Estrup and Nuttall 1974, Soper and Voss 1964). This bird-dispersed species, then, has a rather large surrounding area from which to be transported. *Leymus mollis* has a similar distribution area in the Lake Superior region (Guire and Voss 1963), though it is a wind-dispersed species.

### Steppe

While the limnoclimate of the islands is responsible in large part for the conditions suitable for arctoalpine and other northern species, it is also responsible in some aspects for a warmer or more xeric climate which facilitates the growth of plants normal to more southern regions. These are manifested in two main varieties; the steppe plants at Ushkanii and several southern species at Caribou.

Steppe species on the Ushkanii Islands are, like those of Olkhon Island, a



prominent botanical feature and, to a large degree, a result of the influence of Baikal on climate (Иванова 1969, Пешкова 1972). Although the steppe areas of the Ushkani Islands represent some of the northernmost steppe areas in the world, the long northern summer days, combined with the usually cloudless sky over Baikal during summer, combine to create a very hot, very xeric microclimate on the south slopes of the Ushkaniis. This is a similar response as that of Olkhon Island and the islands of the Maloye More Strait, with the exception that there is not as strong a rain shadow at Ushkani as there is near the Maloye More (Скрябин 1987). The distribution of steppe plants on Bolshoi Ushkani Island corresponds with the suitable climatic conditions mapped by Vuikhristyuk (Вухристюк 1980) and others. For example, higher summer temperatures and a longer growing season, lower humidity, shallower snow cover in winter, and higher soil temperatures in summer can be clearly seen in Vuikhristyuk's maps coinciding with the steppe areas on Ushkani. Additionally, the slope aspect and angle of the south slope allows a greater insolation amount. Steppe fragments along the west and east sides have a somewhat less "typically" steppe microclimate, although the lack of deep snow cover in winter may enhance the desiccation of plants other than the hemicryptophytes typical of the steppe communities.

The steppe communities of the Ushkani Islands have a similar, though smaller flora than that of the Olkhon Island steppes and those of the islands of the Maloye More Strait (Скрябин 1984, Пешкова 1972). These plants are most common on the steppe areas of the island, such as the malyan of the south slope and the northeast slope of Bolshoi Ushkani Island and the south rocky slopes of all the islands in the group, though many occur to varying degrees elsewhere on the islands. Likewise, many of the species are also found in other xeric habitats such as in the mountain

slopes, cliffs, and talus slopes of the areas near Baikal.

### Southern

There are at the Caribou Islands several plants which have normally a much more southern distribution. The most noteworthy example of a southern disjunct is *Thalictrum revolutum*, skunk meadow-rue, which grows very locally near the north end of the island, in the low grassy bay south of Gull Island. Elsewhere in Ontario it is known only from the southern part of the province. This plant has its closest stations to Caribou Island in two counties of the Upper Peninsula of Michigan and two in the lower southeast of the state (Voss 1985). In Ontario it is likewise rare, and restricted to only several sites in southernmost Ontario (Argus and White 1983), in addition to its station on Caribou Island. Argus and White (1983) also show two locations on the Bruce Peninsula, but Morton and Venn (1984) refer them to *T. dasycarpum*. I examined specimens of *Thalictrum* on Caribou Island, and found them to key properly to *T. revolutum* using Fasset (1976) and Gleason and Cronquist (1991). On Caribou Island it grows on the west side, near the north tip of the island and on Gull Island, never further than several meters from the water's edge. This is an area where it might be expected that winds coming from the northwest and north, as is often the case during the winter, after traveling long distance over the open lake water would have a warming influence on the microclimate of the island. However, there is also probably a lower snow cover than inland areas of the island as well, and other aspects of the microclimate which might indicate a rather harsher environment compared to its southern areas.

In addition to the above species, several less extraordinary, though still note-

worthy species occur which are near their northern limit at Caribou. They include *Claytonia caroliniana* (spring beauty), *Symplocarpus foetidus* (skunk cabbage), and *Acer rubrum* (red maple). *Claytonia caroliniana* and *Symplocarpus foetidus* are generally more southern plants and uncommon in the region, but find suitable habitat occasionally in the region, particularly in deciduous forest areas. *C. caroliniana* is common in the deciduous forests of the eastern United States, and finds suitable habitat in deciduous forests in areas close by on the mainland, as on Caribou Island, where it is restricted to the small area of deciduous forest on the southwest corner of the island. *S. foetidus* is of dubious presence on Caribou Island, but also occurs in other areas of the region, such as on the mainland in Lake Superior Provincial Park (Brunton 1991), Montreal Island (Carol Dersch; personal communication May 1996), and on Michipicoten Island (Noble 1984). On Caribou it has been reported from the alder thicket between the southwest deciduous forest areas. These two early spring species both grow on Caribou in the only significant areas of deciduous tree cover, other than the small area of Gull Island. *Acer rubrum* is found on nearby mainland areas where a suitably warm microclimate exists, though it is generally an eastern deciduous forest species and much more common south of the Caribou Islands.

### Western

Several species of western affiliation are found disjunct in the upper Great Lakes region, and three of them, *Rubus parviflorus* (thimbleberry), *Vaccinium membranaceum* (mountain bilberry), and *V. ovalifolium* (tall bilberry), occur at the Caribou Islands. Such species often have a Cordilleran-Black Hills-upper Great Lakes affiliation (Fernald 1935, Guire and Voss 1963). Species of this affiliation have had

a variety of hypotheses forwarded for their origin (see Fernald 1935, Butters and Abbe 1953, and Marquis and Voss 1981). Their rather widespread distribution in the region indicates their ability to survive well in the environments of the upper Great Lakes despite their absence in the lands between the region and the Black Hills and the Cordillera, and beyond the Great Lakes.

The two species of *Vaccinium* are distributed in the boreal interior forest of Caribou Island, which is similar to their typical distribution on the mainland areas of the region. *Rubus parviflorus* is found only on Lighthouse Island. It is possible that it was planted there by former lighthouse keepers, or may have been bird-transported there.

A fourth western species, *Amelanchier alnifolia* (Saskatoon-berry) is a western species with a wide range through the prairies, but is at or near its eastern limit at Caribou. It is described as ranging from "western Cordillera and northern Great Plains ...with reputedly outlying stations in Ontario and even (western) Québec" (Gleason and Cronquist 1991, 269). According to Marie-Victorin (1995), the species is indeed known rarely from Québec, and, according to Soper and Heimbürger (1982), there are no localities further east in Ontario than the southeast side of Lake Superior. Noble (1984) reports it from Michipicoten Island, and Morton and Venn (1984) report it to Manitoulin Island. Soper, Garton, and Given (1989) report it to be found along the northern shoreline areas of Superior in meadows, waste places, and forests save for the central area approximately from the Slate Islands to Michipicoten Island. Voss (1985) and Soper and Heimbürger (1982) discuss the possible confusion of this species with other more eastern species of *Amelanchier*.

## Eastern

*Potamogeton confervoides* (algal-leaved pondweed) is a rare plant of aquatic habitats found in scattered locations in the Upper Peninsula of Michigan, the Michipicoten area of Ontario, east of Georgian Bay, and generally further eastward, with its main range along the Atlantic coast from Delaware to Newfoundland. It also grows disjunct on Caribou Island, in the waters of Deer Lake, on the east central side of the island.

## Plants Common in the Regions but Absent on the Islands

There are some plants which are *not* found on the islands in this study which are otherwise common in their regions, and would be expected. Indicator plants and their distribution on the islands give interesting clues to the origin and ecology of the islands, but the absence of certain species can also be used to similar effect. Although the reasons for such plants being absent surely vary, they do indicate at least some qualities missing from the environments of the islands which are otherwise present, and the tendency for islands to have such species.

Bracken fern (*Pteridium aquilinum*) is common around Lake Baikal, but it has not been found on any of the Ushkani Islands. This seems unusual, since the dry soil, open pinelands, and burned areas would otherwise seem ideal for bracken in the Baikal region. In *Flora of Siberia* (Флора Сибири), this fern is shown to be common to the area with the exception of west central and northwestern Baikal, though it is common on the eastern areas opposite the Ushkaniis. I have seen *P. aquilinum* many times on the Baikal mainland in situations similar to the forests of the Ushkani

Islands. In the Barguzin Zapovednik, for example, it is common; in dry pine and larch woods; in mountain forests, and on the shores of Baikal (Тройцкая и Федорова 1989). Sukachev and Lamakin (Сукачев и Ламакин 1952) noted the conspicuous absence on the Ushkaniis of *Padus avium* (of the family Rosaceae), which is a common shrub of the Pribaikal taiga, and found in the forest on the northwest and northeast sides of Baikal. In the Barguzin Zapovednik it grows along rivers, in forests, and on the shores of Baikal (Тройцкая и Федорова 1989).

Several plants have not been found on Caribou Island which might otherwise be expected there. The sandy shores bordering most of the island provide a habitat which is similar in many ways to that of nearby areas of the mainland, such as that due south in Luce and Chippewa Counties, along the eastern shore near Batchawana Bay, or in Lake Superior Provincial Park. In these mainland areas several plants are common which are conspicuously absent at Caribou.

Trembling aspen (*Populus tremuloides*), while common nearly everywhere in the Lake Superior region, is absent from Caribou Island save for a few small, obviously young specimens found along the west shore. This is likely a result of several causes, including the fact that there has been no large fire in the recent past and possibly that the large population of beavers keep any trees effectively "mowed" before they can establish a viable population.

Curiously, white pine, *Pinus strobus*, was seen only in three examples on the entire area of Caribou Island, and this raises interesting questions. The trees were found at separate sites, all on the east interior of the island. All trees are large, old, and tall. They all occur on well drained sand at the edge of wetlands. No seedlings were found under the trees, despite searching, and no dead trees or old logs, stumps,

etc. were seen which could have been white pine. This indicates that there was not logging of large white pines on the island, as white pine stumps are quite resilient in other nearby areas where logging has taken place in the last 100 years or so. It is possible that these white pines are remnants from a formerly more extensive occurrence of the tree on the island, which changed because of changing climatic, hydrologic, or vegetative conditions. Although the island is not large, it appears that there is habitat suitable for more pine trees on the island. Morton and Venn (1996, pp 10 and 19) reported white pine "scattered, often stunted... (in) the edge of the forest behind the dunes" and "a few stunted trees on the dunes on the east side of the island", though repeated searchings of all backdunes and forest edges revealed no white pines of any size in these areas. Could an especially harsh season or insect damage be the result? This could also account for the absence of small white pines near the large trees seen during 1996.

Morton and Venn (1996) noted the distinct lack of some of the typical sandy shore species on the island, such as *Cakile edentula* (sea-rocket) and the weedy *Corispermum hyssopifolium* (bugseed), although these species are not recorded for Lake Superior Provincial Park (Brunton 1991) or Michipicoten Island (Noble 1984). Guire and Voss (1963) show the range of *Cakile edentula* as mainly in the lower Great Lakes, where it is a common wave and wind-transported shoreline feature. However, *Arabis lyrata* (lyre-leaved rock -cress), a wind and water-dispersed species common to shorelines of the Great Lakes, does occur in LSPP (Brunton 1991), Isle Royale (Voss 1985), and on Michipicoten Island (Noble 1984), but not on Caribou Island.

Several plants which are not necessarily "conspicuous" in their absence at the

Caribous nonetheless may be used for some indication of the island's conditions. Example can be drawn from *Acer rubrum*, which, while found in several small trees along the west shore, does not have a large presence on the island, although it is rather common along the east shore of Lake Superior. This is probably because of a colder climate on Caribou, as well as possibly a poorer soil. Also, jack pine (*Pinus banksiana*) might be expected on some of the dune areas or interior boreal forest. The lack of any large disturbance such as fire in recent history may be also a factor in the lack of jack pine on the island.

#### Protected Plants

Several species of plants occur on the Ushkani Islands which are protected under various oblast (Buryat Republic), republican (Russia), and (formerly) federal (Soviet) statutes (Попов 1990). When applicable, such plants were listed in the Red Data Books (which contain a listing of endangered species and their critical data) for their political unit, according to IUCN Red Book guidelines (Попов 1990, Walter and Gillet 1998).

Several plants on the list, however, such as *Rhododendron dahuricum*, are not strictly rare at the Ushkaniis or many other areas of Baikal to which I have been. These are included, for example, in a status similar to that of Michigan wild plants such as *Trillium*, which are, although more common than many unlisted species, quite visible when a component of the vegetation landscape, and therefore also easily noticed when disturbed. Such species can be termed "charismatic" endangered species—highly visible and popular to the public, and serving to educate people on the dang-



ers facing many other species.

Endemic species on the Ushkanii Islands (such as *Betula insularis*, *Populus tremula* f. *uczkanensis*, *Cotoneaster tjuliniae*, or *Larix ushkanensis*), if validated as such, should immediately be included in the Russian and Buryat Red Books as well. Owing to their unusual forms they might be nonetheless justifiably included on at least locally protected lists, even if they are not considered as endemic species.

There are only two species (*Potamogeton confervoides* and *Thalictrum revolutum*) on the Caribou Islands which are officially protected in Ontario. In addition, White (1995) suggests that the occurrence of *Lathyrus palustris* is also noteworthy for the region because of its relative infrequency in the region. Several plants of Caribou Island would be more noteworthy, however, if the island was situated just a little farther south—or if the US Border were just a little further north. Brown (1982) originally made this point; it is worthy of reiteration here: several plants would surely be included on the list of those protected in Michigan, including *Sagina nodosa*, *Calamagrostis stricta*, and *Empetrum nigrum* (Anonymous 1992). One would probably be added, in the case of *Rubus chamaemorus* (which has not yet been recorded in Michigan).

#### Plants Common to Both Sites

There are a number of taxa which grow at each site, and an examination of these plants may give data useful to comparison of the environments of the islands. There are significant difficulties associated with attempting to ascribe common designations to plants on opposite sides of the earth (or even closer). As Hultén (1958.

1964, 1971) has shown, plants considered a single species may have quite different climatic and other physiographic preferences and tolerances, as evidenced by their ranges in different areas. Classifications into groups such as arctoalpine, steppe, and so forth are of course arbitrary and imperfect, and often are not consistent from area to area. Other plants may be considered as fitting into a “significance” status at Superior but not at Baikal, or vice versa. White (1995), for example, considers *Lathyrus palustris* to be “regionally significant”, while at Baikal it is more common. This suggests that, although plants may share a common species designation, they are often quite plastic in their physiology and other aspects, and their optimum niche at one region may not be identical at another. Some plants which occur at both Ushkanii and Caribou have similar habitats (e.g., *Poa palustris*, *Linnaea borealis*). Others have different habitats on each (*Rosa acicularis*). Though difficult to quantify, many ecologically (and taxonomically?) analogous species are found between the sites<sup>1</sup>, for example, the grasses *Calamagrostis canadensis* at Caribou and *C. langsdorffii* at Ushkanii. Indicative of the imperfect state of circumboreal nomenclatural consensus, at least one plant common to both sites, Marsh cinquefoil; *Potentilla palustris* (as it is known in North America) is also known “officially” by another name in Siberia: *Comarum palustre*, although they are considered one circumboreal species (Hulten 1971, Czerepanov 1995, Gleason and Gronquist 1991), albeit with a variable name. Additional information on these examples can be found throughout the conspectus section of this thesis.

---

<sup>1</sup> Although it was a floristic comparison of the north shore of Lake Superior with the Alps, Agassiz's (1850) report on the comparison and analogs of these two floræ is a significant attempt at this difficult process.

### Plants Considered Unusual at Only One Site

The arctoalpine plants of the Lake Superior region as commonly defined (e.g., Given and Soper 1981) include such species as *Primula mistassinica* and *Leymus mollis*. These species, although they may have their central or main distributions in the Arctic, are more widespread than strictly arctic species. Another example is *Potentilla multifida*, which is considered an arctoalpine disjunct at Superior (Given and Soper 1981), and would surely be recognized as significant at Caribou. In Asia, however, it is much more common, and even weedy. Its range there extends from the Arctic to Central Asia and southern China, including the Ushkani Islands and Baikal (Hultén 1962). *Vaccinium vitus-idaea* has a similar status at the lakes, and is one of the “celebrated” arctoalpines at Lake Superior. It would be significant at Caribou Island, though common at Baikal. Spiny-spored quillwort, *Isoetes echinospora*, is, conversely, much more common to northeastern North America, including on Caribou Island. It is, however, rare and disjunct in Asia, including only a few locations at northern Lake Baikal and the nearby mainland areas (Мальшев и Пешкова 1979, Hultén 1958).

### Similarities to Other Large Lake Islands

Although the vegetation of the Ushkani and Caribou Islands have a number of similarities, they also share similarities with other large lake islands. Islands in the upper Great Lakes and Baikal make a reasonable comparison because of the size and climate similarities between the lakes (as opposed to smaller lakes or large southern lakes).

Most such islands examined in previous studies have been found to have flora sizes related to their area and distance from mainland, such as the islands in northern Lake Michigan studied by Hazlett (1988), or those of the Maloye Morye Strait (Скрябин 1987). As referenced previously, Figure 34 shows the relationship between island size and number of species recorded for a variety of Great Lakes and Lake Baikal islands.

Other lake islands also have populations of rare plants, such as arctoalpines, regional endemics, and disjuncts. Isle Royale in Lake Superior is probably the most cited example of this in the Great Lakes (Slavick and Janke 1987). Other Lake Superior Islands including Michipicoten (Given and Soper 1981, Noble 1984), the Slate Islands (Given and Soper 1981), the Apostle Islands (Judziewicz and Koch 1993), Manitou Island (Thompson and Wells 1974), Grand Island (author's observations), and the Sandy Islands (Crins 1996). Other northern Great Lakes Islands also have significant species, including Beaver Island (author's observations), islands of northwest Lake Michigan (Forzley, Grudzien, and Wells 1993), the Fox Islands (Hazlett 1993), and Manitoulin Island (Morton and Venn 1984). In Baikal other islands have found to have arctoalpine and steppe species, including the islands of the Maloye Morye Strait (Скрябин 1987), Chivirkuisky Bay (Попов 1990), and Olkhon Island (numerous authors). In many cases the unusual species on these lake islands are frequently distributed close to the shorelines, as they are on the Ushkaniis and Caribou Island.

## CONSERVATION

Step more lightly knowing these are underfoot, making a soil which accumulates only fractions of inches in hundreds of years. And wonder at the wisdom of trampling remaining woods even for education, or of paving and building that promise towns in this solitude. How is it to be shared without destroying?

–Torkel Korling (1973, 46)

The Ushkanii and Caribou Islands have had markedly different human histories, which has affected their management, conservation, and human influence. In some ways, this has led to both the protection and the degradation of different aspects of the natural environment at both sites. Often, where there has been a positive situation at one site, the opposite is the case at the other. For example, the Ushkanii Islands have long had official designation as a protected area, while the Caribous have no such protective status. Conversely, the Ushkanii Islands have had considerable human impact, while the Caribous have had very little. These and other situations are important to the vegetation, ecology, and future state of the islands, and each site has conditions which might be changed to better protect their natural landscapes.

### Conservation Issues at the Ushkanii Islands

The Ushkanii Islands, like all of the natural wonders of Baikal, are known not only in our land, but in many lands; and our sacred duty is to protect them!

– Imetkhenov (Иметхенов 1991, 17)

### Human Activity at the Ushkanii Islands

The history of the Ushkanii Islands is less studied than that of the Caribou Islands, and information that is available for the Ushkanii Islands is minimal, but re-

ates mainly to the scientific activities there.

Tools of prehistoric man have been found in a cave areas on the Ushkaniy Islands, as they have been at several other sites on Baikal (Байкал атлас 1993, Иметхенов 1991, Галазий 1988). Lamakin (Ламакин 1952) also reports that this cave has been used "to the present time" (mid 20th century) by seal hunters, and that during times of inclement weather could harbor as many as 15-20 people with a fire, although a large portion of the cave's roof has collapsed during this century (probably during one of the frequent earthquakes that are felt in the region) (Галазий 1988). Indeed, signs of fire were visible in the large cave on the southeast side of the island in 1995. Whether this was recent I could not tell, and it is possible that the cave is still used as a recreational resource by visitors to the island, authorized or otherwise.

The next reference to human activity on the Ushkaniy Islands that could be found is in reference to fishermen and seal hunters who used the islands as a seasonal and temporary station. Ivanova (Иванова 1969) makes reference to locations on the east side of the island, north of Peschanaya Bay, as "near old settlement"; this may be one such station. This was likely a fishing or seal-hunting cabin. Nature is erasing the signs in this area, though, and I did not find any evidence of this old settlement in 1995.

During the later half of the 20th century a number of semi permanent occupations have been established on the Ushkaniis, mainly on Bolshoi Ushkaniy Island. Since the late 1950s there has been a nearly continuous scientific-technical presence on the islands, based at the southwest shore of Bolshoi Ushkaniy Island (Figure 40). These operations and habitation are largely carried out within a small station located at the southwest side of the island. This station consists of three houses, several out-

buildings including outhouses and a *banya* (Russian sauna), small storage facilities, and a meteorological station array.



Figure 40. The ZNP Ranger Station on Bolshoi Ushkanii Island.

There was a year-round presence on Bolshoi Ushkanii Island as of 1995, which consisted of a Zabaikalskii National Park (ZNP) forest ranger and a worker of the Russian Meteorological Service who attends the meteorological station there. Additionally, the ranger is joined in the summer months by visiting ZNP officials, his family, and occasional researchers (such as the present author) and guests. ZNP officials visit the island periodically, though usually for one day or less, and researchers are frequent visitors to the island, usually during the summer months, and may stay for several days to several months. The park ranger welcomes his family and friends

during the summer months, a pleasant change from the long winter isolation. Tourists are occasional visitors as well, and visits must be arranged through the ZNP administration. During my time there several small groups stopped for several hours for a fast walk along the shoreline or to look at seals.

Though human activity such as tourism will likely increase in the future, hopefully in a controlled and limited fashion, there was in the past a more active presence on the island—of scientific workers. During Soviet times, there was a much busier and larger contingent of scientific workers involved with various research projects and monitoring programs, and the period of the 1970s and 1980s was the most populous time at the station, with a permanent presence of approximately half a dozen workers and often their families (Alexander Timonin, personal conversation June 1995). The natural vegetation of the ZNP station area has been largely cleared, and there are few trees in the immediate area. Many weedy species are found on the "lawn" of the area, and there are small areas of gardens (though the climate of the island does not allow a very successful harvest).

#### Human Influence on the Environment of the Ushkani Islands

Sukachev and Lamakin (Сукачев и Ламакин 1952) report that during the time of Sukachev's initial investigations on the island in 1914 there were few signs of human influence on the islands and that they were in a well-preserved natural state. They state that until that time (1952) there had been no known permanent residence on the island, only temporary stations related to hunting of nerpa, but since the turn of the (20th) century there had been construction of a lighthouse on the main island, and seasonal stationing of attendants. There was an occasional station of a conservation



officer to regulate seal hunting activities during the mid 20th century as well. The remains of the original lighthouse are still on the site, though the lighthouse was automated and moved to near the southwest side of the island in the 1960s.

Since the mid 20th century, the increased presence of personnel on the Ushkani Islands associated with scientific operations has caused some negative consequences on the island's environment. The presence of a year-round habitation on the island results in stresses on the natural environment, however carefully controlled or managed. In addition to fire and introduction of domestic animals, other serious immediate effects to the integrity of the islands are from firewood cutting, fuel spills, and garbage dumping from the permanent and seasonal staff and visitors to the islands.

#### Pollution and Dumping

There are areas of garbage dumps just west of the ZNP station at the southwest side of the island which include various items which might be considered hazardous waste. Household garbage is also a problem at the site, and is likely to be on the increase—on a *per capita* basis—since during the last several years there has been a substantial increase in the amount and type of packaging used on most food and other consumer products available in Russia. Most garbage was observed in 1995 to be disposed of in the frame of an old building at the base, with older areas of garbage visible from past years, including some containing traces of electronic equipment, batteries, and paint products. No removal of refuse from the island was practiced by ZNP staff during 1995.

Electricity is provided by a diesel generator and storage batteries. The gen-

erator ran for approximately 4-5 hours per day in the summer of 1995. Fuel for this generator is stored near the front of the ZNP station and in the rear, near the generator. Leakage from storage containers was noted in small amounts while I was there, and larger fuel spills are a potential problem. Areas of soil near the ZNP station, particularly near storage and transfer areas, have been saturated with fuel oil and gasoline. In addition, transfer of fuel to the island was observed, and consisted of rolling metal barrels from a small boat along a board and onto the rocky shore. The barrel slipped from the intended path several times and into the water, and a fuel slick on the water was visible.

#### Pets and Other Domestic Animals

Perhaps the most serious continuing human impact on the biodiversity of the Ushkanii Islands is the dilemma of domestic animals. During the summer of 1995, there were 3 dogs and one cat who were pets of the park ranger at the island. All were allowed to roam free. On numerous occasions the dogs were encountered in areas far from the ranger station, such as on the west side or at Pescherka Bay. In addition, the barks of the dogs could often be heard at night, far from base, apparently chasing something. There has likewise been domestic pets on the island throughout most of the latter half of the 20th century. There was also several domestic chickens and one pig at the island during my stay, though their influence was, of course, smaller than that of the dogs and cat.

Although the influence of the animals on the vegetation is probably minimal, their effect on the fauna is severe, and one is reminded of the damage done on the Galapagos and Hawaiian Islands by domestic introductions. Dogs and cats, as well as

other domestic animals, should not be on the islands, let alone free-ranging (e.g., ЛИТВИНОВ 1982). In addition to damage caused by hunting, disturbing, and chasing indigenous fauna and impacts on vegetation, they may also host pathogens harmful to native fauna.

It is indeed likely that the cat and the dogs have a large influence on the fauna of the islands, most notably the nerpa, who, despite a large number of offshore and onshore rocks on the east side of the island, were rarely seen at Bolshoi Ushkanii Island. Smaller animals, if they exist on the island or were to arrive, could be affected as well. For instance, a red polëvka (*Clethrionomys rutilus*) was seen killed by the cat during my stay on the island in 1995. It is most probable that the avifauna of Bolshoi Ushkanii is also considerably affected by the cat and perhaps the dogs. When this question was discussed with a visitor to the island (a friend of the ranger) that the presence of the pets might likely affect the native fauna, the response was that "one couldn't live in such a place without pets". Regardless of the companionship value of pets, however, allowing them to range free in the area of a national park is not consistent with the goals of protected areas management.

