A Biophysical Inventory and Evaluation of the

Lulu Island Bog

Richmond, British Columbia

Neil Davis and Rose Klinkenberg, editors

A project of the Richmond Nature Park Society Ecology Committee

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2008

Recommended Citation:
Davis, Neil and Rose Klinkenberg (editors). 2008. A Biophysical Inventory and Evaluation of the Lulu Island Bog, Richmond, British Columbia. Richmond Nature Park Society, Richmond, British Columbia.

Title page photograph and design:
David Blevins

Production Editor:
Rachel Wiersma

Maps and Graphics:
Jose Aparicio, Neil Davis, Gary McManus, Rachel Wiersma

Publisher:
Richmond Nature Park Society

Printed by:
The City of Richmond

Additional Copies:
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PROJECT SPONSORS

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PREFACE

The idea for a nature park in Richmond began in 1962 when the Corporation of the Township of Richmond recognized the site on Westminster Highway as a potential park. As outlined in detail by Bret Jagger in Chapter 17 of this report, by 1968 a group of local volunteers united under the guidance of Will Paulik and the Richmond Rod and Gun Club had developed the concept and petitioned Council to create a public nature centre for the purposes of environmental education, outdoor exploration and conservation of an undisturbed parcel of Richmond's once extensive bogs.

Within two years the concept became a reality and by 1971 the not-for-profit Richmond Nature Park Committee was established to work with Richmond to develop the park and its programs. A temporary "nature display building" was located on site in 1972, trails were developed, and a basic inventory of the flora and fauna of the park was conducted through the Local Initiatives Program. In 1975 plans were approved for the construction of a permanent nature interpretation centre through the combined resources of the Recreation Department of the Township of Richmond, the Kinsmen Club of Richmond and the Provincial Government. The Richmond Nature House opened November 14, 1976.

The bog has defined the history and heritage of Richmond. It was a resource to First Nations and both a challenge and a boon to early colonists. The bog continues to influence the community through agriculture and development, recreation, education, conservation and research. A growing understanding of bogs as sources of pharmaceuticals and gene banks and for their value in carbon sequestering and the potential relationship to global climate change is raising their profile still further.

Bogs were once a common feature, encompassing almost half of Lulu Island. Now considerably reduced, they are found in three principle locations: the East and West properties of the Richmond Nature Park and the adjacent Department of National Defence lands, plus several small remnant parcels, including the Northeast Bog Forest. Totaling 86 hectares, the two Nature Park properties protect 2/3 of the remaining boglands on Lulu Island – a fragile remnant of a vanishing environment.

Richmond Nature Park exists both as a place to preserve a unique ecosystem in Richmond and for people to explore a personal connection to that environment. For generations who have grown up here or for newcomers alike, the Nature Park is a gateway to nature in Richmond. We are indebted to the visionaries who created this opportunity and are grateful to those who continue to give of themselves to ensure the Nature Park remains a vital part of this community.

Volunteers have made immeasurable contributions to projects and operations in the Park. Perhaps the most intensive effort, involving thousands of hours of volunteer time, is the biological inventory of the bog which began in 2002 and concluded with the production of this document - a report card on the condition of Richmond's bogs providing insight into bog ecology and factors that affect it. It is a current inventory of species present or missing from the bog, changes since the first systematic examination of the bog in the early 1970's and projections for the future. It is a benchmark to gauge changes in the bog and to facilitate informed action.

This document is testament to the dedication of so many people who've given their time and expertise on behalf of the Nature Park. We welcome this report and know it will be a valuable tool in ensuring there will always be a place for the environment in Richmond.

Kristine Bauder
Richmond Nature Park Coordinator
March 30, 2007

EXECUTIVE SUMMARY

By Neil Davis

A biophysical inventory and evaluation of the Lulu Island Bog was conducted from 2001 to 2008. This report summarizes the results of the inventory and evaluates the bog's significance as a natural area and contributor to regional biodiversity.

Twenty-four years have passed since any inventory was conducted in the Lulu Island Bog and much has changed in the interim. By documenting the flora, fauna, and vegetation cover types present in the bog, this inventory sought to enable informed comparisons with earlier inventory work and provide a baseline for monitoring and responding to future changes. The inventory was carried out in the three properties on Lulu Island that were determined to comprise the largest remaining viable remnants of the Lulu Island Bog: the Department of National Defence property, the Richmond Nature Park, and the Richmond Nature Study Area. Inventory work followed provincial inventory standards and recognised survey techniques.

The results of the inventory demonstrate that the bog plays a number of important ecological roles. Bog ecosystem functions and processes persist in parts of the study area in spite of its small size. This is indicated by the continued active growth of *Sphagnum* mosses in areas where disturbance and drainage effects are minimal, and by the persistence of an associated suite of representative bog species. Because of the loss of natural peatlands on Lulu Island, many of these bog species are no longer found in any abundanceon the island today outside of the Lulu Island Bog.

In a regional context, bogs make up less than 5% of the total land area within the Temperate Wetland Region, which covers much of the southwest corner of British Columbia. Thus, the Lulu Island Bog provides representation of an uncommon regional ecosystem. The bog also supports relatively high species numbers for its size, rivaling Burns Bog, which is a much larger bog that incorporates a greater range of bog and wetland habitats. It also hosts several rare, threatened, or endangered species and vegetation communities, including three species listed under the federal Species At Risk Act. More broadly, diverse wildlife populations benefit from the bog as a unique habitat refuge on Lulu Island.

The Lulu Island Bog is also a link to Richmond's natural history and an important educational resource. Bogs covered one third of Lulu Island at the beginning of European settlement in the 1860s. It represents the largest and most intact remnant of these ecosystems. The Nature Park's trails host between 80,000 – 100,000 visitors each year and the Richmond Nature Park Society delivers environmental education programs to approximately 5,600 children annually.

Though the bog serves the roles outlined above, it is significantly threatened by several interrelated forms of disturbance. First, the bog's hydrological regime has been altered by fragmentation and drainage. Drainage is drying the bog and as a result, a growing portion of the ecosystem is shifting away from an open, heath-dominated bog community towards a bog forest community. Drainage has also enabled the spread of invasive species – the second primary form of disturbance in the bog. Species such as cultivated blueberry, Scotch heather, and hybrid birch are increasingly displacing native bog species, particularly in the Department of National Defence and Richmond Nature Park properties. If nothing is done to mitigate these threats, the study area will continue to evolve away from a bog ecosystem and some of the important roles it currently plays will diminish.

Conservation of the Lulu Island Bog would contribute to several local and regional environmental initiatives, such as Richmond's participation in the Partners for Climate Protection program and Metro Vancouver's Livable Region Strategic Plan. However, successful conservation of the bog ecosystem requires that numerous steps be taken. First, stronger protection mechanisms are necessary to ensure the bog's future as a natural area. This includes protecting the Department of National Defence property, whose future is currently uncertain. Second, an integrated ecosystem management plan should be developed to address bog restoration, invasive species management, and research needs. Third, an environmental impact assessment process should be established to evaluate the implications of any works undertaken in the bog and the surrounding area where this would influence the bog ecosystem. Last, a planning process should be established to discuss and implement the first three recommendations. These recommendations provide a starting point for conserving the Lulu Island Bog as a healthy bog ecosystem.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FOREWORD

The editors and authors of this report are to be highly commended. With plenty of expertise, but also with limited resources, they have researched and documented the biological and physical components of the Lulu Island Bog in Richmond, British Columbia. This bog, comprised of three contiguous properties, is all that remains of the formerly extensive Lulu Island Bog in the Fraser River Delta.

But to view this report as *only* a description of these small areas would be to miss the main point. This report is as much a political statement as a scientific report. So in my interpretation, this report consists of two messages. One is the actual text: the explicit biophysical inventory. The other is the subtext: the implicit political argument in support of the long-term conservation of these three remaining parcels of bog.

It is the political argument that I would like address because so much is at stake. Indeed, the future of humanity is at stake. At first glance, this will sound like an outrageous exaggeration. But the Richmond bogs are small parts of a global environmental condition - biodiversity - that is essential for humanity in the long term, and the global rate of biodiversity loss is now of crisis proportions. In an unprecedented joint statement in 1992, the Royal Society in London and the US National Academy of Sciences warned world leaders that the current rate of biodiversity loss "has serious consequences for the human prospect in the future." In the same year, most of the world's nations, including Canada, signed the Convention on Biological Diversity under the auspices of the United Nations. All signatory parties (i.e., nations) agreed to conserve biodiversity primarily by way of establishing, in each country, a sufficient network of parks and protected areas, and by the protection (and if necessary, the recovery or rehabilitation) of rare and endangered species and ecosystems.

All of this has a direct bearing on the three small parcels of bog land in Richmond. But first, here is a condensed version of the full argument:

> We are now in the beginning of the sixth major mass extinction event of all time. In each of the previous five such events, deep in the geological past, most of the world's species went extinct. We do not know what caused the first four, but we do know what caused the fifth event at the end of the Cretaceous period 65 million years ago. A large asteroid collided with the Earth, instantly creating both the Gulf of Mexico and the equivalent of a nuclear winter, and by the time all the dust settled, the dinosaurs and most other species on Earth had been wiped out. The geological record shows us

that after each of the first five events it took tens of millions of years for evolution to replenish the world with new species.

The cause of the current major mass extinction event is not some geological upheaval or extraterrestrial surprise. Instead, human activities, increment by increment, day by day, nearly everywhere on the globe, are eradicating species by direct or indirect means. The alteration, fragmentation, or destruction of species' habitat is the single largest cause of biodiversity loss globally. The overexploitation of resource species such as the world's marine fisheries, as well as the human-conveyed introduction of 'exotic' species into ecosystems where they do not belong, also takes their toll. And climate change is predicted to compete with habitat loss as the leading cause of biodiversity loss in the next few decades.

It may not seem as potent as an asteroid slamming into the Earth, but the human-caused loss of biodiversity will be just as deadly and nearly as quick (both in ecological and human time scales – a matter of decades). As Ronald Wright put it in his recent book, *A Short History of Progress*, "We have already caused so many extinctions that our dominion over the Earth will appear in the fossil record like the impact of an asteroid. So far, we are only a small asteroid compared with the one that clobbered the dinosaurs. But if the extinctions continue much longer… then the next layer of fossils will indeed show a major hiatus in this planet's life."

Exactly what is biodiversity, and why is it so important for humanity? Curiously, the answers to these questions have been somewhat elusive until recently, even among conservation biologists. In the past, the relevant literature described biodiversity as, roughly speaking, the sum of nature's bits and pieces – the sum of the world's species, of the genes within species, and of the different types of ecosystems. And the value of biodiversity was described in similar terms – as the sum of the value of the *useful* bits and pieces, either now or in the future.

This definition and these values seem straightforward, but they are also part of the root cause of the current biodiversity crisis. Here's why.

Relatively few species have economic value. Among the world's 5 to 30 million species, 12 crop species provide half the daily food for humanity, and a few hundred or perhaps even a few thousand others provide the rest. We also use species for raw materials (e.g., timber, rubber, pharmaceuticals), but once again only a few thousand are useful. And if we look into the near future, we might discover new foods or sources of raw materials in not-yet-tapped species. So a few thousand additional species might be useful someday. Even if we were to go wild with our estimates and say that 100,000 species might be useful someday, we cannot account for the direct utility of the vast majority of the world's species.

Conservation biologists point out that potentially useful species live in ecosystems alongside their neighboring species, and therefore we should conserve those neighboring species too. There is some truth to this argument, but we also know from experience that many species can be annihilated from an ecosystem without precipitating a chain reaction that wipes out most of the species in any one ecosystem. Conservation biologists also point out that entire ecosystems provide us with what are known as 'ecosystem services' such as the assimilation of air and water pollution, local climate control, water storage, and carbon sequestration. National and global economies are fully dependent on these ecosystem services; we cannot do without them. Again, this is true, but we also know that many species can be lost from ecosystems without noticeable or meaningful losses in ecosystem services. In short, it's probably true that many or most of the world's species are economically useless in a direct sense.

But thinking about biodiversity in an economic sense is misplaced from the start. Viewing the value of biodiversity *as if* it were simply the current or potential economic value of the bits and pieces – genes, species, and ecosystems – is part of the problem.

Biodiversity is not simply the sum of the pieces, nor can we value it in these terms. Instead, biodiversity is a concept at a higher logical plane. Biodiversity is an emergent property of the biosphere; it is an environmental condition. More importantly, it is an *essential* environmental condition for humanity because it is necessary for the maintenance of biological resources in the long term. Humans are absolutely dependent on biological resources, and the maintenance of biological resources in turn is absolutely dependent on the environmental condition we call biodiversity. Put differently, this means that biodiversity is the *source* of biological resources upon which humans depend.

To place this in context, I sometimes compare biodiversity to other large, essential environmental conditions. The annual orbit of the Earth around the Sun, and the steady rate of solar influx are two examples. If either one of these conditions were to change slightly we might be able to adapt. The world would grow a little colder or a little hotter, and some nations would experience worse effects than others, but it is possible that humanity could adjust. However, a sudden and major change in either one of these environmental conditions would spell disaster for humanity; we would either freeze or burn to death. We need not concern ourselves with these doom and gloom scenarios. We can depend on the Earth maintaining its same old orbital trajectory, and we can depend on the Sun for a steady rate of light energy.

We are just as dependent on the biodiversity – source of biological resources – in the long term, but we are facing not just a slight change in this environmental condition; humans are precipitating the sixth major mass extinction event of all time. Given this reality, we can understand why one of the world's foremost biologists, E. O. Wilson, in an address to the US Congress in 1982, said that, "The worst thing that can happen … is not energy depletion, economic collapse, limited nuclear war, or conquest by a totalitarian government. As terrible as these catastrophes would be for us, they can be repaired within a few generations. The one process ongoing [currently] … that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us."

Since the 1980s, the situation has grown worse. Species are now driven to extinction at the rate of 100 per day according to some estimates. Half of all deforestation in history (forests are the most biologically diverse terrestrial ecosystems) has occurred since 1950 and the rate has accelerated significantly in recent years. In 1998, a group of leading fisheries biologists announced that the world's marine fisheries are in a state of collapse, and the latest assessments are worse. Global climate change is predicted to eliminate 15 to 35% of the world's terrestrial species by 2050, with an even higher proportion of losses among marine species. And the largest cause of biodiversity loss, once again, is the alteration, fragmentation, or destruction of species' habitats, almost entirely for short-term economic benefits.

How does all this relate to the three parcels of bog land in Richmond? I suggest five ways.

First, the global loss of biodiversity consists almost entirely of small, local land-use decisions. It is the net total of land-use conversions from relatively natural land to more economically useful lands such as agricultural lands, urban areas, and transportation corridors that is the most important factor driving the sixth major mass extinction event. As a result, every small, local land-use decision is important, including the fate of Richmond's three parcels of bog.

Second and in a related manner, the power of incremental loss has been underestimated. At the level of the *next* local land-use decision, whether or not to convert a small, natural area for economic gain seems of so little importance on a global scale. But when all the increments are added up, it produces a global effect. The only way to stop the global effect is to decide to conserve instead of convert – at the local level. And this includes Richmond's bogs. The global loss-of-biodiversity phenomenon is not inevitable; it consists of human decisions – again, at the local level. Each incremental decision either contributes to the global trend of loss or contributes to its reversal. In this sense, local decision-makers have a small part of the fate of humanity in their hands. It's a responsibility not to be underestimated.

Third, the importance of incremental economic gain has been overestimated. When the value of a proposed development project is compared to the seemingly useless species (or local population of a species) that it would destroy, the development project seems infinitely more valuable. On a case-by-case basis, development almost always comes out the winner. But this kind of comparison is at best deceptive and at worst irrational. Of course a seemingly useless species has no economic value; its true value is not commensurable with economic value. Instead, it is part of the essential and therefore priceless environmental condition we call biodiversity. A deliberate decision to obliterate a species' habitat is an incremental part of a larger decision – albeit somewhat delayed and indirect – to eliminate human life. The attraction of incremental economic gain can blind us to this reality.

Fourth, biodiversity loss by habitat elimination is not something that happens only in other areas of the world and not here in BC. The BC provincial government's own scientific authority, the BC Conservation Data Centre, has listed 1,367 species that are at risk of extinction in BC along with an additional 315 distinct ecological communities, for a total of 1,682 'elements' at risk. Harvesting old-growth forests and land-use conversions are the main culprits. Richmond's bogs, depending on whether they are converted or protected, could contribute to this trend or resist it.

Finally, the primary means of preventing biodiversity loss is to designate a network of parks and similar protected areas where species and natural processes can remain relatively undisturbed. A network among all governments is required. The federal government's system of national parks is not sufficient alone. Nor is each province's system of provincial parks. Nor is the combination of national parks and provincial parks. Regional and municipal governments must also contribute. The Greater Vancouver Regional District has designated parks, and so do its municipalities, including Richmond. The relative importance of Richmond's bog lands therefore should not be underestimated; they are part of a larger network.

A development-minded skeptic might argue that Richmond's bogs cannot be important for biodiversity conservation; they are already too small. This is where the biophysical inventory comes into its own. We now have the evidence that these areas are intensively used by many species, and some of these species are in trouble, meaning that any further habitat loss would put them in jeopardy. Or the skeptic might argue that Burns Bog is protected, so the three remnant parcels of the Lulu Island Bog are redundant and not needed for conservation purposes. But once again, we now have the evidence: many of the species mentioned in this report are already at risk of extinction even with the combination of Burns Bog *and* the three Richmond parcels. If it were possible, we should be trying to rehabilitate lost bog lands, not adding to the problem. Finally, the skeptic might want to argue that failing to develop the three parcels of bog lands represents opportunity costs that are too high. But in response, we can now ask, 'Too high for whom?' The costs might be too high for the developers perhaps, or for those who can think only about short-term benefits. But knowing what is at stake, we can see the importance of Richmond's bogs for humanity, and we now have the evidence to support it.

Dr. Paul M. Wood, RPF, RPBio
Associate Professor of Conservation Policy, University of British Columbia
Vancouver, July 2005

ACKNOWLEDGMENTS

We would like to express our thanks to the Richmond Nature Park Society for supporting the inventory work in the bog throughout the many years of field work and report preparation. The Society provided office space, funding support through grant applications, and supplies for the project. Special thanks to Brenda Bartley-Smith, Dolly Lewko and Mickey Range for their on-going support through all stages of the project.

We would also like to thank the City of Richmond and the Richmond Nature Park staff for logistical support of the project, and for specific contributions to and reviews of the inventory report throughout this process. A particular thank you to Kris Bauder, Peter Harris, and Petra Murphy of the Richmond Nature Park, Mike Redpath (Richmond Parks Planning), and Bill Purver (Archives). Kris Bauder's knowledge of park history was a significant resource, and Mike Redpath's input on restoration ideas and recommendations for the bog were critical contributions. A special thanks to Terry Crowe and his staff for assistance with many parts of the project, including review and comment on the recommendations section of the report (David Brownlee), map preparation (Stuart Jones), and insight into the city planning process, including city by-laws, city zoning, and specifics of the Agricultural Land Reserve.

Thanks must also go to the funders who have supported the project through grants for hiring project biologists (Service Canada) and for coverage of printing costs for the report (TD Friends of the Environment Foundation, the Department of National Defence Chilliwack Region, and the City of Richmond). A special thank you to the City of Richmond for printing the inventory report.

The substantial support and in-kind donations provided by several government agencies and individuals were a significant part of the inventory project. A very special thank you to Sylvia LeTay (BC Ministry of Environment), Brian Naito (Fisheries and Oceans Canada), Ross Vennesland (Parks Canada), and Jamie Smith (University of British Columbia) for equipment loans, presentations on Species at Risk, and key information on the fish species of Lulu Island. This was critical support that made our project possible. Claudio Biancini, Libor Michalak, Shawn Hilton, and Dave Nagorsen provided key guidance on small mammal survey and identification.

A big thank you to Rachel Wiersma for taking on the task of production editor and guiding the report through the layout, production, and printing process.

Many thanks to Don Benson who provided critical proofreading of the final report.

Aside from these special supporters of the project, our thanks must go to the members of the ecology committee of the Richmond Nature Park Society and to many others for ongoing support and contributions throughout the length of this project. So many people have contributed to the project that its success and completion are truly a product of their efforts. It was the ecology committee members who suggested that we conduct an inventory and who offered their expertise and time in the process. Thank you to the following people and agencies for field assistance, dip well monitoring, assistance with breeding bird surveys, guidance in survey methods, species identifications, photo contributions, information provision and compilation, historical information, and trap digging and placement:

> Alex Fraser Research Institute, Jose Aparicio, Roger Ashton, Jane Bachman, Michael Beck, Don Benson, Claudio Biancini, Gina Choe, David Blevins, Laurence Brown, Kent Brothers, Kathleen Churcher, Jim Dickson, Robert Forsyth, Laura Fries, Karen Golinski, Bev Gordon, Marie Goulden, Shawn Hilton, Alana Hilton, Ashley Horne, Ingrid Hwang, Stephen Ife, Dave Ingram, Jocie Ingram, Mariko Jagger, Nikaiah Jaguar, Ruth Jones, Helen Kennedy, Rex Kenner, Dennis Knopp, Paul Kroeger, Ian Lane, Olivia Lee, Jeff Lemieux, Simon Liao, Christine Lynn, Kevin Mack, Brent Matsuda, Libor Michalak, Gertie Moore, David Nagorsen, Tim Oke, Eliza Olsen, Nick Page, Michael Price, Doug Ransom, Ian Robertson, Patrick Robinson, Pamela Rutherford, Wilf Schofield, Tony Sinclair, Jamie Smith, Spencer Entomological Museum, Harold Steves, Mary Tait, Elizabeth Thunstrom, Patty Thomas, Vivian Tong, Rob Vandermoor, Kristine Voghell, E. R. White, Heather Williamson, Michael Wolfe, Pamela Zevit.

Thank you to the following photographers who contributed photos to this report: Alex Fraser Research Forest, Kent Brothers, Shannon Cressey, Lori Daniels, Jamie Fenneman, Robert Forsyth, Karen Golinski, Hugh Griffith, Ashley Horne, Stephen Ife, Dave Ingram, Mariko Jagger, Brian Klinkenberg, Rose Klinkenberg, Ian Lane, Fred Lang, Gary Lewis, David Nagorsen, Royal British Columbia Museum, David Shackleton, Rachel Wiersma, Diane Williamson.

A special thank you to Michael Beck for his long-term survey of the birds in the bog, and to Kevin Mack and Michael Wolfe for monitoring dip wells in the bog over extended periods.

Thanks must also go to our contract biologists who carried out our fish and small mammal trapping and prepared key components of the inventory reports. The inventory wouldn't have been the same without the contributions of Shannon Cressey, Bret Jagger and John MacQueen, who worked with small mammals, fish, birds, land snails and plants.

PART I: INTRODUCTION AND GEOGRAPHY

CHAPTER 1: INTRODUCTION

By Rose Klinkenberg and Neil Davis

1.1 Overview

The Lulu Island Bog is a remnant of a once much larger raised bog ecosystems located on Lulu Island in Richmond, British Columbia. Bog ecosystems are significant in Richmond and the Fraser River Delta because they support complements of species and plant communities that differ from the surrounding landscape and are important elements of regional biodiversity. Worldwide, bogs play a significant role in global carbon sequestering. For Richmond, the Lulu Island Bog is central in supporting hundreds of species of plants and animals and occupies a prominent role in local history.

Photo 1.1: The open expanse of the Lulu Island Bog with dwarfed shore pines, circa 1929, prior to draining. Photo: City of Richmond Archives.

Most of the original expanse of the Lulu Island Bog has been lost to urban and agricultural development. The remaining portions are in decline as a result of drainage and subsequent drying of the bog, with a noticeable shift away from open heath-dominated[1] bog with low, dwarfed conifers (Photo 1.1), to bog forest. In recognition of the importance of the bog and the changes it is undergoing, the Ecology Committee of the Richmond Nature Park Society determined that there was

[1] Plant species in the heath family of plants, the Ericaceae.

a need for an updated, comprehensive inventory in order to build an information base that could inform future bog management. As Janzen (2000) argues, "inventory is basic infrastructure for a multitude of expected and unexpected passive and active management decisions."

In undertaking a study of the bog, the Committee determined that inventory work would focus on baseline data gathering as well as evaluation of the bog and its role in biodiversity representation and regional wildlife support. The inventory was conducted from 2002 to 2007 with the assistance of more than 40 volunteers from the Ecology Committee.

In this report, the results of the inventory and evaluation are presented in four parts: 1) introduction, history and geography of the bog, 2) the flora, fauna and vegetation of the bog, 3) evaluation, understanding and the future of the bog and 4) appendices, including species checklists.

1.2 Regional Context

The Fraser Lowland[2] (Figure 1.1) or Lower Mainland[3] region of British Columbia is rich in biodiversity and encompasses a variety of habitat and ecosystem types that range from large marshlands, such as Sturgeon Banks in Richmond, to the small Garry Oak ecosystems found near Yale and on Sumas Mountain. The region also includes other specialty habitats such as hot springs, caves, balds, cliffs, seepage slopes, deep ravines and bogs. Each of these contributes to the high biodiversity of the region. Of the many habitat types and ecosystems present in the Fraser Lowland, however, the bog ecosystems found in the Fraser River Delta (hereafter "Fraser Delta") stand out. These colder than normal ecosystems support many northern species of plants not commonly found in the region. Many of these reach the southern limits of their distribution in the region. The species found in bogs are often specialists and are often from the heath family of plants[4] (refer to Chapter 2 for more details about bog structure and function).

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[2] The Fraser Lowland Eco-section (hereafter "Fraser Lowland") is a component of the Lower Mainland Eco-region, which is part of the Georgia Depression Eco-province. Campbell et al. (1990) define the Fraser Lowlands as "the Fraser Delta, estuary, lowlands and associated uplands". For further information on this region, visit the South Coast Conservation Program web site: http://www.sccp.ca, and refer to Campbell et al. 1990.
[3] The Lower Mainland region of British Columbia is variously defined. In this report, we use the term synonymously with the Fraser Lowland.
[4] Plants in the heath family (*Ericaceae*) are adapted to the cold, wet, acidic conditions found in bogs that inhibit water absorption and result in "xeric" or desert-like conditions. The thick, waxy leaves of these plants slow evaporation and retain moisture levels.

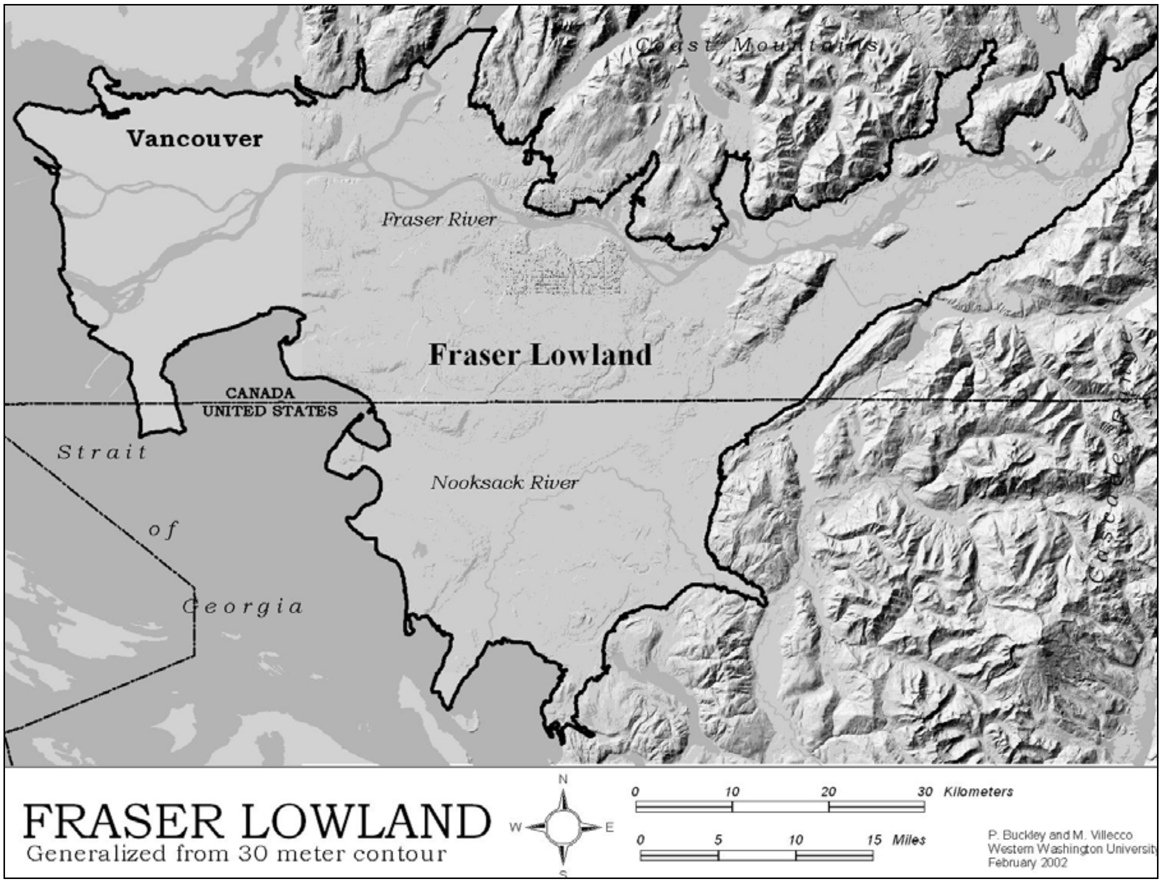

Figure 1.1: The Fraser Lowland Eco-Section of the Georgia Basin Depression.
Source: Buckley and Belec 2005.

Twenty-one historical bogs have been identified in the Fraser Delta (Hebda et al. 2000) (Figure 1.2, Table 1.1). The bogs in the lower Fraser Delta are the largest of these, and include Burns Bog (Photo 1.2) and the two historical bogs in Richmond: the Greater Lulu Island Bog and the Lesser Lulu Island Bog. These bogs formed along the path of the Fraser River as it meandered its way through the delta to the Pacific Ocean.

Many bogs in the Lower Mainland have been significantly altered and much reduced in size and condition as a result of urban development, agricultural development, and peat mining. Loss of bogs in the Fraser Delta has been rapid, particularly in the last decade, and it has left behind fragmented, disturbed ecosystems, and tiny remnants of boglands in some areas. These remnants, for the most part, can no longer support the extensive populations of larger mammals that were once a component of the region's bogs. For this reason, Burns Bog, the largest bog in the Lower Mainland, is tremendously important. It is big enough to continue to support a bear population (Hebda et al. 2000), big enough to provide an idea of what regional boglands once looked like in scope and extent, and it provides critical representation of bog habitat and a broad variety of bog-related plant communities in the delta. However, while large bogs offer the best representation of bog ecosystems, and support larger numbers of species, we hypothesize that even small remnants play a significant role.

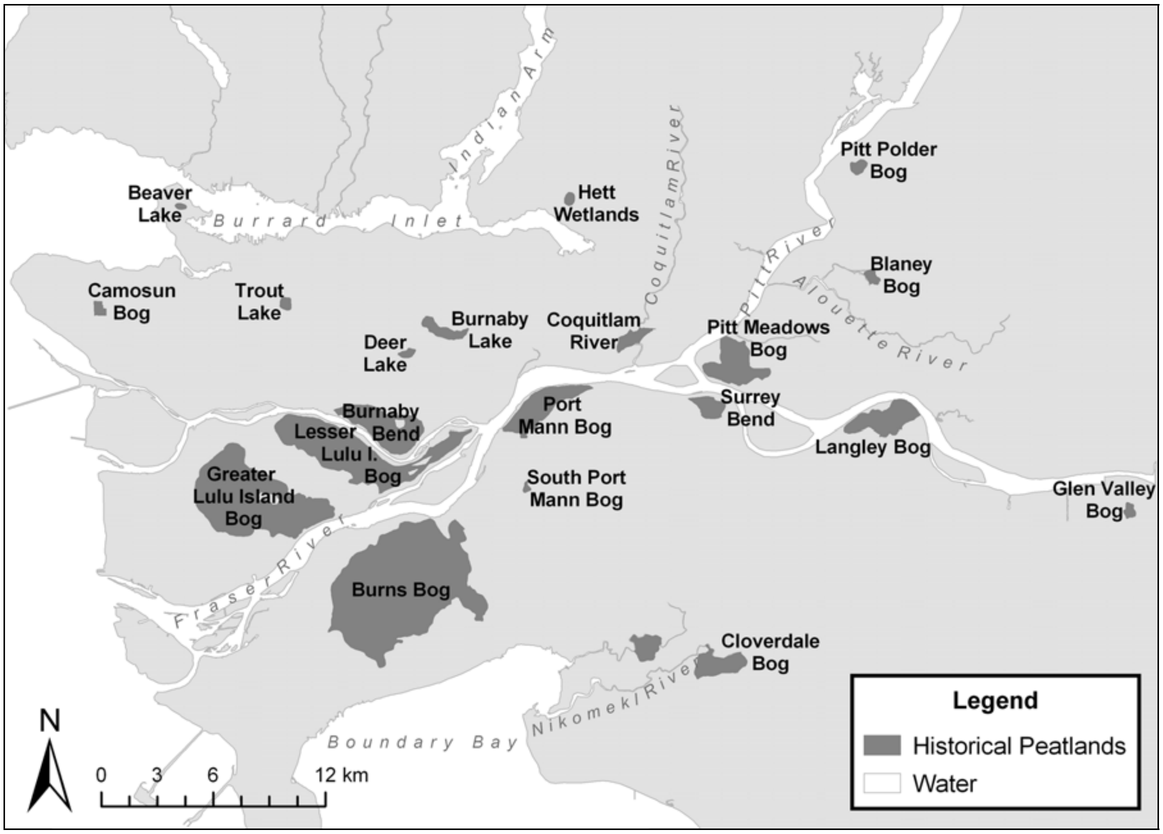

Figure 1.2: Historical bogs of the Lower Mainland. Source: Hebda et al. 2000.

Table 1.1: Historical Bogs of the Fraser Delta. Source: Hebda et al. 2000.

Beaver Lake Bog	Langley Bog
Blaney Bog	Lesser Lulu Island Bog
Burnaby Bend Bog	Richmond Northeast Bog Forest
Burns Bog	Pitt Meadows Bog
Camosun Bog	Pitt Polder Bog
Coquitlam River	Port Mann Bog
Cloverdale Bog	South Port Mann Bog
Deer Lake	Surrey Bend Bog
Greater Lulu Island Bog	Trout Lake
Glen Valley Bog	Unnamed Bog
Hett Wetlands	

Photo 1.2: Burns Bog, the largest bog in the Fraser Delta and Fraser Lowlands. Photo: David Blevins.

1.3 The City of Richmond and the Lulu Island Bogs

The City of Richmond is unusual. It is an island municipality located in the mouth of the Fraser River, and consists of a series of 24 islands that are currently recognized by the City (Brownlee pers. comm. 2005) (Figure 1.3). The larger of these include Lulu Island, Sea Island, Barber Island, Rose Island and Gunn Island. Most of the remaining islands are small and undeveloped, or have had very limited development and use, and are comprised primarily of wetlands or bottomland forest subject to tidal influences and seasonal flooding. The largest of the islands is Lulu Island, which supports most of the urban and agricultural development in Richmond - the downtown core, the suburban development and agricultural areas.

While the Fraser River itself is the heart and soul of Richmond, the bogs of Lulu Island have played a prominent role in Richmond's life and history. Other authors have reported that First Nations used and managed bogs in the area (Cairns 1973). The bogs have also influenced the pattern of modern settlement on Lulu Island and shaped how people moved about the landscape. Peat fires, and a mix of fog and smoke, were historically part of living on Lulu Island. Poet E. Pauline Johnson immortalized the influence of Lulu Island's bogs in her poem *"The Ballad of Yada":*

There are fires on Lulu Island, and the sky is opalescent
With the pearl and purple tinting from the smouldering of peat.
And the Dream Hills lift their summits in a sweeping, hazy crescent,
With the Capilano Canyon at their feet.

There are fires on Lulu Island, and the smoke, uplifting, lingers
In a faded scarf of fragrance as it creeps across the day,
And the Inlet and the Narrows blur beneath its silent fingers,
And the Canyon is enfolded in its grey.
(Johnson 1913)

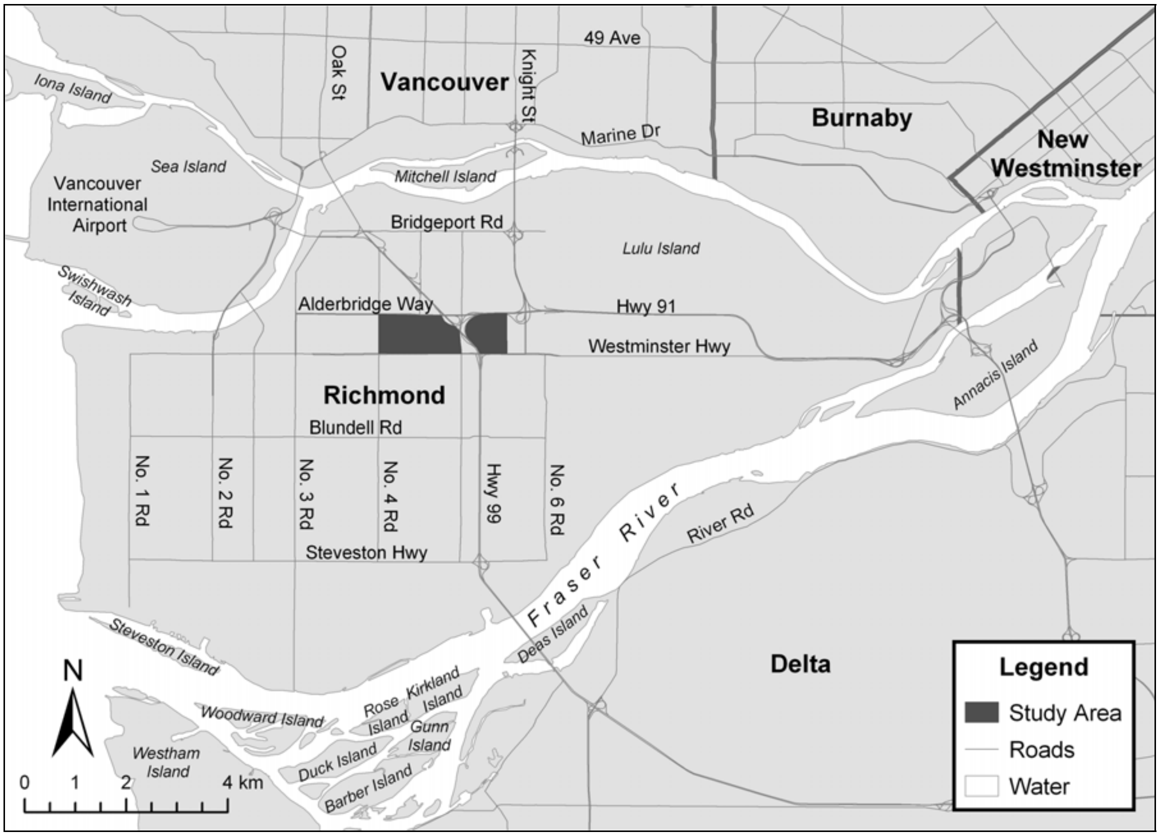

Figure 1.3: City of Richmond and surrounding islands.

Lulu Island was home to two large bogs the formerly extensive Greater Lulu Island Bog and the Lesser Lulu Island Bog (Figure 1.4). Today, the bogs of Lulu Island have been severely reduced in size and integrity as a result of direct loss and conversion for agriculture and urban development. Many cranberry and blueberry farms now operate on the peatlands of the island. A few significant parcels of boglands remain, plus many small, scattered fragments. The largest of these parcels are now referred to as the Northeast Bog Forest and the Lulu Island Bog:

- **The Northeast Bog Forest**: The Northeast Bog Forest is owned by the City of Richmond, and is a tiny successional remnant (77 ha) (Grenier and Bijsterveld 1982) of the Lesser Lulu Island Bog. It is heavily drained by deep perimeter ditches and surrounded by active cranberry fields. This site is now predominantly bog forest, although some typical bog species persist.

- **The Lulu Island Bog**: The Lulu Island Bog is the largest remnant of the former Greater Lulu Island Bog, and is comprised of four properties:
  - Two properties that constitute the Richmond Nature Park - the city-owned Richmond Nature Park proper (referred to in this report as the RNP west) (43 ha) and the adjacent Richmond Nature Study Area[5] (referred to in this report as the RNP east) (43 ha);
  - The federally owned Department of National Defence property (DND) (59 ha);
  - The federally owned Department of Fisheries and Oceans property (DFO)[6], immediately east of the DND property (55 ha).

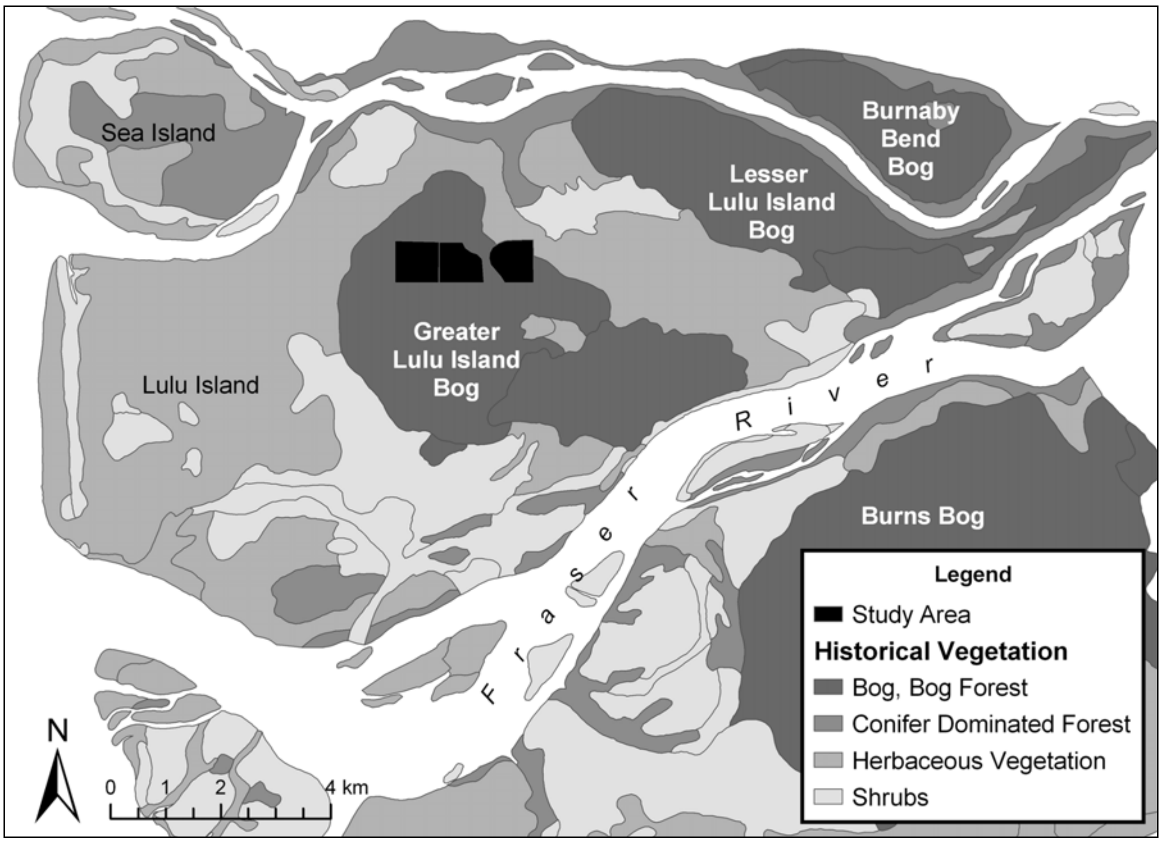

Figure 1.4: Historical vegetation of Lulu Island, showing comparison between the remnant Lulu Island Bog and the original extent of the peatlands. Source: North 1989.

At 200 ha, these combined properties represent the largest remaining fragment of bog in Richmond. Many smaller fragments and remnants of the Greater Lulu Island Bog

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[5] This property is variously known as the Richmond Nature Park East Property, Richmond Nature Study Centre and Richmond Nature Study Area. For the purposes of this report, it will be referred to in this document as the Richmond Nature Study Area (RNP east).
[6] This property is now generally referred to as the Garden City lands.

persist in the surrounding areas, but these do not function as a single ecological unit. These patches are mostly strips of drier, drained, bog forest adjacent to agricultural fields and subdivisions and along roadways.

1.4 The Study Area

The Lulu Island Bog is a primary raised bog[7] located in the north-central portion of Lulu Island. It is comprised of four city blocks bounded by Westminster Highway to the south, No. 4 Road to the west, Alderbridge Way and Highway 91 to the north, and Jacombs Road to the east (Figure 1.5). In initiating this inventory, the Ecology Committee of the Richmond Nature Park Society made the decision to include only the DND property and the two nature park properties. The federally owned DFO property was not included in the study because of imminent development[8]. Thus, throughout this report, the term "study area" to refers to the three city blocks that include the two Richmond Nature Park properties and the DND property. It also includes immediately adjacent peripheral habitats, including perimeter ditches and open field sites around these properties.

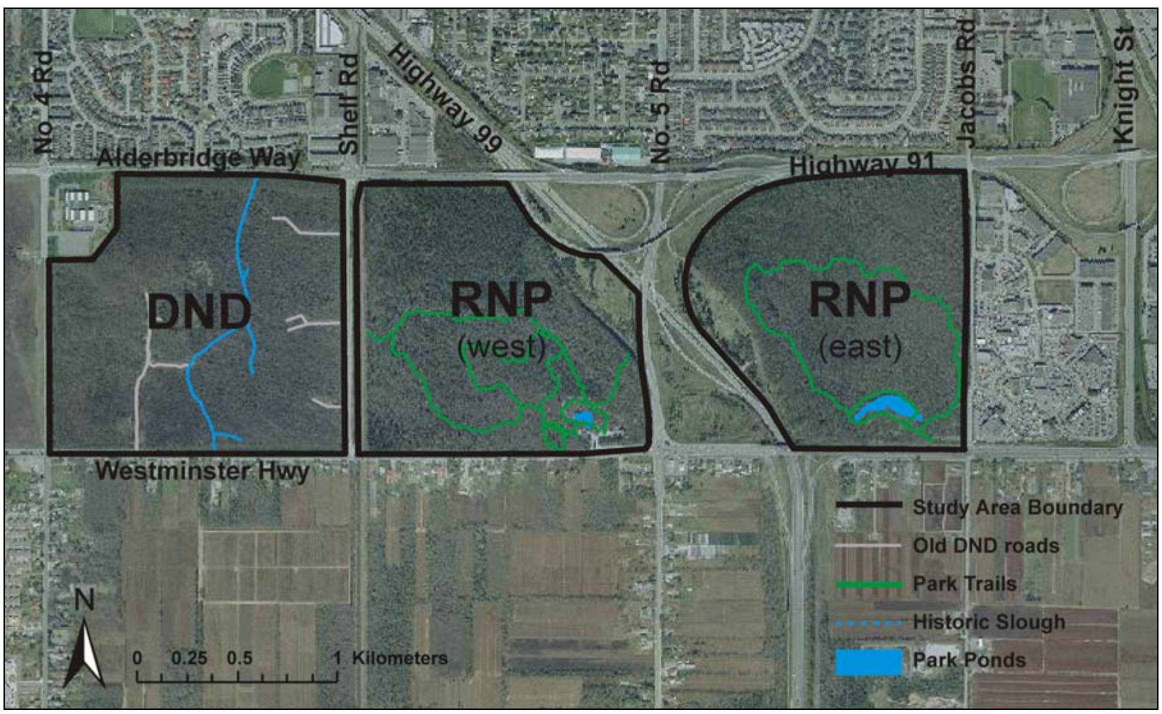

Figure 1.5: The Lulu Island Bog study area, showing surrounding urban and agricultural development. Map Source: City of Richmond 2005.

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[7] A primary bog is one that has never been cut for peat extraction.
[8] Development has not yet occurred in the DFO lands, as of November 2008. While disturbed and regularly mowed, the site still functions as bog ecosystem, and continues to support bog species and provide wildlife habitat.

In the past, prior to draining and human settlement, the Lulu Island bogs rivaled the size and scope of Burns Bog. In the photo below (Figure 1.6), the darker colour patches on Lulu Island illustrate the former extent of the peatlands, much of which have now been converted to agricultural fields.

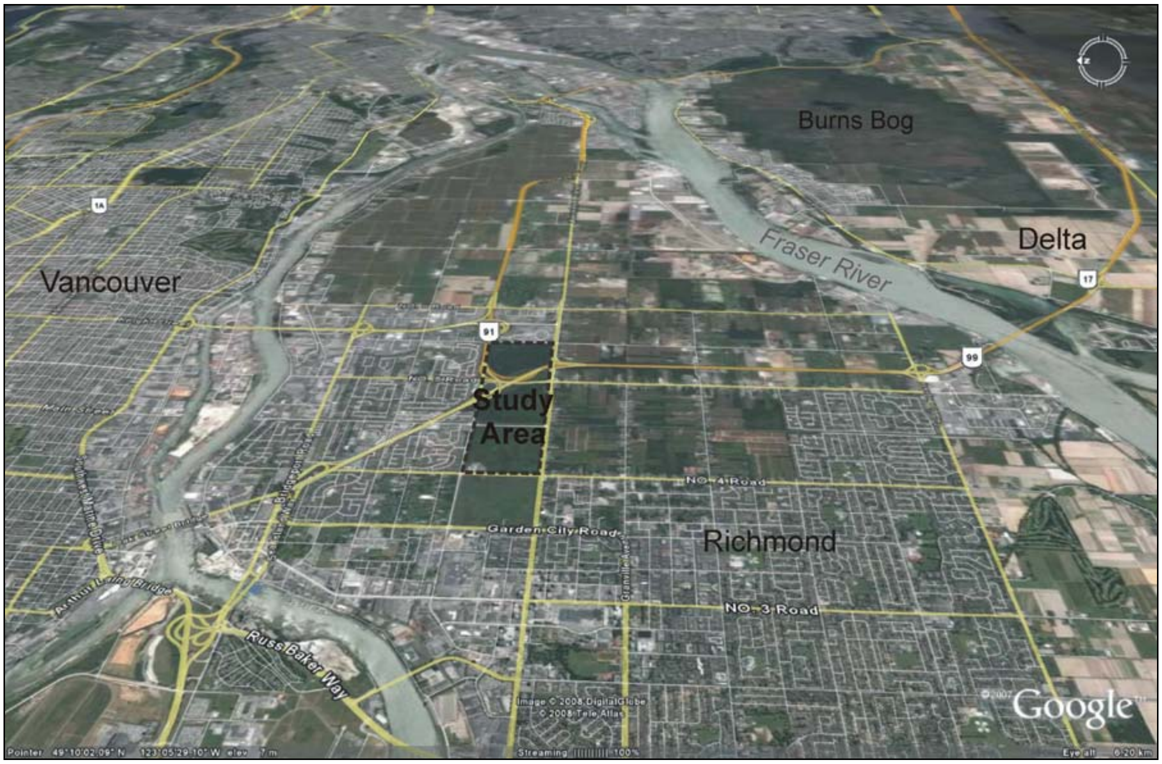

Figure 1.6: Lulu Island looking east, showing the study area, former extent of the peatlands on the island (the darker patches of underlying peat), and proximity and relative size compared with Burns Bog. Source: Google Maps 2007.

From March 2002 to November 2007, the Ecology Committee coordinated and carried out a biophysical inventory and evaluation of the remnant Lulu Island Bog. Following a preliminary assessment of the bog and its role both locally and regionally, the Ecology Committee identified the following objectives for this study:

- To inventory and document the biophysical features of the Lulu Island Bog, including vegetation, flora, and fauna, in order to develop baseline data;
- To identify significant species in the bog, including provincially blue- and red-listed species[9], federally listed species under the Species at Risk Act (SARA)[10], and other species of concern;

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[9] Blue-listed: any native species considered to be of special concern in BC (formerly designated as vulnerable). Red-listed: includes any indigenous species or subspecies that have - or are candidates for - Extirpated, Endangered, or Threatened status in BC. See the BC Species and Ecosystems Explorer for provincial status designations and definitions (http://a100.gov.bc.ca/pub/eswp/).

- To develop a geographical understanding of the formation and function of the bog;
- To evaluate the bog as a remnant and to examine its role in regional biodiversity representation;
- To evaluate the importance of the bog for regional wildlife;
- To assess the importance of the bog in education;
- To assess the historical importance of the bog;
- To assess the condition of the bog and the feasibility of restoration.

Data generated from this inventory serves a historical purpose, but will also allow future comparison between this bog and others in the region. The inventory will provide valuable data for comparison with earlier survey work in the study area that will allow us to evaluate change over time in the bog. It will also provide insight into management needs for this small but important regional representative of bog ecosystems.

1.5 Inventory Methods

During this inventory of the Lulu Island Bog, our survey team generally followed provincial inventory (RISC[11]) standards and recognized techniques for each wildlife group wherever possible. Voucher specimens were generally collected for plant groups and deposited in the UBC Herbarium. Standardized sampling techniques were used for faunal groups, including small mammal trapping (live trapping by permit), fish trapping (by permit), and direct pond sampling for insect groups. Insect specimens were deposited at the University of British Columbia in the Spencer Entomological Museum. Breeding bird census techniques were used for bird inventory work. Recognized sampling strategies (pitfall traps and debris cover) were employed to assess reptile and amphibian presence in the bog. Complete details on inventory methodologies are included in each chapter.

1.6 Evaluating the Bog

Evaluating the importance of the Lulu Island Bog, both ecologically and socially, is one of the objectives of this study. The site was assessed for ecological integrity and function, its value as a natural area or nature reserve, its role in regional biodiversity, its role as "green space" in the region and local area, and its importance to outdoor education and recreation in Richmond.

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[10] Federal Species at Risk Act 2005.

[11] Resources Information Standards Committee (RISC)

In gaining insight into these topics, some specific questions that were asked during the study included:

- How disturbed is the bog?
- What effects have urbanization had on the bog?
- How viable is this bog remnant as an ecosystem in an urban matrix?
- How large does the bog need to be to retain viability?
- What function does the bog play in maintaining wildlife populations?
- What influence has fragmentation had on the bog?
- How connected is it to other natural areas?
- Is there species exchange? Are source-sink dynamics at work? Can population recruitment occur from outside the bog?
- Is the bog a viable natural area or nature reserve?
- Is active management of the bog required to maintain the current extent of the bog ecosystems?
- Can the bog be restored towards more historical bog conditions?
- What role does the bog play in education and recreation?
- How important is the bog as a green space?
- What is the historical importance of the bog?

These questions and more are explored in this report.

CHAPTER 2: WHAT IS A BOG?

By Neil Davis and Rachel Wiersma

2.1 Introduction

Bogs are the most common type of wetland in northern Canada and are very common across the entire northern hemisphere in previously glaciated areas. Bogs receive water only from precipitation (Charman 2002). This separates them from other wetlands, such as fens, that receive other inflows of water. This restricted source of water results in a low availability of nutrients in bogs (Dennison and Berry 1993). Similar to Burns Bog, the Lulu Island Bog is a raised bog (Hebda pers. comm. 2006); a type of bog also referred to as an ombrotrophic or domed bog (Photo 2.1). It shows the typical characteristics of a raised bog, including a dome shape: "a peat mound raised above the marginal wetland surfaces, an internal water mound raised above the regional water table, acidic nutrient-poor water derived directly from precipitation, a two-layered peat deposit (acrotelm and catotelm) … and peatland communities dominated by *Sphagnum* and members of the heath family (Ericaceae)" (Whitfield et al. 2006, citing Hebda and Biggs 1981).