#### The Russian Economic Problem

The present economic situation of Russian scientific and nature conservation organizations does not always allow the luxury of choice in matters of preservation. This is a very complex problem, and is beyond the scope of this thesis other than as a cursory mention. For greater illumination of this situation the reader is referred to Pryde (1997), Shtilmark (ШТИЛЬМАРК 1996), and Simonov and Stepanitsky (1995). The dilemma of protection vs. exploitation, even in the national parks and other

"protected" areas of the former USSR, is very problematic, especially when one considers that salaries of park workers and scientists in the 1990s often cannot be paid for months (and over a year in some regions). Moreover, this underfunding weakens the ability of the officials to regulate activity on park lands because of the lack of resources—personnel, time, vehicles, supplies, and equipment—available to rangers.

These problems are, however, a most important facet of the conservation future of the Ushkanii Islands. When I was on the Ushkanii Islands in 1995, the ZNP ranger stationed there had not been paid in many months (his salary was, moreover, ridiculously low even by Russian standards), and he survived in great part by fishing and duck hunting at the waters near the Ushkanii Islands, and sometimes bartering this game with passing ships. Fuel for the generator was only one such commodity obtained this way. Obviously, this is not a good way to continue to "fund" rangers stationed on the islands, but without such bartering there may be no possibility of having a ranger at the islands. Sometimes, the short-term exploitation of the very resources valued by preservationists are the best (or only) means of protecting the resources. Given these crises, then, it might often be expedient to allow some exploitation to occur (albeit reluctantly), if the return is to be able to pay staff salaries (and retain valuable personnel). It is in this context that the current management policies must be considered.

### Tourism

Baikal has always been much more a spiritual symbol to its residents than an economic one. The ideal of the Lake as an inviolable superlative is widely held by local residents, the Buryats (an indigenous people of the Baikal area), as well as citi-

zens throughout the former USSR. Only recently, however, has the question of the free-market economic significance of Baikal come under close scrutiny. There has been an increased attention given to the natural character of Baikal as an economic entity in itself via tourism (see for example Davis 1993, and Koptug and Upperbrink 1996). Tourism and "ecotourism" demand of Baikal a scenic and natural experience, but to maintain this high quality of experience, resources and infrastructure are needed. It has been estimated that the Baikal region can host many times the number of tourists who currently visit the area annually (Koptug and Upperbrink 1995). The Ushkanii Islands, however, can probably only support a *very* small number of tourists without significant degradation to the natural landscape.

Despite the care taken by tourism firms and other involved bodies, however, some influence on the environment is sure to occur. A case in point can be made from the Ushkanii Islands. A helicopter was observed several times during July 1995 making low passes over the island, and small groups of strictly regulated visitors were also brought to the island for several hours as part of tours organized by administrations of the ZNP and Baikal Museum in Listvyanka (a small research museum associated with the Limnological Institute [LIN] and the Russian Academy of Sciences). In addition to these paying tourists, occasional friends and other visitors visited the islands. Although this has the potential to earn needed income, it also has the potential to increase negative impacts on the nature of the islands, and needs to be carefully limited and managed if allowed. The helicopters may cause adverse disturbance to the nerpa, birds, and other wildlife as well as significantly detracting from the wilderness quality of the islands. The organized visits were very brief (approximately 3-4 hours total on Bolshoi Ushkanii Island), and consisted of a guided

hike and wildlife (nerpa) viewing. Despite this brief occupation, some slope degradation in the steppe area and small litter were observed. The influence of tourists on nerpa rookeries may also be negative. At present these effects are minimal, but they are indicative of the fragility—and inability to support a large number of visitors—of the islands.

It is important that—in the new Russia of a small but increasingly affluent and mobile upper class—the Ushkaniis do not become just another exotic destination for boaters and adventurers. In addition to the impacts on the nerpa, human activity such as camping, boat landing and wake, and excessive foot travel can have a negative influence on the natural landscape.

### Protection Status

The Ushkaniis Islands have had a series of protective designations applied to them during recent decades. The islands were given protection status in October 1980 by the government of the Buryat Oblast (now the Republic of Buryatia), declaring them an Oblast "natural monument" (памятник природы местного [областного] значения); IUCN category III, which carries implied importance of scientific, cultural, and natural history value. The declared features which were to be protected are the unique vegetation, extensive ant colonies, picturesque caves and cliffs with prehistoric human artifacts, and the areas of nerpa rookeries (Иметхенов 1991, Рожков et al. 1986). The Ushkaniis Islands are now part of the Zabaikalskii National Park (ZNP); IUCN category II, which was founded in 1986 and includes a total of 267,200 ha. This contains the Ushkaniis in their entirety and a large area of the mainland including the Svyatoi Nos Peninsula and areas bordering on the Bargu-

zin Zapovednik (nature reserve). The park is managed from the main office in Ust Barguzin, southeast of the Svyatoi Nos Peninsula. A longtime goal of the supporters of Lake Baikal nature protection was realized in 1996 when Lake Baikal and its landscapes (including the Ushkanii Islands) were declared a world heritage natural area by UNESCO (Greenpeace 1996).

### Management Recommendations for the Ushkanii Islands

With the conservation designations mentioned above, it would appear that all is in place for the continued protection of the Ushkanii Islands. There are however, several issues on the islands for which further changes should be made to accomplish effective conservation. Management policies could be initiated within the ZNP mandate which would protect the islands' natural landscape. The perspective of the present author is obviously biased toward the preservation of the islands in their entirety, as an environment unique in the world and one of the most noted and integral features of the Baikal landscape. The position, ostensibly, of the regional population and management authorities is similar, though a great deal of human impact has already been rendered on the islands. Most of the negative impacts could be eliminated and, in time, ameliorated, and several situations could be immediately changed (e.g., forest cutting, fuel storage, domestic animals). The following are some possible options I suggest for the conservation of the islands:

1. The effects of human-caused fire are probably the most severe influence on the Ushkanii Islands' vegetation, and it will take many decades or even centuries to return to

an approximation of their natural state. Besides the obvious statement that great care should be taken so no further fires will be accidentally started on the islands, what is needed is—in addition to great preventative care—proper equipment to prevent and control fires. Given the isolation of the islands, this probably cannot consist of any heavy equipment, but instead should include portable equipment necessary for control of small fires before they become uncontrolled and severe.

2. Other changes could be made which would have a more immediate return. The control of pets is paramount to the maintenance of the island's biodiversity. Strict regulation—including removal—should be implemented regarding pets, pack animals, and livestock at the Ushkanii Islands, and no further animals should be introduced there.

3. To protect (or “buffer”) the islands from the spread of introduced plant species, a small natural landscaping project might be implemented near the ranger station to favor those species which are native to the islands, and disfavor those which are weedy or introduced.

4. Inclusion of the endemic forms or species of the islands on protected lists would bring attention to their rare status and possibly add impetus to their conservation. They might then be able to draw financial support for their conservation from Russian or international organizations as "charismatic" (attractive and endangered) species.

5. Another non-native species, man, must also be regulated. Reasonable limits to the purpose, frequency, and method of travel to and on the islands should be implemented, in strict accordance with ZNP mandates. Foot travel should be prohibited without a guide, or limited to well-marked trails, and should not be allowed on the Small Ushkaniiis. No other form of travel on the islands would seem compatible with the goals of ZNP nature conservation mandates. For the ZNP activities no motorized travel other



than possibly for emergency fire control should be allowed. It might however be expedient for the ranger to have a bicycle for use in patrolling the island, though more than occasional use would probably have some impact on the soil and vegetation.

6. Fuel for the generator and other uses at the ranger station should be handled carefully to prevent spills. Installation of a small but adequate dock would greatly reduce the chance of fuel barrel puncture, as well as make other boat transfers much easier. A more efficient storage area would likewise reduce the risk of spills and contamination.

7. Garbage is a problem on any island, and will only continue to accumulate on Ushkaniis unless it is removed or no longer produced. Given the inclusion of some toxic wastes in the refuse of the island, as well as the limited space for disposal, a management plan should be implemented which both reduces the amount generated and attempts to remove some or all of the more harmful materials from the islands for proper disposal elsewhere.

8. Wood cutting is a serious dilemma at the island, though the year-round presence necessitates heating during all months of the year. Heating alternatives might be used instead of wood, or wood could be brought to the island, to reduce damage to the forests from cutting.

Despite the above concerns, it is important to remember that the islands are part of a Russian national park, and are meant to be appreciated by the citizens of that country and their visitors. To introduce or maintain restrictions which limit access to the islands to all but the most fortunate would be to contradict the ideal of a national park, and risk the popular disdain of the citizens to whom it belongs. Tourism to the Ushkaniis can, if carefully managed, provide an educational and pleasurable experience for visitors. The permanent stationing of a ZNP ranger at the islands provides service as an important pub-

lic ambassador, a safeguard against unregulated activity, a first defense against fire, and a continual monitoring of the natural features; it should continue. Whether this will happen or not is uncertain, however, given the difficult and changing situation of the region.

### Conservation Issues at the Caribou Islands

I hope it will be possible to preserve Caribou Island for all time and protect it as a remote and isolated outpost; an unspoilt remnant of what this country once was like

—John K. Morton (1976)

### Human Activity at the Caribou Islands

The interesting human history of Caribou Island has been well covered in an article by Carter (1979), and the reader is referred to that monograph for an entertaining and comprehensive account of the subject. The influence of human activity has been far less extensive at Caribou than Ushkanii, and I will report only in brief the aspects of human history at the islands which have had an influence on the quality of the natural environment. Most of the historical information which follows here is from the same source, with additional information from Ontario Government land records on file in Sault Ste. Marie and Thunder Bay Land Registry offices.

The first recorded visit to Caribou Island (as well as what would later be called Lighthouse Island) was by Alexander Henry and his fellow travelers and guides in May of the year 1771 (Henry 1809). The islands, Henry had been told, were regarded by the local natives as the site of giant snakes, which zealously guarded the island and its treasure. Although Henry's motivation had admittedly been the possible exploitation of the gold he had imagined lying on the beaches of "the Island of the Yellow Sands", and had heard of possibly some evil spirit-guardians, he found

primarily a robust woodland and bogs accommodating a sizeable caribou herd.

Little else was written of the island until the 20th century. It is probable that the island was used periodically by fishermen, as the shoals around the island remain to this day a bountiful fishing area during the late summer. A lighthouse was first erected in 1886 on Lighthouse Island, and the first of a series of lighthouse keepers, who would continue seasonally until full automation in the 1980s, took residence there. Later modifications and structures were added and removed to the lighthouse facilities, and the present lighthouse was built in 1911 (Carter 1979).

Caribou Island was transferred to private hands for the first time in 1903, for \$1 an acre (Ontario Land Registry records, Sault Ste. Marie, ON). At this time the Canadian Government retained areas of the island which remain federal land to this day: a 17 hectare plot at the south tip of the island, and a 10 ha area on the south bay. Also, a one chain (20.1 meter) "highway corridor" is retained on the circumference of the island, including all of Gull Island, amounting to approximately another 21 ha. Lighthouse Island is federally owned as well, and under the jurisdiction of the Canadian Coast Guard.

Later the island became owned by a group of US citizens, among whom was Chase Osborn (the Governor of Michigan) and his wife. Their intent was to organize a private hunting preserve on the island (Osborn and Osborn 1949). Osborn reports that he found no caribou on the island at the time of his initial visit, and a decision was made to stock the island artificially. Six caribou were acquired from Newfoundland and transferred to Caribou Island. Despite early infestations of a fly-carried larvae, the herds reportedly prospered under the stewardship of the lighthouse-keeper, who acted as game warden. In 1912 the keeper reported the herd at 50 (Carter 1979).

Osborn gives a much higher—perhaps exaggerated—number for the eventual size of the herd: “there came to be hundreds”, he writes (p. 62). The Caribou Island caribou herd reportedly left the island *en masse* during a winter when there existed an ice-bridge to the mainland; some of them later returned via the same route.

The island later passed through various shares and ownership to another US citizen, Captain Roys Ellis, who built a small cabin and spent time there during the summer months. Ellis died in the early 1980s, and the ownership passed to the Elizabeth Elliot Foundation. The status of this organization is unknown, and repeated attempts by myself and the Ontario MNR have had no success in contacting them as of Autumn 1997. Thus, the present legal and conservation planning state of Caribou Island, and likewise the intent of the owners, are unknown.

#### Human Influence on the Environment of the Caribou Islands

Caribou Island is remarkably well preserved in a natural state. This can be attributed to the great care which the previous and present owners have taken (or *not* taken) of the island. Although the island was used as a hunting reserve, and later as a vacation retreat for Ellis, they appear to have made little modification, and constructed few structures on the island, with the exception of several small shacks and a few trails. The inaccessibility of the island has prevented casual travel to the island, further reducing the threat of fire or other damage by default. It is, in all likelihood, one of the most pristine areas on the Great Lakes. There has been some rather minimal human influence, however, and Figure 41 shows the location of the main areas of impact and activity.

There has been relatively little human influence upon the natural environment

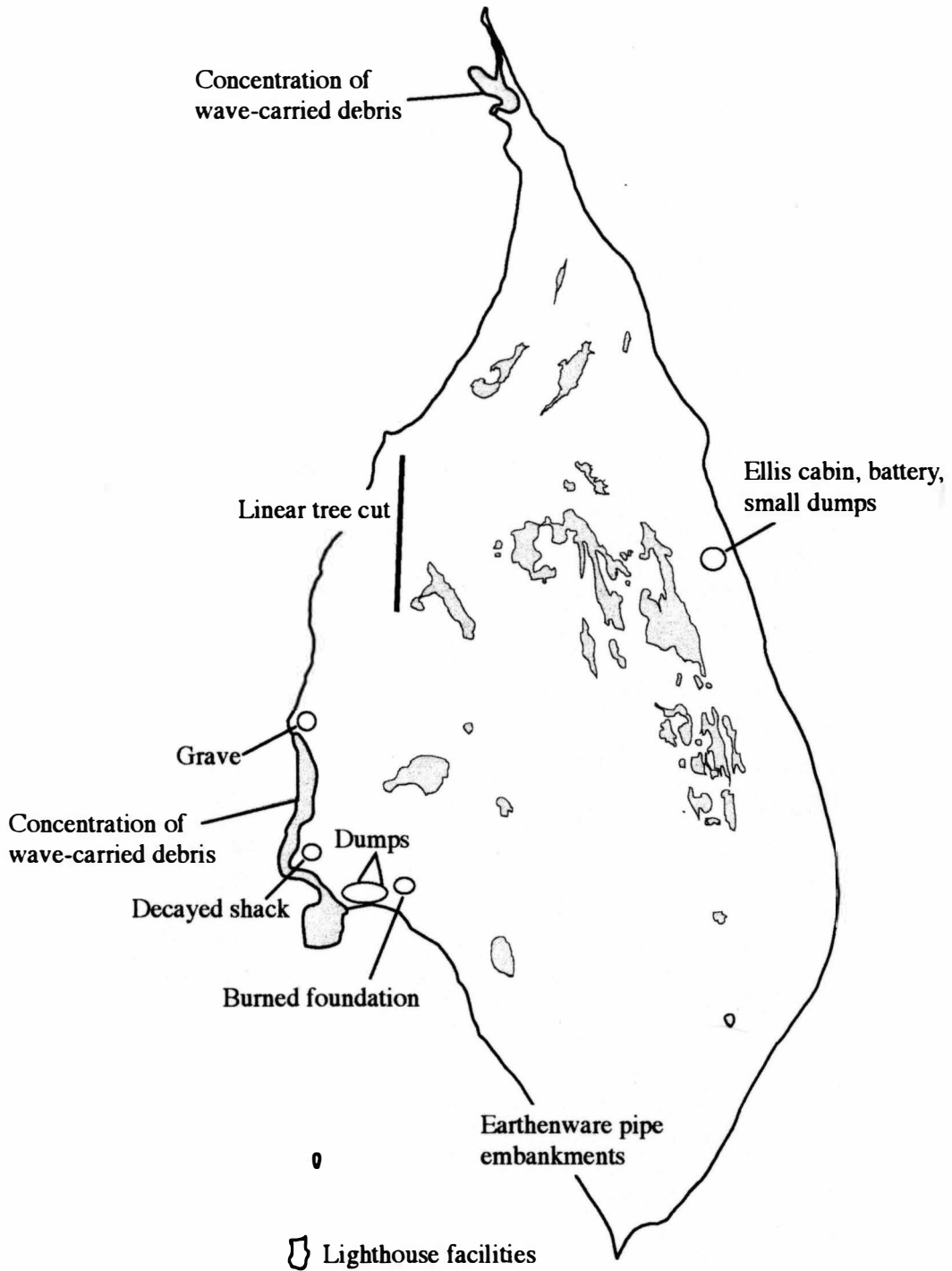


Figure 41. Human Influence Map of the Caribou Islands.

at Caribou Island, including the vegetation. Other than trails, now overgrown, and some minimal tree cutting near former cabins, and one unusual tree cut line mentioned below, there was no vegetation influence seen. Lighthouse Island is, however, extensively human altered, and the vegetation bears little resemblance to its original state.

There are no signs of fire or other large scale anthropogenic influences other than the lighthouse structures on Lighthouse Island. Although White (1995, 59) reports "some old fire evidence" from the South Bay dunes, I was unable to find any evidence of fire on Caribou other than an old burned foundation from a small building, and it appears that the island itself has not burned in a very long time.

The only signs of permanent structures on Caribou Island (other than the foundation mentioned above) are the small cabin of Roys Ellis (which still stands, although in a decaying state), the scattered remains of a smaller cabin nearby, and largely decayed small building in the southwest deciduous forest area.

Foot trails were made on Caribou Island by Captain Ellis (Morton and Venn 1996), and probably by other users in the past, but I was unable to find any traces of these trails. There is an unusual cut line of trees on the northwest side of the island which runs straight north-south, and for which I have not been able to find an adequate explanation. It consists of a tree cut, approximately 5-10 meters wide, which runs in a straight line from the northern west side bog area north out to the shore. This peculiar phenomenon has the character of a utility cut, as for transmission lines or a pipeline, though there are no such facilities, nor any reason for them, on Caribou Island. It appears that the cut was made about 10 to 15 years previous to my 1996 investigation, and it can be seen clearly on the 1994 aerial photographs, but not on the

1974 photos.

There are several small refuse dumps on the island on the South Bay dune areas, most likely from the lighthouse keepers. As White (1995) indicated, there are several items in these dumps which can be considered hazardous waste, including old batteries and paint cans (now dry). In addition to those of the South Bay, there are small areas of garbage buried and exposed in a pit near the Ellis cabin. Perhaps more serious, there is a large storage battery, about 1.5 meters long, near the front of the cabin, apparently used by Capt. Ellis to store electricity from a generator or other apparatus for use in the cabin. This battery did not appear in 1996 to be leaking. White suggests, and I agree, that such items should be removed before they can further pollute the otherwise pristine island.

Although I could not see evidence of it in 1996, there is a "burial place" marked on the southwest shore of the island on the 1902 land survey map on file in Sault Ste. Marie at the Ontario Land Registry Office. No further information on this could be found, and Carter (1979) makes no mention of a grave.

A number of earthenware pipes of short length (approximately 50 centimeters) are partially exposed on the south-central shore, and these are also unexplained, though they must have been some sort of erosion check measure. This is somewhat puzzling because there are no human features associated with their location.

Although a difficult to control non point-source pollutant and a conspicuous feature of all shores of the Great Lakes, wave-carried debris presents probably the greatest present pollution impact to Caribou Island. Numerous rusting, partially filled drums were observed, several of them leaking petroleum products. This presents a great hazard to animal life and, potentially, to vegetation. Additionally, the

visual appeal—albeit a strictly human perception—of an otherwise pristine shoreline is marred by numerous mylar balloons, bottles and cans, metal and plastic household chemical containers, fishing items, industrial shipping detritus, and other debris carried from the open lake waters or other shorelines. This is especially evident on the western shore, where there is greater deposition of wave-carried debris.

Human influence at Lighthouse Island is, as previously mentioned, much greater than at Caribou Island, and an OMNR report (Kor 1993, 1) states "Lighthouse Island has been extensively modified by the building of lighthouse facilities. It consequently has no [conservation] values". Gull Island is impacted only by wave-carried trash from offshore, including several leaking petroleum containers.

#### Protection Status

Caribou Island is, unlike the Ushkanii Islands, under no special protection status other than that provided for under Ontario laws concerning shoreline areas and land development. The island is largely privately owned, with the exceptions previously noted. At present, the intention of the island landowner is unknown.

The Ontario Government has expressed interest in the island and the protection of its natural features, including several studies (Noble 1982, Kor 1993; 1995a and telephone conversation April 1996, OMNR undated, White 1995, T. Beechey telephone conversation March 1997). Ideally, the island would be obtained by the Ontario or Canadian Governments and designated a National or Provincial Nature Reserve Park (IUCN category 1 or 3). A more likely possibility, and the one that the Ontario Government is more likely to be able to afford, is a conservation easement agreement with the island's owners to prevent future degradation and misuse (T.



Beechey telephone conversation 1997). At present, neither of these options appears very likely in the near future. The best protection measure currently is by default: the remote location of the islands, the surrounding shallow rocky waters, and the lack of any specific features—other than the islands' great beauty and solitude—that might draw visitors.

### Management Recommendations for the Caribou Islands

Other than the possible conservation measures proposed by the OMNR, there are few measures which could be specifically adopted to protect the islands. Furthermore, any such measures would be the responsibility of only the island's owner. Having noted this complication, I suggest the following as reasonable (and in accordance with the suggestions of previous authors):

1. Occupation of the island should be limited to short, low impact visits by individuals or very small groups, for study purposes rather than for leisure.
2. Restrictions should be placed on further construction of facilities or buildings on the island, with the possible exception of the reconstruction of the Ellis cabin. The fragile landscape of the islands may suffer significant damage if larger facilities were to be built, though the Ellis cabin, still restorable as of 1996, could be maintained and used by visitors to the island.
3. The removal of some of the existing hazards (battery, materials in dumps, shoreline toxic debris) should be undertaken, and these materials properly disposed of on the mainland.
4. No forest cutting should be practiced, except possibly that necessary to construct small pathways necessary for access to interior areas of the island (such as

those built by Ellis).

5. Restriction of all vehicles on the island (including motorized and non-motorized vehicles) would protect the landforms, animal life (including birds), and vegetation from erosion and other degradation, and only foot travel is advisable.

6. No introductions of plants or animals to the islands should be allowed.

As was appropriate for the Ushkanii Islands, a postscript is merited to add context for the Caribous. Although the Caribou Islands have been preserved well to date, there is no guarantee that this will continue. Since they are privately owned no implementation of management plans is required and, other than standard Ontario land codes, there is no restriction on what may be done to the islands. Implementation of any management practices—which have been practiced thus far by design as well as default—are the prerogative of the legal owners of the island, and the continued protection depends on the intent of the owners.

## CONCLUSION

Of course, there was much in it that we did not understand, or of which we missed the deeper sense. But do not the bewitching powers of all studies lie in that they continually open up to us new, unsuspected horizons, not yet understood, which entice us to proceed further and further in the penetration of what appears at first sight only in vague outline?

—Pyotor Kropotkin (1899, 171)

### Summary

The floræ of both the Ushkanii Islands on Lake Baikal and the Caribou Islands on Lake Superior have been examined on site and through literature and consultation. Compared to each other, the floræ show certain similarities in their composition, arrangement, and distribution, though most of their actual species differ. Both sites have vegetation patterns which appear to be correlated to their limnoclimates, and these phenomena are strongest near their shorelines. The floræ of the islands also show correlation with general principles of island biogeography in their number and variety of species, have numbers of taxa which are lower than might be expected of similar habitats on the mainland, and fit within a consistent species-area relationship when examined with other lake islands of the regions. Unusual plants are present at both sites, and can be placed into several main categories: arctoalpine, southern and steppe, endemic, and western and eastern disjuncts. The distribution of such rare plants follow similar patterns which are consistent with limnoclimatic conditions on the islands. The most unusual plants of the islands (such as arctoalpines and other disjuncts) are restricted mainly to nearshore areas, where the influence of limnoclimate is strongest and rare in the interiors, where the influence of the lake waters

and climate is reduced. Other factors related to their macroclimate, geology and topography, edaphic features, hydrology, human and natural disturbance, and dispersal methods have also been discussed as important influences on the phytogeography of the Ushkanii and Caribou Islands.

Based on these observations, some conclusions on lake island phytogeography have been drawn from the islands in this study. Some properties consistent with island biogeography theory that are common to the Ushkanii and Caribou Islands, and other lake islands previously studied by previous researchers, and “traditional” oceanic islands are:

1. The number of species on the islands are positively correlated with island age and island size.
2. The number of species on the islands are negatively correlated with distance from mainland.
3. Many of the dispersal methods and methods of propagule transport to lake islands are similar to oceanic islands (bird, water, wind and airborne).

Some aspects which are unique to the Caribous and Ushkaniis (and other large lake islands of the temperate zone):

1. Lake islands are affected by the limnoclimate of their lakes—a climate dissimilar to that of other areas.
2. The islands have never been connected by land to the mainland—unlike most nearshore oceanic islands.
3. The islands are sometimes connected to the mainland by seasonal ice bridges.
4. The islands are much younger than most oceanic islands.

5. As a result of their age, endemism is a much smaller factor in lake island floræ than in those of oceanic islands—but still important, as seen at the Ushkanii Islands.

The islands in this study are, because of the phenomena mentioned in this thesis and elsewhere, significant landscapes that should be maintained as natural laboratories of lake island biogeography and as monuments of the beauty of Nature; protected from further human disturbance.

#### Recommendations for Further Study

I have seen few studies which do not recommend, in their closing, further study. Perhaps this is self-serving to the researcher; or perhaps it is evidence that new questions have arisen even as others have been answered. In any event, I shall make no exception here, and have identified several areas for further study which are indicated by my research. Investigation of these, and other, areas of lake island biogeography would shed light on the unique principles involved, and allow a continued increase in the knowledge and understanding of these interesting and unusual areas.