Photo 2.1: Burns Bog is the largest raised bog in the region. Photo: David Blevins.

The morphology of this type of bog is such that a raised or domed centre causes water to drain from the centre radially outwards. The environmental conditions in which raised bogs form are dominated by climatic boundaries where the precipitation is greater than the evapotransporation by 100 - 150 mm per year (Damman 1977, Proctor 1995), the local humid, temperate climate facilitates *Sphagnum* peat accumulation (Clymo 1992, Giller and Wheeler 1986) and the water table is at or near the ground surface year round (Ingram 1982, Schouwenaars and Vink 1992).

Bogs are typified by acidic (low pH) growing conditions and very little water flow. These conditions create very specialized habitats dominated by mosses and supporting many heath species. *Sphagnum* moss species are competitively dominant in acidic growing conditions and play a central role in bog formation (Dennison and Berry 1993, Vitt 1994, Van Breeman 1995). *Sphagnum* is capable of floating on the water surface due to a high concentration of air in its cells, and forms a mat that can expand over adjacent areas (Dennison and Berry 1993); eventually developing what is known as a quaking bog1. It also contributes to the acidification of the bog environment, a positive feedback mechanism that serves to reinforce growing conditions favourable for bog development (Vitt 1994).

Peatlands in general have distinctive thermal climates (Oke pers. comm. 2006). Bogs are colder than the surrounding landscape and other ecosystems. They support many species of plants that are more commonly found further north. The lower temperature of bogs often results in fogs, a feature that once typified Lulu Island, when bogs were a predominant and undisturbed feature of the Richmond landscape (Photo 2.2).

Photo 2.2: Lulu Island Bog in winter. Photo: David Blevins

[1] Quaking bogs are wetlands that have formed over the surface of shallow ponds, creating unstable quaking surfaces. The Lulu Island Bog is a quaking bog.

Additionally, because of their unique conditions (acidic, cold, low nutrient environment), they support species that are bog specialists--species that thrive in these unusual conditions and are not found outside of them. In spite of being saturated with water, little water in a bog is actually available to most of the plant species that grow there. The low pH of bogs inhibits water uptake, resulting in what is ecologically a xeric, or dry, habitat. The high and stable water table, low water flow and low nutrient content typical of healthy bogs create very slow rates of decomposition which leads to the accumulation of dead organic matter, called peat, which is another key feature of bogs. Peat is the organic soil that forms the bog substrate. Because only bog specialists can grow under bog conditions, bogs tend to be low in species diversity. However, the species and plant communities found in bogs are not commonly found in other ecosystems. So while they have low diversity, the species they support are rare at lower latitudes.

Bogs are found across the north temperate zone of North America, Europe and Asia (Dennison and Berry 1993). Wetlands, of which bogs are one type, cover approximately 6% of B.C., and are commonly found in low-lying areas where water accumulates. These areas are also frequently the most subject to agricultural, industrial and urban development. In the Lower Mainland, developments like this have led to significant alteration and destruction of bogs (Banner and Mackenzie 2000).

2.2 Bog Classification

At the national level, numerous wetland classification systems have been developed to serve different purposes for different end users. To create a common foundation that would foster understanding across different user groups, the Canadian Wetland Classification System was developed based on the categorization of key ecosystem processes such as water budget, carbon budget, and water quality (Zoltai and Vitt 1995). Bogs are one of the five classes of wetlands defined in this system.

The provincial wetland classification method in British Columbia integrates several classification systems to reflect the importance of numerous factors including climate, hydrology and geomorphology, each of which is cited as a driver of environmental variables in wetlands (Dennison and Berry 1993, NWWG 1993 as cited in Banner and MacKenzie 2000). In British Columbia, the Biogeoclimatic Ecosystem Classification (BEC)--originally developed for terrestrial ecosystems--is the primary tool for classifying wetland features, with standard BEC criteria modified to better describe wetland site associations (MacKenzie and Banner 1995). The environmental gradients used to define wetlands include Soil Nutrient Regime, Soil Moisture Regime, pH/Base Cations ratio and Hydrodynamic Index (Vitt 1994 as cited in Banner and Mackenzie

2000) (Figure 2.1). Physical characteristics important in determining wetland type, such as hydrophysical form and hydrogeomorphic form, are also incorporated into classification (Banner and MacKenzie 2000). Hydrophysical form describes the hydrological landscape feature. Hydrogeomorphology describes topographic position in relation to hydrological factors.

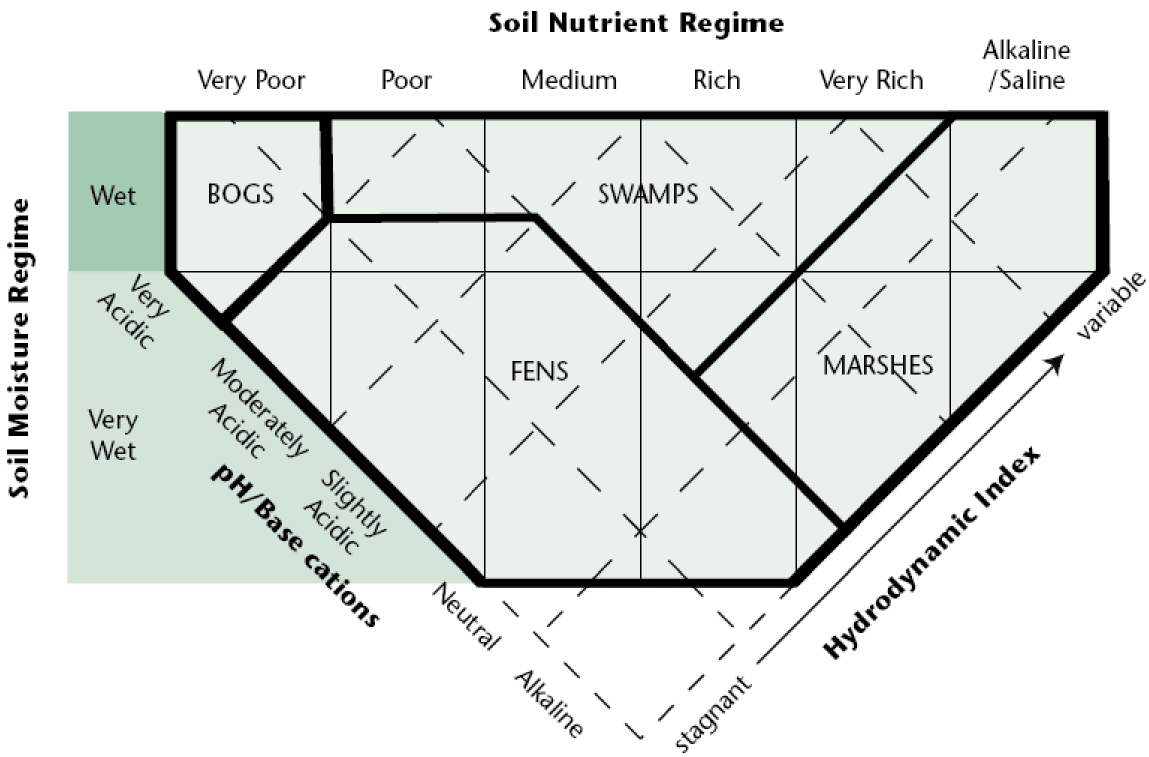

Figure 2.1: Environmental gradients shaping wetland ecosystems. Source: Vitt 1994, as modified in Banner and MacKenzie 2000.

CHAPTER 3: A GLOBAL PERSPECTIVE ON BOGS

By Lori Bartley and Neil Davis

3.1 The Global Issue

The global issue facing bogs/peatlands is their destruction. Over 50% of the earth's wetlands are bog ecosystems and they are considered threatened internationally (International Mire Conservation Group 1984). They are the targets of development for agriculture, forestry, horticulture, fuel and other commercial ventures around the world. On a global scale, all natural bogs have been eliminated in the Netherlands and Poland. Switzerland and Germany each have only 500 hectares of remaining bogs. In the United Kingdom and the Republic of Ireland, nearly 90% of the peatlands have been destroyed (Irish Peatland Conservation Council 2002).

Photo 3.1: Cultivated or highbush blueberry (Vaccinium corymbosum), an eastern species, is grown as a blueberry crop in Richmond. Photo: Brian Klinkenberg.

Agriculture has greatly affected peatlands. Millions of hectares have been drained and converted into farms around the world. Much of the land in the United Kingdom that is currently used for agriculture was once peatland. In other parts of the world, peatlands have been converted to pastures for grazing animals or fields for rice paddies. Canada alone has altered thousands of hectares of peatland to produce market gardens as well as blueberry (Photo 3.1) and cranberry farms. British Columbia is the world's third largest producer of cranberries, after Massachusetts and Wisconsin. Berries are grown in Richmond, Pitt Meadows and Langley. Growers produce about 17 million kilograms of berries a year, valued at nearly 25 million dollars (Ministry of Agriculture, Food and Fisheries 2003).

Commercial forestry operations have also resulted in peatland destruction around the world. Over one third of Finland's peatlands have been drained to facilitate tree harvesting (Ministry of Agriculture and Forestry 2001). In Malaysia, large tracts of peatlands are being burned in order to plant trees for the forest industry. In Canada, nearly 25,000 hectares of peatlands have been partially drained to facilitate forest operations (Daigle and Gautreau-Daigle 2001).

The use of peat for horticulture is of worldwide concern. It is used as a soil supplement to enhance water retention and plant growth and as a soil base for greenhouse production. To harvest a bog for peat moss, it must first be drained, dried and then cut. The resulting peat-based fields can be too dry for *Sphagnum* to regenerate and even if the water level returns to normal, it can take dozens or hundreds of years for mined bogs to return to their former state. Canada ranks second in the global production of horticultural peat after Germany, and currently produces 22% of the world's horticultural peat with a market value of 170 million dollars. Of Canada's 113 million hectares of peatlands, 17,000 hectares are being used for peat harvesting, employing about 1600 rural workers (Daigle and Gautreau-Daigle 2001).

Mining peat for fuel is another issue facing bogs. Ireland has depleted nearly 90% of its peatland as a result of peat mining for fuel in addition to draining for agriculture (Irish Peatland Conservation Council 2001). In the United Kingdom the statistics are equally grim and Eastern Europe is aggressively mining peat to provide a source of home heating, as well as fuel for power plants. In addition to these threats, peat is being used in alcoholic drinks, environmental improvements and purification systems, oil spill clean ups, spa therapies, medicines and pads (Statement on the Wise Use of Peatlands 2002).

Loss of biodiversity is a direct result of the destruction or alteration of bogs. Rare and endangered species in Canada that use peatlands include Whooping Cranes, Piping Plovers, Trumpeter Swans and Wood Bison. Many plants are specialized and live only in bogs, and will not be found anywhere else. These include insect-eating plants such as sundew (*Drosera rotundifolia*), pitcher plants (*Saracenia purpurea*), and bladder-worts (*Utricularia* spp.). They occupy a niche to which few other species are suited.

3.2 International Bog Conservation Efforts

The values of wetlands were formally recognized at the international level in 1971 at the Ramsar Convention. An intergovernmental treaty signed at the Convention by 144 countries provided a framework for national action on the conservation and wise use of wetlands. The Ramsar Convention has contributed to increasing global awareness of the importance of wetlands and acted as an impetus for conservation. At the 6th Ramsar Convention in Australia in 1996, attention was drawn to the issue of peatland conservation. While peatlands represent more than 50% of all terrestrial and freshwater wetlands, they account for only 6% of the land area protected under the Ramsar Convention. To address this shortfall, a resolution was drawn up making peatlands a higher priority for Ramsar.

The International Mire Conservation Group (IMCG) was established in 1984 to promote the conservation of mires and their complete range of natural diversity throughout the world by ensuring their wise and sustainable use (IMCG 1984). IMCG is a partner in the Global Peatland Initiative, a platform program that promotes, facilitates and finances projects for the wise use and conservation of peatlands. They publish newsletters, handbooks, organize international conferences and training sessions and inventory peatlands around the world.

The Southeast Asia Peatland Action Plan and Management Initiative (SEA-PEAT) is a member of the International Mire Conservation Group. SEA-PEAT is an information network that links individuals working on peat-related issues. Its objective is to develop a comprehensive action plan for the conservation and sustainable use of peatlands in Southeast Asia and share that information with interested parties. The 35-40 million hectares of peatland in Southeast Asia accounts for 60% of the world's tropical peatlands and for roughly one tenth of the entire extent of our global peatland resources (SEA-PEAT 2002).

3.3 Bogs and Climate Change

The Kyoto Protocol, an amendment to the United Nations Framework Convention on Climate Change negotiated in 1997, bound signatories (including Canada) to, among other things, the "protection and enhancement of sinks and reservoirs of greenhouse gases" (UNFCCC 1997). This has indirectly highlighted the importance of wetlands, and more specifically, peatlands (including bogs), which play a significant role in reducing the amount and rate of carbon emitted into the atmosphere (Kusler1999). Peatlands act as significant carbon reservoirs (Armentano and Menges 1986). Peatlands cover approximately 400-500 million hectares of the earth's surface (Gorham 1990 as cited in Keddy 2000, Ramsar 2005), which is approximately 4% of the world's ice-free land area (Keddy 2000). However, they are estimated to contain a quarter to a third of the world's pool of soil carbon (Armentano and Menges 1986, Gorham 1991, Ramsar 2005). Carbon is sequestered from the atmosphere by photosynthesis in plants and remains largely unreleased due to the very slow rates of organic matter decomposition characteristic of peatlands' cold, waterlogged and acidic soils (Gorham 1991). The accumulation of this undecayed organic matter has built up for thousands of years in many peatlands around the world. The carbon would otherwise be released into the atmosphere as carbon dioxide, one of the gases principally responsible for climate change.

Peatlands are not only reservoirs of carbon stored in dead, undecayed organic matter, they can also be active carbon sinks if the rate of carbon sequestration via photosynthesis exceeds the rate of carbon release. Past studies have shown that peatlands can act as sources or sinks of carbon depending on a number of factors (Worrall et al. 2003). Development or alteration of peatlands can have a significant negative impact on their carbon storage capacity, and can change them from sinks to sources of carbon. Drainage leads to the oxidation of the peat layer and the accelerated release of carbon dioxide, methane and other greenhouse gases into the atmosphere (Kusler 1999). Drainage water outflow can also increase carbon dioxide release from bogs in the forms of dissolved organic carbon, particulate organic carbon, dissolved inorganic carbon and dissolved carbon dioxide (Worrall et al. 2003). Proposed strategies to meet the Kyoto stipulation of protecting and enhancing greenhouse gas sinks and reservoirs have included blocking drainage in bogs. This can serve to reduce carbon release and preserve their function as carbon sinks and reservoirs. It has been suggested that this strategy may be a cheaper method of carbon storage than other strategies such as afforestation. Moreover, blocking drainage in bogs can have other positive outcomes such as improved ecological health of bog ecosystems.

In a local context, Richmond is a participant in the "*Partners for Climate Protection*" program, a group of Canadian municipalities and regional governments working to reduce greenhouse gas emissions in their communities (City of Richmond 2005). Richmond is currently completing an emissions inventory and must develop a local action plan to reduce emissions and monitor progress. The existence of remnant boglands in Richmond presents municipal government with an opportunity to preserve a significant carbon reservoir and active sink on Lulu Island while simultaneously conserving green space and biodiversity. Blocking drainage around the bog remnants may reduce the carbon dioxide emissions in water outflows and prevent further oxidation of the peat layer. It may also serve to sustain the bog ecosystem by maintaining a higher water table that would help preserve its function as a carbon sink. At a longer time scale, this can help ensure continued accumulation of peat and thus, growth of the carbon reservoir.

CHAPTER 4: PHYSICAL GEOGRAPHY

By Rachel Wiersma with contributions by Bret Jagger

The Lulu Island Bog is a remnant of a unique and fragile ecosystem in the Fraser River Delta. It is unique because bogs are formed under unusual environmental conditions that occur in mid to high latitudes. In this region, these conditions were created during the development of the Fraser River Delta in the Holocene Epoch. There are four remnant bogs located on the delta deposits of the Fraser River--the Greater and Lesser Lulu Island Bogs in Richmond, the Burnaby Bend Bog north of the river in Burnaby and Burns Bog in Delta Municipality, south of the river (Figure 1.4). These four bogs may once have been joined, but now each exists, like the Lulu Island Bog, in a delicate ecological balance with the surrounding agricultural, urban and industrial developments. This chapter describes the evolution of the Greater Lulu Island Bog, from the ecosystem's development on the emerging landform of the Fraser Delta to the present day.

4.1 History of the Fraser River Delta

The Fraser glaciation began some 30,000 years ago, when an increase in snowfall led to the development of permanent snow banks and small glaciers in the coastal mountains. For about 10,000 years, glaciers grew in the mountains and pushed into the low central interior of British Columbia, where they coalesced to form the Cordilleran Ice Sheet. When the ice sheet was fully developed, its surface was over 2300 metres in elevation, covering much of southern British Columbia (Figure 4.1). It carried vast amounts of rock and sediment that were removed by the glaciers from the coastal mountains. In the Strait of Georgia region, the ice sheet reached its maximum extent around 14,500 years ago (Clague 1998). The subsequent rapid deglaciation removed the weight of the glacier ice from the land causing isostatic uplift and fluctuations in sea level (Clague 1998).

4.2 The Growth of the Fraser River Delta

The Fraser River travels 1,325 kilometres from its headwaters in eastern British Columbia to its mouth in the Strait of Georgia (Figure 4.2). It carries water and the associated load of dissolved and solid materials eroded from approximately a quarter of the area of the province. The evolution of this river played an important role in the formation of the Fraser Delta and of the Lulu Island Bog.

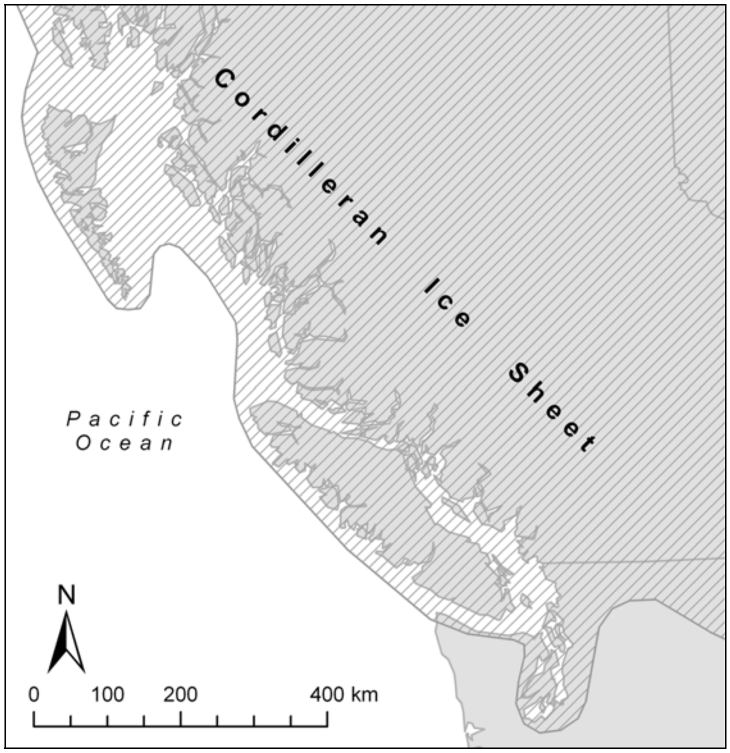

Figure 4.1: Cordilleran Ice Sheet maximum of the Fraser Glaciation. Source: Clague 1998.

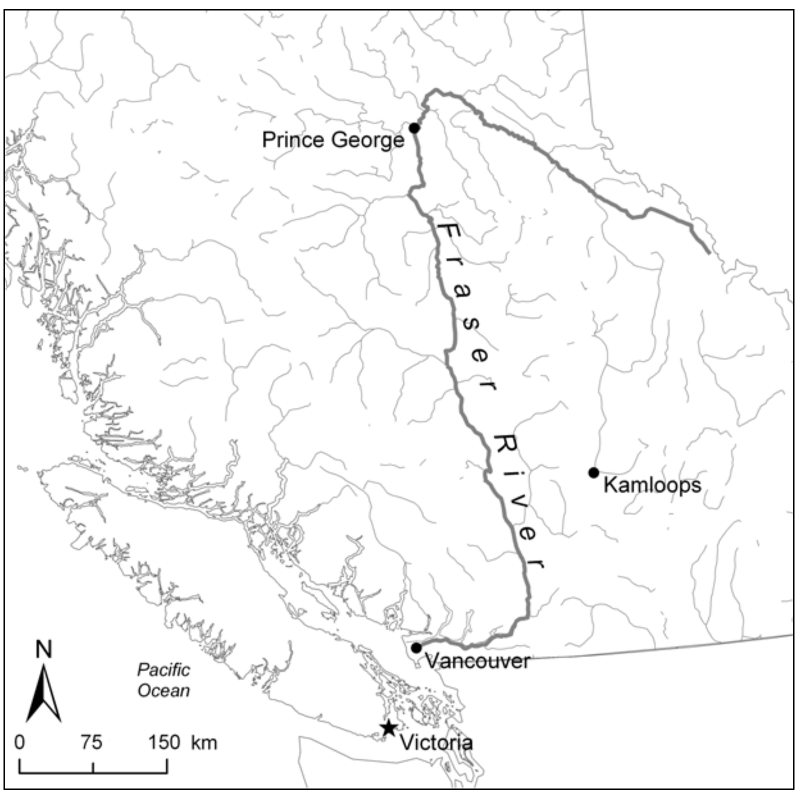

Figure 4.2: The Fraser River from the headwaters to the mouth.

The delta of the Fraser River southwest of New Westminster did not exist at the end of the Fraser glaciation. Instead, the area was part of the Strait of Georgia; Point Roberts Peninsula was an island and the sea reached the base of the Surrey Uplands. About 10,500 years ago, the delta was built across and up the Pitt Fjord, isolating Pitt Lake from the sea (Figure 4.3). Shortly thereafter, the Fraser River extended its floodplain west to New Westminster and began emptying into the Strait of Georgia proper.

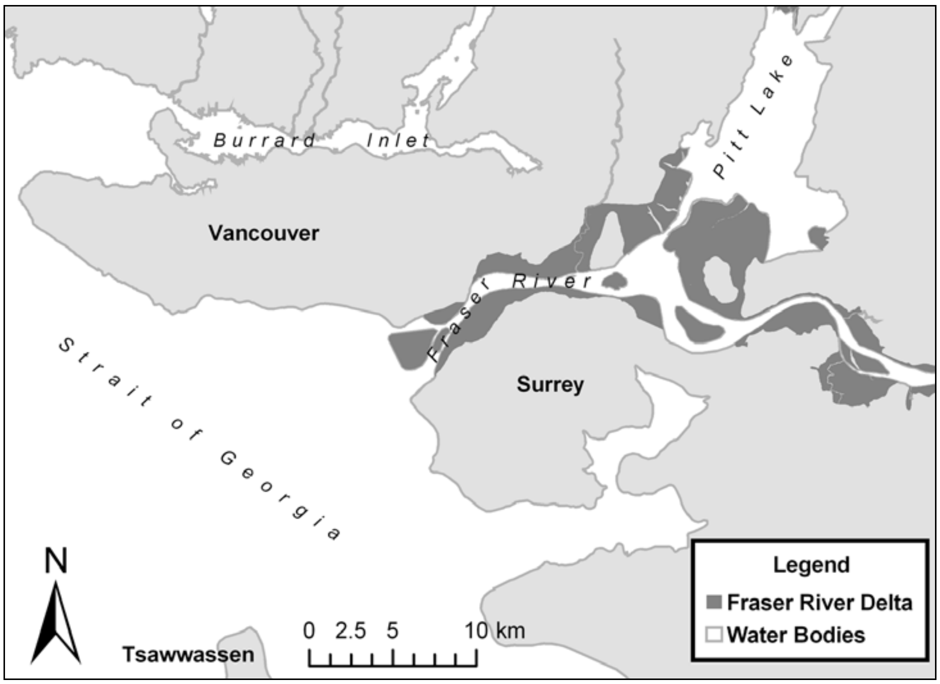

Figure 4.3: Fraser River Delta 10,000 years ago. Source: Clague 1998.

Remnants of the Cordilleran Ice Sheet supplied meltwater and sediment to the Fraser River until perhaps as late as 10,000 years ago, when ice completely disappeared from the lowland valleys and plateaus in the interior of British Columbia. Around this time the elevation of sea level was similar to the present (Clague 1983).

By 7,000 to 8,000 years ago, the sea was at its lowest level. After this period, the sea level began to rise, which triggered an increase in sedimentation of the Fraser River floodplain and caused parts of the Fraser Delta to become submerged. The relatively rapid sea-level rise continued until about 5,500 to 5,000 years ago, at which time the Fraser River floodplain again became stable (Figure 4.4). The sea level rose to within two metres of its present level (Clague1983).

As the delta grew, there were major changes in the channel patterns near the mouth of the Fraser River. The zone in which channels shifted often migrated seaward in step with the advancing delta front (Clague 1983). Deposits of sand or silt continually blocked channels during times of low water flow.

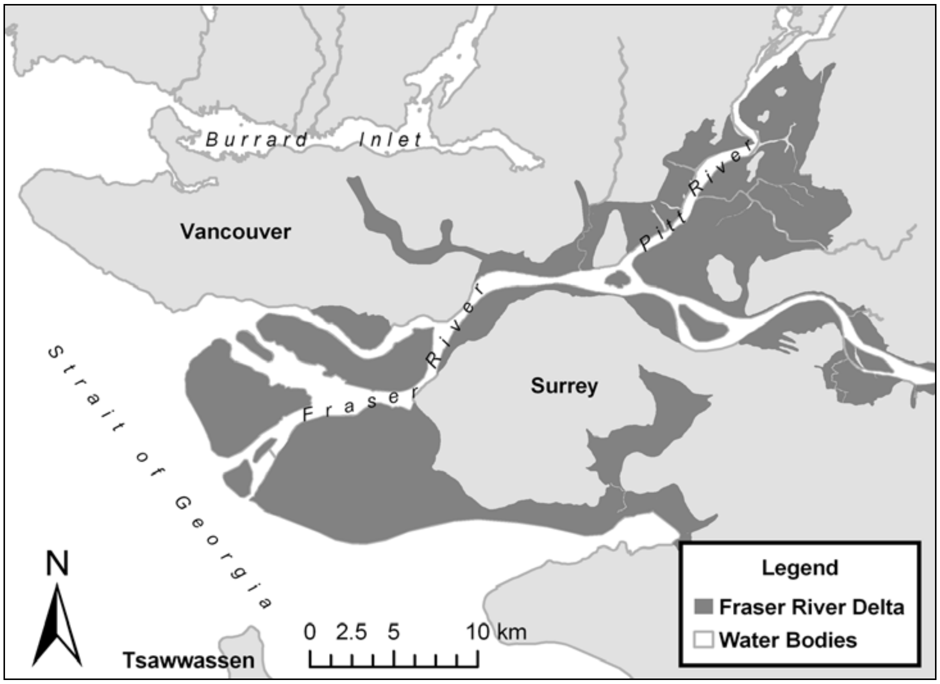

Figure 4.4: Fraser River Delta 5,000 years ago. Source: Clague 1998.

A former distributary channel of the Fraser River flowed across what is now the central part of Lulu Island, separating the previously contiguous bog into two parts--the Lesser and Greater Lulu Island Bogs (Figure 4.5). At some time less than 5,000 years ago that channel was silted up and a new channel developed along what is now the North Arm of the Fraser River, isolating the Burnaby Bend Bog that developed south of Burnaby (Mathews 1977). The Main Arm of the river breached the Burns-Greater Lulu Island Bog, causing a portion of the water to flow westerly into the Strait of Georgia. With the uplifting of the area, the North and Main Arms of the Fraser River divided to form Lulu Island and Sea Island. The former channel through Lulu Island filled with sand and was abandoned (Blunden 1975).