The study of more large lake islands is, of course, one way to get a better “sample” size, and better document the range of variation in lake islands. Further comparative work would add much to the understanding of lake islands and their floræ. In particular, the question of the origin of lake island floræ is a logical area for research. An excellent comparison with Caribou Island would be Leach and Montreal Islands, both of which are approximately the same size and have the same substrate (Jacobsville Sandstone) as Caribou Island. They also have a similar variability of habitats. Montreal and Leach are both less than 10 kilometers offshore, and therefore

would be expected to have a larger number of species than Caribou. The comparison of these three very similar islands would provide an excellent “triangulation” of the island phytogeography of the region. Analysis of the floræ would give insight to the ability of different plants to successfully migrate to islands, indicating how important distance is as a factor in lake island biogeography.

A quantitative comparison of the vegetation and habitats on Caribou, Ushkani, or other islands with similar habitats on the mainland (such as the study by Hazlett [1988]) would provide valuable clues on this problem as well.

The islands of Lake Nipigon are extremely varied in size, distance to mainland, and other characteristics (Timoney 1980, 1983; OMNR 1994). Additionally, Nipigon is situated at a botanical “crossroads” of sort; many western and prairie species reach their eastern most distribution in the region, and many eastern species their western. Likewise it is at a transition of the boreal and Great Lakes-St. Lawrence forest zones. Because of its position on this multiple botanical “frontier”, Lake Nipigon might have some interesting botanical distributions on the islands. They have not been studied botanically to any great extent, and further work is desired for management purposes (OMNR 1994) as well as a potentially excellent study on lake island biogeography.

Because of the relative youth of Caribou Island, and the presence of several plant populations which appear to be remnant (*Pinus strobus*, *Thuja occidentalis*, *Epigaea repens*), and the extensive peatlands there which may hold pollen and other fossilized remains, there might be excellent opportunity to further investigate the early composition of the island’s flora, such as with palynological or dendrochronological techniques.

Finally, the beaver population of Caribou Island would also make a very good zoogeographical study of the effects of isolation: they are free of predators, have most likely negligible genetic input, have a limited habitat, and exist in dense populations. Disease, inbreeding, habitat availability, and food supply probably play a role in their demography, but to what extent remains to be learned. This might make as interesting a long-term study as the moose of Isle Royale or the Caribou of the Slate Islands.

**Appendix A**

**Conspectus of the Floræ of the Caribou and Ushkanii Islands**



## Notes on the Botanical Nomenclature

Because of the wide range of researchers at the two sites and years between surveys, the accepted names of the plants recorded at the islands have occasionally changed to reflect newer international (or regional) standards. Fortunately, there have been updated conspecta of the floræ published in the intervening years, so that names could be put into a somewhat standardized format.

The Latin nomenclature here follows Gleason and Cronquist (1991) for the Caribou Island Plants and Czerepanov (1995) for the Ushkanii Island plants. The nomenclature of the Lycopodiaceae follow *Flora of North America*. There are several exceptions. Where there is an additional contradiction, such as when a taxon occurs on both islands, Gleason and Cronquist is followed, with the following exception. A unique problem exists with the genus *Oxycoccus*, referred to as belonging to *Vaccinium* by Gleason and Cronquist, but retaining the generic name *Oxycoccus* by most Russian and Soviet botanists, including Czerepanov (1995). On Caribou Island, *Vaccinium oxycoccus* L., also known as *Oxycoccus palustris* Pers., is a common bog and shoreline plant, while on the Ushkanii Islands, *Oxycoccus microcarpus* Turcz. ex Rupr. is known from Bolshoi Ushkanii Island. These two taxa are very closely related and are members of a larger complex, the edges of which are blurred by interhybridization and divergence (Hultén 1968, 1971), who also uses the generic name *Oxycoccus*. He devotes considerable attention to this problem in *The Circumpolar Plants II* (1971). Since it seems superfluous to separate the species each according to its “political” name, I have taken the liberty of acting by default as a taxonomist, and the generic *Oxycoccus* has been used. In the case of *Leymus flexilis*, also known as *L. dasystachys*, Czerepanov lists both of these as being valid species names, and the former is used. Additional discrepancies are noted with the plants concerned.

Synonyms given are not meant to be a comprehensive listing of the history; such information is available in many of the taxonomic sources consulted in this

project. Rather, they are provided when they have been used by one or more of the authors consulted during this project as the primary name. Plants for the Ushkanii Islands are a particularly good example of this, since there has been much taxonomic revision in the period since the reports of Lamakin and Sukachev (Ламакин и Сукачев 1952), Ivanova (Иванова 1969), and others. Additionally, they are also provide indication past or present thought on the relationships of species and varieties, e.g., *Oxycooccus* and *Larix x czekanowskii*.

Common names are provided as well. Although there is a wide variation and abundance of names used, I made an attempt to use the most popularly used names for the area concerned in both English and Russian. Common names are for English taken mainly from Gleason and Cronquist (1991), Voss (1996, 1985, 1972), Lellinger (1985), Morton & Venn (1996). The Russian common names have been taken mainly from Ivanova (Иванова 1969), various volumes of the *Flora of Siberia* (Флора Сибири), Malyshev and Peshkova (Мальшев & Пешкова 1979), and others. I have also attempted to emphasize local usage of common names which I encountered during my experiences in the Baikal region. Russian common names given in the literature often follow the meaning of Latin names, while others are from origins. Common names given for plants on the Ushkanii islands may occasionally be based on Latin names of genera and species which may have been changed since the publication of the source (such as in Иванова [1969] or Мальшев & Пешкова [1979]). Since Czerepanov does not include common names, the older common names have in many cases been retained here.

#### Excluded Taxa

There are several accounts of the floræ of the Caribou and Ushkanii Islands which are, for various reasons, excluded here. These are discussed below.

#### Caribou

Brown's (1982) report on the vegetation of Caribou Island contains a number

of species which have not been reported by other investigators, and which are not represented by vouchers. This situation is discussed further in the thesis with previous research of Caribou Island. None of Brown's records have been included here if not found by other investigators.

### Ushkanii

*Conioselinium longifolium* is mentioned by Ivanova (Иванова 1969) in her description of the Small Ushkanii Islands, but it is not included in her conspectus. It is assumed that *C. tataricum* was actually the plant she was referring to; and *C. tataricum* is referenced in her conspectus as occurring on Dolgii Island. I include the latter species in the conspectus but not the former.

Boikov et al. (Бойков et al. 1991) have reported a number of taxa as present on the Ushkanii Islands; however, they make no reference to herbarium vouchers. In fact, many taxa listed in their conspectus as occurring on the Ushkanii Archipelago do not appear there in the distribution maps of the same volume! In addition, a number of species previously reported by Ivanova (Иванова 1969) and Sukachev and Lamakin (Сукачев и Ламакин 1952) do not appear in their list. For this reason, I consider their reports with caution, and they have not been incorporated in this conspectus. It is possible that the species discrepancies are the result of new reports (for example, those of Molozhnikov; see section on previous Ushkanii Island investigations) or reexamination of the previous specimens, but I have been unable in the scope of this thesis to ascertain their validity.

Sukachev and Lamakin (Сукачев и Ламакин 1952) report that collections may have been made previous to their investigations, but that those collections, if they existed, could not be located. They do report one species, *Sanguisorba baicalensis* (*S. tenuifolia*) not mentioned by Ivanova; this is discussed further in the text of this thesis.

## Key

In the conspectus that follows, the first name given is the accepted name (according to the rules above). Additional Latin names are synonyms encountered in the research for this project. Common English and Russian names follow where applicable. A capital letter U indicates that the taxon occurs on the Ushkani Islands, and a C indicates the Caribou Islands. Additional designations are as follows. aa= arctoalpine, S= steppe, W= alien. Distributions on the islands given here follow very closely those given previously for the islands (Sukachev and Lamakin [Сукачев и Ламакин 1952]; and Ivanova [Иванова 1969] for the Ushkaniis; and White [1995] and Morton and Venn [1996] for the Caribous) when similar to my own (RJL) findings, or when I did not observe the species. When my observations were significantly different from those previously given, annotation has been made to show which author reported each distribution. Additional notes on the taxa follow when important.

## The Plants:

## LYCOPODIOPHYTA

## LYCOPODIACEAE Clubmoss family U C

*Diaphasiastrum complanatum* L. (Houlb.) (*Lycopodium anceps* Wallr., *L. complanatum* L.) northern ground-cedar плаун обоюдоострый U: Bolshoi: larch woods on lower terraces and on northern slope. Kruglii: larch and Empetrum woods. C: Backdunes and forest edges.

*Lycopodium annotinum* L. stiff clubmoss плаун годовальный U: Bolshoi and Kruglii: Empetrum shrubbery near northern coasts; rare. C: Caribou; common in forest.

*L. clavatum* L. running-pine, common club-moss, running club-moss C: Common on backdunes and forest border

*L. dendroideum* Michaux ground-pine, round branched ground-pine, northern tree-clubmoss C: Open forest in east central interior.

*L. inundatum* L. bog clubmoss C: On bogs and lakesides.

*L. lagopus* (Laest.) Zinserl ex Kuzen one-cone clubmoss C: Grows in association

with *L. clavatum*.

*L. lucidulum* Michaux shining clubmoss C: Common in forest.

*L. obscurum* L. princess-pine, ground-pine C: Forest edge on north side of island.

*L. tristachyum* Pursh. ground-cedar, wiry ground-cedar C: On vegetated dunes on West Bay.

### SELAGINACEAE Selaginella family U

*Selaginella selaginoides* (L.) C. Mart. northern selaginella плаунок  
плауновидный, Селагинелла зубчатная U: Bolshoi, on northern shore; damp  
meadows at beach; rare.

*S. rupestris* (L.) Spring. *S. sibirica* (Milde) Hieron. rock selaginella плаунок  
скальный U: Bolshoi: dry cliff slopes on southern slope.

*S. sanguinolenta* (L.) Spring. плаунок кровяно-красный S U: Bolshoi: southern  
slope, on fractured carbonate cliffs.

*S. borealis* (Kaulf.) Rupr. *Lycopodium boreale* Kaulf. плаунок северный U:  
Listed for Ushkanii only in *Flora of Siberia*, and described as occurring on shaded  
cliffs. Possibly given by Ivanova as *S. sanguinolenta*, though it is unclear whether  
both species occur on the island.

### ISOËTACEAE Quillwort family C

*Isoetes echinospora* Durieu *I. setacea* Durieu spiny-spored quillwort C:  
Common in the peat bottom of Deer Lake.

## EQUISETOPHYTA (Horsetails)

### EQUISETACEAE Horsetail family C U

*Equisetum arvense* L. common horsetail, field horsetail хвощ полевой U:  
Bolshoi Ushkanii: Stony beaches and shorelines. C: Caribou: gravelly areas.

*E. fluviatile* L. water horsetail C: In fen near South Bay Headland.

*E. x mackaii* (Newman) Birchan C: on shoreline marsh at north end of Caribou  
Island.

*E. pratense* Ehrh meadow horsetail хвощ луговой U: Bolshoi Ushkanii: on lower  
terraces at bottom of sharp slopes; moist larch woods.

*E. scirpoides* Michx. dwarf scouring-rush хвощ камышковый U: Bolshoi,  
Tonkii, and Kruglii: dry fields near shore, larch woods on lower terraces, primarily on

northern sides. Occasional on Bolshoi in pine woods.

*E. varigatum* Schleicher variegated horsetail C: On shoreline marsh at north end of Caribou Island.

## POLYPODIOPHYTA (Ferns)

### ASPLENACEAE Spleenwort family U C

*Athyrium filix-femina* (L.) Roth. lady-fern C: Reported for unspecified location by White (1995).

*Asplenium ruta-muraria* L. wall-rue костенец, рута постенная S U: Bolshoi Ushkanii: south shore near Pescherka Bay; crevices in marble on lower terrace slope. Found in only one site.

*Cystopteris fragilis* (L.) Bernh. *C. filix-fragilis* brittle bladder-fern пузырьник ломкий U: Bolshoi Ushkanii and Kruglii Islands: crumbly, rocky slopes.

*Dryopteris carthusiana* (Villars) H. P. Fuchs toothed wood-fern C: On Gull Island.

*Dryopteris cristata* (L.) A. Gray crested wood-fern C: On Sphagnum moss in southwest Alder swamp; in partial sun. Few plants only. Not reported by previous investigators.

*Dryopteris expansa* (C. Presl) Fraser-Jenkins & Jermy northern wood-fern C: Common in well drained forest areas.

*Dryopteris intermedia* (Muhl. ex Wild.) A. Gray fancy wood-fern C: Common in forest.

*Gymnocarpium dryopteris* (L.) Newman *Dryopteris linneana* C. Chr. oak-fern C: In cobbly open forest at South Bay headland (SBH). Common at various locations around Baikal, but absent on the Ushkaniis.

*Thelypteris phegopteris* (L.) Slosson. Narrow beech fern, northern beech-fern C: Found on rich soil in a transition area between the south side of the South Bog and one of the complex of linear marshes occurring inside the south west shore. Not reported by previous investigators.

*Gymnocarpium jessoense* (Koidz.) Koidz *G. remoti-pinnatum* (Hayata) Ching голокучник, щитовник U: Bolshoi Ushkanii Island: Northwest and southwest shores, on rocky beaches; two stations with several individuals. Kruglii: northeast shore, on rocky beach, one station.

### DENNSTAEDTIACEAE Bracken fern family C

*Pteridium aquilinum* (L.) Kuhn bracken fern, brake C: In better drained areas (Morton and Venn 1996). Found commonly in areas near south and southwest shores of Baikal in open birch and aspen woods, but absent on the Ushkaniis.

#### **OPHIOGLOSSACEAE Adder's tongue family C**

*Botrychium multifidum* (S.G. Gmelin) Ruprecht Leathery grape-fern C: At backdunes on South Bay Dunes.

*Botrychium matricariaefolium* A. Braun daisy leaved grape-fern C: Along with *B. lunaria* on Gull Island. Not reported by previous investigators; see below.

*Botrychium lunaria* (L.) Swartz. moonwort C: Reported by Brown (1982) to Gull Island (along with *B. matricariaefolium*, but unconfirmed until my relocation in 1996. Found under protection of small shrubs on the southwest side of Gull Island,, in association with other species of *Botrychium*. Probably much limited by geese browsing, as specimens found were all near shrub cover, and plant health and vigor decreased in accordance to distance from cover. This is likely why the individuals found were under the "refuge" of shrubs; relatively inaccessible. However, many specimens were somewhat damaged, including some collected, further exacerbating the identification of this already difficult genus.

*Botrychium virginianum* (L.) Swartz. rattlesnake -fern C: Open graminoid area on Gull Island.

#### **ONOCLEACEAE Sensitive fern family C**

*Onoclea sensibilis* sensitive-fern C: Reported by Brown to Caribou island, habitat and location unspecified, but not confirmed until found by the present author on the west side of Gull Island, on wet, sunny ground among rocks and graminoids.

#### **OSMUNDACEAE Royal fern family C**

*Osmunda cinnamomea* L. cinnamon-fern C: Fen at back of SBH.

#### **POLYPODIACEAE Polypody family U**

*Polypodium vulgare* L. *P. virginianum* L. polypody Многоножка обыкновенная U: Bolshoi Ushkani: Upper parts of northern and western slopes, protected rocky areas; rare.

### **PINOPHYTA (Gymnosperms)**

#### **CUPRESSACEAE Cypress family C U**

*Juniperus sibirica* Burgsd. Siberian juniper можжевельник сибирский U: Bolshoi: northwest and northern shore, lower slope of first terrace. Two stations. Seen only once; on west side at beach edge slope (RJL).

*J. communis* L. common juniper C: common on backdunes Morton and Venn 1996). Occasionally on mid and back dunes of east and northwest sides, also on southeast headland (RJL).

*Thuja occidentalis* L. northern white cedar, arborvitæ C: small area of Morton and Venn also report "A few moribund trees on the interior of the island by the South Bay trail", though I (RJL) did not find these. I did find them as small and unhealthy trees along east side of north end of the large west bog.

## **PINACEAE Pine family U C**

*Abies balsamea* (L.) Miller balsam fir C: Ubiquitous in boreal forest, including some very large diameter trees (RJL).

*Abies sibirica* Ledeb. Siberian fir пихта сибирская U: Bolshoi: several small trees on northern coast and one on eastern, on bottom of slopes of lower terraces, among mosses. Tonkii: several trees in the main Empetrum-larch woods. One large tree on west side of island (RJL). Sukachev and Lamakin stated that on the small Ushkanii Islands spruce and fir were not seen.

*Larix x czekanowskii* Szaf. *L. czekanowskii* Szaf., *L. ushkanensis* Sukaz & Lamak. nom. nud. лиственница Чекановского U: The predominant tree species on all of the Ushkanii islands. Predominant tree species of the islands; more common on lower elevations and on west side (RJL). Sukachev and Lamakin (Сукачев и Ламакин 1952) noted that Sukachev has found the majority of larch trees to be over 300 years old.

*Larix lariçina* (Duroi) K. Koch Larch, tamarack C: Common on bogs (Morton and Venn 1996). Uncommon on west side wetlands (RJL).

*Picea glauca* (Moench) Voss white spruce C: Common in forest and backdunes (Morton and Venn 1996). Common tree of the forest; probably second most common after *Abies* (RJL).

*Picea mariana* (Miller) Britton, Sterns & Pogg. black spruce C: On wetlands of west side.

*Picea obovata* Ledeb. ель сибирская U: Bolshoi and Kruglii: several trees near lower slopes of lower terraces on the northern coast. "Several scruffy shrubby examples were found distributed likewise (to *Pinus sibirica*) on the north side, on an old gravel beach, at the bottom of the terrace" (Сукачев и Ламакин 1952). I (RJL) did not see this tree, however, the forest ranger at the Ushkaniis in 1995 reported to me that there is one tree only of this species on the island, which I was unable to locate. See notes for *Sorbus sibirica*. Sukachev and Lamakin (Сукачев и Ламакин 1952) state that on the small Ushkanii Islands spruce and fir were not seen.

*Pinus pumila* (Pall.) Regl. кедровый стланик aa U: Bolshoi: northern coast; several trees near the lower slopes of of the first terrace, also on the upper parts in thin forests ("бровки") and larch-lingonberry herbaceous woods with occasional



*Empetrum*. Dolgii and Kruglii: several plants in *Empetrum*-larch woods on northern slope. "In similar conditions (as *Pinus sibirica*), and similarly along the north side of the island. Two small shrubs" (Сукачев и Ламакин 1952). A few small examples on the west side at edge of beach (RJL).

*Pinus sibirica* DuRoi Siberian pine Сибирский кедр U: Bolshoi: Northern shore, several young trees on lower terrace in thin woods ("у бровки"). Tonkii: several young trees in the main larch woods near northern slope. Sukachev and Lamakin (Сукачев и Ламакин 1952) noted for this species "one pathetic tree, growing on the northern side of [Bolshoi Ushkani Island], at the edge of the slope to the gravel beach. ...on Tonkii, Lamakin saw 5 [*P. sibirica*] and one [*Sorbus sibirica*], on Tonkii south part, one 2.5m tall [*Pinus sibirica*], on Kruglii on various sites 7 [*Pinus sibirica*]. [an] old Baikal hunter (see notes for *Sorbus sibirica*) stated that presently (1950) the main distribution of [*Pinus sibirica*] can be found on the south-west part; 11 small individuals". Several small trees on west side near edge of beach and approximately 50 meters into the forest (RJL).

*Pinus strobus* L. white pine C: A few stunted trees on dunes on east side of island (Morton and Venn 1996). Only three examples of this tree seen on Caribou Island, all quite large, and no young trees or seedlings were seen (RJL).

*Pinus sylvestris* L. scotts pine, scotch pine Сосна обыкновенная U: Second only to larch as most common tree on the islands. On Bolshoi, usually on the southern slope and top of island. On the small Ushkaniis, occasional in the larch woods (Иванова 1969). More common than *Larix* on higher elevations and east and southeast side (RJL).

#### **TAXACEAE Yew family C**

*Taxus canadensis* Marsh. yew C: Common as understory shrub of forest and on backdunes (Morton and Venn 1996). In the southwest deciduous forest areas, forming dense understory (RJL).

#### **EPHEDRACEAE Ephedra family U**

*Ephedra monosperma* C. A. Mey. Ephedra, joint-pine хвойник односемянный S U: On Bolshoi and Tonkii Islands: cliffs, dry slopes, comparatively rare (Иванова 1969). Two areas, one on west side at slope near beach edge; the other along south rocky areas on slopes, also among rocky areas of shoreline (RJL). Specimens from some areas of Baikal show differentiating characteristics according to Malyshev and Peshkova (Мальцев и Пешкова 1979).

## MAGNOLIOPHYTA (Flowering Plants)

## Magnoliopsida (Dicots)

## ACERACEAE Maple family C

*Acer spicatum* Lam. mountain maple C: Found (by RJL) to be a major component of the understory on the west side forest, between the robust shoreline edge of the forest and the edge of the big bog. Not reported by previous investigators.

*Acer rubrum* L. red maple C: Morton and Venn (1996): scattered stunted trees at backdunes of West Bay and in forest edge of north end, Caribou Island. RJL: Occasional small trees near forest edge on west side.

## APIACEAE (UMBELLIFERAE) Parsley family U C

*Aegopodium alpestre* Ledeb. сыть горная U: All Ushkanii Islands: larch woods. Also on Bolshoi Ushkanii occasionally in pine woods.

*Angelica tenuifolia* (Pall. ex Spreng.) M. Pimen. *Peucedanum salinum* Pall. ex Spreng. дудник U: Ushkanii Islands: moist meadows at shoreline.

*Angelica decurrens* (Ledeb.) B. Fedtsch. *Archangellica decurrens* Ledeb. дудник низбегающий U: Bolshoi, Tonkii, Kruglii: gravel beaches.

*Anthriscus sylvestris* var. *nemorosa* (Bieb.) Trautv. *Anthriscus aemula* (Woron.) Schischk. кушерь лесной W U: Bolshoi: southwest shore near meteorological station. Introduced.

*Bupleurum scorzonerifolium* Willd. володушка козлецоволистная S W U: Bolshoi: westernmost point and at Pescherka Bay. A weed.

*Carum carvi* L. тмин обыкновенный W U: Bolshoi: Pescherka Bay in field near old habitation. Possibly introduced.

*Cicuta bulbifera* L. bulbous water hemlock C: Fen behind SBH.

*Conioselinum taticum* Hoffm. *Conioselinum vaginatum* (Spreng.) Thell. гирчовник татарский U: Dolgii: beach on northeast shore.

*Heracleum dissectum* Ledeb. борщевик рассеченный U: Bolshoi: understory rich larch woods on lower terraces of the southwest and northwest shores.

*Heracleum lanatum* Michaux cow-parsnip C: gravel and cobbles under tree cover; Lighthouse Island, North Point, and SBH.

*Kitagawia baicalensis* (Redow. ex Willd.) M. Pimen *Peucedanum baicalense*

(Redows.) C. Koch. горочник байкальский S U: Bolshoi, Kruglii, Tonkii: south steppe slopes and cliffs.

*Pachypleurum alpinum* Ledeb. *Lingusticum alpinum* (Ledeb.) F. Kurtz толстореберник альпийский U: Bolshoi: southwest tip of island on gravel shore at the water's edge.

*Phlojodicarpus popovii* Sipl. *Phlojodicarpus baicalensis* M. попов вздутоплодник Попова U: Bolshoi: north shore on gravel beach and moss-lichen slope of lower terrace.

*Pleurospermum uralense* Hoffm. реброплодник уральский U: Bolshoi and Dolgii: bottom of slope of lower terraces; predominately on northern shores. Also in larch woods of lower terraces.

#### **AQUIFOLIACEAE Holly family C**

*Nemopanthes mucronatus* (L.) Loes. mountain holly C: Common around bogs, in swampy openings of forests, and in fens.

#### **ARALIACEAE Ginseng family C**

*Aralia hispida* Vent. bristly sarsparilla C: Though reported by Morton and Venn (Morton and Venn 1996) as "Locally common at the back of the dunes and in sandy openings in the forest" I saw only several individuals of this plant in a very limited area just north of my base camp on the southeast side, on the mid dune area.

*A. nudicaulus* L. wild sa(r)sparilla C: abundant in forest.

#### **ASTERACEAE Aster or Composite family U C**

*Achillea asiatica* Serg. тысячелистник азиатский S W U: Bolshoi: Pescherka Bay, edge of larch woods not far from old settlement; introduced.

*Achillea millifolium* L. ssp. *lanulosa* (Nutt.) Piper yarrow C: Around lighthouse.

*Anaphalis margaritacea* (L.) Brenth & Hook. f. pearly everlasting C: Frequent at backdunes.

*Artemisia campestris* L. ssp. *borealis* (Pallas) H. M. Hall & Clements C: Stabilized South Bay dunes.

*Artemisia commutata* Bess. польнь замещающая S U: Bolshoi and Dolgii: south steppe slopes.

*Artemisia dracunculus* L. польнь эстрагон S U: Bolshoi: Pescherka Bay, on south steppe slopes of the lower terraces.

*Artemisia frigida* Willd. польнь холодная S U: Bolshoi: maryan on southern

slope near gate of Pescherka Bay, on steppe slopes.

*Artemisia gmelinii* Web. польнь Гмелина S U: Bolshoi: southern steppe slopes of the lower terraces; rare.

*Artemisia lacinata* Willd. польнь рассеченная S U: Bolshoi: southern slope, on lower terraces; rare.

*Artemisia santolinifolia* Turcz. ex Bess. польнь сантолинолистная S U: Bolshoi: southern slope on lower terrace; found only by Ivanova on one site.

*Artemisia sericea* Web. польнь шелковистая S U: Bolshoi: steppe, steppe edge pine and larch woods. Kruglii and Tonkii: steppes.

*Artemisia tanacetifolia* L. польнь пижмолистная U: All islands: steppes and forests.

*Artemisia vulgaris* L. польнь обыкновенная U: Bolshoi: southern steppe slope on lower terraces; rare.

*Aster alpinus* L. s. l. Астра альпийская S U: Bolshoi: forests.

*Aster lanceolatus* Wild. ssp. lanceolatus paniced aster W C: Marshy area on Gull Island.