During the last 2,000 years, relative sea level has varied no more than one metre, indicating that isostatic, tectonic, and residual isostatic effects have largely compensated for one another (Clague, 1998). Today, the Fraser River breaks into three distributary channels: the North, Middle and Main Arms near New Westminster. As the last major island to form in the delta, Lulu Island is isolated by the North and Middle arms to the north and the Main arm to the south. Figure 4.6 shows the Fraser Delta today, a position that it probably reached 100 years ago. It continues to build into the Strait of Georgia; and the present foreshore areas of the delta will one day become terrestrial, extending the landmass of the delta ever further to the west.

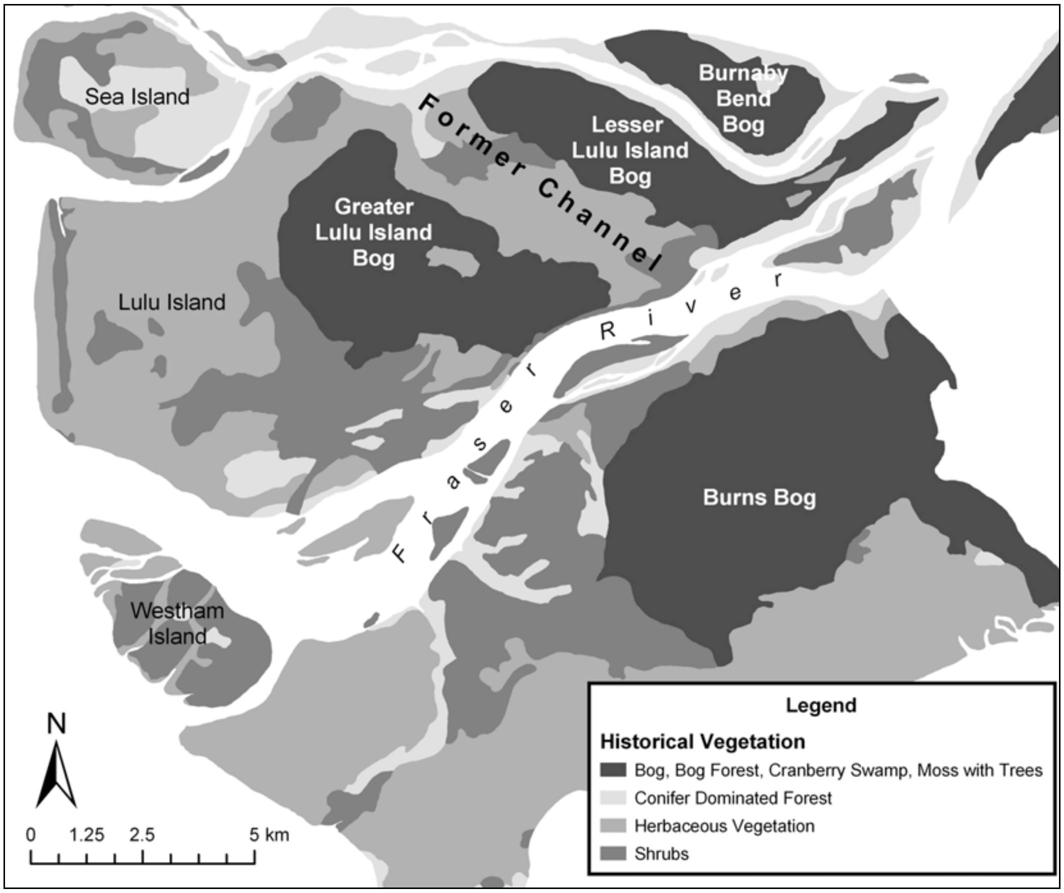

Figure 4.5: Channelization in the Fraser River[1]. Source: North et al. 1979.

4.3 Sediments of the Fraser River Delta

As discussed in the previous section, the Fraser Delta is a landform that has developed in the recent geological past. The delta is made up of sand, silt and clay, deposited by the Fraser River where it meets the Strait of Georgia. At the end of the Fraser glaciation, 11,000 years ago, meltwater carried vast amounts of rocks and sediments, loosened by the glaciers, into rivers. The Fraser River still carries a vast load from its drainage basin. These loose sediments move downstream in the water; whenever and wherever the energy of the flow decreases downstream, the heaviest pieces are dropped, forming bars and islands in the river channel. Finally, losing all its forward-flowing energy as it meets the sea in the Strait of Georgia, the river deposits all its load of sediment to build the delta (see Chapter 6 for further details).

[1] Channelization is an on-going process. In the past, Burns Bog and the Lulu Island Bogs were one large bog, but have since been separated by changes in the path of the river as mapped by North et al. 1979.

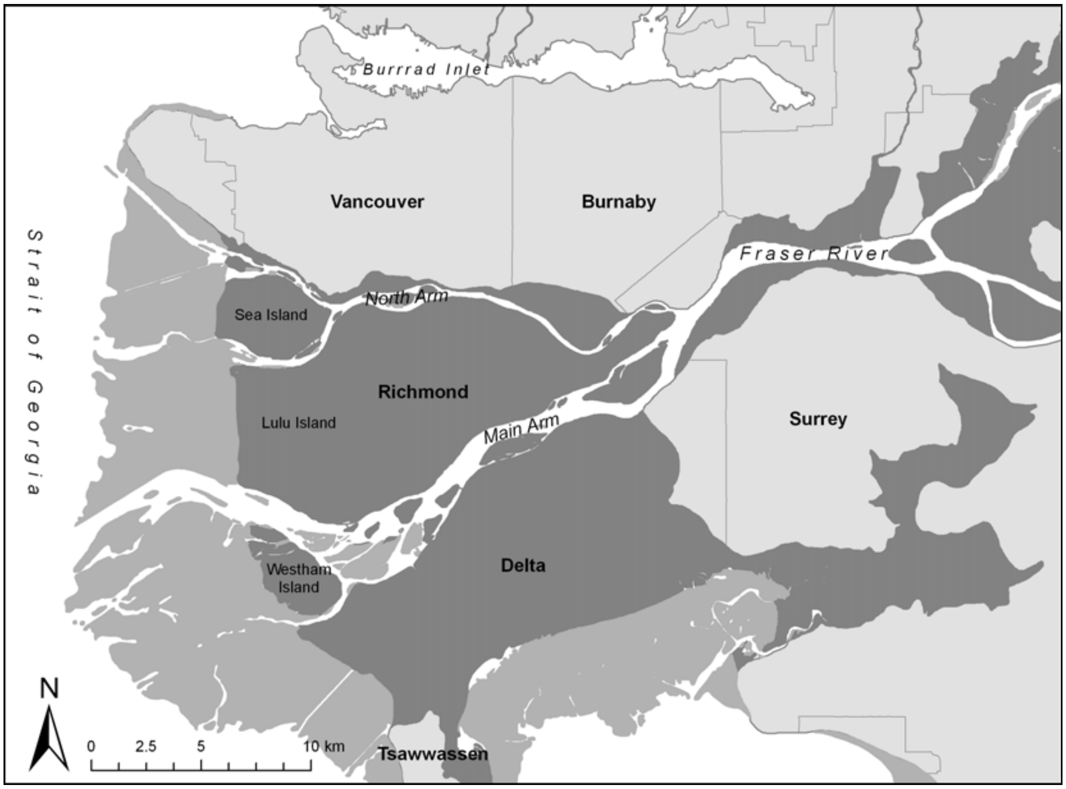

Figure 4.6: Fraser River Delta at present. Source: Clague 1998.

There are two factors that control the size of deltas: erosion and sedimentation. The action of the sea can erode deltas. Long-shore drift gradually redistributes materials along the coastlines adjacent to the mouth of rivers, thus significantly reducing the size of deltas. Conversely, sedimentation, which is the deposition of materials suspended in the river, can increase the size of deltas. Whether a delta grows or shrinks depends on the balance of these two processes. If sedimentation is faster than erosion, the delta advances; if it is slower, no delta will form, or an existing delta will be reduced in size. For the past 10,000 years, these sedimentation processes have been occurring more rapidly than erosion at the mouth of the Fraser River.

Another site of deposition of sediments has been occurring for the past 10,000 years on the surface of the delta. Every year, the high flow period after snow melt in the drainage basin of the Fraser River floods part of the delta surface, as the channels are too small to carry all the water to the sea (see Chapter 6). Because it takes more energy to carry heavier sediments, the largest debris is deposited closest to the river channels, whereas smaller particles are deposited further away. As flood events recur, the largest debris accumulates to form levees, raised banks, along the edges of the river channels (Figure 4.7).

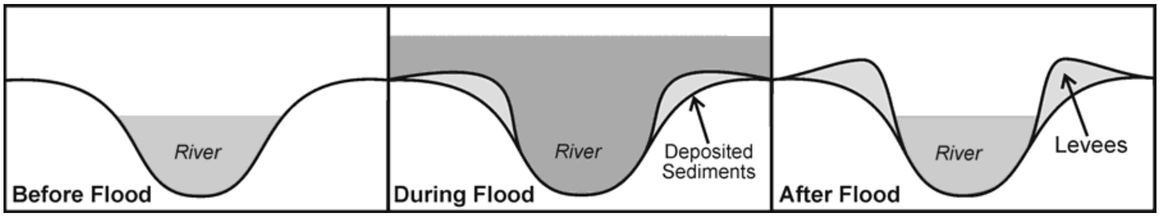

Figure 4.7: Formation of Levées. Source: Ho et al. 2004.

4.4 Development of the Lulu Island Bog

The finest-grained floodplain sediments, fine silt and clay, remain suspended the longest. These sediments are carried furthest from the channels by annual flood waters and deposited in the lowest lying areas where the water table is at or near the ground surface year round (Ingram 1982, Schouwenaars and Vink 1992). Cessation of annual flooding in the easterly areas of the delta was the precursor to the development of the bog ecosystem that derives its water entirely from local precipitation. Richmond is located where the Pacific Ocean moderates temperatures and provides a reliable source of moisture. Winters are mild and summers are relatively cool; precipitation exceeds evapotransporation by 100-150 mm per year (Damman 1977, Proctor 1995). The local humid, temperate climate facilitates *Sphagnum* peat accumulation (Clymo 1992, Giller and Wheeler 1986). This combination of topography and climate produces the necessary poorly-drained sites in which raised bogs form.

Under these circumstances the Lulu Island Bog developed as a raised bog in the depression left by an abandoned channel of the Fraser River that formed as the river changed course (Hansen 1940). The ponding of water in this depression was further facilitated by the formation of levees along the river (Hansen 1940). The morphology of this type of bog is such that a raised or domed centre causes water to drain radially outwards from the centre and this runoff may form a fen or lagg surrounding the bog (Charman 2002). This type of peatland is not influenced by floodwaters of streams or rivers – it is entirely dependent on local precipitation.

Precipitation provides seasonally variable moisture above the water table which results in a fluctuating depth to the zone of saturation in the water table. Water flows both within the water table and in the peat above, towards the outer perimeter. The details of this flow and the effect of peripheral drainage on it have not yet been determined for the Lulu Island Bog. Understanding the complex relationships between water availability and plant and animal species is essential to any management of the bog, and is the subject of ongoing studies (Chapter 5 outlines the state of knowledge and research to date).

4.5 Surface and Sub-surface Materials in the Lulu Island Bog

The Lulu Island Bog achieved its current depth by 4,000 years ago (Ross 1979). It was formed on top of a 200-metre bed of post-glacial Fraser River deposits (Defence Construction Canada 2001). The deposits are characterized by a two-metre layer of sand and clay loam over a 15-metre layer of floodplain sand and silt (Defence construction Canada 2001). Below this is a 185-metre estuarine deposit of fine sand and silt (Defence Construction Canada 2001). As the ice sheet and glaciers retreated between 14,000 and 10,000 years ago, the bedrock (approximately 45 million-years old) began uplifting (Ross 1979, Cairns 1973), attaining its current height 2,500 years ago. Wildlife also contributed to the peat-bog-forming, island-building process. Thomas Kidd (1927) observed that beaver dams in sloughs and streams retained water throughout the island, contributing to the development of the peat bogs. Damming caused the formation of shallow lakes in the interior of the island, and this caused an unequal distribution of clay deposition. Less clay, and of a finer grain, was deposited in the interior than at the perimeter (Kidd 1927). For this reason Lulu Island has been described as a "bowl of glacial till" (Wade 1972).

Table 4.1: Characteristics of Triggs and Lumbum Soil Series. Source: Luttmerding and Sprout 1969.

	Triggs	**Lumbum**
Parent Material and Texture	The topography is level to very gently sloping and the elevations range from about 3 metres on the margins to almost 7 metres in the centre of the bogs. The domed character is caused by successive growth of new moss on older moss. Growth is more rapid and decomposition slower near the center of the bogs than at the margin. Triggs soils have developed from deep (greater than five feet), relatively intact accumulations of *Sphagnum* moss.	The topography is flat to very gently undulating and elevations range from about 1.5 to 3 metres. These soils have developed from deep (more than 130 centimetres) organic materials, mainly remains of moss and shrubs in the upper part and sedges and reeds at depth. The surface horizon is usually intact and is underlain by moderately decomposed horizons to at least one metre. In a few areas, varying amounts of surface organic material have been removed by peat harvesting.
Soil Moisture	Drainage is very poor and where no artificial drainage has been installed, the water table is at or near the surface for most of the year. The soils are moderately pervious and have very high water holding capacity and slow surface runoff.	Lumbum soils are very poorly drained. The water table is at or near the surface during the winter, spring and early summer if not artificially drained. They are moderately pervious and have very high water holding capacity and slow surface runoff.
General Soil Description	Soil reaction is extremely acid.	Soil reaction is extremely acid throughout.

Hansen (1940) cites sampling by the Canadian Geological Survey that indicated that the Lulu Island Bog was uniform in depth and did not exceed 6.7 metres. Blundon (1974) described the surface material of the bog as a mat of organic peat that ranges in depth from 1 to 6 metres. This organic material is classified into two types of organic soils; the RNP west and DND sites contain Triggs-Lumbum soils and the RNP east is Lumbum-Triggs. See Table 4.1 for a description of these soil series. Below the layers of peat lie sand and silt sediments, approximately 60 metres deep, deposited during the formation of the delta. Hansen (1940) describes the early development of the Lulu Island Bog, and discusses periodic flooding indicated by deposits of silt beneath the peat in the bog and throughout the peat. Flooding by salt water, resulting in salt marsh vegetation, is indicated by pollen analysis, although Hansen (1940) indicates that while shifting river channels may have shifted pollens, the soil profile correlates to that of other local bogs. The depth to bedrock is approximately 500 metres (Ventura et al. 2004).

The layers of organic peat soils are classified based on the hydrological regime in each layer. The living upper layer of the bog is known as the acrotelm. It contains the roots and plants living on the bog surface and is aerobic. When the living plants complete their life cycle and die, they contribute peat to the surface soil layer, where it subsequently undergoes decomposition. The permanently saturated lower peat layer is called the catotelm, or the "dead layer". The lower limit of the water table in the bog is the approximate marker between the acrotelm and the catotelm. The catotelm is much thicker. Here the peat is waterlogged and anaerobic. Whatever peat survives decomposition in the surface layer eventually becomes waterlogged and stored in the catotelm. The amount of water stored in this layer is the most distinct feature of the hydrological system in a bog. Table 4.2 summarizes the general hydraulic characteristics of peatlands with respect to depth.

Table 4.2: Characteristics of peat layers. Source: Charman 2002.

Character	Acrotelm (upper layer)	Catotelm (lower layer)
Water table	Fluctuating	Absent
Water content	Variable	Constant
Aeration	Periodically aerobic	Anaerobic
Microbial activity	High with aerobic and anaerobic activity present	Low with only anaerobic activity present
Water movement	Relatively fast, variable from surface to base of acrotelm	Very slow, constant
Exchange of energy and matter	Rapid	Slow

Because the bog ecosystem is dependent on the presence of aerobic and anaerobic soil conditions that are in turn dependent on the local precipitation, the entire system is extremely sensitive to hydrologic changes in the surrounding environment.

4.6 External Influences on the Hydrology of the Bog

Although the Fraser River has had a significant role in the formation of Lulu Island and the inorganic sediments that underlie its bogs, the main influence that the river has on the central regions of the island today is in maintaining the relatively high water table. The Fraser is a tidal river; the river surface height and chemical composition can vary as far upstream as Mission. This daily and seasonal fluctuation can influence the water table on the outer edges of Lulu Island, thus affecting the height of the standing water in the bog.

However a greater influence on the water table is the effect of drainage. Throughout most of the delta, including Lulu Island, the land elevation is less than two metres above sea level (Clague 1998). When the first settlers arrived here in the mid-nineteenth century to farm the land, the construction of dykes to protect land from seasonal flooding was required. A system of drainage ditches was also created to facilitate the drying out of water-logged soils (Photo 4.1). This network of ditches that outflow to the Fraser River has been progressively extended to drain the low lying land along the Fraser River where major settlement was taking place. All three properties in the study area are included in this area that is being drained by ditches and sewers around their perimeters to divert water away from roads and the railway.

Photo 4.1: Drainage ditch, Northeast Bog Forest. Photo: Brian Klinkenberg.

4.7 Impact of Agricultural and Urban Development on the Lulu Island Bog

While the delta continues to grow out into the Strait of Georgia, the Greater and Lesser Lulu Island Bogs have decreased dramatically in size because of the combined effects of agriculture, urbanization and associated infrastructure development. The Lesser Lulu Island Bog is now only a tiny remnant, surrounded by major drainage ditches and blueberry and cranberry fields (Photo 4.2). The original heath bog has succeeded into bog forest, with tall trees dominating over active *Sphagnum*. The Greater Lulu Island Bog (now referred to as the "The Lulu Island Bog") is surrounded by subdivision development to the north, industrial development to the east, and converted peat lands (blueberry fields) to the south. It is actively drained by (comparatively smaller) perimeter drains. These changes have resulted in alterations to the hydrologic system essential to the bog's survival. Native bog vegetation in the remnant bog has been affected by the lowering of the water table, drying of the soil, and an associated decrease in soil acidity, resulting in taller growth of usually stunted pine trees, for example, and allowing for invasion by non-bog species. Overall, the following uses occur in the Lulu Island Bog:

- The RNP west has become an urban recreational park with bark mulch trails, nature centre, parking lot, and other facilities. Northwest of the Nature Centre is the artificially created nature park pond which is supplemented by tap water in the drier months when draw down occurs. While there is considerable disturbance, and much die-off of the active peat layer in portions of the nature park, good representation of bog ecosystem remains, particularly in the northern half of the park. Active lawns and hummocks are present;
- The RNP east serves as a nature reserve and outdoor study area. There is a parking lot and a picnic shelter. This site also contains an artificially constructed pond that presently supports an actively developing Sphagnum layer on the pond surface. This is the driest of the three bog properties, and as such much of the site has succeeded into bog forest. However, active Sphagnum growth is present and typical bog plants such as Cloudberry persist;
- The DND land was used for military exercises until recently (see Chapter 7). A seasonally wet stream that was historically present is still found near the centre of the site, and meanders through the small fen-like community, indicating that this property functions as a catchment area. This, plus small elevational changes from east (highest) to west (lowest), account for the wetter sites conditions that prevail here. Together, these factors help to actively maintain good representation of the bog ecosystem in this site. Trees remain stunted, active peat mat covers much of the area, and most invasive species, while present, are much less dominant. The exception to this is Scotch

heather (*Calluna vulgaris*), an alien species that has heavily invaded the DND property in response to the many small fires that have occurred.

Photo 4.2: Agricultural field in Richmond. Photo: Brian Klinkenberg.

CHAPTER 5: HYDROLOGY - EXISTING AND ONGOING STUDIES

By Rachel Wiersma

5.1 Introduction

The hydrology of the Lulu Island Bog, including stratigraphic information about the bog, is complex and poorly understood. Hydrological information about natural areas is important because it includes the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere. Stratigraphic information is also important because variation in the layers of organic material directly influences the flow of groundwater in the bog and the overall hydrologic regime. Groundwater flow through organic soils depends on the degree of decomposition of the vegetation. Highly compressed or decomposed organic soils will have lower permeability than those that are loosely packed or partially decomposed. The distributive subsurface pathways of water within the peat are a key factor influencing the distribution of plant and animal species.

5.1.1 Existing Knowledge and Data Sources

A hydrological study was conducted in the Richmond Nature Park properties of the Lulu Island Bog in the early 1980s by Jonathan Smyth (Smyth 1984). At that time, a series of peizometers were installed throughout the RNP west and east properties in order to assess the impact of drainage ditches that had been constructed around the perimeter of the park. Peizometer readings taken at that time indicated that while the drainage ditches had an impact on the bog, direct impact appeared to be limited to the perimeter of the bog.

In addition to the impact of drainage ditches, some hydrological impact has occurred resulting from the excavation of a pond in the Park property shortly after its opening in 1972. Because there is little or no groundwater flow into the pond during the summer months (a result of raised bog morphology), the pond dries up during the annual summer draw down. To remedy this problem and attempt to maintain water levels in the pond, tap water has been added to the pond during the summer months since the early 1980s (Griffith pers. comm. 2006). The impact of this additional water source on the surrounding vegetation is not known and warrants investigation.

5.1.2 Current Study and Methods

A hydrology component was added to the Lulu Island Bog inventory. The hydrology team located most of the original peizometers installed by Smyth, creating GPS locations for each of these (Photo 5.1). Regular readings of the peizometers to reassess site hydrology were not undertaken. Instead, under the direction of bog ecologist

Karen Golinski, a series of new dipwells were installed in major bog plant communities in the three properties that comprise the Lulu Island Bog study area. The purpose of the dipwells was to obtain data on water table depth relative to the bog surface (i.e., annual minimums, maximums, and the differences between them) and the resulting correlation with bog plant community composition. Three dipwells were placed within each key bog vegetation community (Table 5.1).

Photo 5.1: Searching for peizometers in the Richmond Nature Park. Photo: Rachel Wiersma.

The relationship of the site to the depth below grade to the water table represents the balance between precipitation inputs, groundwater flow, and evapotranspiration rates.

Ecology Committee volunteers took dipwell readings from September 2002 to the present. The dipwell reading at each site is the distance from the ground to the water level. This is determined by taking two measurements. First, the water level is determined by blowing through a long tube until the water level is reached and then measuring the length of the tube. Then the distance from the ground level to the top of the tube is measured and subtracted from the length of the tube to determine the dipwell reading. This was done at each dipwell location within each site and these dipwell readings were averaged to get the value for the site.

Table 5.1: Dipwell Locations in the study area as located by Golinski (2003).

Dipwell Site #	Location Description	Vegetation Characteristics	Northing (DD)	Westing (DD)
1	Located by post 8 on the Time Trail, on the east side of RNP west property	Shore pine (*Pinus contorta*), birch (*Betula pendula*), salal (*Gaultheria shallon*), *Sphagnum*, and velvet-leaf blueberry (*Vaccinium myrtilloides*)	49.1726	123.0950
2	Located on the Bog Forest Trail on the west side of the RNP west, at the south end of the board walk	Labrador tea (*Rhododendron groenlandicum*[1]), highbush blueberry (*Vaccinium corymbosum*), and bog blueberry (*Vaccinium uliginosum*)	49.1716	123.1001
3	Located on the Bog Forest Trail about 0.2 km north of Site 2	Labrador tea, highbush blueberry, and bog blueberry	49.1724	123.1004
4	Located on the Bog Forest Trail at the northwest curve, in the RNP west	Low shrub heath, Labrador tea, and bog blueberry (*Vaccinium uliginosum*)	49.1734	123.0987
5	Department of National Defence property	*Sphagnum,* Labrador tea, bog blueberry and bog cranberry (*Vaccinium oxycoccus*)	49.1728	123.1051
6	Department of National Defence property	*Sphagnum,* Labrador tea, bog blueberry and bog cranberry	49.1730	123.1060

5.1.3 Weather Readings

In addition to dipwell readings, meteorological readings for the bog were also compiled. There is a meteorological station located in the Richmond Nature Park (RNP west). Park staff and park volunteers take measurements twice daily, including maximum and minimum temperatures and precipitation, and submit this to Environment Canada. Climate Data Online has all the weather data for the Richmond Nature Park from March 1977 to October 2004, while the RNP has copies of the more recent data. The precipitation data from these readings have been incorporated into Figure 5.1 below. Precipitation data is the total precipitation of the previous week.

[1] The genus *Ledum* has now been renamed as "*Rhododendron*".

5.2 Results

The measurements taken at the dip wells throughout the study area have been designed to monitor the depth from the surface to the water table that fluctuates in the acrotelm. The seasonal fluctuation of the water table due to variation in precipitation input can be seen in the data collected at the six sites. The water content of the upper peat layer is also directly related to precipitation input, but is higher than the volume of water beneath the water table. This reflects the greater water storage capability of live peat because of the biological properties of *Sphagnum* mosses.

Figure 5.1 illustrates the results of the dipwell readings in the bog, and the precipitation recorded by the park weather station for the same period. Other than the period of missed readings it is clear that there are patterns in the response of vegetation communities in the bog to the precipitation input into the bog. During the winter (November to March) the water table is typically about 100-200 mm below the ground surface. However, by the end of the summer (August-September) the water table falls between 500 to 800 mm, dropping to between 700 to 1000 mm below the ground surface. Site 1 has the greatest average depth below grade to the water table; Site 2 has the second greatest depth to water; Site 3 has the third; Site 4 the fourth; Site 5 the fifth and Site 6 the lowest.

5.2.1 Limitations

Manpower availability to take regular dipwell readings has been a major limitation of this study. Taking daily readings for all six sites takes several hours each time, and it has not been possible to consistently maintain this. This has resulted in a number of inconsistencies in data collection, as seen in Figure 5.1. There is a large gap in 2003 as a result of a lack of volunteers to collect the data. Also, there was a change in the volunteers who were collecting the data, which may introduce variation in readings. In general, readings were taken once a week, but there are many periods when the frequency of readings was reduced to every two or three weeks.

5.2.2 Future Hydrologic Study Needed for Management

While it is evident from the data collected that there are patterns in the response of vegetation communities in the bog to the precipitation input into the bog, it is difficult to predict the response without a more substantial data set. Detailed and complete hydrologic studies are needed in order to fully assess vegetation/hydrology dynamics.

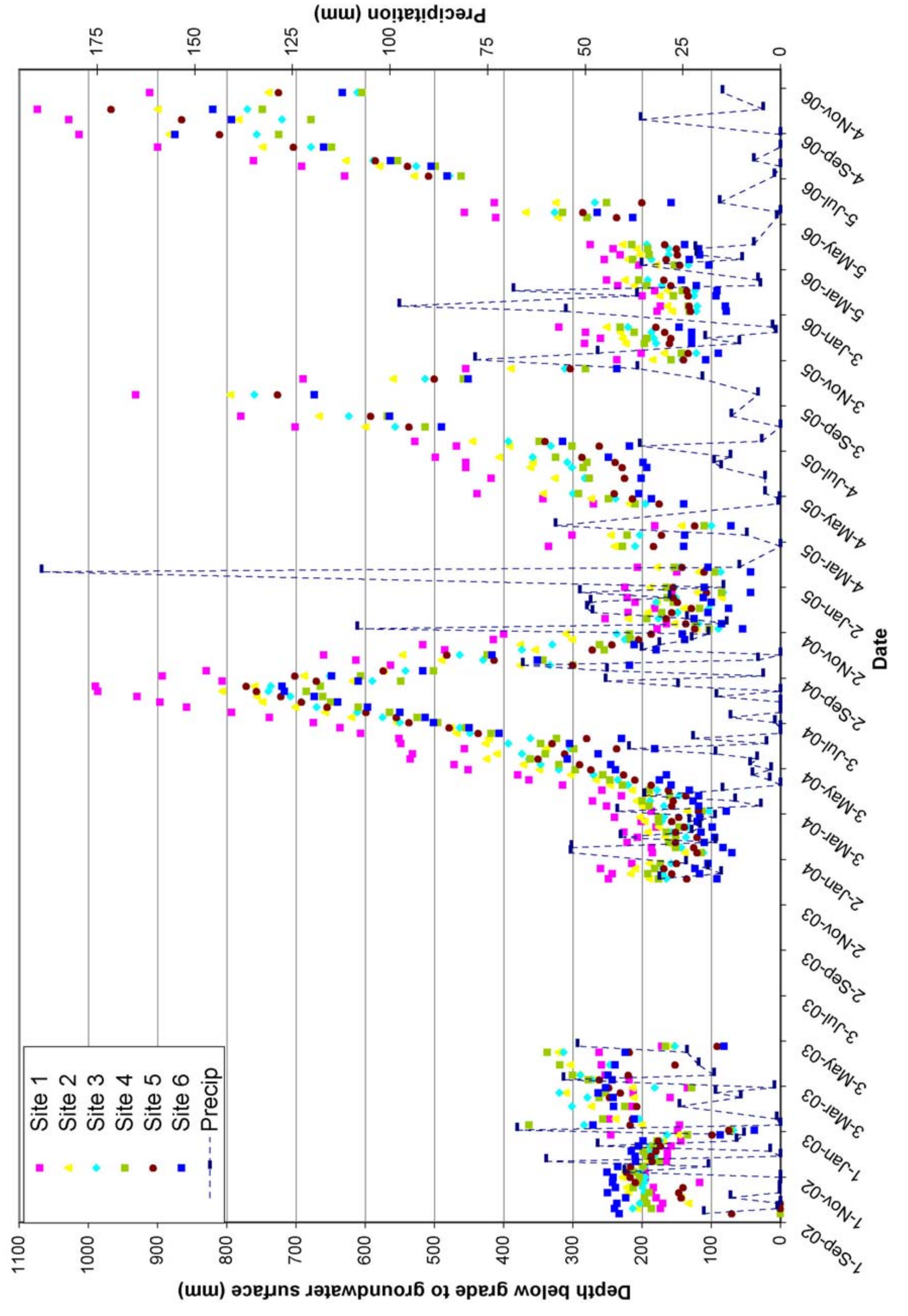

Figure 5.1: Depth Below Grade to Groundwater Surface in the Lulu Island Bog

CHAPTER 6: THE VEGETATION OF THE FRASER RIVER DELTA BEFORE EUROPEAN SETTLEMENT: A PEEP INTO THE PAST

By Margaret E.A. North

6.1 Introduction

The Fraser Delta is an evolving landform, emerging from the waters of the Strait of Georgia as the sediments from the Fraser River are dumped where the river meets the sea. This area is now covered with subdivisions, shopping centers, industrial land and farmland. Transport routes dissect the landscape. There is little left of the original, pre-settlement vegetation such as our first land surveyors would have encountered. Many of the plants found here today are introduced species from Europe and Asia, arriving as a result of agriculture or garden landscaping. Even remnant natural areas have been altered by deliberate or accidental changes to the environment. So what was the vegetation that grew here before European settlement?

6.2 Geologic Origins

An understanding of the development of the Fraser Delta is crucial to our knowledge of the vegetation that grew on it. We have to go back a long way in geological time to start our story (Figure 6.1). In the last million years, several major ice advances have occurred. Climate cooling in the past allowed snow to accumulate in excess of annual melting and the mountainous area north of the delta was covered with ice. There was no vegetation. Vast glaciers flowed slowly southwards, one between the mainland and Vancouver Island. However the ice sheets did not extend much further south than Bellingham, just across the border. The area known as the delta did not exist at this time.

The delta only began to accumulate after the last, minor ice sheet in the Fraser Valley melted away, about 10,000 years ago. We can imagine the mountains bordering the Fraser River being exposed as the ice melted away and the melt-water carrying the loosened rocks from the slopes into the valley. Here the river picked up the sediments and carried them downstream, dropping the heaviest pieces whenever and wherever the energy of the flow diminished, forming bars and islands in the river channel. Finally, losing its forward flowing energy as it meets the sea; the river deposits its load of sediment. Only the very lightest, finest sizes of rock particles, the clays, and the dissolved chemicals from the weathered minerals are swept right out to sea. This milky "plume" of fine sediment is visible from the air or from a boat sailing in the Strait of Georgia off the mouth of the Fraser.

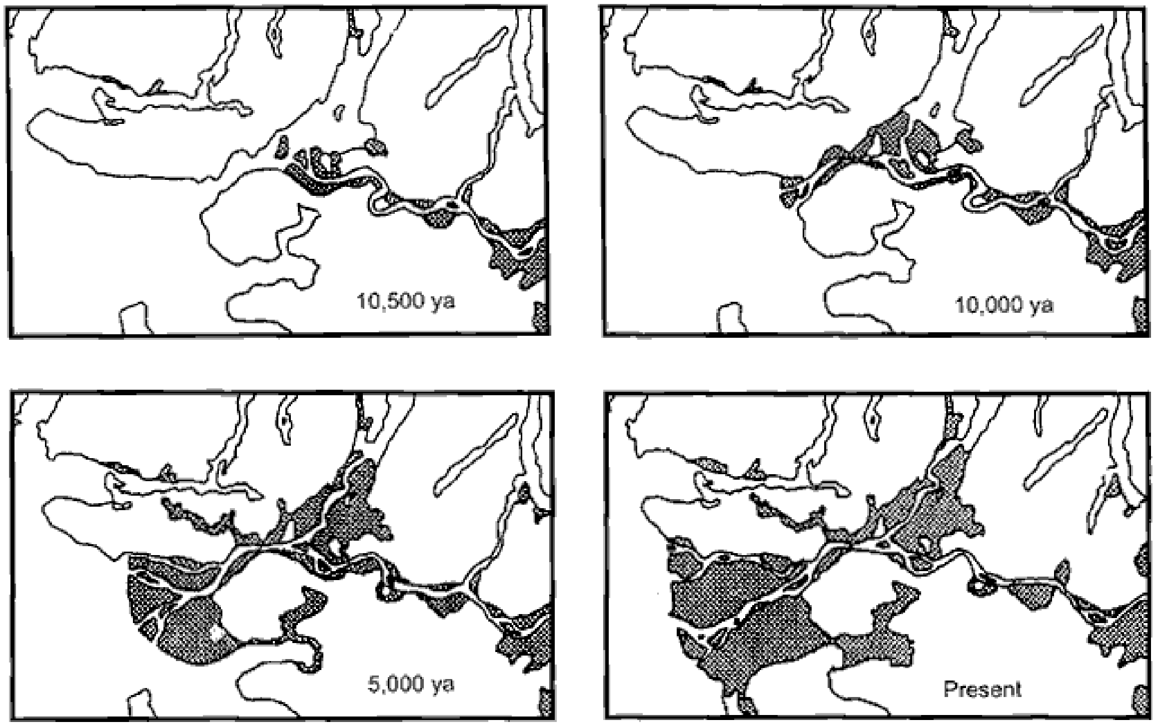

Figure 6.1: Evolution of the Fraser Delta. Source: Clague and Luternauer 1982.

Just as it takes different amounts of energy to pick up and move the different sizes of sediments that make up the river's load, so the loss of energy leads to the differential deposition of sediment. Thus any delta is made up of coarser top-set, medium sized fore-set and fine bottom-set beds (Figure 6.2). Top-set beds are deposited first, nearest to the land. On the Fraser Delta these beds are mainly medium to fine sand and silt size particles. The fore-set beds are fine sands to silt; the bottom-set beds are primarily clays. These top-set and bottom-set beds are usually deposited horizontally; the fore-set beds are always sloping, following the configuration of the ocean basin, and maintaining an approximately 30 degree angle of repose. The size (or texture) and the slope (or attitude) of these deposits allow us to reconstruct where the front of the delta was at various times in the past. From the analysis of sediment cores taken at various places on the delta, geologists have been able to reconstruct the evolution of the delta as it emerged from the sea; at the place we now call New Westminster, about 10,000 years ago.

As the river emerges from its constricted valley at New Westminster it breaks into a number of distributary channels, the North, Middle and South (or Main) Arms. In the past there were probably more channels (see Chapter 4). They shifted across the emerging delta landform as a deposit of sand or silt blocked one channel after another during times of low water flow. Every year the high flow period, after snow melt in the drainage basin of the Fraser, would flood part of the delta surface because the channels were inadequate to carry all the water to the sea. Flood water would deposit sediments in the same sequence of coarse to fine that occurs from the mainland into the sea, but this time the sequence would be from coarsest, deposited closest to the river channel, to finest, at the greatest distance the floodwater flowed from the channel. These variations in texture also produced a minor variation in the height of the land, the riverbanks being higher and coarser in texture. We will see how this microtopography has affected the vegetation.

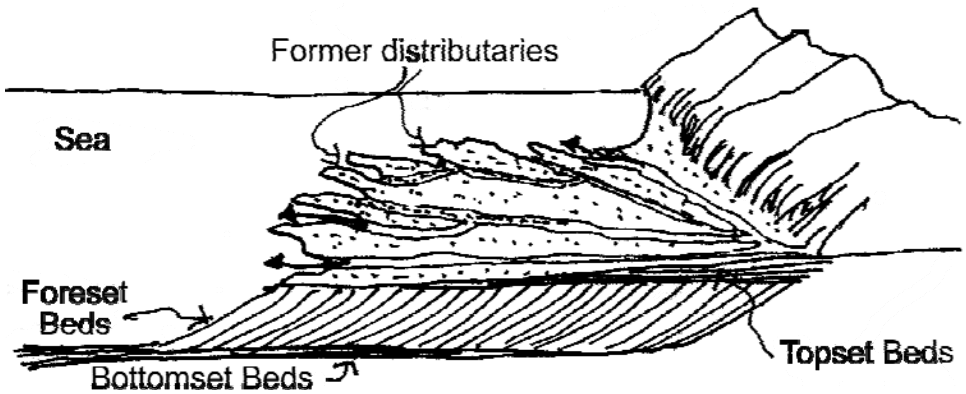

Figure 6.2: Delta deposits. Based on Strahler and Strahler 1978.

6.3 The Vegetation of the Fraser Delta before European Settlement: A Peep into the Past

When the first European settlers arrived in this part of North America they were preceded by the British Army in the form of the Royal Corps of Engineers, under the command of Colonel Moody. Moody established the site of New Westminster and recorded the vegetation of the Fraser Delta in a map, dated 1859. In this, he indicates that the entire surface was covered by marsh. However, in that same year, the first of the Dominion Land Surveyor's were actually walking across the delta, dragging measuring chains and marking the legal boundaries of land for future purchase. These surveyors were given the job of marking the lot boundaries and also recording the presence of water and type of soil and vegetation. Such information was of crucial importance to future settlers who often purchased their land in the Land Survey Office in New Westminster without even seeing it.

It is the Land Surveyors' Notebooks that allow a "peep into the past" of the delta. We can follow these men as they laid out and marked the Township and Ranges and then subdivided each township into 36 sections. Sometimes they made field sketches in their notebooks; often maps were constructed at a later date to show where the vegetation boundaries were. Even without these maps, the point-specific information is sufficiently detailed to allow the construction of a vegetation map for this early period, 1850 - 1880 (Figure 6.3). Certainly there is more detail than is found on Col. Moody's map from the same time period. His "marsh" becomes separated into communities of grass, grass and shrubs, shrubs, trees, bogs, tidal and salt marshes.

A few remnants of the original vegetation still persist in those areas that the Land Surveyors found unsuitable for agricultural settlement. The surveyors often only went to the edge of these areas and thus they were not completely surveyed (note the limits of survey on the map). The central parts of the largest delta bog (Burns Bog) were not surveyed. Here the peat is very deep and it has never been used for agriculture and remains covered by bog vegetation. The smaller areas of the two Lulu Island (Richmond) bogs were traversed by the surveyors so we have a record of what plant communities were there. These bogs have been more significantly altered by agriculture use. Only a few areas of the Lulu Island bogs remain; the Richmond Nature Park properties and the DND Property are such small remnants.

Large areas of the tidal marshes survive seaward of the farmland. They occupy a strip of tidal land at the landward end of the foreshore. In Mud Bay, similar locations are occupied by the salt marshes. The plant species in these two marsh types differ because of the different amount of salinity in the tidal waters. The tidal marshes at the western end of the delta are exposed to vast amounts of fresh water flowing out of the Fraser. This dilutes the salt concentration of the seawater producing brackish water that can be tolerated by the grass-like reeds and rushes. Where there is no such addition of freshwater, the salinity of the seawater prevents the growth of the reeds and rushes, instead the plant community is dominated by low growing, broadleaf, fleshy plants such as perennial saltwort (*Salicornia virginica*).

Occasional narrow strips of natural vegetation remain clinging to the riverbanks including lines of willow and cottonwoods, or occasionally, spruce and cedar. This riparian forest is more likely to survive on small islands, like Poplar Island, in the North Arm, that are too small for agricultural use. On a few isolated reserves, as in the northwest corner of Sea Island, we can find patches of the former extensive grass and grass and shrub communities, as described by the surveyors in the 1850s. We can use these remnants to help us visualise the past vegetation.

If we were to take a cross section across Lulu Island (or walk from west to east across what is now Richmond), with the surveyors in 1850, we would have encountered the following types of vegetation. Growing at the top end of the currently forming fore-set beds, in the area affected by regular tidal action, is a community dominated by sedges and cattails (*Scirpus* spp. and *Typha latifolia*), this is the tidal marsh (Photo 6.1). In detail, we can see today that within the tall, grass-like *Scirpus* community there is a gradation from one species to another following a salinity and exposure gradient. Thus the plant communities dominated by different sedge species are arranged in bands paralleling the coast.

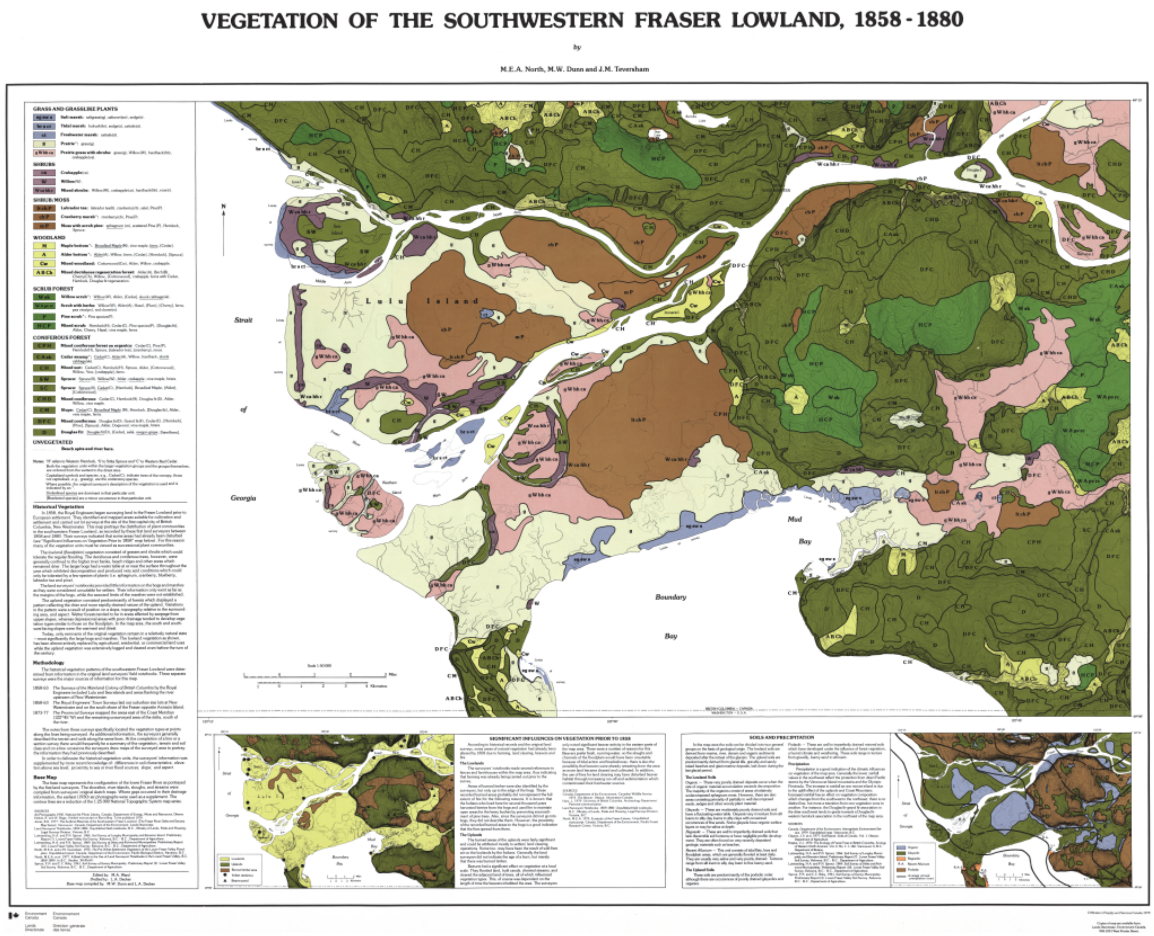

Figure 6.3: Vegetation of the Southwestern Fraser Lowland, 1858-1880. Source: North et al. 1979.[1]

Beyond the tidal influence the plant species that dominate are land plants. Vast areas of grass, described by the Surveyors variously as "good grass", "prairie" or "red-top grass" extended over all the lowest areas. These lands were subject to annual floods and no woody plants could survive the long periods of inundation. Land that was either slightly higher, or was further away from both river and sea floods, supported a community of grass and scattered shrubs. The shrubs usually included hardhack (*Spiraea douglasii*). Willows (*Salix* spp.), Pacific crabapple (*Malus fusca*) and rose (*Rosa nutkana*) were also commonly found scattered through the grass. Dense

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[1] Author's Note: The map shown above is in its entirety. Full size copies may be purchased in the Geographic Information Centre, UBC Department of Geography, and can then be studied in detail. The following colours are used to show different cover types: brown is bog, whitish green is grassland, pink is grassland with scattered shrubs, purple is shrub dominated, green indicates forest, blue is marshland.

patches of willows occupied abandoned channels where the finest silts and clays had settled out in stagnant water.

Photo 6.1: Extensive cattails mashes persist on Sturgeon Banks. Photo: Brian Klinkenberg.

Ridges provided higher and drier sites and were often covered with dense shrubs, occupying narrow strips either along the riverbanks, or along the front of the delta on what is presumably an old beach ridge. The higher these ridges and the older they are the more likely that trees have invaded the shrub communities. Thus the riverbanks at the eastern end of the delta supported cottonwoods (*Populus trichocarpa*), and conifers (*Pseudotsuga menziesii*) were recorded on the higher beach ridges of Westham Island, and along the banks of the Chilukthan and Crescent Sloughs. Much of Sea Island was covered with an unusual combination of Sitka spruce (*Picea sitkensis*) and willow. A modern day remnant of this community exists along Widgeon Slough, on the west side of Pitt River.

The delta surface was mainly treeless before agricultural settlement. Apart from on the higher and drier sites, trees were found only in the bogs. The only tree species here that can survive the high water table and acid conditions of the bog soil is the Shore pine (*Pinus contorta*). In the bog it grows very slowly and in contorted shapes.

The Surveyors did not go into the middle of the Burns Bog, as they realized that it was not a suitable area for settlement. However they traversed the Lulu Island bogs and recorded the presence of pine and cranberry and moss. They also reported the evidence of fire. This leads us to suspect that the vegetation of the bogs may not be "natural" and the bogs might already have been altered for human use by the 1850s.

Our knowledge of the long history of fire in the bogs has come from sediment analysis (Figure 6.4).

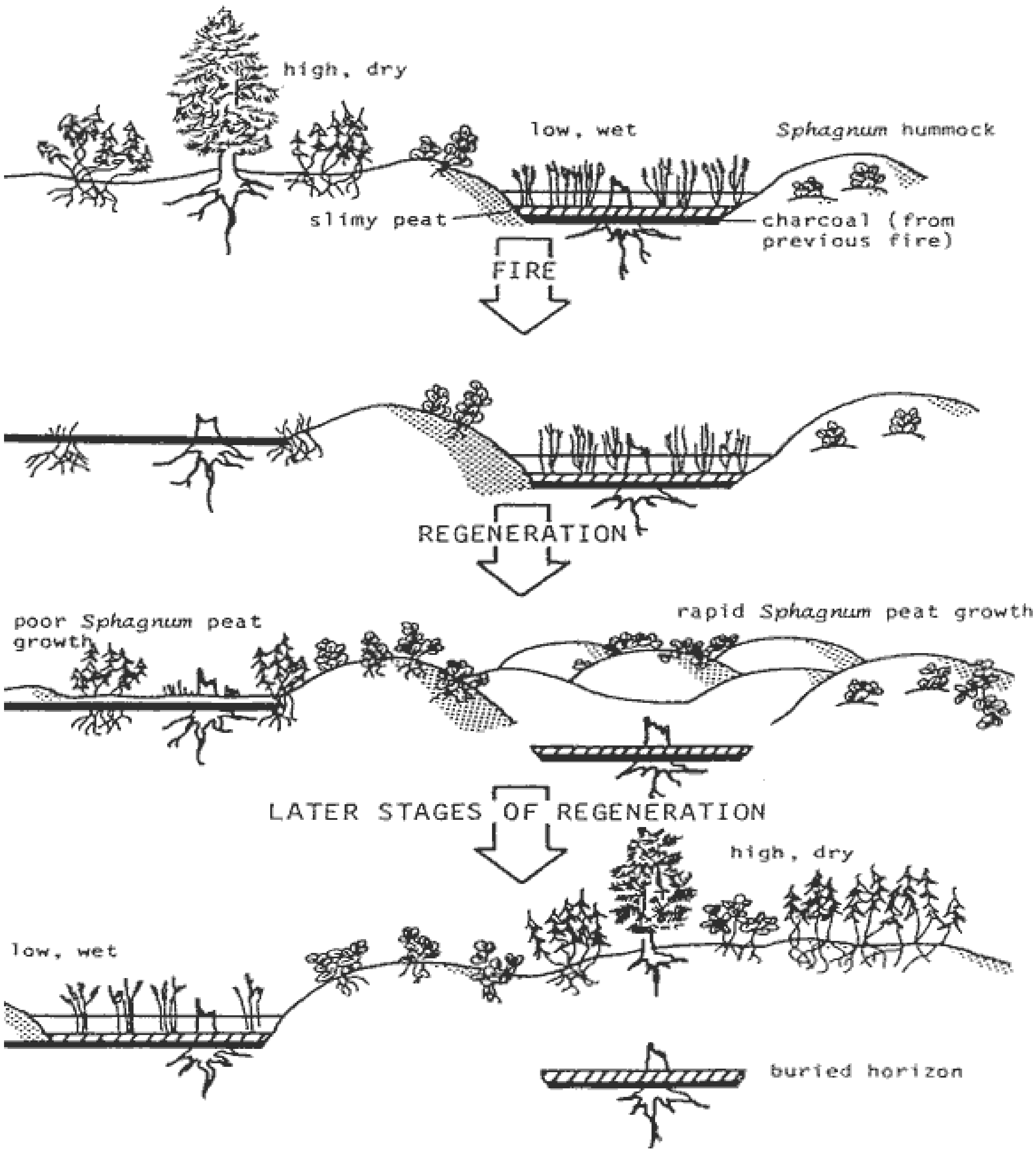

Figure 6.4: Fire induced hummock-hollow recycling. Source: Hebda 1977.

The sedimentary record allows us to look further back into the past, beyond the time of written records. Peat cores extracted from the entire thickness of Burns Bog have been used by Richard Hebda (Hebda 1977) to establish both the age of the bog and its complex history. At least 4000 years ago the Burns Bog started to form in shallow ponds on the top of top-set beds of fine sand and silt. Pollen grains and plant fragments in the inorganic sediments directly below the peat showed that the plant assemblages were identical to the tidal marshes of today. But as time advanced, these sediments were covered by organic sediments made up of dead plants. At first there were aquatic plants, such as yellow pond-lilies (*Nuphar lutea*), indicating the open water habitat. As the aquatic plants died they decomposed only slowly and partially in the water, creating increasingly acid water. The presence of these acid conditions is signaled by the appearance of *Sphagnum* moss (*Sphagnum* spp.), which rapidly comes to dominate the sediments. Shrub species, such as Labrador tea (*Rhododendron groenlandicum*), bog-laurel (*Kalmia microphylla*) and blueberry (*Vaccinium* spp.) appear, and eventually trees, specifically pines. Studies of the bogs today show that this successional change is still going on. As the organic accumulation – the peat – builds continually higher, conditions become drier and this change allows pines and eventually other tree species to become established.

The occurrence of fire in the bogs has had the effect of halting changes in the bog by killing the trees and the shrubs. The shrubs re-established rapidly but the trees take longer to grow back. The frequency of fire is established from the numerous charcoal layers in the sediment cores and the presence of charred pine stumps at various depths. First Nations' use of the bogs involved the setting of fires to maintain the shrub and moss communities for human and animal use (Cairns 1973). Both cranberries (*Oxycoccus* spp.) and blueberries (*Vaccinium* spp.) were harvested and traded. Labrador tea was collected and used for medicinal purposes and as a tea. *Sphagnum* had many uses because of its sponge-like properties. These useful plants were gathered from the bogs. The open bog communities also supported resident browsing animals such as deer, moose and bear as well as vast flocks of migratory birds that provided sources of meat for the hunters.

First Nations people were already living in the uplands around the Strait of Georgia before the delta emerged from the sea. They thus were able to observe succession in the bogs, from open moss to shrubs to trees. They used fire as their management tool to prevent the closing over of trees that would have resulted in shading out of the valuable shrub and *Sphagnum* layers. The bog fires seem to have spread beyond the confines of the bogs and are the probable cause of grassland communities in areas where grass and shrubs or even trees might have been expected. Grassland patches are also found in the areas around the permanent settlements of the First Nations. These sites would obviously have been selected above the general floodwaters and should thus have shrubs, if not trees, growing on them.

The result of human alteration of the vegetation is far more obvious today. Natural plant communities have been deliberately replaced with plants of greater economic or aesthetic value. Even in areas that have not had a complete replacement of the early vegetation, the changes brought about by dyking and draining of the farmland has led to changes in the adjacent remnant vegetation. The purpose of the dyking is to prevent floods. The drains that run under and around the fields facilitate the drying out of the soils that tend to be at or near saturation in the winter and spring. Both these changes lead to the drying of soils and hence to faster successional changes. Shrubs that were not recorded as being present by the Surveyors in 1850 now invade the remnant grasslands in the northwest of Sea Island. Today, birches have invaded the bogs, yet the Surveyors did not record this tree species. Birch is and was a common component of the surrounding upland forests and its prolific wind-born seed would have been readily available. Its absence in the 1850s indicates that no suitable habitat existed on the delta for its successful growth. However, hybridization in the 20th century with the alien European birch (*Betula pendula*), a water-tolerant species, and the availability of suitable habitat, has allowed for the establishment of birch throughout the delta lowlands.

Management of the bogs has been continuous throughout the past century. Mining of peat for various industrial purposes has occurred at different locations. Conversion of the thinner bog soils started with the first farmers who simply extended their fields into the bogs. Later drainage ditches were extended to dry out the edges. Wholesale conversion to commercial cranberry fields has replaced much of the Lesser Lulu Island Bog (present day city-owned Northeastern Bog Forest). Commercial blueberry farms have made steady in-roads into all the bog areas. The spread of highbush (cultivated) blueberry[2] varieties into the remnant bogs, particularly the area of the Richmond Nature Park, has significantly altered the natural habitat. The most extreme form of change to the bogs has been the covering of its surface with landfill. Recovery of the natural bogs might be possible from all the other changes, but this change is too extreme.