*Aster nemoralis* Aiton bog aster C: Common on bogs and around peaty lakes in central Caribou Island.

*Cirsium arvense* (L.) Scop Canada thistle C: Marshy shore on north end of Caribou Island (Morton and Venn 1996). Also on open meadow on Gull Island (RJL).

*Crepis sibirica* L. Скерда сибирская U: Bolshoi: larch and pine woods, predominately on southern slope.

*Dendranthema zawadskii* (Herbich.) Tzwel. *Dendranthemum zawadskii* (Herb.) Tzwel. (sic?), *Chrysanthemum sibiricum* Turcz. дендрантема Завадского, хризантема сибирская S U: Bolshoi, Dolgii: forests.

*Erigeron acris* L. *Erigeron acer* L. Мелколепестник едкий U: Bolshoi: Pescherka Bay; on southern steppe slope of lower terraces. Dolgii: cobble beach, rather uncommon.

*Euthamia graminifolia* (L.) Nutt. grass-leaved goldenrod C: Frequent on marshy shores and fen areas.

*Gnaphium viscosum* Kunth clammy cudweed C: South Bay Dunes.

*Heteropappus hispidus* (Thumb.) Less. гетеропашус щетиносто-волосистый S U: Bolshoi: south steppe slopes.

*Hieracium canadense* Michaux Canada hawkweed W C: South Bay; cobble shores and backdunes (Morton and Venn 1996). On low ground at south side of Gull Island (RJL).

*Hieracium virosum* Pall. ястребинка ядовитая S U: Bolshoi and Dolgii: rocky beaches.

*Hieracium vulgatum* Fr. ястребинка обыкновенная U: Bolshoi: beach on southern shore.

*Lactuca sibirica* (L.) Maxim. *Lactuca sibirica* (L.) Benth. латук сибирский U: Bolshoi: Pescherka Bay on gravel beach.

*Saussurea controversa* DC. соссурея спорная S U: Ushkanii Islands: forests.

*Saussurea salicifolia* (L.) DC. соссурея иволистная S U: Bolshoi: south slope cliffs.

*Scorzonera austriaca* Willd. козлец австрийский S U: Bolshoi: steppes of south slopes, steppe edge and herbaceous-lingonberry pine woods.

*Scorzonera radiata* Fisch. et Ledeb. *Scorzonera radiata* Fisch. козлец лучистый U: Bolshoi: Pescherka Bay; on southern steppe slope of lower terraces.

*Solidago dahurica* Kitag. *S. virgaurea* L. complex, *S. virga-aurea* L. var. *dahurica* Kitag. золотая розга, Золотарник даурский U: Bolshoi and Dolgii: forests.

*Solidago uliginosa* Nutt. bog goldenrod C: Uncommon on bogs near west shore of Caribou Island.

*Tanacetum vulgare* L. common goldenrod пижма обыкновенная U: Bolshoi: beaches.

*Taraxicum officinale* Wigg. s. l. (*Taraxicum officinale* Web. ex Wigg. s. l., *Taraxicum officinale* G. Weber) dandelion одуванчик лекарственный W U: Bolshoi: eastern shore, lower terrace slope; possibly introduced. C: Around lighthouse and occasional on southwest and northwest sides, usually on gravel and sand near high wave zone.

*Youngia tenuifolia* (Willd.) Bab. et Stebbins *Crepis tenuifolia* Willd. юнгия узколистная S U: Ushkanii Islands: southern steppe and cliff slopes.

#### **BALSAMINACEAE Touch-me-not family C**

*Impatiens capensis* Meerb. touch-me-not C: Swampy forest openings and marshy areas (Morton and Venn 1996). Common along wetland edges, especially on western and southern areas (RJL).

**BETULACEAE Birch family U C**

*Alnus incana* (L.) Moench. *A. rugosa* speckled alder C: Occasional along the southwest shoreline and west side (RJL). Not noted by previous investigators.

*Alnus viridus* (Chaix) DC. ssp. *crispa* (Dryander ex Aiton) Turrill *A. crispa* green alder C: Common along west side, especially southwest gravel shore; forms thicket at SBH.

*Betula divaricata* Ledeb. *B. mittendorffii* Trautv. et Mey. берёзка растопыренная, б. Миддендорфа аа U: Bolshoi: several individuals on northern coast noted by Sukachev and Poplovskaya (Сукачев и Пошлавская 1914), and Sukachev and Lamakin (Сукачев и Ламакин 1952). Not noted by subsequent researchers, and possibly extirpated by lake level rise.

*Betula divaricata* Ledeb. X *B. exilis* Sukacz. U: Dolgii: Empetrum-larch woods on northern shore. Ivanova (Иванова 1969) notes that possibly, the second parent is *B. rotundifolia*, since this species is known on Kruglii, and not *B. exilis*, which is unknown from the Ushkanii Islands.

*Betula hippolytii* Sukacz *B. platyphylla* Sukacz. s. l. берёза Ишполита U: Bolshoi: southwest shore in larch wood of lower terrace. Apparently less common than *B. pendula*. Dolgii: Empetrum-larch woods.

*Betula papyrifera* Marshall white birch, paper birch C: Common in boreal forest. Some very large trees.

*Betula pendula* Roth. *B. insularis* V. Vassil, *B. verrucosa* Ehrh. берёза повислая, б. островная, б. бородавчатая U Bolshoi: on second layer of larch and pine woods. A specimen from Bolshoi Ushkanii Island V. N. Vasilyev has named as a new species *B. insularis* V. Vassil, syn. *B. ushkanensis* Sukacz. (nom. nudum.) (Иванова 1969). Czerepanov (1995) gives *B. insularis* as the legitimate name, but I have used *B. pendula*, as explained in the text.

*Betula pubescens* Ehrh. берёза пушистая. U: Bolshoi (Иванова 1969) not seen by Ivanova et al., but noted by Sukachev and Lamakin for Bolshoi (Иванова 1969)

*Betula rotundifolia* Spach. *B. nana* ssp. *rotundifolia* (Spach.) Malyshev берёзка круголистная аа U: Kruglii: Empetrum-larch woods on northern shore.

*Duschekia fruticosa* (Rupr.) Pouzar. (*Alnus fruticosa* Rupr.) душекия кустарниковая, Олха кустарниковая U: Bolshoi: wet larch and pine-*Duschekia*-rhododendron woods.

**BORAGINACEAE Borage family U**

*Myostis suaveolens* Walst. & Kit. *Myostis asiatica* (vestergren) Schischkin et Serg. незабудка душистая S U: Bolshoi, Tonkii, Kruglii: southern steppe slopes of

lower terraces, also on gravel beaches.

*Lappula redowskii* (Hornem.) Greene *Lappula intermedia* M. Pop. липучка  
Редоуска S U: Bolshoi, Kruglii: southern rocky steppe slopes.

### BRASSICACEAE (CRUCIFERAE) Mustard family U C

*Alyssum lenense* Adams бурачок ленский S U: Bolshoi: southern stony steppe slopes and cliffs.

*Alyssum obovatum* (C. A. Mey.) Turcz. бурачок обратно-яйцевидный, б. двусемянный S U: Bolshoi: Maryan; cliffs.

*Arabis pendula* L. Резуха висячая W U: Bolshoi: northern extreme of Pescherka Bay on slope of lower terrace at beach. One station only; introduced.

*Barbarea vulgaris* R. Br. winter cress W C: Cobble shores of Gull Island.

*Capsella bursa-pastoris* (L.) Medikus shepherd's purse W C: Around lighthouse.

*Clausia aprica* (Steph.) Korn.-Tr. клаусия солнцепечная S W U: Bolshoi: Pescherka Bay at edge of larch woods near old habitation. Introduced.

*Descurainia sophia* (L.) Webb ex Prantl. *Descurainia sophia* (L.) Schur. Дескурения София W (?) U: Bolshoi: Pescherka Bay on gravel beach near signs of old residence. r-selective and weedy in disturbed areas. May have been introduced at Ushkaniis; in any event grows there on human-disturbed land.

*Descurainia richardsonii* (Sweet) O.E. Schuz gray tansy-mustard C: Shingle ground at lighthouse.

*Draba cinerea* Adams крука серая aa U: Bolshoi: southern, southeastern, and southwestern shores; on cliff slopes of lower terraces and on gravel beaches. Arctoalpine.

*Draba nemorosa* L. крупка перелесковая S U: Bolshoi: southern steppe slope of lower terraces.

*Erysimum cheiranthoides* L. wormseed mustard W C: A weed at Lighthouse Island.

*Erysimum hieracifolium* L. *E. marschallianum* Andrz. Желтушник Маршалла S U: Bolshoi: southwest, southern and eastern coasts on gravel beaches; predominately along shoreline erosion slopes. Kruglii: eastern shore on gravel beach; predominately at old high water erosion bank.

*Isatis oblongata* L. woad вайда продолговатая S U: Bolshoi and Dolgii: gravel beaches of predominately the south shores.

**CABOMBACEAE Water-shield family C**

*Brasenia schreberi* J. Gmelin water-shield C: Peaty water in Deer lake and Long Slough.

**CAMPANULACEAE Bellflower family U**

*Campanula glomerata* L. колокольчик скыченный S W U: Bolshoi: edges of larch woods near old settlement at Pescherka Bay; introduced.

*Campanula rotundifolia* L. колокольчик круголистный S U: Bolshoi and Dolgii: cliff slopes and gravel beaches.

*Campanula turczaninovii* Fed. колокольчик Турчанинова U: Bolshoi: larch woods, with exception of steppe edge forests.

**CANNABACEAE Hemp family U**

*Urtica canabina* L. крапива коноплевая W U: Bolshoi: Pescherka Bay on coast near old settlement. Probably introduced.

*Urtica angustifolia* Fisch. et Hornem. крапива узколистная W U: Bolshoi: Pescherka Bay near old settlement. Probably introduced.

**CAPRIFOLIACEAE Honeysuckle family U C**

*Diervilla lonicera* Miller v. *lonicera* bush-honeysuckle C: Well-drained gravel and cobble on north end Caribou Island and near lighthouse.

*Linnaea borealis* L. twinflower линнея северная U: All islands: all types of forest, except steppe edge. C: common in boreal forest and backdunes.

*Lonicera coerulea* L. *L. turczaninovii* Pojark. жимолость светло-синий U: All islands: larch woods, most often in moister areas.

*Sambucus racemosa* L. ssp. *pubens* (Michaux) House red-berried elderberry C: Well drained and stony areas on north end Caribou Island and around lighthouse.

**CARYOPHYLLACEAE Pink family U C**

*Cerastium arvense* L. ясколка полевая S U: Bolshoi and Kruglii: gravel beaches.

*Cerastium vulgatum* L. *C. fontanum* Baumg. mouse-ear chickweed W C: Around lighthouse.

*Dianthus versicolor* Fisch et Link гвоздика разноцветная S U: Bolshoi: southern steppe slopes.

*Moehringia lateriflora* (L.) Fenzl. мерингия бокоцветная U: All Ushkanii Islands:



Common in the herbaceous and herbaceous-shrub larch woods.

*Oberna behen* (L.) Ikonn. *Silene latifolia* (Mill.) Rendle et Britt. смолевка широколистная, хлопунка W U: Bolshoi: southwest shore on moist meadow at beach. One station; possibly introduced.

*Sagina nodosa* (L.) Fenzl. knotty pearlwort aa C: Shoreline near southwest side, reported only by White (1995). Listed as threatened in Michigan.

*Silene jensiseensis* Willd. смолевка енисейская S U: Bolshoi: south steppe slope and cliffs.

*Silene nutans* L. смолевка пониженная U: Bolshoi: steep rocky areas of southern slopes.

*Silene repens* Patrin. смолевка ползучая S U: Bolshoi: south steppe slope, pine forest edge and herbaceous-lingonberry pine woods, occasionally in larch woods. Dolgii and Tonkii: south steppe slopes.

*Stellaria angarae* v. *baicalensis* M. Pop. Baikal chickweed Звездчатка ангарская U: Bolshoi: Pescherka Bay; moist field at water level.

*Stellaria borealis* Bigelow ssp. *borealis* *Stellaria calycantha* s.l. northern chickweed C: Marshy, grassy area on Gull Island and behind SBH.

*Stellaria dahurica* Wild. ex Schlecht. Dahurian chickweed Звездчатка даурская U: Bolshoi: northwest and southwest shores on mossy areas of beach.

#### **CHENOPODIACEAE Goosefoot family U**

*Chenopodium album* L. lamb's quarters, pigweed Марь белая U: Bolshoi: southern rock slope. Comparatively rare.

*Kochia prostrata* (L.) Schrad. Кохия распростертая S U: Bolshoi: maryan.

*Teloxys aristata* (L.) Moq. *Chenopodium aristatum* L. Марь остистая S U: Bolshoi: southern rocky steppe slope.

#### **CISTACEAE Rockrose family C**

*Hudsonia tomentosa* Nutt. false heather C: Dominant on most mid-dunes (Morton and Venn 1996). Common on the dunes of the east and northwest sides, and the south headland (RJL).

#### **CORNACEAE Dogwood family C**

*Cornus canadensis* L. Canada dogwood, bunchberry C: Abundant, often dominant, in forest and stabilized dunes (Morton and Venn 1996). Ubiquitous in boreal forest, mid and backdunes, and occasional in wetlands (RJL).

*Cornus stolonifera* Michaux. red-osier dogwood C: Marshy, gravelly, rocky shores.

### CRASSULACEAE Orpine family U

*Sedum aizoön* L. очиток живучий S U: Bolshoi: cliffs on south slope.

*Orostachys spinosa* (L.) C.A. Mey горноколюсник колочий S U: Bolshoi and Kruglii: cliffs and stone steppes of south slopes.

### CUSCUTACEAE Dodder family U

*Cuscuta europaea* L. повилика европейская W U: Bolshoi: Pescherka Bay, southwest, and northeast shore at locales of former and present habitations. Weedy.

### DROSERACEAE Sundew family C

*Drosera anglica* Hudson greater sundew Росянка английская C: Uncommon on bogs.

*Drosera intermedia* Hayne spatulate-leaved sundew Росянка C Common on bogs, more so than the above species, less so than the below.

*Drosera rotundifolia* L. round-leaved sundew Росянка круглолистная C Common on bogs.

### EMPETRACEAE Crowberry family U C

*Empetrum sibiricum* V. Vassil. Siberian crowberry шикша сибирская U: Bolshoi: thickets at bottom of and partially up northern slopes of lower terraces. Small Ushkaniis: dominant ground cover in larch woods on northern slopes and thickets at bottom of northern lower terrace slopes (Иванова 1969). RJL: Common on rock on south shore, in west side larch forest, and on Tonkii Island. Forms extensive dominant ground cover on northwest corner of Bolshoi and on Tonkii Islands. Closely related to the species below.

*Empetrum nigrum* L. black crowberry шикша чёрная aa C: common on dunes (Morton and Venn 1996) On northeast side dunes, also occasional on hummocks in big bog (RJL). Listed as threatened in Michigan.

### ERICACEAE Heather family U C

*Andromeda polifolia* L. ssp. *glaucophylla* (Link.) Hultén bog rosemary C: Common on the wetlands.

*Arctostaphylos uva-ursi* (L.) Sprengl. bearberry, kinnikinick толокнянка обыкновенная, медвежья ягода U: Ushkaniis Islands: common in forests and on rocky shores and shoreline woods, especially on south side. C: common on Caribou Island on dunes and forest edges, occasionally on bogs.

*Chamaedaphne calyculata* (L.) Moench leatherleaf C: Ubiquitous on wetlands; often dominant in fens and less acidic bogs and forming extensive thickets on open bogs. Occasional along west side shore-forest edge.

*Gaultheria procumbens* wintergreen C: Boreal forest southwest side close to shore between South Bay dunes and South Bay headland (White 1995). Reported first by White; I only saw this species on one small hummock on south side of the big bog.

*Gaultheria hispidula* (L.) Muhlenb. creeping snowberry C: Common in forest and edges.

*Epigaea repens* L. trailing arbutus C: Found only at two stations in limited area. Found in one small area near the south-center of the island between small bogs, the total patch was no larger than 5x5 m, oddly on somewhat wet peaty soil, while more "typical" well-drained sandy hillside soil was directly adjacent but free of *E. Repens*. Later, a much larger area, approximately 10x15 m, was found slightly further north (perhaps 750 m), on more "typical" site conditions of well drained sandy soil under fir and white spruce. Not noted by previous investigators.

*Kalmia polifolia* Wangenh. bog laurel C Common on wetlands.

*Ledum groenlandicum* Oeder Labrador tea C: Common on bogs, around inland lakes, and swampy areas of forest (Morton and Venn 1996). RJL: Common on wetlands and wetter areas of the boreal forest. Also occasional in upland areas, especially on north center of Caribou Island.

*Ledum palustre* L. Багульник болотный U: Ushkanii Islands: in less well drained humid larch woods of northern terrace slopes (Иванова 1969). Occasional in lower forests of west side and north side (RJL).

*Oxycoccus microcarpus* Turcz. ex Rupr. *Vaccinium oxycoccus* var. *microcarpus* (Turcz.) Fedtsch. & Flerov. small cranberry Клубка мелкоплодная U: Bolshoi: reported by Ivanova (Иванова 1969) to northern shore on *Sphagnum* hummock. Not seen by the present author (RJL); the only *Sphagnum* observed was on the southwest interior of the island. A possible vegetation change. Hultén (1958) notes that this species and *O. palustris* are closely related.

*Oxycoccus palustris* Pers. *Vaccinium oxycoccus* L. in part; *O. quadripetalus* Gilib. small cranberry C: Abundant in bogs. Hultén notes that this species and *O. microcarpus* are closely related.

*Rhododendron dahuricum* L. Dahurian rhododendron Рододендрон даурский, багульник U: Bolshoi: on all slopes except southern; understory in larch and pine woods. Tonkii: one shrub on southern slope in lingonberry-raznotravye larch woods (Иванова 1969). Sukachev and Lamakin (Сукачев и Ламакин 1952) indicate that the Bolshoi Ushkanii Island forests quite often had lush, even impenetrable growth of this species. Included in Red Book of Buryat Republic.

*Vaccinium angustifolium* Aiton lowbush blueberry C: Abundant on dunes.

*Vaccinium macrocarpon* Aiton. *Oxycoccus macrocarpon* Large cranberry C: reported first by White (1995). I (RJI) found this species several times on west side bogs and small east side interior wetlands. Rather common, though overlooked (?) by Morton and Venn (1996).

*Vaccinium myrtilloides* Michx. velvet leaf blueberry C: Occasional in central boreal forest and near dry hillsides and wetland margins.

*Vaccinium membranaceum* Douglas mountain bilberry C: Common in east side boreal forest.

*Vaccinium ovalifolium* Smith oval-leaved bilberry, tall blueberry C Common in forest.

*Vaccinium uliginosum* L. alpine bilberry, bog whortleberry Голубика, гоноболь U: Bolshoi: larch and pine woods with *Duschekia* and *Rhododendron*. Tonkii: in *Empetrum* thicket on northern shore.

*Vaccinium vitus-idaea* L. lingonberry, mountain cranberry, cowberry Брусника U: Ushkanii islands: larch and pine woods.

#### **EUPHORBIACEAE Spurge family U**

*Euphorbia discolor* Ledeb. молочай двуцветный S U: Bolshoi, Tonkii, Dolgii: forests.

#### **FABACEAE (LEGUMINOSAE) Bean or Pea family U C**

*Astragalus austrosibiricus* Schischk. Астрагал южносибирский U: Bolshoi: southern steppe slopes. At edge of range on Ushkanii.

*Astragalus frigidus* (L.) A. Gray Астрагал холодный U: Bolshoi: northern coast; bottom of lower terrace slope, among mosses. arctoalpine

*Astragalus membranaceus* (Fisch.) Bunge. Астрагал перепончатый U: Bolshoi: predominately steppe edge and graminoid-shrub pine woods.

*Astragalus sericeocanus* Gontsch. Астрагал шелковисто-седой U: Dolgii: steppe of southern slope and edge of larch woods.

*Astragalus suffruticosus* DC. *A. fruticosus* Pall.; *A. fruticosus* Pall. DC. Астрагал полукустарниковый S U: Bolshoi: southern rocky steppe slopes.

*Lathyrus humilis* (Ser.) Spreng. *Lathyrus humilis* Fisch. Чина приземистая U: Bolshoi, Tonkii and Dolgii: forests.

*Lathyrus japonicus* Wild. beach pea C: Common on dunes and near lighthouse.

*Lathyrus palustris* L. *Lathyrus pilosus* Cham. marsh pea Чина волосистая U: Bolshoi, Dolgii, Kruglii: damp shoreline meadows. C: Reported by Morton and Venn (1996) for 1976 to marshy grassland on Gull Island, though I (RJL) found it only in marshy shore area between the two Deciduous forest areas, and not on Gull Island. The discrepancies between the locations of Morton and Venn and myself raise questions: are the two locations the result of one or two establishments? Did they exist together or separately in time?

*Lathyrus pratensis* L. Чина луговая U: Bolshoi: gravel beach at Pescherka Bay.

*Lupinaster pentaphyllus* Moench. *Trifolium lupinaster* L. Клевер пятилистный; Клевер люпиновый W(?) S U: Bolshoi: Pescherka Bay and southwest shore; on gravel beaches. Grows on sites of former and present settlement.

*Oxytropis strobilacea* Bunge. Остролодочник шишковидный U S: Bolshoi: western tip; on southwest facing steppe slope of lower terraces at beach edge; one location only.

*Trifolium pratense* L. Клевер луговой W U: Bolshoi: Pescherka Bay; small meadow of larch woods on site of abandoned settlement. Introduced.

*Trifolium repens* L. *Amoria repens* (L.) C. Presl. (in Czerepanov) white clover Клевер ползучий W (both) U: Bolshoi: Pescherka Bay, on beach near old settlement; introduced. C: Weedy around lighthouse and at grassy area at north end of Caribou Island.

*Vicia cracca* L. Горошек мышиный U: Ushkanii Islands: forests and damp meadows on shorelines.

*Vicia multicaulis* Ledeb. Горошек многостебельный S U: Ushkanii Islands: forests and locally on steppe slopes.

#### FUMARIACEAE Fumitory family U

*Corydalis sibirica* (L. fil.) Pers Siberian corydalis Хохлатка сибирская U: Bolshoi: northern shore in larch woods on bare soil in pit at roots of wind thrown tree (Иванова 1969). At southeast forest-steppe slope transition (RJL).

#### GENTIANACEAE Gentian family U C

*Gentianella plebeja* (Cham. ex Bunge) Czer. *Gentiana plebeja* Cham. et Schlecht. Горечавка простая U: Bolshoi, Tonkii: damp small meadows on shoreline, occasionally in forests.

*Halenia deflexa* (J. E. Smith) Griseb. spurred gentian C C: Reported by White (1995) for undisclosed location.

*Gentianopsis barbata* (Froel.) Ma *Gentiana barbata* Froel. горечавка бородатая  
U: Bolshoi and Tonkii: moist meadows at shorelines.

*Lomatogonium rotatum* (L.) Fries *Lomatogonium rotatum* (L.) Fries ex Nym.  
ЛОМАТОГОНИУМ КОЛЕСОВИДНЫЙ U: Bolshoi, Kruglii: moist meadows at shorelines,  
predominately northern shores.

#### GERANIACEAE Geranium family U

*Geranium pratense* L. Герань луговая W U: Bolshoi: Pescherka Bay on small  
meadow on shoreline, near the place of former settlement. Introduced.

*Geranium sibiricum* L. Герань сибирская S W U: Bolshoi: Pescherka Bay, on  
beach near old settlement. Introduced.

*Geranium pseudosibiricum* J. Mayer (*G. coeruleum* Patrin.) Герань  
ложносибирская, герань голубая S U: All Ushkanii Islands: forests. Попов (Попов 1956) named this as an individual species (*G. uschkanense* M. Pop.; *G. coeruleum* v. *uschkanense* M. pop.), owing to its overall smaller size, and longer peduncles and pedicels.

#### GROSSULARIACEAE Gooseberry family U C

*Ribes glandulosum* Grauer skunk currant C: Gravel and cobbles; on Lighthouse  
Island, North Point, and SBH.

*Ribes pauciflorum* Turcz. ex Pojark. *R. nigrum* var. *praecox* E. Wolf Смородина  
малоцветковая U: All islands: rocky shores and gravel beaches (Иванова 1969).  
RJL: Not seen on Bolshoi Ushkanii, noted on east side of Tonkii Island. The ZNP  
ranger noted that it grows only on the Small Ushkaniis.

*Ribes oxycanthoides* L. bristly wild gooseberry C: Gravel at lighthouse.

#### GUTTIFERAE St. Johns Wort family C

*Hypericum majus* (A.Gray) Britton large St. John's wort C: Wet sandy area at  
south end Long Slough; with *H. mutilum*.

*Hypericum mutilum* L. ssp. *boreale* (Britton) J. M. Gillet dwarf St. John's wort C:  
Wet sandy area at south end Long Slough; with *H. majus*.

*Triadenum fraseri* (Spach.) Gleason marsh St. John's wort C: Fen near Deer Lake.

#### LAMIACEAE (LABIATAE) Mint family U C

*Dracosephalum nutans* L. dragon-head змееголовник поникший U: Bolshoi:  
south rocky steppe slopes.

*Dracocephalum ruyschiana* L. dragon-head змееголовник Руйпа W U:  
Bolshoi: Pescherka Bay on stone beach near old habitation. Rare and possibly  
introduced.

*Galeopsis bifida* Boenn. *G. tetrahit* L. hemp-nettle пикульник двунадрезный,  
жабрей W U: Bolshoi: Pescherka Bay near old habitation. Several individuals,  
introduced.

*Lamium album* L. white dead-nettle яснотка белая, глухая крапива U: Bolshoi,  
Dolgii, Kruglii: gravel beaches, encountered rather rarely.

*Thymus serpyllum* L. s. l. wild thyme чабрец, тимьян, богородицина травка S  
U: Bolshoi, Dolgii: cliffs on southern slopes and rocky steppes. Ivanova (Иванова  
1969): A specimen from Bolshoi Ushkaniï Island was described by M. V. Klokovym  
on p. 526 of volume 21 of *Flora USSR* (Флора СССР, т. XXI) as a new species  
*Thymus eubaicalensis* Klokov.

*Lycopus uniflorus* Michaux tuberous water-horehound, northern bugle-weed C:  
Edges of Deer Lake.

*Prunella vulgaris* L. heal-all C: On Gull Island and northwest shore.

*Scutellaria galericulata* L. marsh skullcap C: Fen behind SBH.

#### **LENTIBULARIACEAE Bladderwort family C**

*Utricularia cornuta* Michaux horned Bladderwort C: Wet peat by Deer Lake and bog  
behind West Bay.

*Utricularia minor* L. lesser bladderwort C C: Reported by White (1995) for  
undisclosed location.

*Utricularia intermedia* Hayne flat-leaved bladderwort C: Common in shallow open  
water on bogs.

*Utricularia vulgaris* L. common bladderwort C: Deer Lake.

#### **LINACEAE Flax family U**

*Linum perenne* L. *L. sibiricum* DC. Лен многолетний, лен сибирский S W  
U: Bolshoi: western tip, close to meteorological station, at edge of larch woods;  
possibly introduced.

#### **MENYANTHACEAE Bog-bean family C**

*Menyanthes trifoliata* L. buckbean, bog-bean C: Common on the wetlands,  
especially on west side.

**MONOTROPACEAE Indian-pipe family U C**

*Hypopithys monotropa* Crantz. *Monotropa hypopithys* L. pinesap, false beech-drops, yellow bird's nest Подбельник обыкновенный U: Bolshoi: larch and pine forests (lingonberry-raznotravye and Rhododendron); rare.

*Monotropa uniflora* L. indian-pipe C: Occasional in forest.

**MYRICACEAE Bayberry family C**

*Myrica gale* L. sweet gale C: In fens and less acid bogs, as well as marshy area on northwest side.

**NYMPHAEACEAE Water-lilly family C**

*Nuphar x robrodiscum* (Morong) Fern. yellow water-lilly C: In Deer lake.

**ONAGRACEAE Evening Primrose family U C**

*Epilobium angustifolium* L. *Chamenerium a.* (L.) Scop. по Ивановой Fireweed иван-чай U: Ushkanii Islands: recently burned areas. C: Common in open, well-drained areas such as backdunes, gravelly areas, cobbly shores and forest edges.

*Epilobium ciliatum* Raf. northern willow-herb C: Marshy shore on north of Caribou Island.

*Epilobium leptophyllum* Raf. narrow-leaved willow-herb C: Marshy woodland on SBH.

*Chamenerium latifolium* (L.) Th. Fr. et Lange *Epilobium latifolium* L. хаменерон широколистный аа U: Bolshoi, Dolgii, Kruglii: rocky shores and gravel beaches. Arctoalpine.

*Oenothera biennis* L. evening-primrose C: Occasional on dunes; most common on south bay headland.

**OROBANCHACEAE Broom-rape family U**

*Orobanche coerulescens* Steph. заразиха синеватая S U: Bolshoi: southern steppe slopes. Parasitic on roots of *Artemisia commutata*.

*Boschniakia rossica* (Cham. & Schlecht.) B. Feldtsch. *Boschniakia rossica* (Cham. et Schlecht.) Hult. бошнякия русская U: Bolshoi: in small rhododendron-larch wood on northern slope; one station only.

**OXALIDACEAE Wood-sorrel family C**

*Oxalis acetosella* L. wood sorrel C: Occasional in forest (Morton and Venn 1996). Frequent on soil and rotting wood in southwest deciduous forest (RJL).



**PAPAVERACEAE Poppy family U**

*Chelidonium majus* L. celandine Чистотел большой U: Bolshoi: bottom of slope of lower terraces. Rare.

**POLYGALACEAE Milkwort family U C**

*Polygala sibirica* L. истод сибирский S U: Bolshoi: southern steppe slopes and cliffs.

*Polygala comosa* Schkuhr. *P. hybrida* DC. истод хохлатый S U: Bolshoi and Dolgii: pine (and less often larch) herbaceous-lingonberry and rhododendron-steppe edge woods.

*Polygala paucifolia* Wild. gay-wings, fringed polygala, fringed milkwort C: Common in forest and backdunes Common at backdune-forest edge.

**PARNASSIACEAE Grass of Parnassus family U** Sometimes included in the Saxifragaceae (e.g, Gleason and Cronquist 1991).

*Parnassia palustris* L. Grass of Parnassus белозор болотный U: Ushkani Islands: wet meadows and beaches.

**PLANTAGINACEAE Plantain family U**

*Plantago media* L. подорожник средний W U: Bolshoi: Pescherka Bay at edge of larch woods near former habitation. Introduced.

**POLYGONACEAE Buckwheat family U C**

*Aconogonon divaricatum* (L.) Nakai ex Mori (*Polygonum divaricatum* L.) горец растопыренный W(?) U: Bolshoi: northern shore on gravel beach.

*Aconogonon ochreatum* v. *laxmanii* *Polygonum laxmanii* Lepesch. горец Лаксмана U: Bolshoi: southeast coast (below Maryan).

*Bistorta vivipara* *Polygonum viviparum* L. горец живородящий U: Bolshoi: gravel beach.

*Bistorta major* *Polygonum bistorta* L. горец змеиный U: Bolshoi: southwest shore; moist meadow at beach. One station.

*Polygonum amphibium* L. water smartweed C: Marshy area on north side Caribou Island.

*Polygonum cilinode* Michaux fringed black bindweed C: Northwest end Caribou Island on open area.

*Polygonum persicaria* L. lady's thumb W C: Reported for undisclosed location by White (1995).

*Polygonum lapathifolium* L. pale smartweed, dock-leaved knotweed C: Weedy at Lighthouse and Gull Islands.

*Rumex thyrsiflorus* Fingerh. щавель пирамидальный W? S U: Bolshoi: Pescherka Bay at edge of larch woods; possibly introduced.

*Rumex acetosella* L. sheep sorrel W C: Scattered on dunes, and at lighthouse.

*Rumex crispus* L. curled dock W C: Weed at Lighthouse Island and shore of north end Caribou Island.

*Fallopia convolvulus* (L.) A. Löve *Polygonum c. L.* Горец вьющийся S W? U: Bolshoi: southwest coast on beach near anthill; one station. Possibly human introduced.

#### **POLEMONIACEAE Phlox family U**

*Polemonium boreale* Adams *Polemonium pseudopulchellum* V.Vassil Jacob's ladder синюха aa U: Bolshoi: northeast shore, among mosses at base of slope of lower terrace.

#### **PORTULACAEAE Purslane family C**

*Claytonia carolineana* Michx. spring beauty C: Found in abundance only in the central area of the northern of the two deciduous forest areas on the southwest side of the island; not found in south deciduous area (RJL; not noted by previous investigators). First seen in full flower on 21 st of June, by the 5 th of July there were no traces of the plants to be seen.

#### **PRIMULACEAE Primrose family U C**

*Androsace amurensis* Probat. *Androsace lactiflora* Pall. проломник амурский S U: Bolshoi: southern steppe slopes.

*Androsace incana* Lam. проломник седой S U: Bolshoi: southern steppe slope and cliffs near the Pescherka Bay.

*Lysimachia terrestris* (L.) Britton, Sterns & Pogg. swamp candles C: Common on fens and marshes.

*Primula farinosa* L. первоцвет мучнистый U: Bolshoi: damp meadows on beaches.

*Primula mistassinica* Michaux bird's eye primrose aa(very nominally) C Common on low ground and shores of northwest side near (and on) Gull Island and along southwest side, especially near the areas of marshy shore near the deciduous

forest areas and alder thicket.

*Primula nutans* Georgi *P. sibirica* Jacq. первоцвет поникший U: Bolshoi: damp meadows on beaches.

*Trientalis borealis* Raf. starflower C: Common in forest and backdunes. Common in forest and backdunes.

*Trientalis europea* L. Eurasian starflower, chickweed wintergreen седмичник европейский U: Bolshoi, Dolgii, Kruglii: humid larch woods on lower terraces of northern shores.

### **PYROLACEAE Wintergreen family U C**

*Chimaphila umbellata* (L.) Barton pipessewa, wax-flower C: Backdunes of east side.

*Moneses uniflora* (L.) A. Gray one-flowered wintergreen C: Occasional in forest, more common on mid- and backdunes.

*Orthilia secunda* (L.) House *Ramischia secunda* (L.) Garcke. one-sided shineleaf, nodding wintergreen ортилия однобокая U: Bolshoi, Kruglii, Tonkii: forests.

*Pyrola asarifolia* Michx. pink shineleaf, pink pyrola C: Found in only one area on the northern shore opposite Gull Island; among *Cornus canadensis* on gravel shore-forest edge, in sun (RJL; not found by previous investigators).

*Pyrola americana* Sweet *P. rotundifolia* L., *P. rotundifolia* v. *americana* (Sweet) Fernald round pyrola C: Reported by White (1995); location not given.

*Pyrola chlorantha* Sw. грушанка зеленоватая U: Bolshoi: raznotravuelingonberry pine woods on upper terrace.

*Pyrola elliptica* Nutt. elliptic shineleaf C: Occasional at forest edge.

*Pyrola incarnata* (DC.) Freyn. *Pyrola incarnata* Fisch. грушанка красная U: Ushkanii Islands: humid larch woods of north shores.

### **RANUNCULACEAE Buttercup or Crowfoot family U C**

*Actaea rubra* f. *alba* white fruited red baneberry C: Southwest deciduous forest.

*Actaea rubra* (Aiton) Wild. red baneberry C: Among cobbles of forest of SBH.

*Acontium barbatum* Pers. борец бородачый S U: Bolshoi and Kruglii: forests and steppes of the southern slopes.

*Acontium septentrionale* Koelle *A. excelsium* Reichb. борец высокий U:

Bolshoi: larch-fescue-sedge-herbaceous woods and sedge openings with tallgrass on lower terraces of the north, northwest and northeast coasts; also on beaches among mosses. Small Ushkanii Islands: among larch-crowberry and herbaceous lingonberry larch woods.

*Anemondium dichotomum* (L.) Holub *Anemone dichotoma* L. ветреница вильчатая U: Bolshoi: southwest coast and Pescherka Bay; moist meadows on sandy parts of the beach. Kruglii: northern coast.

*Anemone canadensis* L. meadow anemone, Canada anemone C: Marshy grassland at north end Caribou.

*Aquilegia sibirica* Lam. бодосбор сибирский U: Bolshoi, Dolgii, Kruglii: gravel beaches, predominately on northern coasts (Morton and Venn 1996). Also seen on west side gravel beaches; flowering later on north side (RJL).

*Atragene sibirica* L. княжник сибирский U: Bolshoi, Tonkii, Kruglii: forests, particularly prominent at forest-shoreline transition of west and north sides of Bolshoi Ushkanii.

*Caltha palustris* L. *C. arctica* R. Br. ssp. *sibirica* (regel) Makino калужница болотная U: Bolshoi and Kruglii: at water level (Иванова 1969). Bolshoi: northwest shore among gravel and rocks at small shoreline marsh; one area only (RJL).

*Coptis trifolia* (L.) goldthread C: Very common in boreal forest.

*Delphinium elatum* L. живкость высокая U: Bolshoi: northern coast on beach among mosses at the bottom of the lower terraces. Kruglii: larch woods.

*Delphinium grandiflorum* L. живкость крупноцветковая W S U: Bolshoi: Pescherka Bay on gravel beach near former habitation; introduced.

*Pulsatilla multifida* (G. Pritz.) Juz. *P. patens* (L.) Mill. var. *multifida* Pritz. *A. patens* L. ssp. *multifida* прострел раскрытый S U: All islands: forests and steppes (Иванова 1969). Common in larch and pine forests (RJL). One very late flowering plant seen on west side near shore on July 25 (RJL).

*Ranunculus acris* L. meadow buttercup W C: Lighthouse Island and gravel shore at north shore Caribou Island.

*Ranunculus propinquus* C. A. Mey. *R. borealis* Trautv. лютик северный U All islands: moist small meadows along beaches.

*Ranunculus reptans* L. creeping spearwort C: Wet sandy shore south end Long Slough.

*Thalictrum foetidum* L. василисник вонючий S U: all islands: south steppe slopes.

*Thalictrum minus* L. василисник мальй U: Bolshoi: grassy larch woods; very rarely among pines. Dolgii: lingonberry-herbaceous larch woods.

*Thalictrum revolutum* DC. skunk meadow-rue C: On marshy and gravel shore near Gull Island. Listed as rare in Canada and threatened in Michigan.

*Thalictrum simplex* L. василисник простой U: Bolshoi: moist small meadows along beaches.

*Trollius asiaticus* L. жарки, жарок азиатский, купальница азиатская U: Bolshoi: northwest coast lower terraces at edge of lingonberry larch woods; found once only (Иванова 1969). Occasional in larch-pine woods on middle elevations of northeast side of Bolshoi Ushkanii Island (RJL). Included in Red Book of Buryat Republic.

## ROSACEAE Rose family U C

*Amelanchier alnifolia* Nutt. Saskatoon-berry C: North Caribou Island shore and West Bay backdunes.

*Amelanchier bartramiana* (Tausch) Roemer. mountain juneberry C: Gravel and cobbles; SBH and on north end of Caribou Island. Also South Bay dunes Voss (1985) discussed the confusion between this species and *A. spicata*.

*Aronia melanocarpa* (Michaux) Elliot black chokeberry W C: Frequent on bogs.

*Chamaerhodos erecta* (L.) Bunge. хамеродос прямостоящая U: Bolshoi: south steppe slopes.

*Chamaerhodos grandiflora* (Pall. ex Schult.) Bunge. *Chamaerhodos grandiflora* (Pall.) Ledeb., *Ch. baicalensis* M. Роров хамеродоси крупноцветковая U: Bolshoi: cliffs on south slope.

*Cotoneaster melanocarpus* Fisch. ex Blytt *Cotoneaster melanocarpus* Lodd. кизильник черноплодный S U: Ushkanii Islands: pine, and less frequently, larch woods and steppes of southern slopes, occasionally encountered on base of lower terraces (predominately here on southern slopes).

*Cotoneaster uniflorus* Bunge. кизильник одноцветковый U S: Bolshoi: southern steppe slopes.

*Cotoneaster tjuliniae* Pojark. ex Peshkova кизильник Тюлиной S U: forests and steppe edges, rocky slopes. This plant is a northern Baikal endemic, described from Bolshoi Ushkanii Island, and is limited to several stations on the northeast, northwest shoreline areas of Baikal and Ushkanii (Флора Сибири). Possibly reported by Ivanova (Иванова 1969) as *C. uniflorus*.

*Fragaria vesca* L. земляника лесная U: Bolshoi: lower portion of southern slope

alder thicket; one location only.

*Malus pumila* Miller *Pyrus malus* Apple яблоко W (Introduced) C: "A single small tree on dunes in South Bay" (Morton and Venn 1996) Not found since 1976.

*Physocarpus opulifolius* (L.) Maxim. ninebark C: Frequent on gravel and cobble shores, and occasional in forest-backdune transition (Morton and Venn 1996). Seen only in ares on South Bay dunes, occasionally on west side, and northwest marsh area (RJL).

*Potentilla acaulis* L. лапчатка бесстебелная S U: Bolshoi: south steppe slopes and cliffs.

*Potentilla altaica* Bunge. лапчатка алтайская, л. пятилисточковая U: Ushkanii Islands: south steppe slopes on lower terraces. According to *Flora of Central Siberia* (Мальшев и Пешкова 1979) this is a possible hybrid: *P. arenosa* x *multifida*.

*Potentilla anserina* L. silverweed Лапчатка гусиная U: Bolshoi: wet meadow at shore; rare. C: Gravel and cobble shores.

*Potentilla bifurca* L. лапчатка вильчатая S U: Bolshoi: south steppe slopes.

*Potentilla conferta* Bunge. лапчатка сжатая S U: Bolshoi: Pescherka Bay and south steppe slopes on lower terraces.

*Potentilla multifida* L. лапчатка многонадрезная W S U: Bolshoi: southwest shore, near vegetable garden. Introduced. considered arctoalpine at Lake Superior; very widespread in Asia.

*Potentilla nivea* L. лапчатка снежная U: Bolshoi: Pescherka Bay on slope of lower terraces among moss cover and on steppe openings.

*Potentilla norvegica* L. rough cinquefoil C: Weedy around lighthouse and on shore at north end of Caribou Island (Morton and Venn 1996). Southwest tip, on sandy beach (RJL).

*Potentilla palustris* (L.) Scop. *Comarum palustre* L. marsh cinquefoil сабельник болотный, лапчатка болотная U: Bolshoi and Kruglii: moist meadows at shorelines. C: Common on bogs and fens. "Accepted name" discrepancy between Siberia (Czerepanov 1995) and North America (Gleason and Cronquist 1991).

*Potentilla tridentata* Sol. ex Aiton three-toothed cinquefoil C: Abundant on dunes.

*Prunus pensylvanica* L. f. pin cherry C: Scattered small trees around shores of Caribou Island.

*Prunus pumila* L. sand cherry C: On dunes.

*Rosa acicularis* Lindley bristly rose роза иглистая, шиповник S (On Ushkanii)

U: Bolshoi, Dolgii, Kruglii: forests, locally on steppe slopes. C: Near shore on north end of Caribou Island (Morton and Venn 1996). Along east and west sides of the narrowest portion of North Point; near "forest" edge (RJL). Morton and Venn (1996) note that some plants appeared intermediate between *R. acicularis* and *R. blanda*.

*Rubus canadensis* L. Canada blackberry C: West Bay backdunes.

*Rubus chamaemorus* L. cloudberry, baked-apple berry, Морожка C: Found in one area approximately 20 x 20 m in the south center of the big bog on the west side of the island, growing on a treeless *Sphagnum* mat in association with *Chamaedaphne calyculata*, *Andromeda glaucophylla*, *Kalmia polifolia*, *Ledum groenlandicum*, etc. This may be significant as the southernmost station of this species in central North America, according to data in Soper and Heimbürger (1985) and Hultén (1970). Not reported by previous investigators.

*Rubus idaeus* L. *Rubus idaeus* L. ssp. *melanolasius* (Dieck) Focke wild red raspberry C: Common at forest edge near shoreline.

*Rubus matsumuranus* Levl. & Vaniot *Rubus sachalinensis* L. (veill) малина сахалинская, м. Матсумурана U: Bolshoi, Dolgii, Kruglii: gravel beaches; rare.

*Rubus parviflorus* Nutt. thimbleberry C: "A clump on the gravel of the Lighthouse Island" (Morton and Venn 1996).

*Rubus pubescens* Raf. dwarf raspberry C: Several sites in forest and edge.

*Rubus saxatilis* L. rock bramble костяника U: Bolshoi, Dolgii, Kruglii: forests, predominately those without understory growth. Also on gravel beaches and rocky shores.

*Sanguisorba officinalis* L. кровохлебка аптечная U: Bolshoi, Tonkii, Kruglii: gravel beaches.

*Sanguisorba baicalensis* Pop. Байкальская кровохлебка In addition to the above species, Sukachev and Lamakin report the Baikal endemic *S. baicalensis* for the gravelly shoreline of Bolshoi Ushkanii Island. Ivanova makes no mention of this plant, however. *S. baicalensis* was grouped with *S. tenuifolia* (of which *S. officinalis* is very closely related) by Yuzepchuk in *Flora of the USSR* (С. В. Юзепчук, Флора СССР, 1941 (X), 427). It is possible that Ivanova's *Sanguisorba* as well as that of Sukachev and Lamakin are the same plant of this difficult genus.

*Sorbaria pallasii* (G. Don fil.) A. Pojark. рябинник Палласа aa U: Bolshoi: southern rocky shore, several individuals at one site. Dolgii: one specimen on gravel beach on south shore.

*Sorbus decora* (Sarg.) C. Schneider showy mountain ash C: Common; usually at forest edge. Also dominant in SBH deciduous forest areas.

*Sorbus sibirica* Hedl. Siberian mountain ash Рябина сибирская U: All Ushkanii

Islands: scattered individuals on lower terraces of northern shores. Sukachev and Lamakin (Сукачев и Ламакин 1952): "One old Baikal hunter who knew the Ushkanii Islands well reported that there were, in 1950, in the forests of the island spruce and mountain ash ["пихта и рябина"], but only 2-3 examples of each." Sukachev and Lamakin also state "these [spruce and mountain ash] are possibly attributed to the several inhabitants of the islands [i.e., introduced]", though the reasoning behind this statement is unclear to me. Also see notes for *Pinus sibirica*

*Spirea alba* Duroi var. *latifolia* (Aiton) Dippel meadowsweet C: Fen areas near Deer Lake and Long Slough.

*Spirea flexuosa* Fisch. et Cambess. таволга извилистая S U: Bolshoi: northwest shore in larch woods at bottom of lower slope terrace.

*Spirea media* Franz Schmidt таволга средняя S U: All Ushkanii Islands: woods, south slope steppes, gravel beaches.

#### **RUBIACEAE Madder family U C**

*Galium asprellum* Michaux rough bedstraw C: Fen near SBH.

*Galium tinctorium* L. Dyer's bedstraw C: Fen near Deer Lake and LS, and northwest side marsh.

*Galium uliginosum* L. подмаренник топяной W (?) U: Bolshoi: Pescherka Bay; encountered only in one station and possibly introduced.

*Galium boreale* L. s.l. подмаренник бореальный, п. северный S U: All Ushkanii Islands: Pine and less frequently larch woods, beaches.

*Galium vernum* L. подмаренник настоящий S W U: Bolshoi: Pescherka Bay near old habitation; southwest side (station) near vegetable garden. Probably introduced.

*Galium triflorum* Michaux fragrant bedstraw C: Common in forest.

#### **SALICACEAE Willow family U C**

*Populus balsamifera* L. balsam poplar C: Few small trees on north end of Caribou (Morton and Venn 1996). Northwest side, on gravel-sand beach near Gull Island; one location only (RJL).

*Populus suaveolens* Fisch. тополь душистый U: Bolshoi: northern and northeast shores. Two small trees at bottom of lower terrace slope (Иванова 1969). West and northwest shores, at forest edge; uncommon (RJL).

*Populus tremuloides* Michx. trembling aspen C: First reported by White (1995) for an undisclosed location, the only examples of this species I saw were three very small saplings along the west side gravel beach. Possibly absent on the island because of a



combination of lack of fire and cutting by beavers.

*Populus tremula* L. (*P. tremula* f. *uskanensis*) осина U: Bolshoi: larch and pine woods (as an admixture); on northern slope predominately on upper parts. Tonkii: one unhealthy tree in *Empetrum*-larch woods (Иванова 1969). Occasional in larch and pine forest; one robust thicket on south center side of island, near shore (RJL). Some signs of an endemic form on the Ushkaniis.

*Salix abscondita* Laksch. ива скрытная U: All Ushkani Islands: wet larch woods on lower terraces. Occasional on gravel beaches.

*Salix bebbiana* Sarg. (*S. xerophyla* Floedr., *S. depressa* ssp. *rostrata* Nilsson) beaked willow, Bebb's willow ива сухолюбивая, И. Бебба S U: Bolshoi: larch and pine woods, occasionally on beaches (southwest shore). Tonkii: larch woods. C: Caribou Island, gravel at north end.

*Salix candida* Flügge sage willow, hoary willow C: Marshy area at north end.

*Salix divaricata* Pall. ива растопыренная aa U: Bolshoi: gravel beach (collected 1954 by M. Popov, L. Malyshev and G. Peshkov). Tonkii, Dolgii: gravel beaches (collected in 1952 I. Andreeva and L. Khanova) (Иванова 1969).

*Salix jensseensis* (Fr. Schmidt) B. Floder ива енисейская U: Bolshoi: larch woods and gravel shoreline slopes; uncommon.

*Salix lucida* Muhlenb. shining willow C: "Thicket and woodland on cobbles at SBH", according to Morton and Venn (1996).

*Salix pseudopentandra* B. Floder ива ложнопятитычинковая U: Bolshoi: south shore on gravel beach. Kruglii: east coast on gravel beach.

*Salix rhamnifolia* Pall. ива крушинолистая, ива зелёносережчатая U: All Ushkani Islands: gravel beaches. Widely distributed.

*Salix starkeana* Wild (*S. livida* Wahl.) ива синевато-серая U: Bolshoi, Kruglii, Tonkii: larch, less frequently wet pine woods (on Bolshoi) and gravel beaches.

*Salix stenolivida* M. Pop. ива узко-синеватая U: Tonkii: larch-lingonberry-herbaceous wood on south slope; only one station. This might possibly be a hybrid: *S. livida* x *S. chlorostachya*, according to Popov and Busik (Попов и Бусик 1966).

*Salix viminalis* L. *S. gmelinii* Pall. basket willow ива прутьевидная, ива Гмелина U: Bolshoi: southwest coast on beach edge rise.

*Salix* x *rubens* Schrank C: Several large shrubs on north tip. According to Morton and Venn, this introduced willow is commonly cultivated, and branches washing onto the shore may have been the original propagule.

**SANTALACEAE Sandalwood family U C**

*Geocaulon lividum* (Richardson) Fern. Northern commandra C: Frequent on dunes, at backdunes, and on forest borders.

*Thesium repens* Ledeb. ленец ползучий U: Bolshoi: larch and pine woods.

### **SARRACENIACEAE Pitcher-plant family C**

*Sarracenia purpurea* L. pitcher plant C: Common on wetlands and hummock-hollows.

### **SAXIFRAGACEAE Saxifrage family U**

*Bergenia crassifolia* (L.) Fritsch. Бадан толстолистный U: Bolshoi: larch, less frequently pine, forests of steep rocky northern and eastern slopes, on northern shore on slope of lower terrace and at base. Tonkii and Kruglii: larch woods.

*Saxifraga spinulosa* Adams каменоломка колючая S U: Bolshoi, Tonkii, Kruglii: rocky slopes and cliffs; predominately of a southern exposure.

### **SCROPHULARIACEAE Figwort family U C**

*Euphrasia officinalis* L. s. l. *E. stricta* D. Wolff ex J. F. Lehm. очанка обыкновенная U: Bolshoi, Tonkii, Kruglii: damp meadows ("луговинки") on beaches.

*Melampyrum lineare* Desr. cow-wheat C: at backdunes on east side Caribou Island Common in the forest, backdunes, forest openings, and hummock-hollows of wetlands.