The natural vegetation of the delta lands has been significantly altered. There are few small remnant areas left to show us what we have lost. Even these few, it seems, have not escaped the impact of human settlement. However, they do provide some glimpse of what this land was like when those early surveyors traversed Lulu Island.

[2] Highbush blueberry (*Vaccinium corymbosum*) is the cultivated blueberry in BC. Because blueberry fields are prevalent on Lulu Island, dispersal of this species by birds into the bog is ongoing.

CHAPTER 7: A SITE HISTORY OF THE LULU ISLAND BOG

By Bret Jagger

7.1 Introduction

At 122 square kilometres, Lulu Island is the largest of the Fraser Delta islands. Its flat to gently rolling terrain averages less than five metres above sea level (Talisman 1983). In the first thousand years of its ten thousand year history (see Chapter 4), a vast bog ecosystem evolved in the Fraser Delta. The Greater Lulu Island Bog and Lesser Lulu Island Bog occupied up to one-third of what is now Lulu Island in the eastern and central regions, and they remained relatively unchanged until almost the present day. During much of this time, there is evidence that First Nations on the island actively managed the bogs with fire to maintain shrub and moss layers that provided resources (Cairns 1973). The first European settlers arrived on Lulu Island in the 1860s, and over the next century, with the exception of a few remnants, the bog ecosystem was all but eliminated in order to accommodate rural and urban development. The greatest loss occurred in the late 1990s. The Northeast Bog Forest is a remnant of the Lesser Lulu Island Bog, while the Richmond Nature Park (RNP east and west) and the neighbouring Department of National Defence (DND) property together with the DFO lands form the largest remnant of the former expanse of the Greater Lulu Island Bog. The first three comprise our study area (Figure 1.4). Technically, this remnant also includes the adjacent Department of Fisheries and Oceans property (DFO or Coast Guard property) west of the DND; however this property is presently slated for development, and is not part of this study.

7.2 Past Ownership

Records in the Richmond Archives show that William and Joseph Wilson of Victoria purchased four sections of land (now the RNP east and west and the DND and DFO properties) as soon as they were surveyed in the early 1860s (Kidd 1927). The sections formed the south end of a large tract that extended to the North Arm of the Fraser River (Kidd 1927). The Wilsons tried unsuccessfully to encourage settlement on their North Arm property through land improvements and funding for the construction of a bridge to the mainland (Kidd 1927). Their lack of success may have led to the decision to sell the lands that would eventually become the Lulu Island Bog study area.

In March 1893, the Wilsons sold two of the four sections (RNP east and west) to the federal government through the Sun Life Assurance Company of Canada. Ten years later (September 1903) they sold the remaining two sections (the DND and DFO properties), also to the federal government, and the lands of the study area have been government-owned ever since.

7.3 Effects of Human Settlement on the Bog Ecosystem

7.3.1 Patterns of Settlement

The deltaic soils of Lulu Island and the Fraser River delta have been described as "incredibly fertile" (Cherrington 1992), making the agricultural potential of Lulu Island one of the primary attractions to the first settlers. The topography of the island was responsible for the patterns of human settlement and expansion on it (Ross 1979). Because of sloughs and bogs, it was easier to move around Lulu Island on water than across it on ground (Ross 1979). Floods periodically inundated the shoreline, and seasonal floods were common even to the middle of the island. Consequently, settlement first occurred mainly around the perimeter of Lulu Island, and communities such as Steveston, Eburne, Bridgeport, South Arm and East Richmond developed in relative mutual isolation (Ross 1979).

Figure 7.1: 1948 air photo of the study area properties (lower half of photo) showing very little development. Source: Province of British Columbia 1948.

Construction of bridges, improvements in transportation and direct government assistance to settlers are some of the factors that have influenced the rate of settlement on Lulu Island. From 1901 to 1904, bridges for horse and carriage traffic were constructed across the North Arm of the Fraser River (Ross 1979). In 1902 the Canadian Pacific Railway built a bridge and a rail line that extended south to service Steveston's fishing industry (Clelland 1972). Before shutting down in 1956 the line had become increasingly important to the island's developing agricultural community (Ross 1979). By 1912 most major roads on the island were re-graded and paved to accommodate transportation by automobile (Ross 1979). One of the most dramatic influxes of settlement on Lulu Island occurred after World War II, with the return of veterans settling in subdivisions created by the federal government under the Veterans Land Act (Ross 1979). Figure 7.1 shows the lack of development in the study area in 1948.

7.3.2 Vegetation of Lulu Island

Unlike the eastern and central regions of Lulu Island, the western end of the island is not characterized by peat bog. Early records show that native vegetation on the western side included cattails and bulrushes growing in the mud flats of Sturgeon Banks (Kidd 1927, Ross 1979). Inland, just beyond Sturgeon Banks, there was a row of wild crab apple trees, with a few scattered spruce trees, that stretched from the south side of the island to the north, and across Sea Island. Open areas of grassland that included bunch grass, red top grass, creeping bent grass, and fields of hardhack lay to the east (Kidd 1927, Ross 1979). Thomas Kidd wrote that the south side of the island was treeless from Sturgeon Banks to a point halfway between No. 2 and No. 3 Roads a quarter mile north of the river (Kidd 1927). From this point, a forest of mixed growth extended east to Bath slough, then north to where the peat bog terminated near the river north of No. 6 Road (Kidd 1927). The mixed forest was composed of spruce, cedar, hemlock, alder, yew, cottonwood, crab apple and elderberry (Kidd 1927). Terra Nova, in the northwest corner of the island, was heavily wooded, as was the Rice Mill area east of No. 5 Road. Willows and cottonwoods grew along the banks of the Fraser River, as well as fir, spruce, yew, and wild roses (Kidd 1927, Ross 1979).

During early settlement on Lulu Island, peat bogs of the central and eastern regions were considered to be detrimental to the interests of farming (Cherrington 1992). By the late 1870s however, bog was the only type of unclaimed land remaining on the island. In addition to drainage activity, in the early 1900s two factors combined to further propel the bog's decline. First, peat moss itself became commercially important in applications such as insulation, packaging, chicken litter, deodorant and stock feed (Ross 1979). In the late 1940s, during the height of peat mining activity on the island, Lulu Island produced up to 50% of Canada's peat products (Ross 1979). The empty fields that remained after the peat was harvested were suitable for commercial cranberry production (and later for blueberry and raspberry farming). In the recent past, Lulu Island produced up to 90% of Canada's total supply of cranberries (Ross 1979). Because of these factors, most of the island's remaining bog areas had been strip-mined by 1950 (Ross 1979). Notably, however, there is no evidence that the three properties that comprise the Lulu Island Bog today were mined.

7.3.3 Wildlife

As in the case of the bird-introduced highbush blueberry species that is growing in the study area, wildlife is an agent for the dispersal and colonization of vegetation. But changes in the vegetation community in turn bring about concomitant adjustments within the wildlife community. For example, an herbivorous insect, new to an area, may take up residence as it follows colonization by its plant-host species. The birch leaf miner (*Fenusa pusilla* Lepeletier), responsible for much of the discolouration of the birch forest in the study area (Humble 2002), is an example of this relationship. It arrived in the bog following invasion by birch. The birch leaf miner is a minute sawfly (a wasp of the family *Tenthredinidae*) that originated in the northeastern US, where it is considered a serious pest. It pupates on the ground, has two or three generations a year, and its larvae make blotch mines in birch leaves. Further effects of development on wildlife are discussed in additional chapters.

7.4 Transportation Corridors

The construction of transportation corridors and their parallel ditches has had an enormous impact on the hydrological regime of the bog study area, through changes to surface drainage and disturbances of the underlying geology. Ditches drain water from the bog, eventually into the sea at low tide. Pumps and floodgates are used to control water flow in the ditches. At high tide, gates prevent salt water from entering the ditches (Ross 1979). Highway 99 was one of the most significant construction projects to affect the Lulu Island Bog ecology (Figure 7.2). During construction, underlying peat, averaging two metres in depth, was excavated to the silt layer and replaced with non-plastic, inorganic sand from the Fraser River (Klohn Leonoff 1984). Construction drained and isolated the two halves of the RNP, and excess fill (nutrient-rich silt) was discarded in the bog (side cast), enriching the bog soils. These factors accelerated the change in the ecology of the study area from bog to bog forest.

The following is a chronology of transportation corridors impinging on the bog study area (for convenience current property names are used.)

- By 1893 (Ross 1979) No. 19 Road formed the south boundary of all three properties of the study area, No. 5 Road divided the RNP to east and west, and No. 4 Road formed the west boundary of the DND.

- By 1906 canals had been constructed across Lulu Island along No. 1, No. 2, and No. 3 Roads (Ross 1979).
- In 1925 No. 19 Road was reclassified as a government highway and renamed Westminster Highway.
- In 1932 the Canadian National Railway built a spur line along what would later become the west boundary of the RNP property. It was one of two spur lines built to service the railway's nineteen-mile grade that ran from 12th Street in New Westminster through Lulu Island along the North Arm (Ross 1979).
- In 1958 Highway 99 was constructed (Ross 1979) roughly parallel to No. 5 Road, along the west boundary of the RNP east (at that time the RNP east and west properties belonged to the Ministry of Transportation and Highways). A seventeen-year pause in road building activity around the study area followed the completion of Highway 99.
- In 1962 No. 5 Road was reclassified as an arterial highway.
- In 1975 0.8 hectares (two acres) were taken from the nature preserve on either side of Highway 99 for the construction of a road connecting Highway 99 to Westminster Highway.
- In 1979, a 12 metre strip of land was removed from the south side of the DND to widen Westminster Highway.
- In 1984 the construction of Jacombs Road on the east boundary of the RNP east marked the beginning of five years of road building around the study area. Until this time the Jacombs Road right-of-way had served as a walking trail (Talisman 1983).
- From 1987 to 1989 the East-West Connector was built. It formed the north boundary of the RNP east, from which a narrow strip of land was taken as part of the highway's right-of-way. A ramp connecting the East-West Connector to Highway 99 also cut off a small portion from the northeast corner of the RNP west. In total, the highway project removed an estimated 5.3 hectares (13 acres) of land from the RNP.
- The last roads to impinge on the study area were Alderbridge Way and the Shell Road extensions, both finished shortly after the East-West Connector was completed (Klohn Leonoff 1984). Alderbridge Way forms the north boundary of the DND and is contiguous with the East-West Connector. The Shell Road extension runs from Alderbridge Way south to Westminster Highway. Together with the parallel CNR tracks, the Shell Road extension divides the DND from the RNP.

Figure 7.2: The study area in 1976, after the establishment of the RNP, after construction of Hwy 99, and prior to building of the East-West Connector. Source: Province of British Columbia 1976.

7.5 History of the Richmond Nature Park[1]

In January 1962, the City's Parks and Recreation Commission first began correspondence with J.R. Baldwin, the Deputy Minister of Transport, for acquisition of the 98.2 hectare tract of land composed of the adjoining sections 1 and 6. Six years later, Will Paulik submitted a proposal to the Parks and Recreation Commission Planning Committee for the Richmond Rod and Gun Club. In the proposal, members of the club asked that the two sections on either side of Highway 99 be set aside as a nature preserve (Richmond Rod and Gun Club 1968). In support of this goal they emphasized avoiding drainage of the property to protect the vegetation of the bog. They recommended designating the western section as a nature park, where the public could participate in activities and displays designed for their enjoyment and education of nature (Photo 7.1). The nature park would be "a sanctuary of all living creatures and plants that make the [*Sphagnum*] bog [their] habitat". An outdoor activities park was envisioned for the eastern section, including an outdoor education facility and an indoor rifle range. Of ultimate concern for the eastern property was that it be left as undisturbed as possible so that it could provide for long-term scientific research. The proposal for a rifle range was dropped after 1975 due to public opposition.

At the time of the Rod and Gun Club's submission, the greatest sources of drainage in the park were the large ditches along Highway 99 and the No. 5 Road interchange.

[1] Much of the information on the history of the Richmond Nature Park contained in this section of Chapter 7 is drawn from a report prepared by Koralee Nickarz for the Richmond Nature Park Society in 2003 (see references).

These ditches had been designed to exceed the requirements for highway runoff (Talisman 1983). Also, there were two shallow ditches on either side of the CNR tracks, and one on the north side of Westminster Highway. The club reported that water flowed from south to north and that trees were most dense along the drainage ditches. Bog water levels were stated as being lowest along these ditches and highest in the centre of the land mass, and that the land mass had large, open, treeless areas where "water tolerant bog plants thrive" (Richmond Rod and Gun Club 1968). The club also included a recommendation for a canal in the park, with the objective of concentrating as great a natural diversity as possible (Steves 2002). The club envisioned a meandering canal with two enlargements for ponds, and floodgates to protect water levels. A catchment was suggested, to collect runoff from the highway overpass to replenish the canals.

Photo 7.1: Wildlife Garden in the Richmond Nature Park. Photo: Brian Klinkenberg.

By 1969 the City of Richmond had acquired the property through a trade in which the federal government received an equal amount of land on the south shore of the island west of No. 8 Road, to be used for waste disposal. The nature park was created in the following year, and placed under the administration of the Richmond Department of Leisure Services and the Richmond Nature Park Committee. In November 1970 the committee held its first meeting. One of their first acts was to elect an executive to submit applications for federally funded Local Initiatives Program grants on behalf of the citizen groups involved in development of the nature park.

In 1972, the name "Richmond Nature Park" received official recognition, and the executive secured federal funds to study the flora and fauna of the park, conduct historical research pertaining to Richmond, and to develop trails within the park. Also in 1972, a local construction company donated a temporary structure to house the park's first nature displays. The other building on site at the time was the Kinsmen Pavilion, built by the Kinsmen Club of Richmond in 1971.

The canal proposed by the Rod and Gun Club was realized in 1972 with the creation of a pond in the west property (Photo 7.2). It was stocked with domestic ducks, but these were later removed to encourage native waterfowl to use the pond. Shortly after it was created, however, it became evident that the pond, together with the ditch on the east border of the property, posed a threat to the bog ecology because it was depleting water levels in the park. Later that year, the committee's research coordinator sent a report to the Parks and Recreation Commission warning that if the depletion went uncorrected the bog would disappear in five to ten years (Wade 1972). The coordinator further objected to the pond in that it was not truly part of the bog ecosystem, and that duck waste associated with it would unnaturally enrich the otherwise nutrient-starved ecosystem with nitrogen. Despite these warnings, another pond was dug in the following year, in the east property.

In 1974, a fire broke out along the railroad, clearing a small area of mixed pine and birch forest. Of greater concern to the research coordinator was the chronic problem of blueberry pickers in the park. Early in the park's history it became evident that something had to be done to discourage the destructive practice of blueberry harvesting. The delicate ecology of the bog, already under stress from depleting water levels due to drainage, would not be able to survive these activities. The situation was greatly improved in 1974 when by-law 1988 was amended to prohibit the removal of berries, mushrooms, trees, shrubs, or any other native life from the park.

With the creation of the pond in the RNP east in 1973, a trail was cleared and an open-sided shelter with a concrete floor was constructed. The Richmond Nature Park Committee later realized that such work conflicted with the need to leave the east property as undisturbed as possible. This requirement was a condition in the original designation of the property as "study area" by the Richmond Rod and Gun Club. Therefore, in January 1975, the committee wrote a letter to the Parks and Recreation Commission recommending that no further development be allowed on the east property, so that it might fulfill its intended role as a study area. Subsequently all development was cancelled in the east property (except for the replacement of a rotted bridge in 2000). Later in 1975, however, the committee experienced an event of greater significance, over which it had no control. A road was constructed to connect Highway 99 to Westminster Highway, resulting in the removal of approximately 0.8 hectares (two acres) of the bog on either side of the highway. The committee's only recourse was to send a letter to the Parks and Recreation Commission demanding a halt to any further reductions to the area.

Photo 7.2: The artificially created pond in the Richmond Nature Park (RNP west).
Photo: Brian Klinkenberg.

In 1975, the Kinsmen Club of Richmond offered to donate $15,000 in materials and volunteer labour to build a full-size building in the RNP west property that would serve as a nature interpretation centre. The Parks and Recreation Commission recommended the plan for authorization, depending on a contribution of $63,000 from the Recreation Department and provincial funds of $22,000. The building was constructed in 1976 and on November 14 of that year the doors of the Nature House first opened to the public.

In 1977, the Richmond Nature Park Committee was renamed "Richmond Nature Park Society". They prepared a five-year project and development plan, which gained the City Council's approval upon submission in 1982. Later that year, the first of several of the projects was completed with the building of a boardwalk surrounding the pond, with a viewpoint and observation tower overlooking it. In 1984, the Time Trail was constructed and a trail guide for its use was published. With construction of the new trail, a concurrent Bog Ecology Protection Zone was also established, although this has not been worked with since. A Habitat Conservation Grant was also obtained, which would provide funds for a three-year study. The first of the RNP water table studies was initiated during 1984. However, in the midst of these positive developments, a project involving earthmoving equipment had just been finished across from the RNP (east), and more gear would shortly be deployed along the north and west boundaries of the two properties.

The Richmond Auto Mall and Jacombs Road were constructed in 1984. This was the last phase of the Crestwood Industrial Estates Expansion, a development of the 121-hectare tract of land between Knight Street and Jacombs Road, directly opposite the park. From 1965 to 1970, Will Paulik and Harold Steves had been monitoring the area for effects on the vegetation as a result of the construction of Highway 99 (Steves 2002). They felt the Crestwood Expansion would put an excessive strain on the park's water levels. They were also concerned about the loss of natural habitat bordering the east property. They formed a group called the Richmond Agricultural Land Use Association and opposed construction of the auto mall on the basis of the land's greater value under agricultural zoning, and the need for natural habitat for wildlife in the park. As a concession for the approval of the auto mall, the city dedicated an area of bog forest on the northeast side of the island as a nature preserve (now called the Northeast Bog Forest). Additionally, drainage of the auto mall was designed to be isolated from that of the park (Steves 2002). During construction of the auto mall the Parks and Recreation Department prepared the Richmond Nature Park Master Plan, to put safeguards in place for the long-term protection of the RNSA. In accordance with this plan, in 1986 the city built a berm along Jacombs Road, with the addition of fencing and trees.

At the same time that the city was considering plans for the auto mall, the Ministry of Transportation and Highways (MoTH) was considering a project of its own. In 1983, they commissioned Talisman Consultants to assess the impact of the proposed East-West Connector along Gilley Road, on the north side of the park. Among direct impacts the consultants projected a loss of 5.3 hectares (13 acres) from the RNP. Among indirect impacts they predicted a shift in the distribution of the bog plant species that were closest to the highway. They also estimated that the new sources of drainage would worsen the water deficit in the park, drying out the organic deposits and eventually degrading the bog vegetation. They also warned of an opposite effect on drainage; as is the case with any highway and road construction, compacting of the soil can result in surface ponding in adjacent land.

Construction of the East-West Connector began in 1987. The project took two years to complete. In conjunction with the highway, Alderbridge Way was constructed on the north side of the DND, and Shell Road was extended from Alderbridge Way to Westminster Highway. The completion of Shell Road and Alderbridge Way brought about the final subdivision of the study area into three separate parts. From this point on, species that required relatively large home ranges or dispersal that is not blocked by roads and vehicular traffic were faced with likely elimination from communities in the study area.

During construction of the East-West Connector, the CNR improved drainage of its spur line passing through the park by installing a north-flowing box culvert on the west side of the tracks (Talisman 1983). Records indicate that the park's pond dried out in the summer after construction began. In response, in 1988, park staff blocked the perimeter with temporary dams to retain ground water. In May 1989, MoTH followed up on one of the environmental consultant's recommendations (Talisman 1983) and built five water control weirs at strategic sites around the park. The weirs were designed to retain water in the park while ensuring that no part of the highway could be flooded. They were built with sandbags surrounding culverts equipped with manually controlled gates. With gates positioned near the tops of the weirs, water could be retained longer in the park. However, it was understood that the structures were a temporary solution, as they could only provide a minimal extension to soil saturation periods in the park. Indeed early observations confirmed this, showing that water tended to equalize on either side of the weirs before mid-summer or sooner. At present, no attempt is made to maintain water levels in the bog during mid-summer drought. One of the MoTH's last follow-up measures was to screen the highway from the north side of the park by planting conifers.

Photo 7.3: Launi Lucas and Karen Needham collecting aquatic insects in the bog.
Photo: Brian Klinkenberg.

In 1995, Natural Resources Canada initiated the Forest Insect and Disease Survey to assess the presence of introduced insects in the park. Also of potential ecological significance, the nature park pond continues to receive top-up water in mid-summer, and since tap water is used, it follows that associated nutrients in the tap water are making their way into the bog.

In 2002, the Ecology Committee of the Richmond Nature Park Society initiated this ecological and biophysical inventory of the study area, to document and assess the biological significance and biodiversity values of the Lulu Island Bog, and to document the occurrence of rare, threatened and endangered species (Photo 7.3). This inventory is the first major inventory of the study area that has been undertaken in the bog, and includes documentation of both plant and animal species, vegetation types, site disturbance, potential for restoration, and much more.

7.6 History of the DND Property

The DND property is approximately 61.9 hectares. As part of the Provincial Agricultural Land Reserve, it is municipally zoned as AG1 for agricultural use. Currently storm sewers drain the property along its west, north, and east boundaries, and a ditch drains along the south boundary. Its wildlife community overlaps and complements that of Richmond Nature Park.

In 1903, the Department of the Interior administered all four of the quarter sections sold to the government by the Wilsons. In 1936 the three sections now occupied by the DND, RNP west and RNP east were transferred to the Department of Transport. In 1944, the DND took over the westernmost of these sections (Section 2). Between 1944 and 1949, the military cleared woody vegetation from a small portion of their property (Steves 2002) and placed transmitter arrays in the cleared areas. The arrays comprised 45 to 60 antennae on wooden poles reinforced with steel towers. A transmitter station was built in the centre of the property, on ground likely first cleared of peat for building the foundation.

The transmitter station comprised six concrete structures, including three buildings, a staff headquarters and barracks, and a diesel operated electrical generator or auxiliary power unit. A main north/south road was established in this central area, as well as an east/west branch road. Two parallel ditches were constructed, extending west to the municipal storm sewer at No. 4 Road. Ditches were also extended south to the municipal ditch on the north side of Westminster Highway. Aerial photographs indicate that a water supply line may have been constructed from No. 4 Road to the building compound prior to 1954. In fieldwork conducted in 2000, a bubbling water pipe was found near one of the building sites. It was eventually traced to a leaking shut-off valve near Westminster Highway.

More tree and shrub cover was cleared from the property between 1954 and 1963, and aerial photographs from 1970 show that the property had much less woody vegetation than the adjacent RNP (Figure 7.2). Encroaching vegetation in the photographs also shows that some roads had been abandoned between 1963 and 1971, while a new branch road was extended east from the main central road, closely paralleling Westminster Highway. In addition, three side roads entering the DND from the Shell Road right-of-way were cleared during this time, and a clearing was also made in the northwest corner of the property. Aerial photographs show that the Colonel Sherman Armoury was constructed at the Northwest corner of the site between 1994 and 1999.

The transmitter site was abandoned in 1971, one year after the establishment of Richmond Nature Park. It was subsequently decommissioned in 1972, and most of the aboveground portions of the structures were removed in that year. A fire may have destroyed some of the building remnants at this time. Concrete building foundations were removed sometime between 1997 and 1999. Small ponds now mark the place where these buildings once stood. Ash and asbestos-containing debris piles were removed in 1999.

Environmental investigations began in 1995 to assess remediation and risk management options for the DND transmitter site. They ended with a detailed qualitative risk assessment, prepared by Jacques Whitford Environment Limited in 2001. Signs of testing are evident throughout the property. They include boreholes drilled in 1996 and 1999, and 35 test pits excavated in November 1995. Hummocks throughout the DND are also the result of these investigative activities. Early studies found intermittent contamination by hydrocarbons, metals such as lead, copper and zinc, polychlorinated biphenyls (PCBs), dibenzodioxins (dioxins) and dibenzofurans (furans) in groundwater and soils at levels above agricultural regulatory standards.

Sources of contaminants are thought to be historically buried debris, minor spillages of diesel fuel near aboveground and underground diesel fuel storage tanks, discards of petroleum hydrocarbons associated with a septic system, and imported fills, in the case of some metals. Other potential sources are electrical transformers that used PCB-containing oils, and the improper disposal of lead paints. A gray-coloured ash found during the study period may have been the primary source of dioxin and furan contamination. A minor source of contamination appears to have been creosote-treated foundation pilings.

The risk assessment included both a human and ecological health risk assessment component, to determine the risk of contamination associated with the transmitter site (Goulden 2002). The study confirmed earlier findings of discrete contamination of groundwater, surface water, soils and sediment. Contamination appeared to be restricted to a small area around the excavated building sites, and the risk is considered to be minimal (Goulden 2002). Earlier studies had not included an elevation survey, and had assumed that water flowed along a southwest gradient on the site. The risk assessment corrected this assumption, finding that groundwater occupies two different strata below the site, and flow patterns within the strata are independent of each other. Groundwater of the deeper sand strata flows toward the Fraser River in the northwest. In the shallower peat strata there are two patterns of groundwater flow: gravity drainage, caused by a layer of clayey silt under the peat layer, and surface runoff.

Currently the DND uses the site for ground troop training exercises, based at its Colonel Sherman Armoury in the northwest corner of the property. No live fire exercises are conducted on the property. Signs have been erected around the perimeter of the DND to discourage trespassers, but people are frequently observed using the area for recreational activities such as berry picking.

CHAPTER 8: DISTURBANCE IN THE BOG

By Danielle Cobbaert and Neil Davis

8.1 Introduction

Only four main fragments of the once extensive Greater Lulu Island Bog now remain as natural areas in Richmond- the two Richmond Nature Park properties (RNP west - the Richmond Nature Park proper, and the RNP east - Richmond Nature Study Area), the Department of National Defence Property (DND), and the Department of Fisheries and Oceans property (DFO property, or now referred to as the Garden City Lands). The DFO property was not included in this inventory because it is slated for development.

Photo 8.1: The DND property is the least disturbed portion of the Lulu Island Bog, with lower dominance of invasive species and stunted tree growth. Photo: Brian Klinkenberg.

In urban settings, natural areas are frequently quite disturbed, and this disturbance is reflected in the site conditions, vegetation composition and animal species that are able to persist in disturbed conditions. The Lulu Island Bog is no exception. Portions of the two RNP properties are very disturbed, with die-off of the peat mat, invading tree and shrub growth, and a shift from open bog towards bog forest in many areas. This is particularly true in the RNP east; where considerable vegetation change has occurred in conjunction with numerous disturbances over the past 60 years (see Chapter 7 for a history of disturbance events). The DND property is the least disturbed fragment (Photo 8.1). This property has a relatively high and stable water table, less invasions of tree and shrub growth, and a plant community characteristic of a natural bog ecosystem. Past use of the site by the military, including establishment of radio towers and building construction for barracks and other uses, has resulted in areas of bare peat and some contamination (see Chapter 7). Although the towers have been removed, testing for contaminants is ongoing (Photo 8.2). However, all three properties have been impacted by human activities in the surrounding landscape. These include highway construction, associated disposal of sidecast and river sediment in the bog, fire suppression, vegetation clearing, agricultural and urban development and associated drainage changes, and the construction of ponds and trails. While water control structures were put in place in the 1980's in order to maintain summer water levels, they are not used. The results of these impacts on the bog ecosystem include fragmentation, colonization by invasive and introduced plant species, accelerated woody growth, changes in substrate properties, and significant die-off of the *Sphagnum* mosses in many areas. These human-related stressors have fundamentally altered the natural hydrologic regime of the bog with indirect impacts to the plant communities and wildlife habitat.

Photo 8.2: Testing for contaminants in the DND property is ongoing. Photo: Brian Klinkenberg.

8.2 Drainage

The amount and the distribution of water are central to the formation of bogs, their functioning and their ecology. Consequently, water is at the heart of many of the impacts that degrade a bog (Charman 2002). The Lulu Island Bog is surrounded by drainage ditches, with particularly large ditches paralleling the railway tracks, and parallel to Highway 99. The significance of hydrology in the maintenance of the Lulu

Island Bog ecosystem was recognized by the Rod and Gun Club in their initial proposal for the RNP (see Chapter 7). They stated in their proposal that drainage of the property must be avoided to protect the bog. However, there was no action on the heels of this foresight, and while some temporary measures were introduced to slow drainage in later years (e.g., sandbagging and drain closures), a number of projects and planning decisions have since led to the dehydration of the remnant bog. This includes the construction of the East-West Connector.

The most prevalent cause of peatland drying in the Lulu Island Bog is direct drainage by ditches. Lowering of adjacent watercourses or the local groundwater table via drainage ditches hastens the drying of surface peats. The construction of ponds in the two city-owned park properties involved the removal of peat, which has dried the local area. This peat removal facilitated peatland drying by increasing the hydraulic gradient between the cut and uncut areas (see Section 8.7 for more details on the impact of the ponds). Peat removal also enhances vertical seepage to the mineral soil, and accelerates drying. Finally, the invasion of non-bog species, particularly shrubs and trees, has increased evapotranspiration (vertical movement of water via plants) and led to further drying of the peatland surface. All of these processes are contributing to the drying of the nature park properties, where perimeter ditches range from small to large. In the DND property, invasive species and direct perimeter drainage have contributed to a lowering of the water table. However, drainage impacts in this property are counteracted by the naturally wetter site conditions.

Ditches provide a route for increased surface water runoff and ultimately lower the water table of the peatland. This drainage eventually leads to shrinkage of the peat. This can be seen along ditches in the RNP where slumping peat is visible. Dry conditions accelerate the decomposition of peat and vertical subsidence and compaction of the peat may occur. Ultimately the water storage capacity of the bog is reduced and much of this damage is irreversible. However, re-wetting the site by blocking the ditches and other measures will raise the water table and limit further slumping and decomposition of the peat.

Vegetation changes can accelerate dehydration of the bog through increased evapotranspiration. In the Lulu Island Bog, this is occurring as a result of invading birches and highbush blueberry (*Vaccinium corymbosum*). In some sections, the bog has succeeded from a heath plant community towards a bog forest community as a result of severe dehydration. Near the ditches of the RNP west and RNP east, tall and vigorous shore pine trees (*Pinus contorta* var. *contorta*) now stand. In undisturbed bog habitats, these trees exhibit a stunted and contorted growth form, rarely growing more than one to two metres in height (Pojar and MacKinnon 1994). Birch trees (*Betula pendula*) are now abundant in the RNP west property, and in the RNP east, yet the land surveyors in the 19th century did not record any birches in the Lulu Island Bog (see Chapter 6) and archival photos circa 1929 do not show tall tree cover in the bog (Photo 1.1). The current bog forest understorey is dominated by woody shrubs, including invasive highbush blueberry. *Sphagnum* mosses are declining in many portions of the bog.

The chemistry of surface peats may change with peatland drainage. In general, phosphorus and nitrogen concentrations increase, while potassium concentrations decrease. However, the responses of nutrient levels are highly variable depending on the properties of the peat and climate. Detailed chemistry analyses of the peat are required to determine if the nutrient status of Lulu Island Bog has been altered.

8.3 Introduced and Invasive Plant Species

The RNP and the DND properties have been colonized by numerous introduced and invasive species. The invasion is most pronounced in the RNP west property, particularly along some sections of the park trails. Invasive species have originated from several sources, including but not limited to:

- urban gardens via birds, animal droppings, wind, etc;
- agricultural crops via birds, animal droppings, wind, etc;
- bird and squirrel feed, including acorns;
- the nature park wildlife garden.

Highbush blueberry (*Vaccinium corymbosum*) is now prevalent in the study area; this is an agricultural escapee with a natural distribution in eastern North America. Dense growth of highbush blueberries are out-competing native bog species and causing *Sphagnum* die-off in many areas of the nature park. Birch trees (*Betula pendula)* are prevalent on both properties (see Chapter 10 for a discussion of birches in the study area). Additional exotic species observed in the bog include English holly (*Ilex aquifolium*), Scotch heather (*Calluna vulgaris*), evergreen blackberry (*Rubus laciniatus*), European mountain ash, and many others. The Scotch heather is ubiquitous in the DND, with thick cover in recent burn areas. It appears to invade quickly following fire.

There is also a large concentration of exotic species near the Nature House and the wildlife garden; many are European species that have naturalized in the area including creeping buttercup (*Ranunculus repens*), field bindweed (*Convolvulus arvensis*), Himalayan blackberry (*Rubus discolor*) and evergreen blackberry. The latter is increasing in the park (Griffith pers. comm. 2005). English Oak (*Quercus robur*) occurs near the nature park pond in several spots and originates from acorns brought in to feed squirrels (Bauder pers. comm. 2004).

The Richmond Nature Park wildlife garden is a point source of introduced exotic species. The garden was established as an exhibit to illustrate how to attract wildlife in a period before the impacts of invasive species on native ecosystems were well known. Since that time, it has been somewhat neglected and sporadic recent plantings have been a mix of native and non-native species (Griffith pers. comm. 2005). Recent park construction replaced part of the garden space and a compensatory expansion of the garden is planned for the near future[1]. With respect to future plantings in the wildlife garden, the city is endeavoring to plant only native species (Lusk pers. comm. 2008).

Non-native and non-bog species and cultivars that have been planted in the garden include periwinkle (*Vinca minor*), English holly, Hops (*Humulus lupulus*), and English ivy (*Hedera helix*). Several of these species, such as periwinkle, English holly and English ivy have been identified as some of the invasive species of the most concern in the Lower Mainland and elsewhere. They are being targeted by cooperative initiatives to control invasive plant species by several groups and agencies, including non-governmental organizations (e.g., the Greater Vancouver Invasive Plant Council), regional bodies (e.g., Metro Vancouver) and local governments. Additionally, Labrador tea (*Rhododendron* sp.) planted on the Highway 99 median adjacent to the park may be a non-native species (Griffith pers. comm. 2005). Non-native bog species could threaten native bog species such as Labrador tea (*Rhododendron groenlandicum*) through competition or hybridization and should be removed.

Further discussion of invasive species is provided in Chapter 10.

8.4 Trampling

Bogs are sensitive to moderate disturbance caused by trampling due to the soft peat surface and low stature of bog plants (Charman 2002). Borcard and Matthey (1995) found that systematic trampling for 10 minutes, repeated three times a year for three years almost destroyed the cover of *Sphagnum recurvum* and *Sphagnum fuscum.* The soil fauna also changed dramatically (Bocard and Matthey 1995). To avoid this, boardwalks should be used in bogs. Restricting access in off-trail areas is important and recommended. In the study area, many unauthorized trails are evident, both in the nature park property and in the DND boglands, where trails are created and maintained by blueberry pickers. Additionally, nature park trails are widening where standing water accumulates during periods of high rainfall and park visitors skirt the

[1] The wildlife garden in the nature park is presently undergoing major revitalization. It has been restructured (March 2008), and plantings will begin shortly.

wet areas by moving through adjacent higher ground. This is particularly noticeable along the Time Trail. Placement of partial boardwalks should be a priority in these areas. School groups and classes studying the bog can be a major cause of trampling. Boardwalks should be built in these high traffic areas so that environmental education can continue in the bog with minimal disturbance.

8.5 Fire

Fire is a natural agent of disturbance in peatlands, including those in the Lower Mainland. Fire results in the destruction of living plants, but often has differential effects on various plant species. Plants that regenerate vegetatively can grow back quickly, and species that occupy moist hollows may avoid being killed, such as bog cranberry (*Oxycoccus oxycoccus*). There is documentation of burning in the Lulu Island Bog by First Nations people to maintain natural cranberry crops (Turner 1975, see also Chapter 6). Fire destroys plant litter and surface peat, increases the availability of minerals in the soil, and often leads to more surface water due to reduced evapotranspiration by plants and decreased hydraulic conductivity of the peat (surface peat with high hydraulic conductivity is removed) (Charman 2002). Fire can favour the growth of minerotrophic species (including fen, forest, agricultural and exotic species) at the expense of some bog species (Forbes and Jefferies 1999). It also plays a significant role in suppressing woody growth and slowing both invasion and succession (Photo 8.3).

Photo 8.3: Cloudberry (Rubus chamaemorus) is one species that is invigorated following fire and resprouting is common. Photo: Rose Klinkenberg.

The historical and recent fire events of Lulu Island Bog have not been well documented and require further study. Anecdotal reports and observations suggest that fires occur relatively frequently in the DND site, and there is clear evidence of burns in several spots throughout that property (Photo 8.4). Only one burned area was noted in the RNP west property, adjacent to the railway tracks. In the RNP east property, an area that had been recently burned was noted by geography students during work in the bog in 2002 (Klinkenberg pers. comm. 2004).

Photo 8.4: Burn sites are common in the DND property. Photo: Brian Klinkenberg.

8.6 Land Clearing

Land clearing has played a major role in the recent history of the DND property. Aerial photo analysis clearly illustrates a series of land clearing initiatives on the property. By 1948 (Figure 7.1), much of the southwest quarter of the property was cleared of woody vegetation around the transmitter station structures built by the Department of National Defence. In addition to the clearing during this period, a road running north-south was built with non-plastic gravel and sand. Between 1954 and 1959, the entire property was cleared. The property remained predominantly clear of woody vegetation throughout the 1960s and 1970s. Debris piles are still evident to the sides of the north-south road. Three subsequent roads were also built entering the park from the eastern border of the property, and a fifth was later added entering from the northwest corner.

The land clearing and road building have impacted the property in numerous ways. Roadways into natural areas often act as entry points for invasive species. Exotic species are common and diverse along the edges of the north-south road, suggesting this to be the case. The land clearing may have also contributed to the openness of the DND property as it acted to interrupt the development of shrubs and trees, maintaining a more open community structure stage. However, the openness of the site is also likely due to the slightly lower elevation and naturally wetter conditions as evidenced by the presence of a small fen and a small seasonal stream, which limit the growth of woody vegetation.

8.7 Pond Creation

Shortly after the Richmond Nature Park was created, the Rod and Gun Club proposed the construction of ponds for duck habitat. Two ponds were constructed, one on the west property in 1972 and one on the east property in 1973 (Jagger 2004). These ponds were not part of the study area's natural history (see Chapter 6). The ponds have negatively impacted the bog ecosystem by changing its hydrologic regime and nutrient status and facilitating the invasion of exotic species. The creation of the pond resulted in lower water levels in the surrounding area. This is likely due to increased evaporation of water from the pond and drainage of water from the peat in the surrounding area towards the pond. Additionally, the duck waste associated with the ponds has likely introduced significant amounts of nitrogen into a naturally oligotrophic system.

Shortly after the ponds' construction, in a report to the Richmond Parks and Recreation Commission, the research coordinator of the Richmond Nature Park noted that the ponds were depleting water levels in the park (Jagger 2004). Some sandbagging and drainage channel closures were added to the perimeter ditches, however no other action was taken to remediate the hydrological impacts caused by the ponds and the drainage closures are not used. Today there is significant peat mat die off in the vicinity of the ponds, high and dense blueberry growth, and little to no bog species growth beneath the blueberries. The ponds have increased the diversity of plants and animals in the RNP; however this appears to have come at the expense of the native bog species, and the condition of the bog. The ponds are likely to slump and fill with peat over time due to erosion. Future decisions on whether to re-excavate the ponds should consider the societal values that the ponds afford against the deleterious effects of the pond on the surrounding bog habitat.

8.8 Fragmentation

The two nature park properties and the DND properties are islands in an anthropogenic landscape dominated by farmland and expanding urban areas. Given that bogs depend to a large extent on the maintenance of the complete hydrological and ecological system, these fragmented and degraded remnants will likely deteriorate further unless restoration actions are taken. Hydrologic protection is crucial to a peatland's long-term survival. In fact, raising and maintaining the water level is often the most critical task in bog restoration and management (Charman 2002).

Fragmentation can also threaten the viability of remnant plant and animal populations. In northern England, the fragmentation of peatlands has been associated with a decline in typical peatland plant species (Smith and Charman 1998). The effects of fragmentation on birds and animals are less predictable, as they may also use habitat in adjacent areas. However, even in cases of severe fragmentation and degradation, conservation and restoration efforts may be worthwhile since they provide refuges for smaller animals and other organisms that can survive within smaller areas (Bocard 1997).

PART II: VEGETATION, FLORA AND FAUNA

CHAPTER 9: VEGETATION OF THE LULU ISLAND BOG

By Margaret North

9.1 Introduction

The Lulu Island Bog is a one of a series of raised or domed bogs in the Fraser Delta. Raised bogs are created by the build-up of peat deposits originating as accumulations of semi-decomposed organic sediments in shallow lakes. They are convex in cross-section, resulting from peat accumulation (Glaser 1992, Keddy 2000) and exhibit a well-described structure and pattern of development (Hebda et al. 2000). These organic sediments form an acid and seasonally wet substrate that prevents the growth of all but a specifically adapted, acid-tolerant group of plants that characterize bogs (bog specialists). As peat accumulates, and the height of the bog rises, bog vegetation is less controlled by substrate and more by regional climate (Keddy 2000). "Raised bogs are [geographically] restricted to humid, temperate climates where annual precipitation exceeds water losses to surface evaporation and plant transpiration … by approximately 100-150 mm … Further to our south, raised bogs cannot form because the dry season moisture deficit is too great" (Hebda et al. 2000). Thus the Lulu Island Bog occurs near the southern limit of raised bogs on the west coast of North America (Vitt et al. 1999, Hebda et al. 2000.).

The Lulu Island Bog is a quaking bog. When *Sphagnum* moss grows over water it results in a floating peat mat that quakes as you walk on it. Peat mats can vary in depth over short distances, dependent upon the configuration of the land beneath. The mat can be as deep as 50 feet, or as thin as only a few feet. Hanson (1940) reported that the Lulu Island Bog is fairly uniform in depth over much of its area, and does not exceed 22 ft.

The vegetation of bogs is distinctive and is typified here by the dominant presence of shrubby plants from the Ericaceae or Heath family. Familiar heath species in the Lulu Island Bog include Labrador tea (*Rhododendron groenlandicum*), bog rosemary (*Andromeda polifolia*), bog laurel (*Kalmia microphylla*), bog blueberry (*Vaccinium uliginosum*) and velvetleaf blueberry (*Vaccinium myrtilloides*). The vascular plant species of the Lulu Island Bog are discussed in detail in Chapter 10.

While the original Greater Lulu Island Bog was once extensive (Figure 1.4), it has been much reduced in area by human action. The only surviving substantive remnants occur in the Richmond Nature Park and adjacent properties. These remnants are much altered. An undisturbed raised bog remains wet throughout the year (Hebda et al. 2000), but disturbances to this bog have led to alterations in moisture and nutrients. These environmental changes have influenced both bog structure and vegetation dynamics.

Photo 9.1: Andrea Tanaka and Margaret North during vegetation work in the bog (September 2006). Photo: Rose Klinkenberg.

This chapter examines the vegetation of the Lulu Island Bog as it is now. Inventory and mapping were carried out in the three main properties in September and October 2006, and May 2007 (Photo 9.1). These properties are the Department of National Defence (DND), Richmond Nature Park (RNP west), and the Richmond Nature Study Area (RNP east). This chapter outlines the methods used in the mapping and presents the results in three separate maps, one for each property (Figure 9.1, Figure 9.2, and Figure 9.3). Each vegetation type is described and related to the influence of disturbance as it affects species composition and apparent succession.

9.2 Methods

The mapping of vegetation of the Lulu Island Bog is based upon interpretation of 1995 colour digital orthophotos (Triathlon Mapping Corp. and Selkirk Remote Sensing Ltd. 1995) and stereoscopic examination of 2004 air photos (SRS flight line 6912: photo # 35,36,37, scale 1:20,000, 02 Apr.04). Because orthophotos and aerial photos record the surface by looking straight down at the ground, only the uppermost layer of the plant cover is visible. Hence this type of mapping is referred to as cover type mapping. Vegetation cover types were identified using colour, texture and height variations visible on the air photos. In many areas the vegetation cover changes gradually across wide areas and changes are so slight they cannot be easily demarcated from air photos. In such areas the placing of lines between cover types is subjective, even arbitrary. In other areas, past disturbances (see Section 9.4) have created abrupt changes in the vegetation that are easily seen and hence can be mapped from air photos.

Ground survey provided the identity of plant species in each cover type (for details of this method of mapping see Kuchler 1967). Surveys from all paths and from roads surrounding the properties were completed in 2006 and 2007. This spatially limited information was supplemented by information collected over recent years by professional biologists working in the Richmond Nature Park and the adjacent properties.

It is important to note that though the ground surveys are recent, the lines on the maps are primarily derived from photos that are 12 years old and vegetation changes over this time period. For instance, fire may remove tree cover entirely, as occurred in the DND. Or, less disastrous changes occur, such as the increase of pine in a mixed birch and pine forest as birch dies out due to disease and old age.

This vegetation study has also drawn on information from two earlier mapping studies in the bog:

1. Preliminary vegetation mapping of the RNP east and RNP west was undertaken in 2003 by UBC geography student Kevin Mack as part of a class project (Geog. 448) (for a complete presentation of this project, see the RNP web site produced by the class at: http://www.geog.ubc.ca/courses/klink/g448/2000/rnp/rnp.htm).
2. A formal releve study (sensu Braun-Blanquet, 1927) was conducted in the DND property by Karen Golinski and provided a more complete plant inventory of the Shore pine-*Sphagnum* community (Golinski 2003). This study identified a plant association found in the DND and the northern portion of the RNP west as the BCCDC-listed endangered plant community *Pinus contorta-Sphagnum* community CWHws2/10[1]. Golinski's study is presented in Appendix B.

To characterize the plant communities or associations found within each mapped area, only the dominant species have been indicated on the maps. Upper case letters have been used to indicate the tree species that dominate the area delineated, P for shore pine and a mixture of coniferous species in planted areas, H for western hemlock, B for birch, C for cottonwood, and W for willow. Where the upper case

[1] Search for more information on this ecological community type in the BC Species and Ecosystem Explorer - http://a100.gov.bc.ca/pub/eswp/.

letters appear before a back-slash (/) then the dominant species are above five metres in height. Lower case letters indicate the dominant shrub species in that area, for example: bb for blueberry (no distinction is made between the native and the commercial high-bush blueberry, however the shrub designation bb in all cases indicates the dominant presence of the commercial species); cb for cranberry, e for elderberry, hh for hardhack, lt for Labrador tea, sh for Scotch heather, w for willow, etc. These letters appear after a back-slash (/) indicating that they occupy the shrub layer, not usually exceeding 2 metres in height, often below 1 metre. Upper case letters after the back-slash indicate tree species that are co-dominants with shrubs but are below 5 metres in height, more usually at the height of the shrub layer. There are several cover types dominated by herbaceous, non-woody, plants; these are also shown by lower case letters following a back-slash: f indicates a fen community, g for grass planted along road-sides with mixed coniferous stands in some areas, p for paths now abandoned and growing a variety of species from the surrounding areas.

A legend appears beneath each of the three maps (Figure 9.1, Figure 9.2, and Figure 9.3). There are 26 different cover types delimited on the maps; 10 are shrub or herb dominated and 12 are tree dominated. Six cover types occupy the DND property, 12 occur in the RNP west and 11 in the RNP east property. The legend lists the cover types by plant formation type; the bog shrubs precede the open (oP/bb,lt) and closed treed bog. The order of the first part of the legend is not random but indicates how bog communities might change over time. Non-bog shrub and tree cover types follow with anthropogenically disturbed and/or managed vegetation listed last.

Colour has been used to enhance the appearance of the maps. Different greens have been used to indicate various combinations of dominant tree species. Yellow shows the grass, blue is used for water features such as ponds and ditches. The shrub-dominated communities have been assigned colours that are associated with some aspect of the plants' appearance, such as purple for blueberry, brown for hardhack.

9.3 Results: Plant Communities of the Lulu Island Bog

The vegetation of the Lulu Island Bog, as mapped in 2007, includes 26 cover types identified from air photos followed by ground survey. The vegetation maps are presented in Figure 9.1, Figure 9.2, and Figure 9.3. These cover types may be grouped into the 10 plant communities described below.

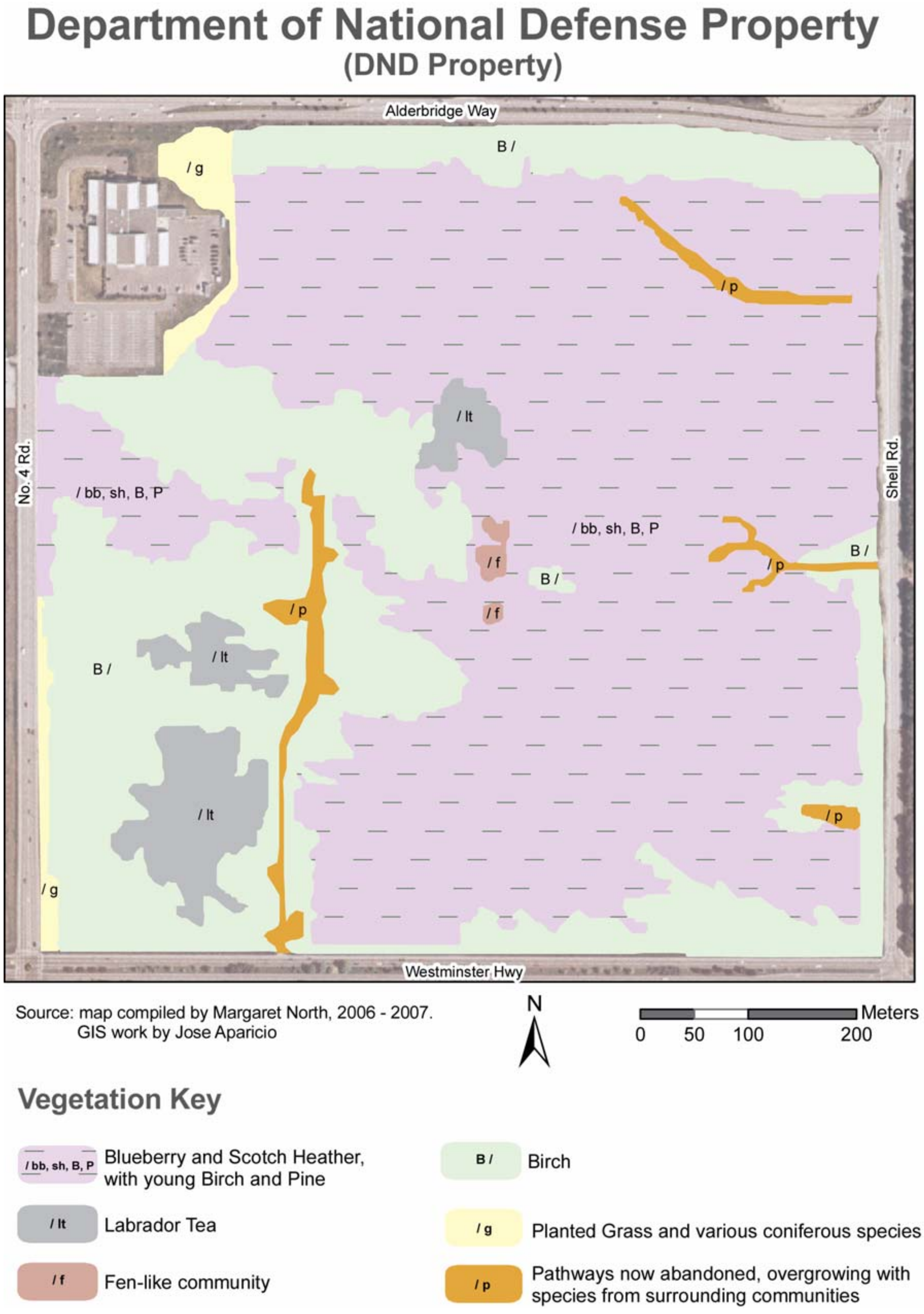

Figure 9.1: Vegetation of Department of National Defense Property (DND)

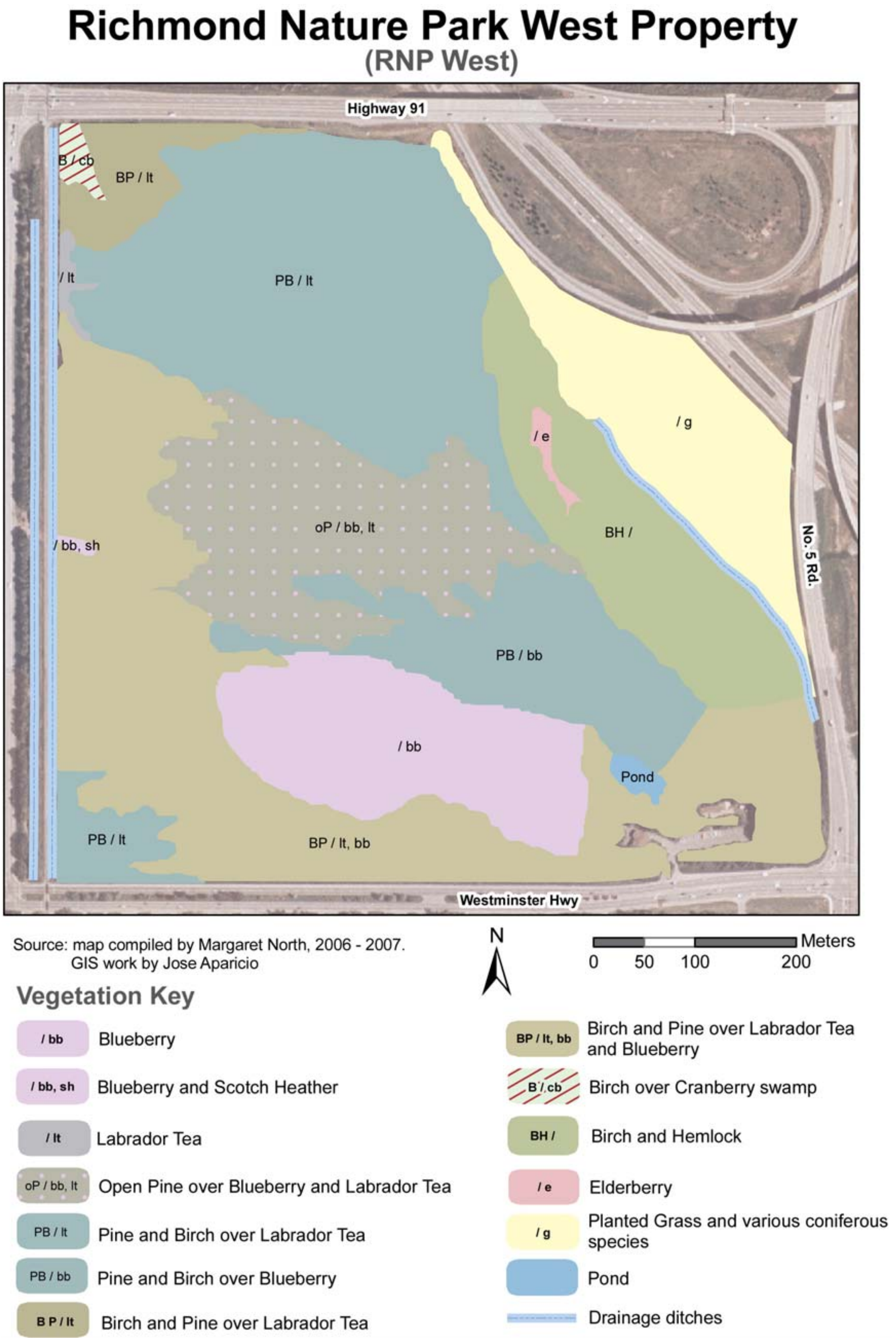

Figure 9.2: Vegetation of Richmond Nature Park West Property (RNP west)