*Pedicularis labradorica* Wirsing. мытник лабрдорский U: Bolshoi: larch woods, except steppe edge, occasionally in raznotravye-lingonberry pine woods. Dolgii and Tonkii: larch woods.

*Pedicularis resupinata* L. мытник перевнутый U: Bolshoi: larch-herb woods of lower terraces.

*Pedicularis uliginosa* Bunge. мытник топяной U: Bolshoi: northwest shore, on lower terrace larch woods; uncommon.

*Pedicularis ventusa* Sprang. ex Bunge. *Pedicularis ventusa* Sprang. мытник миловидный W U: Bolshoi: Pescherka Bay, at edge of larch woods near old settlement; introduced.

*Rhinanthus minor* L. *Rhinanthus minor* Ehrh. погребок малый U: Bolshoi and Kruglii: damp meadows on beaches.

*Veronica incana* L. вероника седая S U: Bolshoi: south steppe slopes and cliffs.

**VALERIANACEAE Valerian family U**

*Patrina rupestris* (Pall.) Duffr. патриния скальная S U: Bolshoi: cliffs of south slope.

*Patrina sibirica* (L.) Juss. патриния сибирская S U: Bolshoi: southern cliff slopes and rocky shore.

*Valeriana officinalis* L. валериана лекарственная U: Bolshoi: south cliff slopes.

**VIOLACEAE Violet family U C**

*Viola blanda* Willd. sweet-white violet C: Fen behind SBH.

*Viola dissecta* Ledeb фиалка рассеченная S U: Bolshoi: south cliff slopes and steppe-pine woods.

*Viola macloskeyi* F. Lloyd northern white violet C: Common in marshes and fens.

*Viola sachalinensis* Boiss. фиалка сахалинская U: Bolshoi: pine and larch woods-except the most humid-of the southern steppe slope. Kruglii: south steppe slope.

*Viola uniflora* L. фиалка одноцветковая U: Bolshoi: western extremity at edge of larch woods on lower terrace; one station.

*Viola lanceolata* L. lance-leaved violet C: "Sandy slack at south end of LS" (Morton and Venn 1996). Occasional on the wetter sand flats (RJL).

**Liliopsida (Monocots)****ARACEAE Arum family C**

*Symplocarpus foetidus* (L.) Salisb. ex Nutt. skunk cabbage C: Reported only by Wormington in 1979 in alder thicket of SBH, and repeated by subsequent authors, but despite repeated searchings of the reported site I was unable to locate it.

**CYPERACEAE Sedge family U C**

*Carex duriuscula* C. A. Mey. осока твердоватая S U: Bolshoi: south steppe slope. Comparatively rare.

*C. alba* Scop. осока белая U: Bolshoi: steppe-pine forest on south slope and steppes.

*C. amgunensis* Fr. Schmidt осока амгунская S U: Tonkii: larch woods with *Empetrum*.

- C. aquatilis* Wahlenb. C: Common in interior wetlands save the most acidic.
- C. brunnescens* (Pers.) Pioret C: Fens.
- C. buxbaumii* Wahlenb. C: Marshy area at Gull Island.
- C. canescens* L. C: Interior wetlands.
- C. capitata* L. осока головчатая U: Bolshoi: northeast and north coast, moist meadows at water level; uncommon.
- C. capillaris* L. осока волосовидная U: Bolshoi: eastern and northern coasts; moist meadows at water edge.
- C. cespitosa* L. s. l. *C. caespitosa* L. s. l. осока дернистая U: All Ushkani Islands: moist meadows at water level.
- C. disperma* Dewey. C: Boreal forest and bog forests.
- C. echinata* Murray C: Common on bogs, also on west side gravelly shoreline.
- C. enervis* C. A. Mey. осока безжилковая U: Bolshoi: southwest coast; sandy part of beaches. Comparatively rare.
- C. ericetorum* Pall. осока верещатниковая U: Bolshoi: larch woods with *Duschekia* and *Rhododendron* on northern slope; one station.
- C. exilis* Dewey осока C: Common in bogs.
- C. humilis* Leyss. осока низкая U: Bolshoi: southwest coast; on steppe slopes of the lower terraces.
- C. korshinskyi* Kom. осока Коржинского S U: Bolshoi: steppe-pine woods transition. Kruglii: larch-*Empetrum* woods. Tonkii: south steppe slope. Comparatively rare.
- C. krausei* Boeck. осока Краузе U: Dolgii: northeast coast.
- C. lenticularis* Michaux C: One station in low sandy area at south side Long Slough.
- C. limosa* L. mud sedge C: Common in "wettest areas of bogs and shallow, peaty ponds" (Morton and Venn 1996).
- Carex lasiocarpa* Ehrh. C: Fen areas.
- C. macroura* Meinsh. осока большехвостая U: Bolshoi: larch woods, less frequently in pine woods. Dolgii: and Kruglii: larch woods.

- C. magellanica* Lam. ssp. *irrigua* (Wahlenb.) НЯт. *C. paupercula* Michaux C:  
Common to bogs and shallow, peaty ponds.
- C. michauxiana* Boeckler C: Common in bogs.
- C. obtusata* Liljeb. осока притупленная S U: Bolshoi: Pescherka Bay on rocky  
steppe on slope of lower terraces.
- C. oligosperma* Michaux C: Common to less acidic bogs and inland lakes and ponds.
- C. pauciflora* Lightf. C: Bogs.
- C. pediformis* C. A. Mey. Осока стоповинная S U: Bolshoi, Tonkii, Kruglii:  
steppes of south slopes. Also occasionally on Bolshoi in steppe-pine woods.
- C. rostrata* Stokes C: Common in wet areas.
- C. sajanensis* V. Krecz. осока саянская U: Bolshoi: northern coast; moist meadow  
on beach.
- C. stricta* Lam. C: Local on marshy shores and fens.
- C. trisperma* Dewey C: Common in swampy forest areas and forest edges.
- C. utriculata* F. Boot. C: Common in bogs.
- C. vesicaria* L. C: Common in wet areas.
- C. viridula* Michx. C: Southwest shore area near marsh.
- Cladium mariscoides* (Muhlenb.) Torrey twig-rush C: In fen behind SBH.
- Dulichium arundinaceum* (L.) Britton three-way sedge, threesquare C: In fen near  
Long Slough.
- Eleocharis acicularis* (L.) Roemer & Schultes slender spike-rush C: Abundant on  
open wet peat near Deer Lake.
- Eleocharis smallii* Britton spike-rush C: Marshy areas at north Caribou Island and  
around Long Slough and Deer Lake.
- Eleocharis tenuis* (Wild.) Schultes C: Wet sand at south side of Long Slough.
- Eriophorum tenellum* Nutt. C: Reported to unnamed location by White (1995);  
probably on open bog or bog forest.
- Eriophorum vaginatum* L. ssp. *spissum* (Fern.) Hultén cotton-grass C: Bogs.

*Eriophorum virginicum* L. tawny cotton-grass C: Common on bogs.

*Eriophorum viridi-caranatum* (Engelm.) Fern. cotton-grass C: Common on bogs and edges of inland lakes.

*Luzula multiflora* (Freyn.) Mischz. (*L. pallescens* (Wahl.) Bess) wood-rush ожика бледноватая U: Bolshoi: larch woods. Dolgii: small meadow at water level.

*Luzula pilosa* (L.) Willd. wood-rush ожика волосистая U: Bolshoi: northern coast; larch-lingonberry-herbaceous and larch-fescue-sedge-herbaceous woods; rare.

*Rynchospora alba* (L.) M. Vahl white-beak sedge C: Common on wettest peat on open bogs.

*Rynchospora fusca* (L.) Aiton f. C: Common in bogs.

*Scirpus cespitosus* L. *Trichophorum caespitosum* (L.) Hartm. deer-grass аа(nominal) C: Bog hummocks.

*Scirpus cyperinus* (L.) Kunth wool-grass C: Fens and swampy forest openings.

#### **ERIOCAULACEAE Pipewort family C**

*Eriocaulon aquaticum* (Hill) Druce *E. septangulare* pipewort C: Abundant on wet sandy peat at edges of Deer Lake and Long Slough.

#### **IRIDACEAE Iris family U C**

*Iris ruthenica* Ker-Gawler Russian iris ирис русский S U: West side of Bolshoi, in edge of larch woods about 2m in from edge of beach edge rise. Near trail; only 5-7 individuals seen (RJL). Not noted by previous investigators.

*Iris versicolor* L. blue flag C: common to fens, marshes, shorelines (Morton and Venn 1996). In wetlands and borders, less frequent on more acid bogs (RJL).

*Iris humilis* Georgi. (*I. flavissima* Pall.) ирис приземельный S U: Bolshoi: south steppe slopes; predominately on maryan.

*Sisyrinchium montanum* E. Greene broad-stemmed blue-eyed grass C: In the marsh near Gull Island (Morton and Venn 1996). On northwest side of Caribou Island in wet swale areas of Caribou and Gull Islands (RJL).

#### **JUNCACEAE Rush family C**

*Juncus alpino-articulatus* Chaix alpine rush C: Wet sandy area south of Deer Lake.

*Juncus brevicaudatus* (Engelm.) Fern. short-tailed rush C: Fens adjacent to Deer Lake and Long Slough.

*Juncus dudleyi* Wieg. Dudley's rush C: Shore of Lighthouse Island.

*Juncus pelocarpus* E. Meyer mud rush, brown-fruited rush C: Wet, open peat and sands at Deer Lake and Long Slough.

*Juncus filiformis* L. thread rush C: Fens adjacent to Deer Lake and Long Slough.

## LILIACEAE Lilly family U C

*Allium anisopodium* Ledeb. лук разноножковый S U: Bolshoi: south steppe slopes.

*Allium schoenoprasum* L. wild chive лук-скорода U: Bolshoi, Kruglii, Tonkii: beaches, at water level (Иванова 1969). South and west (especially southwest) shores, In wet areas of shoreline among rocks (RJL).

*Allium strictum* Schrad. *A. lineare* L.; *A. splendens* Willd. ex Roem. et Schult. лук торчащий S U: Bolshoi, Tonkii, Kruglii: south steppe slopes. Also on Bolshoi in steppe pine woods.

*Clintonia borealis* (Aiton) Raf. bluebead lilly, C: Common on forest, especially on southeast area of island and backdunes.

*Lilium pilosiusculum* (Freyn.) Miscz. (*L. Martagon* v. *Pilosiusculum* Freyn.) Лилия кудреватая U: All Ushkanii Islands: larch and pine woods with herbaceous understory and herbaceous-lingonberry woods.

*Maianthemum bifolium* (L.) F. W. Schmidt Eurasian mayflower Майник двулистный U: All Ushkanii Islands: Common in forest, especially herbaceous and herbaceous-lingonberry woods (more frequent in larch than pine woods).

*Maianthemum canadense* Desf. Canada mayflower C: Common in boreal forest, on backdunes, and occasionally on dry areas near wetlands (RJL).

*Smilacina trifolia* (L.) Desf. three-leaved false Solomon's seal C: common on bogs

*Streptopus amplexifolius* (L.) DC. twisted-stalk C In forest behind SBH and on Gull Island, and by lighthouse.

*Streptopus roseus* Michx. rosy twisted-stalk C: In the southwest deciduous areas.

*Zigadenus sibiricus* (L.) A. Gray Siberian death-camas зигаденус сибирский U: All Ushkanii Islands: forests. Occasional in open pine forest on lower elevations of east side.

*Polygonatum odoratum* (Mill.) Druce *Polygonatum officinale* All. solomon's seal купена аптечная S U: Bolshoi: south rocky slope.

## ORCHIDACEAE U C

*Listera cordata* (L.) R. Br. heart-leaved twayblade C: At backdunes, forest openings, and near thickets on South Point.

*Listera auriculata* Wieg. auricled twayblade C: Found on sand underneath shoreline alders between the two areas of deciduous forest on the southwest shrubby shore; on sandy wet soil. This habitat matches exactly that described by Case (1989). Plants were, though not abundant, seen in the entire area of this habitat. Approximately 30 plants were seen in total; likely the actual population is somewhat larger (RJL). Not noted by previous investigators.

*Cypripedium guttatum* Sw. башмачок пятнистый U: Bolshoi: pine-herbaceous-lingonberry woods, infrequently in larch woods-for example on northwest extremity of island (Иванова 1969). At forest edge of west side of Bolshoi Ushkanii and Tonkii Islands (RJL). Included in Red Book of Buryat Republic.

*Cypripedium calceolus* L. yellow lady slipper башмачок настоящий U: Bolshoi: steep southeast slope, pine woods on carbonate substrate. Reported from only this one location (Иванова 1969). Bolshoi: open pine woods on north center of island "top" (RJL). Included in Red Books of USSR, Russian Federation, and Buryat Republic.

*Cypripedium acaule* Aiton moccasin flower, pink lady-slipper C: Occasionally in forest and on backdunes (Morton and Venn 1996). Very common at back- and mid dunes, also on dry, sandy sunny areas in interior such as at edge of wetlands (RJL).

*Epipactis helleborine* (L.) Crantz. (*E. Latifolia* (L.) All.) helleborine дремлик широколистный U: Bolshoi: steppe-pine woods of the southern slopes (Иванова 1969). On upper forest-steppe areas of south-center slope (RJL). Included in Red Book of Buryat Republic.

*Goodyera repens* (L.) R. Br. creeping rattlesnake plantain гудайера ползучая U: larch-crowberry woods on northern slope (Иванова 1969). Seen only in southwest side rock slope area of larch forest, in partial sun (RJL).

*Goodyera tessellata* Lodd. checkered rattlesnake plantain C: open forest and backdunes of east side Infrequent in boreal forest, especially on east side (RJL).

*Corallorhiza trifida* Chatel. early coral-root, northern coral-root ладьян трехнадрезный U: Bolshoi: larch woods (in Иванова 1969), according to Sukachev and Lamaikin (Сукачев и Ламакин 1952) and Sukachev and Poplovskaya (Сукачев и Поплавская 1914).

*Gymnadenia conopsea* (L.) R. Br. fragrant orchid кокушник комарниковый U: Bolshoi: pine-rhododendron woods on upper parts of western slope and on "top" of island. Rather rare.

*Platanthera obtusata* blunt-leaved orchid C: Reported for unknown location by White (1995).



*Platanthera clavellata* (Michaux) Luer clubspur orchid C: Fen behind SBH and on west side bog.

*Platanthera hyperborea* (L.) Lindley northern green orchid C: Northwest tip of Caribou Island and fen behind SBH (Morton and Venn 1996). Along marshy and sandy wet shoreline of southwest side (RJL).

*Spiranthes romanzoffiana* Cham. hooded ladies'-tresses C: Reported by White (1995); unknown location.

*Dactylorhiza majalis* L. (*Orchis latifolia* L.) ятрышник широколистный U: Bolshoi, Kruglii: moist meadows at beaches.

### POACEAE Grass family U C

*Achnatherum sibiricum* (L.) Lam. (*Stipa sibirica*) crested wheatgrass КОВЫЛЬ сибирский U: Bolshoi: on the southern steppe slope.

*Agropyron cristatum* (L.) Beauv. *Agropyron cristatum* (L.) Gaertn. crested wheatgrass пырей грабенчатый, житняк S U: All of the Ushkaniis: steppes of the southern slopes. Calciphile.

*Agrostis perennans* (Walter) Tuckerman autumn bent-grass, bent C: at forest edge on west side of Caribou Island

*Agrostis scabra* Wild. tickle-grass C: Common in marshy areas.

*Agrostis trinii* Turcz. полевница триниуса S W U: Bolshoi: Pescherka Bay, edge of larch woods near former homestead; possibly introduced by people.

*Ammophila breviligulata* Fern. beach grass C: The dominant dune grass.

*Brachypodium pinnatum* (L.) Beauv. коротконожка перистая U: Bolshoi: southern shore and Pescherka Bay, the predominate herbaceous species in larch and pine herbaceous woods.

*Bromopsis inermis* (Leyss.) Lindm. *Bromus inermis* Leyss.; *Zerna i.* Leyss. кострец безостый S U: Bolshoi: south steppe slope.

*Bromopsis pumpelliana* (Scribn.) Tzwel. (*Zerna p.*; *B. sibirica*; *Bromus pumpellianus*) кострец сибирский U: All Ushkaniis Islands: woods and locally in steppe-forest edge. Disjunct stations in northern lower Michigan (Voss 1972).

*Calamagrostis epigeios* (L.) Roth. feathertop вейник наземный S U: Bolshoi and Kruglii: southern dry slopes, and on Bolshoi in steppe-Pine forest.

*Calamagrostis langsdorfi* (Link.) Trin. reedgrass вейник лангсдорфа U: Bolshoi: Pescherka Bay, one station on stony beach. Closely related to *C. canadensis*.

*Calamagrostis neglecta* (Ehrh.) Gaertn., Mey., & Scherb. reedgrass Вейник незамечаемый U: Bolshoi: grassy areas near water's edge.

*Calamagrostis obtusata* Trin. reedgrass Вейник притупленный U: Bolshoi: moist larch woods, more rarely in the pine woods. On Kruglii Island in the larch-*Empetrum* woods.

*Calamagrostis canadensis* (Michaux) P. Beauv. bluejoint C: Abundant in wet places. Closely related to *C. langsdorfii*.

*Calamagrostis stricta* (Timm) Koeler *Calamagrostis stricta* (Timm) Koeler ssp. *inexpansa* (A. Gray) C. W. Greene, *Calamagrostis inexpansa* Gray reedgrass aa C: Marshy shoreline on north Caribou Island. Arctoalpine. Listed as threatened in Michigan.

*Cinna latifolia* (Trevir.) Griseb. drooping woodreed Синна широколистная C: Woods behind SBH.

*Danthonia spicata* (L.) P. Beauv. poverty grass, poverty oatgrass C: Common on backdunes and on Lighthouse Island.

*Deschampsia flexuosa* (L.) Trin. hairgrass C: On dunes, openings in forest, and on shorelines.

*Deschampsia turczaninowii* Litv. щучка Турчанинова U: Bolshoi: gravel beaches, at water level. Included in Red Books of USSR, Russian Federation, and Buryat Republic.

*Elymus mutabilis* (Drob.) Tzvel. (*Roegneria angustiglumis* Nevski) пырейник изменчивый U Bolshoi: rocky south-facing slopes of the lower terraces and gravelly shore slopes, predominately on southern and eastern shores.

*Elymus sibiricus* L. (*Clinelymus sibiricus* [L.] Nevski) пырейник сибирский U: Bolshoi, Dolgii, Kruglii: south and east shores, on gravel beach zones.

*Elytriga repens* (L.) Nevski (*Agropyrum repens* [L.] P. B. at Baikal); (*Elymus repens* [L.] Gould at Superior) quack-grass, couch-grass пырей ползучий W (at Caribou) U: Bolshoi: western shore and Pescherka Bay, on sandy part of shoreline. C: Near lighthouse and at north end of Caribou Island.

*Festuca lenensis* Drob. овсяница ленская S U: Bolshoi: near lighthouse on southwest corner of island.

*Festuca ovina* L. s.l. sheep fescue овсяница овечья U: All islands, larch woods, less frequently in pine woods.

*Festuca rubra* L. red fescue овсяница красная U: Bolshoi: sandy areas of the beaches. Ivanova (Иванова 1969) notes that var. *arenaria* is "especially frequent".

*Festuca brachyphylla* Schultes. *Festuca saximontana* Rydb. short leaf fescue C: Dunes. Arctoalpine.

*Glyceria striata* (Lam.) A. Hitchc. fowl mannagrass C: Reported by White (1995) for unspecified location.

*Glyceria canadensis* (Michaux) Trin. rattlesnake mannagrass C: Wet sandy peat at Deer Lake and Long Slough.

*Helictotrichon desertorum* (Less.) Nevski скрученноостник пустынный U: Bolshoi Ushkanii; Pescherka Bay, lower terraces of the south steppe slope.

*Helictotrichon schellianum* (Hack.) Kitag. *H. hookeri* (Scribner) Holub ssp. *schelliana* (Hackel) Lomonosova овсец Шелля S U: Bolshoi, Tonkii, and Kruglii: southern steppe slopes.

*Hierochloë odorata* (L.) Beauv. sweet grass зубровка душистая U: Bolshoi: damp meadow clearings near the water level and gravel beaches. C: West side backdunes and among grasses on north Caribou Island.

*Koeleria altaica* (Domin.) Kryl. тонконог алтайский S U: Bolshoi: maryan.

*Leymus flexilus* (Nevski) Tzvel. (*L. dasystachys* (Trin.) Pilg.) колосняк пушисткоколосный U: Bolshoi: Pescherka Bay; gravelly embankment on beach edge according to the *Flora of Siberia* (Мальпшев и Пешкова 1090) and Czerepanov (1995), these are both valid names.

*Leymus mollis* (Trin.) Pilger *Elymus mollis* Trin. American dunegrass C: Common in dunes. Arctoalpine.

*Panicum acuminatum* Sw. hairy panic-grass C: On sandy area at south end.

*Phalaris arundinacea* L. *Phalaroides a.* (L.) Rausch. reed canary-grass двукисточник тростниковый C: Marshy shoreline north Caribou Island.

*Phleum phleoides* (L.) Karst. тимopheевка степная S W? U: Bolshoi: Pescherka Bay; steppe at edge of larch woods close to old settlement. Ivanova postulates that this may be introduced by people.

*Phleum pratense* L. timothy тимopheевка луговая W C: South Bay backdunes, north Caribou Island shoreline, and Lighthouse Island.

*Poa argunensis* Roshev. *P. attenuata* Trin. ssp. *argunensis* (Roshev.) Tzvel. мятлик аргунский S U: Mentioned only in *Flora of Siberia* (Мальпшев и Пешков а 1990); for Bolshoi; presumably on steppe areas.

*Poa annua* L. speargrass мятлик однолетний W C: Lighthouse Island.

*Poa bortyoides* (Trin ex Grieseb). Ком. *P. attenuata* v. *botryoides* мятлик

кистевидный U: Bolshoi, Dolgii, and Kruglii: South steppe slopes. Also on Bolshoi Ushkanii occasional in steppe pine woods.

*Poa compressa* L. Canada bluegrass мятлик сплюснутостебельный W C: Gravel on Lighthouse Island and on north Caribou Island.

*Poa palustris* L. fowl meadow-grass мятлик болотный U: Bolshoi: northern coast; on moss cover near lower slope of first terrace at beach edge. C: Gravelly shorelines of Lighthouse Island and SBH, and on South Bay backdunes.

*Poa pratensis* L ssp. *pratensis* Kentucky blue-grass мятлик луговой W (probably) C: Lighthouse Island.

*Poa sibirica* Roshev. Siberian bluegrass мятлик сибирский U: All Ushkanii Islands: larch woods (especially with herbaceous understory), old beach slopes at beach edges. Also on Bolshoi Ushkanii occasionally in pine woods with *Vaccinium vitis-idaea* and various herbaceous understory.

*Stipa capillata* L. ковыль волосатик, тырса U: Bolshoi: south slope steppes.

#### **POTOMOGETONACEAE Pondweed family C**

*Potamogeton alpinus* Balbus red pondweed, alpine pondweed C: Bay between Gull Island and North Point.

*Potamogeton confervoides* Reichb. algal-leaved pondweed C: Peat at edge of Deer Lake. Listed as rare in Ontario and threatened in Michigan.

*Potamogeton epihydrus* Raf. ribbon-leaf pondweed, emersed pondweed C: Deer lake.

*Potamogeton gramineus* L. variable-leaved pondweed, grass-leaved pondweed C: Water between Gull Island and North Point.

*Potamogeton natans* L. floating pondweed C: In peaty water of south side Deer lake.

*Potamogeton richardsonii* (A. Bennet) Rydb. Richardson's pondweed C: According to Morton and Venn (1996): "sheltered water at north end of (Caribou) island"; presumably the small "strait" between Gull and Caribou Islands.

#### **SCHEUCHZERIACEAE Scheuchzeria family C**

*Scheuchzeria palustris* L. scheuchzeria C: On bogs, especially big west side bog.

#### **SPARGANIACEAE Bur-reed family C**

*Sparganium emersum* Rehmman ssp. *acaule* (Beeby) C. Cook & M. S. Nicholls green-fruited bur-reed C: in Deer Lake

**XYRIDACEAE Yellow-eyed grass family C**

*Xyris montana* Ries yellow-eyed grass C: Common on wet peat of bogs and around inland lakes (Morton and Venn 1996).

## **Appendix B**

### **Noteworthy Plants of the Ushkanii and Caribou Islands**

## Noteworthy Plants of the Ushkanii Islands

### Endemic Forms or Species:

*Larix x czekanowskii* (*L. ushkanensis*)

*Betula pendula* (*B. insularis*)

*Populus tremula* (*P. tremula* f. *uczkanensis*)

*Geranium pseudosibiricum* (*G. uschkanense*, *G. coeruleum* v. *uschkanense*)

*Cotoneaster tjuliniae*

### Officially Designated Protected:

*Deschampsia turczaninowii*: in the Red Books of USSR, Russian Federation, and Buryat Republic

*Cypripedium guttatum*: Red Book of Buryat Republic

*Cypripedium calceolus*: Red Books of USSR, Russian Federation, and Buryat Republic

*Epipactis helleborine*: Red Book of Buryat Republic

*Trollius asiaticus*: Red Book of Buryat Republic

*Rhododendron dahuricum*: Red Book of Buryat Republic

### Arctoalpine:

*Pinus pumila*

*Betula divaricata*

*B. rotundifolia*

*Polemonium pseudopulchellum*

*Salix divaricata*

*Sorbaria pallasii*

*Chamenerium latifolium*

and the nonvascular plants:

*Aulucomnium turgidum*

*Cetraria nivails*

*C. cuculata*

### Steppe and Cliff:

n.b., the species given here are mainly from Peshkova's *Steppe Flora of Baikal Siberia* (Пешкова 1972), and include many steppe species which also occur in other habitat types.

*Asplenium ruta-muraria*

*Ephedra monosperma*

*Selaginella sanguinolenta*

*Stipa capillata*

*Poa botryoides*

*Bromopsis inermis*

*Agropyron cristatum*

*Agrostis trinii*

*Poa argunensis*  
*Calamagrostis epigeios*  
*Phleum phleiodes*  
*Achnatherum sibiricum*  
*Festuca lenensis*  
*Koeleria altaica*  
*Helictotrichon schellianum*  
*Carex duriuscula*  
*Carex korshinskyi*  
*Carex obtusata*  
*Carex pediformis*  
*Allium anisopodium*  
*Allium strictum*  
*Polygonatum odoratum*  
*Iris humilis*  
*Rumex thyrsiflorus*  
*Polygala sibirica*  
*Polygala comosa*  
*Acontium barbatum*  
*Delphinium grandiflorum*  
*Pulsatilla multifida*  
*Thalictrum foetidum*  
*Patrina rupestris*  
*Patrina sibirica*  
*Campanula glomerata*  
*Campanula rotundifolia*  
*Veronica incana*  
*Cerastium arvense*  
*Dianthus versicolor*  
*Silene jensseensis*  
*Silene repens*  
*Achillea asiatica*  
*Artemisia commutata*  
*Artemisia dracunculus*  
*Artemisia frigida*  
*Artemisia gmelinii*  
*Artemisia lacinata*  
*Artemisia santolinifolia*  
*Artemisia sericea*  
*Aster alpinus*  
*Dendranthema zawadskii*  
*Heteropappus hispidus*  
*Hieracium virosum*  
*Saussurea controversa*  
*Saussurea salicifolia*  
*Scorzonera austiaca*  
*Youngia tenuifolia*  
*Androsace amurensis*



*Androsace incana*  
*Astragalus suffruticosus*  
*Lupinaster pentaphyllus*  
*Oxytropis strobilacea*  
*Vicia multicaulis*  
*Geranium sibiricum*  
*Geranium pseudosibiricum*  
*Linum perenne*  
*Cottoneaster melanocarpus*  
*Cottoneaster uniflorus*  
*Potentilla acaulis*  
*Potentilla bifurca*  
*Potentilla conferta*  
*Potentilla multifida*  
*Rosa acicularis*  
*Spiraea flexuosa*  
*Spiraea media*  
*Galium boreale*  
*Galium verum*  
*Bupleurum scorzonerifolium*  
*Kitagawia baicalensis*  
*Phlojodicarpus popovii*  
*Viola dissecta*  
*Kochia prostrata*  
*Teloxys aristata*  
*Alyssum lenense*  
*Alyssum obovatum*  
*Clausia aprica*  
*Draba nemorosa*  
*Erysimum hieracifolium*  
*Isatis oblongata*  
*Sedum aizoon*  
*Orostachys spinosa*  
*Saxifraga spinulosa*  
*Myostis suaveolens*  
*Lappula redowskii*  
*Thymus serpyllum*  
*Orobanche coerulescens*  
*Plantago media*

**Introduced:**

*Agrostis trinii*  
*Phleum phleoides*  
*Urtica canabina*  
*Urtica angustifolia*  
*Rumex thyrsiflorus*  
*Fallopia convolvulus*

*Delphinium grandiflorum*  
*Campanula glomerata*  
*Pedicularis ventusa*  
*Oberna behen* -?  
*Achillea asiatica*  
*Taraxicum officinale* -?  
*Trifolium pratense*  
*Trifolium repens*  
*Geranium pratense*  
*Geranium sibiricum*  
*Silene latifolia*  
*Galium uliginosum*  
*G. vernum*  
*Linum perenne* -?  
*Potentilla multifida*  
*Anthriscus sylvestris* var. *nemorosa*  
*Bupleurum scorzonerifolium* -?  
*Carum carvi* -?  
*Arabis pendula*  
*Clausia aprica*  
*Dracocephalum ruyschiana* -?  
*Descurainia sophia*  
*Galeopsis bifida*  
*Cuscuta europaea*  
*Plantago media*

### Noteworthy Plants of the Caribou Islands

#### Officially Designated Protected or Rare:

*Calamagrostis stricta*: designated threatened in Michigan  
*Potamogeton confervoides*: rare in Ontario and threatened in Michigan  
*Thalictrum revolutum*: rare in Canada and threatened in Michigan  
*Sagina nodosa*: threatened in Michigan  
*Empetrum nigrum*: threatened in Michigan  
*Lathyrus palustris*: considered regionally important by White (1995)

#### Arctoalpine:

*Rubus chamaemorus*  
*Sagina nodosa*  
*E. variegatum*  
*Scirpus cespitosus*  
*Eriophorum vaginatum* ssp. *spissum*  
*Calamagrostis stricta* ssp. *inexpansa*  
*Empetrum nigrum*

*Leymus mollis*  
*Festuca brachyphylla*  
*Primula mistassinica* (nominally)

**Maritime:**

*Lathyrus japonicus*  
*Ammophila breviligulata*  
*Leymus mollis*

**Alien:**

*Elytrigia repens*  
*Phleum pratense*  
*Poa annua*  
*Poa pratensis* ssp. *pratensis*  
*Poa compressa*  
*Rumex acetosella*  
*Rumex crispus*  
*PolYGONUM persicaria*  
*Barbarea vulgaris*  
*Ranunculus acris*  
*Aster lanceolatus* ssp. *lanceolatus*  
*Hieracium canadense*  
*Trifolium repens*  
*Capsella bursa-pastoris*  
*Erisimum cheiranthoides*  
*Cerastium vulgatum*  
*Cirsium arvense*  
*Taraxicum officinale*  
*Prunella vulgaris* (?)  
*Malus pumila*  
*Potentilla norvegica* (?)

**Western:**

*Amelanchier alnifolia*  
*Rubus parviflorus*  
*Vaccinium membranaceum*  
*V. ovalifolium*

**Eastern:**

*Potamogeton confervoides*

**Eastern Deciduous and Disjuncts from More Southerly Regions:**

*Claytonia carolineana*  
*Thalictrum revolutum*

*Symplocarpus foetidus*  
*Acer rubrum*

## BIBLIOGRAPHY

- Adams, C. C. [editor] (1909). An Ecological Survey of Isle Royale, Lake Superior. Lansing, MI: Wynkoop Hallen Beck Crawford Co., 468pp.
- Agassiz, L. (1850). Lake Superior: its Physical Character, Vegetation, and Animals Compared With Those of Other and Similar Regions. 1974 reprint: Huntington, NY: Robert E. Kreiger, 25 + 428pp.
- Albert, D. A., S. R. Denton, and B. V. Barnes (1986). Regional Landscape Ecosystems of Michigan. Ann Arbor, MI: School of Natural Resources, University of Michigan, 32pp + map.
- Anonymous (June 1992). Michigan's Special Plants; Endangered, Threatened, Special Concern, and Probably Extirpated. Unpublished listing of the Endangered Species Program, Michigan Department of Natural Resources and Michigan Natural Features Inventory, 17pp.
- Argus, G. W., K. M. Pryer, D. J. White, and C. J. Keddy [editors] (1982-1987). Atlas of the Rare Vascular Plants of Ontario. Four parts. Ottawa: National Museum of Natural Sciences, National Museums of Canada, unpaginated looseleaf.
- Ayres, L. D. (1969). Geology of Townships 31 and 30, Ranges 20 and 19. Ontario Department of Mines Geological Report 69, 100pp.
- Barclay-Estrup, P. and D. V. Nuttall (1974). Some aspects of the distribution and ecology of crowberry, *Empetrum nigrum* L., on the north shore of Lake Superior. Canadian Field-Naturalist 88: 171-181.
- Berquist, S. G. (1937). Relic flora in relation to glaciation in the Keweenaw Peninsula of Michigan. Science 86: 53-55.
- Böcher, T. W. (1972). Evolutionary Problems in the Arctic Flora. Chapter 7 (101-114) in Valentine, 1972.
- Boerner, R. E. J. (1988). Forest composition of the Lake Erie islands. American Midland Naturalist 111: 173-184.
- Brown, C. A. (1937). Ferns and flowering plants of Isle Royale, Michigan. U.S. Department of the Interior, 90pp.
- Brown, P. M. (1982). The Vascular Flora of Caribou Island, Thunder Bay [Algoma] District, Ontario, Canada. Unpublished report, 12pp.
- Brunton, Daniel F. [editor] (1991). Checklist of the Vascular Plants, Lake Superior Provincial Park, Second edition. Ontario Ministry of Natural Resources, 44pp.

- Butters, F. K., and E. C. Abbe (1953). A floristic study of Cook County, northeastern Minnesota. *Rhodora* 55: 21-55; 63-101; 116-154; 161-201.
- Carlquist, S. (1965). *Island Life; A Natural History of the Islands of the World*. Garden City, N.Y.: Published for the American Museum of Natural History [by] the Natural History Press, viii+451 pp.
- — — (1974). *Island Biology*. New York-London: Columbia University Press, 660pp.
- Carter, J. L. (1979). A trip to lonely Caribou— island outpost of the Lakes. *Inland Seas* 35: 4-12, 95-103.
- Canadian Hydrographic Service (1976). Caribou Island to Michipicoten Island, Lake Superior. Chart 2310, updated to 1976. Map, scale 1:97,280.
- Cody, M. L., and H. A. Mooney (1978). Convergence versus nonconvergence in Mediterranean-climate ecosystems. *Annual Review of Ecology and Systematics* 9: 265-321.
- Cooper, W.S. (1913). The climax forest of Isle Royale, Lake Superior, and its development. *Botanical Gazette* 55:1-44; 115-140; 189-235.
- — — (1914). A catalog of the flora of Isle Royale, Lake Superior. *Annual Report of the Michigan Academy of Science* 16:109-131.
- Crête, M., J. Huot, M-J. Fortin, and G. J. Doucet (1997). Comparison of plant and animal diversity on new reservoir islands and established lake islands in the northern boreal forest of Québec. *The Canadian Field-Naturalist* 111: 407-416.
- Crins, W. J. (1996). *Sandy Islands*. ANSI Life Science Checklist (preliminary working copy). Toronto, ON: Ontario Ministry of Natural Resources, 9pp.
- Critchfield, W. B., and E. L. Little (1966). *Geographic Distribution of the Pines of the World*. Washington: USDA Forest Service Miscellaneous Publication 991. 97pp.
- Crum, H. A. (1983). *Mosses of the Great Lakes Forest*, third edition. Ann Arbor, MI: University Herbarium, University of Michigan, 417pp.
- Crum, H. A., and L. E. Anderson (1981). *Mosses of Eastern North America*. New York: Columbia University Press, 1328pp.
- Crum, H. A., and S. Planisek (1988). *A Focus on Peatlands and Peat Mosses*. Ann Arbor: University of Michigan Press, 306pp.
- Curtis, J. T. (1959). *The Vegetation of Wisconsin*. Madison, WI: University of Wisconsin Press. 657pp.
- Czerepanov, S. K. (1995). *Vascular Plants of Russia and Adjacent States (the*

- Former USSR). Cambridge: Cambridge University Press, 516pp.
- Darwin, C. (1839). *The Voyage of the Beagle: Charles Darwin's Journal of Researches*. 1989 reedition: Janet Browne, Michael Neve (Editors). London-New York: Penguin, 432pp.
- — — (1859). *The Origin of Species: By Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life*. 1993 reprint: New York: Modern Library, 714pp.
- Davis, G. B. (project leader) (1993). *The Lake Baikal Region in the Twenty-First Century*. Planning report: Davis Associates, Wadhams, NY, 177pp. (in Russian and English]
- Dericki, J. A. (1976). Hydrometeorology: Climate and Hydrology of the Great Lakes. pp71-104 *in*: Great Lakes Basin Framework Study, 1976.
- Diamond, J. M., and R. M. May (1981). Island biogeography and the design of natural reserves. Chapter 10 (pp228-252) *in*: May, 1981.
- Dorr, J. A., and D. F. Eschman (1970). *The Geology of Michigan*. Ann Arbor: The University of Michigan Press. VIII+470pp.
- Downhower, J. F. [editor] (1988). *The Biogeography of the Island Region of Western Lake Erie*. Columbus, OH: The Ohio Sate University Press.
- Eichenlaub, V. L. (1979). *Weather and Climate of the Great Lakes Region*. Notre Dame, IN: University of Notre Dame Press. 335pp.
- Energy, Mines, and Resources Canada (1974). Aerial photographs of Caribou Island, taken 1974, June 1. Numbers A23702-165 and A23702-166, flight line 21-5, Chapleau ON. ICAS 74-1, nominal scale 1:51,390
- — — (1986). Lighthouse Island, 41 N/5, edition 1. Map, topographic, scale 1:50 000.
- Euler, D. L., B. Snider, and H. R. Timmermann (1976). Woodland caribou and plant communities on the Slate Islands, Lake Superior. *Canadian Field-Naturalist* 90(11): 17-21.
- Fassett, N. C., and Thomson, O. S. (1976). *Spring Flora of Wisconsin*. Madison, WI: The University of Wisconsin Press, 413pp.
- Fernald, M. L. (1935). Critical plants of the upper Great Lakes region of Ontario and Michigan. *Rhodora* 37(438) 197-222; 238-262; 272-301; 324-341.
- Flora of North America Editorial Committee (1993; continuing in publication). *Flora of North America: North of Mexico*. New York: Oxford University Press.
- Forzley, K. F., T. A. Grudzien, J. R. Wells (1993). Comparative floristics of seven

islands in northwestern Lake Michigan. *Michigan Botanist* 32: 3-21

Geiger, R., R. H. Aron, and P. Todhunter (1994). *The Climate Near the Ground*, fifth edition (pre-press beta version used). unpaginated; approximately. 600pp.

Given, D. R., and J. H. Soper (1981). *The Arctic- Alpine Element of the Vascular Flora at Lake Superior*. *Publications in Botany*, < 10. Ottawa: National Museum of Natural Sciences, National Museums of Canada, 70pp.

Gleason, H. A. and A. Cronquist (1991). *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*, second edition. Bronx, NY: The New York Botanical Garden, 910pp.

Gorman, M. L. (1979). *Island Ecology*. London: Chapman and Hall, 79pp.

Graham, L. R. (1995). *A Face in the Rock: the Tale of a Grand Island Chippewa*. Washington, DC: Island Press, 160pp.

Great Lakes Basin Framework Study. (1976). Appendix 4: Limnology of Lakes and Embayments. Great Lakes Basin Commission, 441pp.

Greenpeace (1996). *Greenpeace welcomes World Heritage nomination for Baikal and Kamchatka*. Official press release of December 6, 1996. Amsterdam: Greenpeace, 1pp.

Gressitt, J. L. (1963). *Pacific Basin Biogeography; a Symposium (Proceedings of the Tenth Pacific Science Conference, Honolulu, HI)*. Honolulu: Bishop Museum Press.

Guire, K. E. and E. G. Voss (1963). Distributions of distinctive shoreline plants in the Great Lakes region. *The Michigan Botanist* 2: 99-114.

Hamblin, W. K. (1958). *The Cambrian Sandstones of Northern Michigan*. Publication 51, Geological Survey Division, Michigan Department of Conservation, 149pp.

Hannon, G. E., and R. H. W. Bradshaw (1989). Recent vegetation dynamics on two Connemara lake islands, western Ireland. *Journal of Biogeography* 16: 75-81.

Hara, H. (1972). *Corresponding Taxa in North America, Japan, and the Himalayas*. Chapter 4 (61-72) *in*: Valentine, 1972.

Hatt, R. T., J. Van Tyne, L. C. Stuart, C. H. Pope, and A. B. Grobman (1948). *Island Life: a Study of the Land Vertebrates of the Islands of Lake Michigan*. Bloomfield Hills, MI: Cranbrook Institute of Science, 179pp.

Hazlett, B. T. (1988). *Factors Affecting Island Floras in Northern Lake Michigan*. Ph.D. dissertation, Botany, University of Michigan, 223pp.

— — — (1993). *The vascular flora of North and South Fox Islands, northern Lake*



Michigan. *Michigan Botanist* 32: 239-264.

Hazlett, B. T., S. P. Hendricks, G. P. Fons, P. W. Thompson and J. R. Wells (1986). A botanical foray to the Fox Islands, northern Lake Michigan. *Michigan Botanist* 25: 3-10.

Hazlett, B. T., and R. J. Vander Kopple (1983). The terrestrial vegetation and flora of North and South Manitou Islands, Sleeping Bear Dunes National Lakeshore, Leelanau County, Michigan. University of Michigan Biological Station Technical Report 11, 142pp.

Henry, A. (1901). *Travels & Adventures in Canada and the Indian Territories Between the Years 1760 and 1776*. 1969 reprint: New York: Burt Franklin, XXXIII+347pp.

Herdendorf, C. E. (1982). Large lakes of the world. *Journal of Great Lakes Research* 8(3): 379-412.

— — — (1990). Distribution of the World's Large Lakes. *in*: Tilzer and Serruya, 1990.

— — — and S. E. Herdendorf (1983). Flora and Fauna of the Islands Region of Western Lake Erie. CLEAR technical report no. 285. Put-in-Bay, Ohio: The Ohio State University Center for Lake Erie Research, 190pp.

Hogg, E. H., and J. K. Morton (1983). The effects of nesting gulls on the vegetation and soil of islands in the Great Lakes. *Canadian Journal of Botany* 61(12): 3240-3254.

Hogg, E. H., J. K. Morton, and J. M. Venn (1989). Biogeography of island floras in the Great Lakes I. Species richness and composition in relation to gull nesting activities. *Canadian Journal of Botany* 67: 961-969.

Hosie, R. C., T. M. C. Taylor, and C. H. H. Clarke (1938). Botanical Investigations in Batchawana Bay Region, Lake Superior. *Bulletin* < 88, Biological series < 23, Canada Department of Mines and Resources, 152pp.

Hultén, E. (1927-1930). Flora of Kamtchatka and the Adjacent Islands. *Kungl. Svenska Vetenskapsakademiens Handlingar* [Royal Swedish Academy of Sciences Proceedings]. 3. ser. Bd. 5: 1-2, bd. 8, no. 1-2. Stockholm: Almqvist & Wiksell.

— — — (1958). The Amphi-Atlantic Plants and Their Phytogeographical Connections. *Kungl. Svenska Vetenskapsakademiens Handlingar* [Royal Swedish Academy of Sciences Proceedings] Fjärde Serien. Band 8 Nr. 5 [series 4, Vol. 8, No. 4]. Stockholm, Göteborg, Uppsala: Almqvist & Wiksell. 275+5pp.

— — — (1960). Flora of the Aleutian Islands and westernmost Alaska Peninsula, with notes on the flora of Commander Islands, second edition, revised and enlarged. Weinheim, Germany: J. Cramer, 376pp. + maps and plates.

- — — (1961). The Distributional Conditions of the Flora of Beringia. pp7-22 *in*: Gressit, 1963.
- — — (1963). Phytogeographical Connections of the North Atlantic. pp45-72 *in*: Löve and Löve, 1963.
- — — (1964). The Circumboreal Plants 1: Vascular Cryptogams, Conifers, Monocots. Kungl. Svenska Vetenskapsakademiens Handlingar [Royal Swedish Academy of Sciences Proceedings) Fjärde Serien. Band 8 Nr. 5 [series 4, Vol. 8, No. 5). Stockholm: Almqvist& Wiksell. 275+4pp.
- — — (1968). Flora of Alaska and Neighboring Territories. Stanford, CA: Stanford University Press. 1008pp.
- — — (1971). The Circumboreal Plants 2:Dicotyledons. Kungl. Svenska Vetenskapsakademiens Handlingar [Royal Swedish Academy of Sciences Proceedings) Fjärde Serien. Band 13 Nr. 1 [series 4, Vol. 13, No. 1). Stockholm, Göteborg, Uppsala: Almqvist& Wiksell. 463pp.
- Judziewicz, E. J., and R. G. Koch (1993). Flora and vegetation of the Apostle Islands National Lakeshore and Madeline Island, Ashland and Bayfield Counties, Wisconsin. *Michigan Botanist* 32(2): 43-189.
- Keen, R. A. (1993). Michigan Weather. Helena, MT: American World and Geographic Publishing, 142pp.
- Koptyug, V. A. and M. Upperbrink (editors) (1996). Sustainable Development in the Lake Baikal Region: a Model Territory for the World. Berlin: Springer-Verlag and NATO Scientific Affairs Division, 373pp.
- Kor, P. S. G. (1993). Caribou Island ANSI report. North York, ON: Ontario Ministry of Natural Resources, 6pp.
- — — (1995a). Geology and Geomorphology of Caribou Island, Eastern Lake Superior. Open File Earth Science Report 9501, Terrestrial Ecosystems Branch, Provincial Parks and Natural Heritage Policy Section, Ontario Ministry of Natural resources, Toronto, ON, 34pp.
- — — (1995b). North Sandy Island, South Sandy Island. Earth Science Inventory Checklist, Ontario Ministry of Natural Resources, Parks and Natural Heritage Branch, North York, Ontario, 6pp.
- Kornas, J. (1972) Corresponding Taxa and Their Ecological Background in the Forests of Temperate Eurasia and North America. Chapter 3 (37-60) *in*: Valentine, 1972.
- Kropotkin, P. A, kn. (1899). *Memoirs of a Revolutionist*. Boston and New York: Houghton Mifflin, xiv+519pp.
- Larsen, J. A. (1980). *The Boreal Ecosystem*. New York-London: Academic Press.

500pp.

- — — (1982). *Ecology of the Northern Lowland Bogs and Conifer Forests*. New York-London: Academic Press, 307pp.
- Leighly, J. (1942). Effects of the Great Lakes on the annual march of temperature in their vicinity. *Papers of the Michigan Academy of Arts, Sciences and Letters*. 21: 377-414.
- Lellinger, D. B. (1985). *A Field Manual of the Ferns and Fern-allies of the United States and Canada*. Washington: Smithsonian Institution Press, 389pp.
- Lindsay, D. R. (1969). Migration and persistence of certain arctic-alpine plants in the Lake Superior region of Ontario. *Lakehead University Review* 1: 59-69.
- Löve, A. and D. Löve [editors] (1963). *North Atlantic Biota and their History: a symposium held at the University of Reykjavík July 1962 under the auspices of the University of Iceland and the Museum of Natural History*. New York: MacMillan, 430pp.
- MacArthur, R. H., and E. O. Wilson (1963). An equilibrium theory of insular zoogeography. *Evolution* 17: 373-387.
- — — (1967). *The Theory of Island Biogeography*. Princeton, NJ: Princeton University Press, 203pp.
- Major, J., and S. A. Bamberg (1967). Comparison of Some North American and Eurasian Alpine Ecosystems. *in*: Wright and Osburn, 1967.
- Marie-Victorin, F. E. C. (1995). *Flore Laurentienne, Troisième édition*. Montréal: Les Presses de l'Université de Montreal, 1084pp.
- Marquis, R. J. and E. G. Voss (1981). Distributions of some western North American plants disjunct in the Great Lakes region. *Michigan Botanist* 20: 53-82.
- Meffe, G. K., and C. R. Carroll [editors] (1997). *Principles of Conservation Biology, second edition*. Sunderland, MA: Sinauer Associates Inc., 721pp.
- Miller, R. W. and R. L. Donahue (1990). *Soils: An Introduction to Soils and Plant Growth, sixth edition*. Englewood Cliffs, NJ: Prentice Hall, 768pp.
- Mlíkovský, J., and P. Střblo (editors) (1992). *Ecology of the Svjatoj Nos Wetlands, Lake Baikal*. Prague, Czechoslovakia: Ninox Press, 243pp.
- Morton, J. K. (1982). *Preliminary Report on Caribou Island*. Unpublished report, 2pp.
- Morton, J. K., and E. H. Hogg (1989). Biogeography of island floras in the Great Lakes II. Plant dispersal. *Canadian Journal of Botany* 67: 1803-1820.

- Morton, J. K., and Venn, J. M. (1984). The Flora of Manitoulin Island, second revised edition. Waterloo, Ontario: University of Waterloo Biology Series Number 28, 181+106pp.
- — — (1996). Vegetation and flora of Caribou Island, Lake Superior. The Michigan Botanist 35:3-25.
- Nature Conservancy Great Lakes Program (1994). The Conservation of Biological Diversity in the Great Lakes Ecosystem: Issues and Opportunities. Chicago: The Nature Conservancy Great Lakes Program.
- Noble, T. (1982). Ontario Nature Reserves Program-Life Sciences Inventory Checksheet for Caribou Island. Ontario Ministry of Natural Resources, Toronto, unpublished report, 5pp.
- — — (1984). Michipicoten Island Life Sciences Inventory. Unpublished report, Ontario Ministry of Natural Resources, Northeastern Region, 71pp.
- Noss, R. F., M. A. O'Connell, and D. D. Murphy (1997). The Science of Conservation Planning: Habitat Conservation Under the Endangered Species Act. Washington, DC-Covelos, CA: Island Press, 246pp.
- OMNR [Ontario Ministry of Natural Resources] (1994). Air photographs of Caribou Island, taken August 9, 1994, numbers 34-01, 34-02, and 34-03; flight line 94-4712, and, numbers 34-05, 34-06, and 34-07; flight line 94-4713, nominal scale 1:20 000
- — — (undated; post-1992). Endangered Spaces Candidate Area Report, Caribou Island. Ontario's Natural Heritage program, unpublished internal checklist, 9pp.
- — — (1994, November). Lake Nipigon Project: Discussion Paper on Protection Opportunities. Unpublished internal memo, OMNR Nipigon District Office, Nipigon, Ontario, 38pp.
- Osborn, C. S. and S. Osborn (1949). Northwoods Sketches. Lansing, MI: The Historical Society of Michigan.
- Peattie, D. C. (1922). The Atlantic coastal plain element in the flora of the Great Lakes. Rhodora 24: 57-70; 80-87.
- Peterson, R. O. (1995). The Wolves of Isle Royale: A Broken Balance. Minocqua, WI: Willow creek Press, 189pp.
- Pettersson, B. (1965). Gotland and Öland. Two Limestone Islands Compared. pp 131-140 *in*: The plant cover of Sweden, 1965.
- Phillips, D. W. (1978). Environmental climatology of Lake Superior. Journal of Great Lakes Research 4(3-4): 288-309.
- Phillips, D. W., and J. A. W. McCulloch (1972). The Climate of the Great Lakes

- Basin. Climatological Studies < 20, Environment Canada, Toronto, 42+57pp.
- Pielou, E. C. (1979). Biogeography. 1992 reprint: Malabar, FL: Krieger Publishing Company, 352pp.
- The Plant Cover of Sweden (1965). Acta Phytogeographica Suecica 50; A study dedicated to G. Einar DuRietz on his 70<sup>th</sup> birthday. Uppsala, Sweden: Almqvist & Wiksells Boktryckeri AB, XXpp.
- Porsild, A. E. (1957). Illustrated Flora of the Canadian Arctic Archipelago. Ottawa: National Museum of Canada Bulletin < 146, Biological Series < 50., 209pp.
- Primack, R. B. (1993). Essentials of Conservation Biology. Sunderland, MA: Sinauer Associates Inc., 564pp.
- Pryde, P. R. (1997). Post-Soviet development and status of Russian nature reserves. Post-Soviet Geography and Economics 38(2): 63-80.
- Pye, E. G. (1969). Geology and Scenery, North Shore of Lake Superior. Ontario Department of Mines Geological Guide Book No. 2, 144pp.
- Quammen, D. (1996). The Song of the Dodo: Island Biogeography in an Age of Extinctions. New York: Scribner, 702pp.
- Rondy, D. R. (1976). Great Lakes Ice Cover. pp105-117 *in*: Great Lakes Basin Framework Study, 1976.
- Saulesleja, A. (editor) (1986). Great Lakes Climatological Atlas. Ottawa: Environment Canada, 147pp.
- Schoener, A. (1988). Experimental island biogeography. Chapter 15 (pp483-512) *in*: Myers and Giller, 1988.
- Schwartz, M. W. [editor] (1997). Conservation in Highly Fragmented Landscapes. New York: Chapman and Hall, 436pp.
- Scoggan, H. J. (1978). The Flora of Canada. Part 1-General Survey. Ottawa: National Museum of Natural Sciences, 89pp.
- Scott, R. W., and F. A. Huff (1996). Impacts of the Great Lakes on regional climate conditions. Journal of Great Lakes Reserach 22(4): 845-863.
- Shafer, C. L. (1990). Nature Reserves: Island Theory and Conservation Practice. Washington and London: Smithsonian Institution Press, 189pp.
- Simberloff, D. (1988). The contribution of population and community biology to conservation science. Annual Review of Ecology and Systematics 19: 473-511.
- Simonov, E., and V. Stepanitsky (1995). Leaders of Russia's protected areas take desperate measures in a desperate time. Russian Conservation News 2: 3.

- Slavick, A. D., and R. A. Janke (1987). The vascular flora of Isle Royale National Park. *Michigan Botanist* 26: 91-134
- Soper, J. H. (1963). Botanical observations along the Lake Superior route. *Proceedings of the Royal Canadian Institute Series 5*, < 10, pp12-24.
- Soper, J. H., C. E. Garton, and D. R. Given (1989). Flora of the North Shore of Lake Superior. Ottawa, ON: National Museum of Natural Sciences, Syllogeus No. 63, 61pp.
- Soper, J. H. and M. L. Heimburger (1982). Shrubs of Ontario. Toronto: Royal Ontario Museum, 459pp.
- Soper, J. H. and P. F. Maycock (1963). A community of arctic-alpine plants on the east shore of Lake Superior. *Canadian Journal of Botany* 41: 183-198.
- Soper, J. H. and E. G. Voss (1964). Black crowberry in the Lake Superior region. *The Michigan Botanist* 3: 35-38.
- Soper, J. H., E. G. Voss, and K. E. Guire (1965). Distribution of *Primula mistassinica* in the Lake Superior region. *The Michigan Botanist* 4: 83-86.
- Swain, W. R. (1989). The World's greatest lakes. *Natural History*: August 1989, pp56-61.
- Thompson, P. W., and J. R. Wells (1974). Vegetation of Manitou Island, Keweenaw County, Michigan. *Michigan Academician* (6)307-312.
- Thornton, I. B. (1967). The measurement of isolation on archipelagoes, and its relation to insular faunal size and endemism. *Evolution* 21: 842-849.
- Tilzer, M. A., and C. Serruya [editors]. (1990). *Large Lakes: Ecological Structure and Function*. Berlin-Heidelberg: Springer-Verlag. 690pp.
- Timoney, K. P. (1980). Higher Plant Biogeography of Islands in Lake Nipigon. M.S. Thesis, Department of Biology, University of Wisconsin, Madison, 47pp.
- — — (1983). Island biogeography of seed plants in Lake Nipigon, Ontario. *The Canadian Field-Naturalist* 97: 16-25.
- Valentine, D. H. [editor] (1972). *Taxonomy, Phytogeography, and Evolution*. London-New York: Academic Press, 431pp.
- Voss, E. G. (1972). Michigan Flora, Part 1: Gymnosperms and Monocots. Cranbrook Institute of Science Bulletin 55 & University of Michigan Herbarium. Bloomfield Hills, MI. 488pp.
- — — (1985). Michigan Flora, Part 2: Dicots (Saururaceaa-Cornaceae). Cranbrook Institute of Science Bulletin 59 & University of Michigan Herbarium. Bloomfield Hills, MI. 724pp.

- — — (1996). Michigan Flora. Part III: Dicots (Pyrolaceae-Compositae). Cranbrook Institute of Science Bulletin 61 & University of Michigan Herbarium, 622 pp.
- Wagner, W. H., E. G. Voss, J. H. Beaman, E. A. Bourdo, F. W. Case, J. A. Churchill, & P. W. Thompson (1977) Michigan's endangered and threatened species program. Michigan Botanist 16: 99-122.
- Wallace, A. R. (1892). Island life: or, The Phenomena and Causes of Insular Faunas and Floras, second and revised edition. London: Macmillan, xx+563 pp.
- Walter, K. S. and H. J. Gillett [editors] (1998). 1997 IUCN Red List of Threatened Plants. Gland, Switzerland and Cambridge, UK: The World Conservation Monitoring Centre-IUCN, lxiv + 862pp.
- Weaver, J. E. and F. E. Clements (1938). Plant Ecology, second edition. New York-London: McGraw-Hill, xxii+601 pp.
- Wells, J. R. and P. W. Thompson (1974). Vegetation and flora of Keweenaw County, Michigan. The Michigan Botanist 13: 107-151.
- Wells, J. R., P. W. Thompson and F. D. Sheldon (1957). Vegetation and geology of North Fox Island, Lake Michigan. The Michigan Botanist 14: 203-214.
- Wetzel, R. G. (1983). Limnology, second edition. Fort Worth, TX: Saunders-HBJ, 780pp.
- White, D. J. (1995). Life Science Survey and Evaluation of the Caribou Island Proposed ANSI. Timmins, ON: Ontario Ministry of Natural Resources, Northeastern Region Open File Ecological Report, 65pp.
- Whitehead, D. R., and C. E. Jones (1969). Small islands and the equilibrium theory of insular biogeography. Evolution 23(1): 171-179.
- Whittaker, R. H. [editor] (1980). Classification of Plant Communities. The Hague: Dr. W. Junk bv, 408pp.
- — — [editor] (1980). Ordination of Plant Communities. The Hague: Dr. W. Junk bv, 388pp.
- Williamson, M. (1981). Island Populations. Oxford: Oxford University Press, 286pp.
- Wormington, A., J. R. Nisbet, and R. G. Finlayson (1986). Some aspects of bird migration at Caribou Island (Lake Superior), Ontario. Ontario Birds 4(3): 85-97.
- Wright, H. E. Jr., and W. H. Osburn [editors] (1967). Arctic and Alpine Environments. Bloomington, IN: Indiana University Press, XII+308pp..
- Yoshino, M. M. (1975). Climate in a Small Area. Tokyo: University of Tokyo

Press. 549pp.

*Russian language literature*      *Литература на русском языке*

n.b.-Russian sources are given in a citation style common in Russian Academy of Sciences publications, standardized to match the style above, and followed by English translations of the author and title in brackets.

Атлас Байкала.(1969). Иркутск–Москва: ГУГК СССР, 30с. [Atlas of Baikal]

Атлас Озера Байкал, Прибережная часть. (1942). Иркутск: РСФСР Министерство Речного Флота, Восточно-Сибирское Бассейновое Управление Пути. [Atlas of Lake Baikal, coastal part]

Байкал. Атлас. (1993). Москва: Российская академия наук и Федеральная служба геодезии и картографии России, 160с. [Baikal. atlas]

Бардунов, Л. В. (1961). Листостебельные мхи побережий и гор Северного Байкала. Труды Восточно-Сибирского Филала СО АН СССР Вып. 42, 120с. [L. V. Bardunov, Acrocarpous mosses of the coasts and mountains of northern Baikal]

— — — (1969). Определитель Мхов Центральной Сибири. Ленинград: Наука, 332с. [Manual of the mosses of central Siberia]

— — — (1992). Очерк Бриофлоры Сибири. Новосибирск: Наука, 97с. [Essay of the bryoflora of Siberia]

Бейдман, И. Н., П. К. Гагарин, и В. Н. Паутова (1969). Продуктивность, Запас Воды и Минеральных Веществ в Некоторых Сообществах Южной Тайги Большого Ушканьего Острова. в сб. Природа Ушканьих Островов на Байкале, 1969. [I. N. Beidman, P. K. Gagarin, and V. N. Pautova, Productivity, water supply, and mineral substances in several associations of southern taiga of Bolshoi Ushkanii Island]

Бойков, Т. Г., О. А. Аненхонов, Т. Д. Лыхалова, Ю. Д. Хапитонов, И. П. Сэкулич, О. В. Данилова, и М. Б. Беркович (1991). Флора Забайкальского Природного Национального Парка. Улан-Удэ: БНЦ СО АН СССР, 138с. [T. G. Boikov, O. A. Anenkhonov, T. D. Luikhalova, Yu. D. Kharitonov, I. P. Sekulich, O. V. Danilova, and M. B. Berkovich, Flora of Zabaikalskii Natural National Park]

Визенко, О. С., В. В. Власенко, Т. В. Кокоева, Н. П. Ладейщиков, Л. И. Лут, К. Н. Мизандронцева, В. А. Оболкин, и В. Л. Потемкин (1984). Климат Больших Озер Сибири. Новосибирск: Наука, 144с. [O. S. Vizenko, V. V. Vlasenko, T. V. Kokoeva, N. P. Ladeischikov, L. I. Lut, K. N. Mizandrontseva, V. A. Oblokin, and V. L. Potemkin, Climate of large lakes of



## Siberia]

- Вотинцев, К. К. [редактор] (1974). Природа Байкала. Ленинград: АН СССР–Географическое Общество СССР, 295с. [K. K. Votintsev (editor), Nature of Baikal]
- Выхристок, М. М. (1966а). Исследование Коротковольной Радиации на О-ве Большой Ушканий. в Галазий и Ладейщиков, 1966. [M. M. Vuikhristyuk, Investigation of shortwave radiation on Bolshoi Ushkanii Island]
- — — (1966б). Методика Стационарных Микроклиматических Наблюдений на О-ве Большой Ушканий. в Галазий и Ладейщиков, 1966. [Methodology of stationary microclimatological observations on Bolshoi Ushkanii Island]
- — — (1969а). Краткая Климатологическая Характеристика Котловины Озера Байкал в Районе Ушканьего Архипелага. в сб. Природа Ушканьих Островов на Байкале, 1969. [Brief climatological characteristics of the depression of Lake Baikal in the region of the Ushkanii Archipelago]
- — — (1969б). Распределение Температуры Воздуха на Большом Ушканьем Острове. в сб. Природа Ушканьих Островов на Байкале, 1969. [Distribution of temperature of the air on Bolshoi Ushkanii Island]
- — — (1976). Метеорологические Условия в Лиственничнике Рододендроновом на О-ве Большом Ушканьем в Различные Вегетационные Периоды. с. 164–178 в: Галазий и Ладейщиков, 1976. [Meteorological conditions in larch-Rhododendron woods on Bolshoi Ushkanii Island during the growing season]
- — — (1980). Фитоклимат Прибрежных Лесов Северного Байкала. Новосибирск: Наука, 216с. [Phytoclimate of the coastal forests of northern Baikal]
- Гагарин, П. К. (1974). Степная Растительность Приольхонья. в сб. Природа Байкала, 1974. [P. K. Gagarin, Steppe flora of the Priolkhon]
- Галазий, Г. И. (1988). Байкал в Вопросах и Ответах, 3-е издание. Москва: Мысль. 288с. [G. I. Galazii, Baikal in questions and answers]
- Галазий, Г. И и К. К. Вотинцев [редакторы] (1987). Путь Познания Байкала. Новосибирск: Наука, Сибирское Отделение, 304с. [G. I Galazii and K. K. Votintsev, Voyage to knowledge of Baikal]
- Галазий, Г. И. и Н. П. Ладейщиков [редакторы] (1966). Климат Озера Байкал и Прибайкалья. Москва: Наука, 176с. [G. I. Galazii and N. P. Ladeischikov (editors), Climate of Lake Baikal and Pribaikal]
- Галазий, Г. И. и Н. П. Ладейщиков [редакторы] (1976). Климатические

- Ресурсы Байкала и Его Бассейна. Новосибирск: Наука, 320с. [G. I. Galazii and N. P. Ladeischikov (editors), Climatic resources of Baikal and its basin]
- Галазий, Г. И. и В. Н. Моложников (1982). История Ботанических Исследований на Байкале. Новосибирск: Наука, 153с. [G. I. Galazii and V. N. Molozhnikov, History of botanical investigations on Baikal]
- Галазий, Г. И., Л. Н. Тюлина, и И. Н. Бейдемман [редакторы] (1976). Природные Условия Северо-Восточного Прибайкалья. Новосибирск: Наука, 368с. [G. I. Galazii, L. I. Tulina, and I. N. Beidman (editors), Natural conditions of northeastern Baikal]
- Герасимов, И. П. [председатель], и редакционная коллегия (1965). Предбайкалье и Забайкалье. Москва: Наука, 493с. [I. P. Gerasimov (managing editor) and editorial colleagues, Pribaikal and Transbaikal]
- Гурулев, С. А. (1992). Звери и Птицы Сибири: Происхождение Названий. Иркутск: Издательство Иркутского Университета, 140с. [S. A. Gurulev, Wild animals and birds of Siberia: origins of their names]
- Гусев, О. К. (1960). К орнитофауне Ушканьих островов. Орнитология, вып. 3: 139-145. [O. K. Gusev, On the avifauna of the Ushkanii Islands]
- — — (1990). На Очарованном Берегу. Москва: Советская Россия, 304с... [On the enchanted coast]
- Динамика Байкальской Впадины [сборник статей] (1975) Новосибирск: Наука, 287с. [Dynamics of the Baikal basin]
- Дягилев, В. Ф. (1936). К Характеристике Растительности Полуострова Святой Нос, Острова Большого Ушканего на Оз. Байкал и Оз. Ранготуй. Иркутск: Известия Общества Изучения Восточно Сибирского Края. 1(56): 99-120. [V. F. Dyagilev, On the character of the vegetation of the Svyatoi Nos Peninsula {and} Bolshoi Ushkanii Island on Lake Baikal, and Lake Rangotui]
- Ескин, А. С., Г. Б. Пальшин, Е. К. Гречищев, и Г. И. Галазий (1959). Геология и Некоторые Вопросы Геотектоники Ушканьих Островов на Байкале. Труды Восточно-Сибирского Геологического Института АН СССР, вып. 2. [A. S. Eskin, G. B. Palshin, E. K. Grechischev, and G. I. Galazii, Geology and some questions of the geotectonics of the Ushkanii Islands on Baikal]
- Иванова, М. М. (1969). Растительность Ушканьих Островов на Озеро Байкал. в сб. Природа Ушканьих Островов на Байкале, 1969. [M. M. Ivanova, Vegetation of the Ushkanii Islands on Lake Baikal]

- Иметхенов, А. Б. (1991). Памятники Природы Байкала. Новосибирск: Наука, 159с. [A. B. Imetkhenov, Natural monuments of Baikal]
- Иметхенов, А. Б., Т. Г. Бойков, Ц. Х. Цыбжитов, Б. О. Юмов, и С. А. Матвейчук (1990). Природа Забайкальского Национального Парка. Улан Удэ, Бурятия: БНЦ СО АН СССР, 193с. [A. B. Imetkhenov, T. G. Boikov, Ts. Kh. Tsuibzhitov, B. O. Yumov, and S. A. Matveichuk, Nature of the Zabaikalskii National Park]
- Красная Книга РСФСР-Растения. (1988). Москва: Росагропромиздат, 592с. [Red book of the RSFSR-plants]
- Ладейщиков, Н. П. [редактор] (1977). Структура и Ресурсы Климата Байкала и Сопредельных Пространств. Москва: Наука, 272с. [N. P. Ladeischikov (editor), Structure and resources of the climate of Baikal and neighboring area]
- — — (1982). Особенности Климата Крупных Озер. Москва: Наука. 139с. [N. P. Ladeischikov, Fundamentals of the climate of large lakes]
- — — (1987) Изучение Климата Байкала. с.76-85 в Галазий и Вотинцев, 1987. [Research on the climate of Baikal]
- Ладейщиков, Н. П. и В. Н. Моложников (1989). Климат и Растительность Южного Прибайкалья [сборник научных трудов]. Новосибирск: Наука, 152с. [N. P. Ladeischikov and V. N. Molozhnikov, Climate and vegetation of southern Pribaikal]
- Ламакин, В. В. (1952). Ушканьи Острова и Проблема Происхождения Байкала. Москва: Государственное Издательство Географической Литературы, 200с. [V. V. Lamakin, Ushkanii Islands and the problem of the history of Baikal]
- — — (1965). По Берегам и Островам Байкала. Москва: Наука, 193с. [Along the shores and islands of Baikal]
- Литвинов, Н. И. (1982). Фауна Островов Байкала. Иркутск: Издательство Иркутского государственного университета, 132с. [N. I. Litvinov, Fauna of islands of Baikal]
- Литвинов, Н. И. и В. Н. Моложников (1969). Позвоночные Ушканьих Островов. в сб. Природа Ушканьих Островов на Байкале, 1969. [N. I. Litvinov and V. N. Molozhnikov, Vertebrates of the Ushkanii Islands]
- Литвинов, Н. И., и Ю. Н. Петроченко (1990). Экосистемы Байкальских Островов. в кн Попов, 1990. [N. I. Litvinov and Yu. N. Petrenko, Ecosystems of the Baikal islands]
- Мальшев, Л. И. и Г. А. Пешкова [редакторы] (1979). Флора Центральной

- Сибири, тт I-II. Новосибирск: Наука, 1048с. [L. I. Malyshev and G. A. Peshkova (editors), Flora of central Siberia]
- — — [редакторы] (1990). Флора Сибири. Том 2 Poaceae (Gramineae). Новосибирск: Наука, 362с. [Flora of Siberia, volume. 2: Poaceae]
- — — [редакторы] (1994). Флора Сибири. Том 7 Berberidaceae—Grossulariaceae. Новосибирск: Наука, 312с. [Flora of Siberia, volume. 7: Berberidaceae-Grossulariaceae]
- Матвейчук, С. А. (1990). Наземные Позвоночные Ушканьих Островов в кн. Иметхенов et al., 1990. [S. A. Matveichuk, Terrestrial vertebrates of the Ushkanii Islands]
- Мизандронцева, К. Н. (1985). Климат Озера Байкал в Погодах. Новосибирск: Наука, 160с. [K. N. Mizandrontseva, Climate of Baikal in weather]
- Моложников, В. Н. (1969). Распределение кедрового стланика на Баргузинском хребте. Ботанический Журнал 54(6): 902-908. [V. N. Molozhnikov, Distribution of kedrovi stlanik (*Pinus pumila*) on the Barguzin Range]
- — — (1974). Полуостров Святой Нос и Чивыркуйское Семиостровье (Состояние Экосистем и Вопросы Охраны их Животных Компонентов). в сб. Природа Байкала, 1974. [The Svyatoi Nos Peninsula and the Chivirkuiskiie „Seven Islands” (composition of the ecosystems and questions of conservation of their animal life)]
- Пармузин, Ю. П. и Г. В. Карпов (1994). Словарь по Физической Географии. Москва: Просвещение, 367с. [Yu. P. Parmuzin and G. V. Karpov, Dictionary of physical geography]
- Пешкова, Г. А. (1972). Степная Флора Байкальской Сибири. Москва: Наука, 208с. [G. A. Peshkova, Steppe flora of Baikalian Siberia]
- — — (1985). Растительность Сибири (Предбайкалье и Забайкалье). Новосибирск: Наука, 144с. [Vegetation of Siberia (Pribaikal and Transbaikal)]
- Положий, А. Б. и Л. И. Мальшев [редакторы] (1994). Флора Сибири. Том 9 Fabaceae (Leguminosae). Новосибирск: ВО Наука, 280с. [A. B. Polozkii and L. I. Malyshev, Flora of Siberia, volume. 9: Fabaceae]
- Попов, Л. В. (ответственный редактор) (1990). Уникальные Объекты Живой Природы Бассейна Байкала. Новосибирск: Наука, 224с. [L. V. Popov, Unique biological features of the Baikal basin]
- Попов, М. Г. (1956). Эндемизм во Флоре Северо-Восточного Побережья Байкала.. (в сб. «Материалы по изучению производительных сил Бурят-

- Монгольской АССР», Вып. II), с. 407-419. [M. G. Popov, Endemism in the flora of the northeast coast of Baikal]
- — — (1957a). Степная и Скальная Флоры Западного Побережья Байкала. В сб.: Труды Байкальской Лимнологической Станции, т. XV, Г. И. Галазий, редактор, 465с.. [Popov, M. G. Steppe and slope floræ of the western coast of Baikal]
- — — (1957b). Флора Средней Сибири, Т. I. М-Л: Наука. [Flora of central Siberia, vol. I]
- — — (1959). Флора Средней Сибири, Т. II. М-Л: Наука. [Flora of central Siberia, vol. 2]
- Попов, М. Г., и В. В. Бусик (1966). Конспект Флоры Побережий Озера Байкал. Москва-Ленинград: Наука, 216с. [M. G. Popov, V. V. and Busik, Conspectus of the flora of the coastal areas of Lake Baikal]
- Потемкин, В. Л. (1975). Байкал: Ушканьи острова. За Науку в Сибири, №23 (704). [V. L. Potemkin, Baikal: The Ushkanii Islands]
- — — (1987). Ушканьи острова. Лес и Человек, с.83-84 (от фотокопии; неизвестные данные тома). [The Ushkanii Islands]
- Природа Байкала (сборник статей). (1974). Ленинград: Академия Наук СССР и Географическое Общество СССР, 295с. [Nature of Baikal, a collection of monographs]
- Природа Ушканьих Островов на Байкале (сборник статей). (1969). Труды Лимнологического института, т. 17 (37). Вып. 3. Москва: 1969. (Nature of the Ushkanii Islands on Baikal, a collection of monographs)
- Рожков, О. И., Д. М. Гиряев, И. Д. Никодимов, С. К. Скворцов и Д. Д. Шаталов (1986). Лесные Памятники. Москва: Агропромиздат, 208с. [O. I. Rozhkov, D. M. Giryayev, I. D. Nikodimov, S. K. Skvortsov, and D. D. Shatalov, Forest monuments]
- Скрябин, Н. Г. [редактор] (1987). Биоценозы Островов Пролива Малое Море на Байкале. Иркутск: Изд-во Иркутского университета, 184с. [N. G. Skryabin, Biocenosis of the islands of the Maloye More strait in Baikal]
- Сукачаев, В. Н., и В. Б. Ламакин (1952). Флора и Растительность Ушканьих Островов. в кн: Ламакин, В. В. (1952). Ушканьи Острова и Проблема Происхождения Байкала. Москва: Государственное Издательство Географической Литературы, 200с. [V. N. Sukachev and V. V. Lamakin, Flora and vegetation of the Ushkanii Islands]
- Сукачев, В. Н. и Г. И. Пошлавская (1914). Ботаническое исследование

северного побережья Байкала в 1914г. Изв. Акад. наук, Пг. №17. [V. N. Sukachev and G. I. Poplavskaya, Botanical investigation on the northern shore of Baikal in 1914]

Тиваненко, А. (1981). Тайны Ушканьих островов. За Науку в Сибири, 23.06.81. [A. Tivanenko, Secrets of the Ushkanii Islands]

Тройцкая, Н. И., и М. А. Федорова (1989). Сосудистые растения Баргузинского Заповедника. из серии „Флора и Фауна Заповедников СССР” Москва: Комисия АН СССР по координации научных исследований в государственных заповедниках СССР, Институт эволюционной морфологии и экологии животных им. А. Н. Северцова АН СССР, Всесоюзный институт научной и технической информации ГКНТ и АН СССР, 72с. [N. I. Troitskaya and M. A. Fedorova, Vascular plants of the Barguzin Zapovednik, from the series „Flora and fauna of the zapovedniks of the USSR”]

Тюлина, Л. Н. (1975). Особенности Поясного Распределения Растительности на Байкальском Хребте. в сб. Динамика Байкальской впадины, 1975. [L. N. Tulina, Fundamentals of the zonal distribution of vegetetaion on the Baikal Range]

— — — (1976). Влажный Прибайкальский тип Поясности Растительности. Новосибирск: Наука, 320с. [Humid Pribaikal-type zonal vegetation]

— — — (1981). Растительность Южной Части Баргузинского Хребта. Новосибирск: Наука, 86с. [Vegetation of the southern areas of the Barguzin Range]

Флинт, В. Е., Ю. Д. Чугунов, и В. М. Смирин (1970). Млекопитающие СССР. Москва: Мысль, 439с. [V. E. Flint, Yu. D. Chugunov, and V. M. Smirin, Mammals of the USSR]

Флора Сибири в 14тт. (1988-1995; продолжение следует). Новосибирск: Наука. [Flora of Siberia in 14 volumes]

Флора СССР (1930-1964). [в 30 Томах] Л-М: Издательство АН СССР, 20.886ст. [Flora of the USSR]

Шимарева, М. К. (1969). Почвы Большого Ушканьего Острова. В. сб.: Природа Ушканьих Островов на Байкале. Труды Лимнологического института, т. 17 (37). Вып. 3. Москва: 1969. [M. K. Shimareva, Soils of Bolshoi Ushkanii island]

Штильмарк, Ф. Р. (1996). Историография Российских Заповедников. Москва: ТОО Логата, 340с. [F. R. Shtilmark, Historiography of the Russian nature reserves]