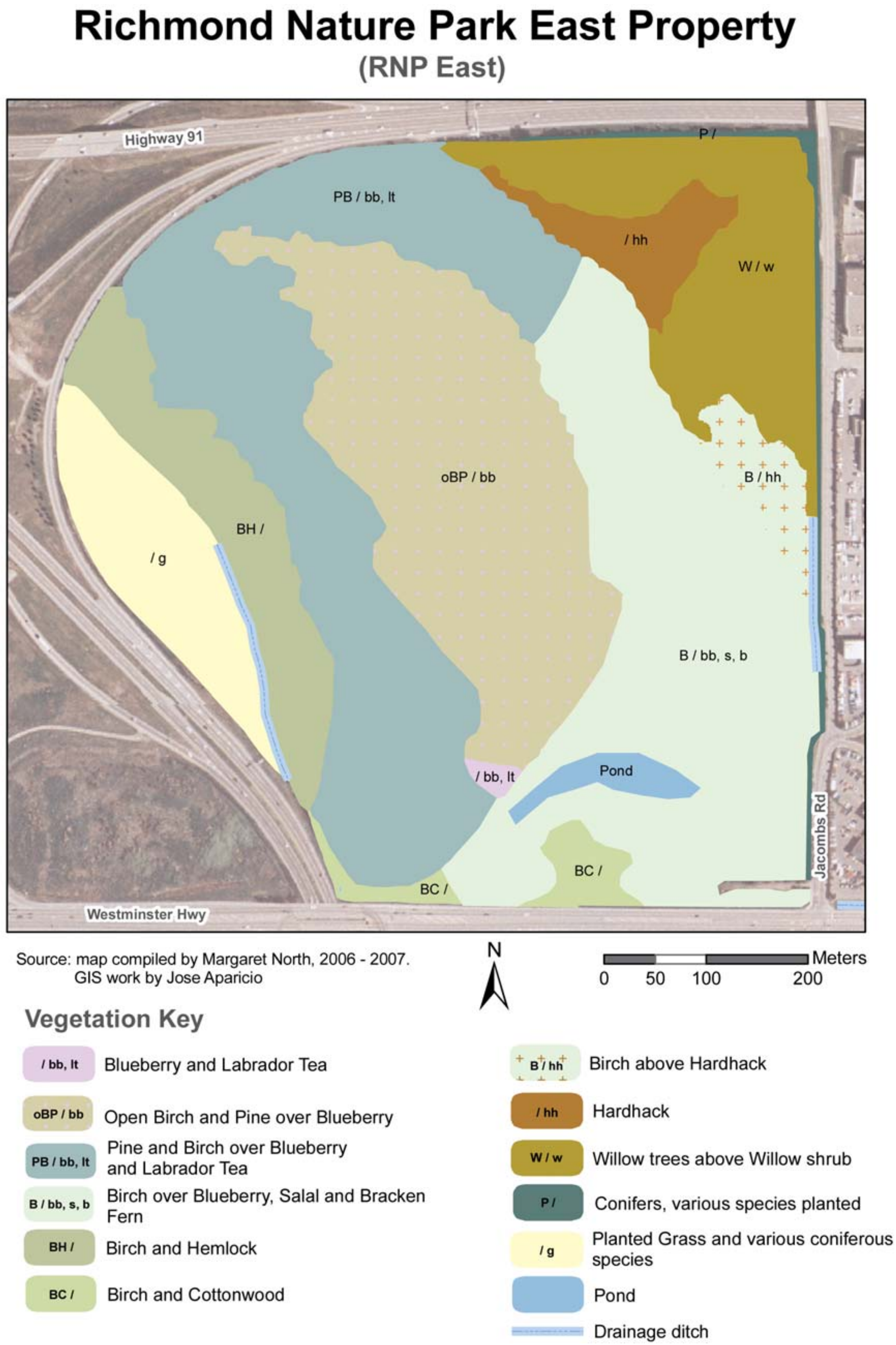

Figure 9.3: Vegetation of Richmond Nature Park East Property (RNP east)

9.3.1 Open Heath Bog

Sphagnum-Rhododendron groenlandicum-Pinus contorta community
Mapped as the following 5 shrub cover-types: /bb,sh /bb,lt /bb /lt /bb,sh,B,P

This community is assumed to represent an early stage of the development of a bog community. Characteristic bog shrubs dominate. Labrador tea (*Rhododendron groenlandicum*), bog blueberry (*Vaccinium uliginosum*), bog-laurel (*Kalmia microphylla* ssp. *occidentalis*) (Photo 9.2), bog cranberry (*Oxycoccus oxycoccus*) and bog rosemary (*Andromeda polifolia*) make up the shrub layer with *Sphagnum* beneath, and the few-flowered sedge (*Carex pauciflora*) is scattered throughout.

Photo 9.2: Bog-laurel (Kalmia microphylla ssp. occidentalis) in the west perimeter ditch of the RNP west property. Photo: Rose Klinkenberg.

The open heath bog community found in the Lulu Island Bog has been identified as an endangered plant community in the province (British Columbia Conservation Data Centre 2005a)[2]. It was identified and mapped in the DND property and in the Richmond Nature Park west, and assessed more completely than other cover types by Karen Golinski (Golinski 2003) using the releve method of survey (see Appendix B). The presence of open heath bog in large areas throughout the DND property is a result of past fires. Photo evidence dates fires from the 1930s and historic sources

[2] This plant community type occurs elsewhere in the province in several biogeoclimatic (BEC) zones. However, in the Coastal Douglas Fir BEC zone it is recognized as a red-listed (endangered) plant community. The official name for this community in the province is *Pinus contorta-Sphagnum (CDFmm)* community. Please refer to the BC Species and Ecosystems Explorer account for this community found at (http://a100.gov.bc.ca/pub/eswp/)

indicate that fire was used by the First Nation's people to maintain an open, cranberry bog in this area (see Chapter 6). Recent fires have destroyed trees in previously treed heath bog or bog forest, leading to a re-establishment of closed shrub cover.

Large patches of native bog blueberry indicate how rapidly native species can occupy these burnt-over sites. However, fire also opens the area to invasive species such as Scotch heather *(Calluna vulgaris)*. Though fire eliminated most of the shore pine (*Pinus contorta*) that had previously dominated the area, a few burnt veterans remaining provided seed for young pine that have begun to establish.

Where fire has removed competition by shrubs as well as trees, large mats or lawns of *Sphagnum* moss dominate open areas in the DND and smaller areas scattered through central northern parts of the RNP west (because of the small size and scattered nature of the moss dominated areas, they cannot be shown at the mapping scale used for this inventory).

The invading commercial highbush blueberry (*Vaccinium corymbosum*) is so successful in the bog that it is the dominant shrub in many of the treeless areas. In some areas, it is so dense that there is insufficient light beneath to support any plant life—these areas are mapped as /bb. In the southern part of the RNP west, west of the pond, highbush blueberries cover 100% of the surface and the underlying *Sphagnum* has died—resulting in the area being described as a "blueberry desert" (Photo 9.3).

Photo 9.3: The "blueberry desert" in the Richmond Nature Park west property.
Photo: Rose Klinkenberg.

9.3.2 Treed Bog

Pinus contorta var. contorta-Sphagnum community
Mapped as the following cover type: oP/bb,lt oBP/bb

In disturbed sites, bog succession is influenced by the type of alteration to the ecosystem. In the Lulu Island Bog open heath bog changes over time to become tree-covered bog. The open treed bog would be a stage in this change, characterised by 10% - 50% tree cover.

This community is dominated by an open cover of young birch (*Betula pendula*) and shore pine (*Pinus contorta* var. *contorta)* and *Sphagnum* moss species. In the dense shrub layer, co-dominants are bog blueberry, and Labrador tea. Associated native species include bog-laurel and bog cranberry (*Vaccinium oxycoccus*). Highbush blueberry occurs throughout the bog, both large cranberry (*Oxycoccus macrocarpus*) and the cultivated cranberry, and Scotch heather are common non-native invaders in more open areas. Particularly in the DND property, recent burning has had the effect of increasing the cover of Scotch heather (Photo 9.4).

Photo 9.4: Fire in the bog often results in thick displays of Scotch heather, a fire-following species. Photo: Rose Klinkenberg.

The presence throughout of non-bog plants such as salal (*Gaultheria shallon*) (Photo 9.5) and birch indicate the vulnerability of the disturbed bog to plant invasion. It is doubtful if either species could successfully invade an undisturbed bog where high water table and low nutrient availability can support only acid-tolerant bog species.

Photo 9.5: Salal (Gaultheria shallon) forms extensive thickets in the RNP east and west properties. Photo: David Blevins.

This community is best represented in the central part of the two RNP properties. The treed bog in the RNP west appears to be more open, the trees are less dense and of lesser height than in the RNP east. The variation of height of trees in the bog may or may not be indicative of age differences as nutrient availability may also affect tree height. The open heath bog that dominates the DND might be expected to develop into a younger version of the treed bog if no further fires occur and if altered moisture conditions facilitate the continued growth of birch that is now present in the shrub layer.

9.3.3 Bog Forest on Drier Peat Subsoil

Betula pendula-Pinus contorta var. *contorta-Vaccinium corymbosum* community
Mapped as 2 types: BP/lt,bb PB/bb,lt

This community is co-dominated by a combination of birch and shore pine. Within this community there are two cover types. In the more disturbed, usually peripheral areas, the birch-pine forest prevails. Here birch trees are replacing older pines, once part of a shore pine-dominated bog forest. Birch appears to have been spreading from the periphery of all three properties; however the recent disease and high mortality of the birch may have slowed this advance. The change to birch as the slightly dominant species indicates that the area, though still a bog developing on peat soils, is drier than the original bog. Away from peripheral effects that may be drying the peat subsoil, the pine appears to be healthier and makes up a greater percentage of the forest canopy. Variable densities of highbush blueberry have established as the prevailing species in the understorey, though Labrador tea is usually present as are other bog shrubs. The more open forest usually has a denser shrub cover. The more pine present, the greater likelihood of finding all the native bog shrubs represented.

9.3.4 Peripheral Forest

Betula pendula community
Mapped as several forest types: B/ B/hh B/bb,s,b

A birch forest dominates the vegetation around the edges of the DND, south, west and north sides of RNP west, and the south and east of RNP east. A shrub layer of varying density and composition underlies the trees. Common associates include salal, elderberry (*Sambucus racemosa* ssp. *pubens*), bracken fern (*Pteridium aquilinum*), evergreen blackberry (*Rubus laciniatus*), Himalayan blackberry (*Rubus discolour*), salmonberry (*Rubus spectabilis*), lady fern *(Athyrium filix-femina)*, hardhack (*Spiraea douglasii)*, European mountain ash *(Sorbus aucuparia)*, and other mostly alien species typical of disturbed sites. The lack of a shrub subscript after the B/ in some mapped areas does not mean that shrubs are absent, simply that these areas have not been studied in the field (birch can be identified by photo interpretation but no shrubs are visible below the closed forest canopy).

This forest type is not a typical bog forest as it is dominated by non-bog species. The reasons for this change probably relate to alterations in drainage surrounding the bog. Large ditches surround all three properties, initially these were part of the field drainage pattern but now they are mainly road drainage ditches. The ditches may have the dual effect of lowering the water table when the ditches are dry, and increasing the water available by seepage from the ditches when they hold water. The seepage water may also add nutrients to the bog soil and hence reduce acidity. The presence of hardhack and other non-bog shrubs in this forest indicate such a reduction in acidity. The birch forest grades into adjacent bog forest. This community type will undoubtedly spread if the high water table and acid conditions, essential to the maintenance of bog species, continues to change.

9.3.5 Peripheral Forest on Road-fill

Betula pendula-Tsuga heterophylla-Polystichum munitum community
Mapped as 2 forest types: BH/

Silts, sands and gravels brought in as roadbed foundations for Highway 99 and similar materials excavated during construction of the Massey Tunnel have been dumped along the sides of the highway as it crosses the bog. This sidecast material has created a soil both better drained and richer in nutrients than the surrounding peat. Here a dense birch forest is being succeeded by a mixed birch-western hemlock (*Tsuga heterophylla*) forest. The birch, being relatively short-lived and shade intolerant, is being over-topped by the slower-growing conifer, and western hemlock will eventually be the dominant forest tree. The present understorey of this community includes mountain ash, hardhack (/hh), salal (/s), elderberry (/e), salmonberry, evergreen blackberry (*Rubus laciniatus*), thimbleberry (*Rubus parviflorus*); sword fern (*Polystichum munitum*) and bracken fern (/b), none of which are bog species though they are indicative of moist sites.

The forests on either side of Highway 99 differ slightly; the eastern forest has fewer hemlock trees and has a greater cover of evergreen blackberries than the forest west of the highway.

Betula pendula-Populus balsamifera spp.*tricocarpa* community
Mapped as: BC/

Two small areas of forest dominated by birch and cottonwood *(Populus balsamifera* spp*. tricocarpa)* occur along the southern edge of the RNP east. The presence of cottonwood here is uncommon in the study area. The larger area appears to coincide with a dump of clay that may have been related to the lining of the pond in the RNP east property (Cairns 1973). The more westerly extension seems to occupy sidecast material from Highway 99 and is also bordered by a large ditch.

9.3.6 Willow Wetland

Salix lasiandra-Alnus rubra-Spiraea douglasii community
Mapped as wetland community: W/w

In the northeast corner of the RNP east (Figure 9.3) is a wet area covered with dense thickets of mixed aged Pacific willow (*Salix lasiandra*), western red alder (*Alnus rubra*), and hardhack. This community, though wet, is not a bog community. The historic vegetation map of the area (see Chapter 6) locates an area of cattail marsh in the vicinity. Cattails still grow in the undeveloped area kitty-corner to this willow wetland. Both willows and cattails require the presence of flowing, nutrient rich water. Before the construction of the East-West Connector (Highway 91), the area was considerably wetter. Any decrease in moisture will lead to changes in the community.

A planted strip of Douglas-fir (*Pseudotsuga menziesii*) and western red cedar (*Thuja plicata*) (Figure 9.3, P/) separates the park from adjacent land use and may provide a seed source in the future for the drying willow area.

9.3.7 Shrub Thickets

Non-bog shrub communities: *Spiraea douglasii* mapped as: /hh and
Sambucus racemosa spp. *puben*s mapped as: /e

Two areas covered densely with non-bog shrubs occur within the RNP west and the RNP east (note that there are other areas dominated by non-bog shrubs but these are too small to delineate at the scale used for the maps as presented).

Bordering and extending south of the willow wetland (RNP east) is an area with a dense, tall cover of hardhack, up to 2 m in height, above a thick blanket of moss (*Polytrichum commune*). Pacific willow is present but not a dominant and rushes (*Juncus effusus*) are common in the ground layer. The soil is clay, unlike the organic soils found in the rest of the park.

In the RNP west property (Figure 9.2) a narrow, deep depression lies within the area of side-cast formed by the deposit of roadbed material used for Highway 99. The vegetation here is dominated by red elderberry, salmonberry and mountain ash growing in a damp mineral soil.

9.3.8 Open Fen-like Community

Rhynchospora alba-Drosera rotundifolia community
Mapped as: /f

Fens are a type of peat land that can vary in composition. Open fens are characterized by the presence of sedges including *Carex*, *Scirpus*, and *Eriophorum* (Zoltai 2007). In the study area, a small fen-like[3] plant association, dominated by white beak-rush (*Rhynchospora alba*), occupies a small distinctive habitat in the DND property (/f in Figure 9.1). Its existence is a result of wetter conditions, and the associated presence of a small surface stream that runs through the bog in this location (see Figure 1.5). This stream flows throughout most of the year, drying in peak summer months. Cottongrass (*Eriophorum chamissonis)* and three-way sedge *(Dulichium arundinaceum)* are prominent here, with *Dulichium* occupying the streambed in places. The small size of the fen-like area, and the fact that it dries out in summer, makes it vulnerable to invasion by surrounding species.

[3] Fens are bog-like wetlands on peat, dominated by grasses and sedges. They differ from bogs by receiving water other than precipitation from small streams and groundwater, which increases nutrient availability, and decreases acidity. In the study area, this plant association is quite small, and no doubt influenced by the surrounding bog rather than entirely being influenced by stream water. This would affect the acidity of the association, placing it somewhere between bog and fen.

9.3.9 Ponds and Ditches

These water features are shown in blue on the maps. Two larger ponds exist in the study area. Both were constructed in order to increase the habitat variety and, hence, species diversity within the park. In the RNP, a pond was created in 1972, with cattails (*Typha latifolia*), rushes (*Juncus effusus*) and sedges (*Scirpus cyperinus*) around the perimeter. In the RNP east, a pond was excavated in the late seventies. A dense birch forest surrounds the pond. Large amounts of *Sphagnum* can be found in the pond, including *Sphagnum capillaceum, Sphagnum papillosum,* and *Sphagnum fallax angustifolium*. Along the margins of the pond, salal is abundant. Both ponds are quite shallow and may dry up in very droughty summers.

Several ditches surround the bog and are mapped. These include a large open water ditch that borders the eastern boundary of the RNP west and provides additional diversity. A variety of aquatic and wetland species, including several willow species (*Salix* spp.), Vancouver Island beggarticks (*Bidens amplissima*), and a variety of sedges (*Carex* spp.) and rushes (*Juncus* spp.), grow here. A second large ditch is found between the railway tracks and the west boundary of the RNP west. The water in this ditch is acidic, and supports a young expanding *Sphagnum* mat, and occasional shrubs of bog laurel.

9.3.10 Anthropogenically Disturbed Vegetation

3 communities mapped as: /g /p P/

Each of the three properties in the study area has a small enclave dominated by built structures that are either frequently or intermittently used. The RNP west has a number of buildings and a parking lot developed in the shore pine-birch (PB/bb) community. Birch dominates the border of the highway, while shore pine increases further into the park. In the center of this enclave a wheelchair accessible boardwalk, completed in 1982, surrounds the cattail pond.

The RNP east contains two distinct areas of disturbance. An area cleared for picnic facilities was overgrown with blackberries in 2006, but has been cleared in 2007 and a more westerly area contains large European birch with a dense understorey of evergreen blackberries. Neither area is large enough to map on present mapping scale.

The DND property has a number of old paths and access roads. The buildings and radio towers that were present on the site have now been removed and the paths are being reclaimed by a variety of indigenous and introduced species (Figure 9.1 /p). Grasses and scattered stands of mixed coniferous species have been seeded into the sidecast soil along Highway 99 (Figure 9.2 and Figure 9.3 /g) adjacent to the east and west RNP properties, and around the DND buildings in the northwest corner of their property (Figure 9.1 /g). Various native and non-native species have begun to invade and establish themselves. Only continued human management (i.e. anthropogenic disturbance) will maintain these areas as grass dominated. A mixed stand of planted conifers borders the north and east perimeter of the RNP east (Figure 9.3 P/).

9.4 Discussion and Conclusions[4]

The Lulu Island Bog is a raised or domed heath bog comprised of regionally typical bog vegetation. Site disturbance, including dumping of silt and other land-fill materials in the two nature park properties (primarily along the Highway 99 corridor), clearance and fires in the DND property, and alterations in water quality and quantity, has impacted and continues to affect the remnant bog. The cumulative effects of these disturbances have lead to a loss of total bog area, alteration in the species composition and changes in normal bog succession. Accelerated tree growth and invasion by birch has led to forest dominating much of the RNP east and portions of the RNP west. These changes are most obvious from the peripheral trails within the two park properties. From the trails it is not obvious that *Sphagnum* moss, the essential bog species, is still growing, although hummocks of *Sphagnum* are visible in the undergrowth. However, away from the trails, and hence from the public eye, lawns and mats of *Sphagnum* moss are growing in wet depressions below the open canopy of the treed bog areas.

Wetter site conditions in the DND property, plus recent fires, have maintained that section of the bog as primarily open heath bog (Figure 9.1 /lt, /bb,sh,B,P), with less of the area invaded by birch and highbush blueberry than in the two adjacent properties. Despite past and ongoing disturbances, much of the mapped area continues to support viable representations of true bog vegetation, including the red-listed *Pinus contorta/Sphagnum* plant community that was identified in the DND by Karen Golinksi (Golinski 2003) and listed by the British Columbia Conservation Data Center (BCCDC 2005a).

The plant cover of the Lulu Island Bog, as represented by the remnants preserved in the RNP west (Figure 9.2), RNP east (Figure 9.3), and adjacent DND property (Figure 9.1), allows us the rare opportunity to explore a lowland raised bog ecosystem. The variations we can see within this bog provide the clues to understanding what has occurred and will continue to occur in this system.

[4] Note: Shortly following the vegetation mapping ion of the Lulu Island Bog, a major wind storm knocked down many birch trees in the bog, thus opening up the bog significantly in several areas.

CHAPTER 10: VASCULAR PLANTS OF THE LULU ISLAND BOG

By Rose Klinkenberg and Brian Klinkenberg

10.1 Introduction

The Lulu Island Bog is a remnant raised bog, and is one of several raised bogs that are found in the Fraser Lowlands of British Columbia. In a natural state, these bogs would be floristically[1] similar (Hebda et al. 2000). Species that are characteristic of bogs in the region include *Sphagnum* mosses (*Sphagnum* spp.) and several species in the Heath family (Ericaceae), including Labrador tea (*Rhododendron groenlandicum*) (Photo 10.1), bog-laurel (*Kalmia microphylla* ssp. *occidentalis)*, bog cranberry (*Oxycoccus oxycoccus*), bog blueberry (*Vaccinium uliginosum*) (Photo 10.2), hardhack (*Spiraea douglasii*) and salal (*Gaultheria shallon*) (Hebda et al. 2000). Associated tree species in these bogs are shore pine (*Pinus contorta* var. *contorta*), with Sitka spruce (*Picea sitchensis*) as an occasional associate (Hebda et al. 2002).

Photo 10.1: Labrador tea (Rhododendron groenlandicum) is a dominant species in the bog.
Photo: Dave Ingram.

In this study, we document the vascular plant flora of the Lulu Island Bog as found in the bog proper and in other habitats within the study area, including willow swamp, ponds and disturbed sites. Previous vascular plant survey work in the study area has been carried out as follows: Bell (1981, revised 1984), Taylor (1973), Harvey (1972a) and Cairns (1973), each of whom documented vascular plant species found in the Richmond Nature Park (RNP west) property. A reconnaissance vascular plant survey

[1] Floristically similar: have many plant species in common.

of the Department of National Defence (DND) property was carried out in 2001 (Klinkenberg et al. 2001). In this update, we aim to provide a checklist of the vascular plants of the study area, insight into rare or significant species, and assessment and discussion of the invasive species that presently have a significant impact on bog ecology. The checklist and discussion will provide baseline data that can be used for comparison during any future bog restoration work.

Photo 10.2: Bog blueberry (Vaccinium uliginosum) is a circumboreal species that is common throughout the study area. Photo: David Blevins.

10.2 Methods

In documenting the vascular plant flora of the study area, three steps were taken: a literature review was carried out, input from knowledgeable individuals was sought, and a field inventory was conducted. Inventory work was conducted in 2002 and followed standard floristic survey methods (Klinkenberg and Klinkenberg 2002, Miller and Antos 2002). A series of transects were walked in each property in the study area in 2002 and additional areas of habitat variation, site disturbance and substrate alteration were specifically targeted. Additional informal survey was conducted from 2002 through to 2006 during periodic visits to all three of the study area properties. From this, a checklist of the vascular plants of the study area was compiled. Observations by Don Benson, Terry Taylor, and John MacQueen were incorporated. Voucher collections were made for many species and will be deposited at the UBC Herbarium.

10.3 Results

In total, 143 species of vascular plants are reported from the study area[2], from both bog habitat and other peripheral habitats. Of these, 80 are native species and 64 are alien species. Sixteen species are true bog and bog associated species typical of our regional bogs (see Table 10.1). This low diversity of bog flora is typical of bogs.

A checklist of the vascular plants of the study area has been compiled and is presented in Appendix D-4.

Table 10.1: Native bog and bog-associated species of the Lulu Island Bog

Scientific Name	English Common Name
Andromeda polifolia	Bog-rosemary
Carex pauciflora	Few-flowered sedge
Drosera rotundifolia	Round-leaved sundew
Dulichium arundinaceum	Three-way sedge
Eriophorum chamissonis	Chamisso's cottongrass
Gaultheria shallon	Salal
Kalmia microphylla ssp. occidentalis	Bog-laurel
Lycopodium clavatum	Running clubmoss
Oxycoccus oxycoccus	Bog cranberry
Pinus contorta var. contorta	Shore pine
Rhododendron groenlandicum	Labrador tea
Rhynchospora alba	White beak-rush
Rubus chamaemorus	Cloudberry
Spiraea douglasii	Hardhack
Vaccinium myrtilloides[3]	Velvet-leaved blueberry
Vaccinium uliginosum	Bog blueberry

10.4 Discussion

Glaser (1992) discusses the floristic diversity of eastern North American raised bogs, indicating that floristic diversity [of true bog species] is generally 26 species or fewer, and less than 20 species in some regions. He relates species richness in undisturbed

[2] Two additional species are historically reported from the Lulu Island Bog by Osvald (1933): water clubrush (*Scirpus subterminalis*) and Rannoch rush (*Scheuchzeria palustris*). Hebda et al. (2000) consider both of these species extirpated from the Fraser Lowland.

[3] Although Szczawinski (1975) speculates that this species is probably introduced in our area (for the fruit) because of the disjunctness of our local populations from populations elsewhere in BC, recent BEC plot surveys record the species in areas in between (E-Flora BC 2008). Ganders (pers. comm. 2008) feels the species is native in our area.

raised bogs to environmental factors. He indicates that mean annual precipitation and annual freezing degree-days with a base temperature of 0°C are the most important factors in determining richness. However, he also points out that additional environmental factors influence species richness in these bogs, including mean annual temperature, the number of wet-to-dry habitats, and the concentration of magnesium and sodium in the surface water.

Photo 10.3: Small ponds and openings in the peat mat are common in the DND property. Photo: Rose Klinkenberg.

Other factors influence overall species composition and species abundances in any site, including habitat variation, disturbance, site use and ecological processes. In the study area, each of these plays a role in determining species composition. Habitat variation in the study area includes the small stream in the DND property, scattered open ponds and bog hollows or lawns in the DND property and the north half of the RNP west (Photo 10.3 and Photo 10.4), and minor elevation changes such as the low ridges in the RNP east and west that have allowed establishment of hemlock stands and associated understorey species. Disturbance in the bog, particularly drainage and subsequent drying of the bog, has resulted in conditions that favour non-bog alien species. Soil dumping in the RNP east and west on top of the peat mat has resulted in heavy invasions of alien species and alteration of bog habitat. Fires in the DND property have resulted in heavy dominance by the alien Scotch heather (*Calluna vulgaris*) at the expense of native bog species; however, fire suppression favours woody growth that lowers water table levels and produces shade, both of which inhibits native bog species and in some areas cause die off of the peat mat.

Photo 10.4: A small stream runs through the DND property. Photo: Brian Klinkenberg.

In the study area, the bog ecosystem comprises most of the site (>95%) (Figure 9.1, Figure 9.2, and Figure 9.3). Species composition includes typical regional bog species, invasive species and, in drier sites, native non-bog species. Birch (*Betula pendula*) and highbush blueberry (*Vaccinium corymbosum*) are visual dominants in the overstorey and shrub layers, but bog-associated species such as shore pine (*Pinus contorta* var. *contorta*) and a variety of native heath species define the site (see Section 10.8.2 below for a detailed discussion on birch and blueberry). The bog is primarily a heath bog, dominated by shrubs in the heath family of plants (Ericaceae).

10.5 Native Species

Labrador tea is the most abundant bog species in the DND property and the north half of the RNP west. In the DND, in particular, it forms large thickets of varying heights and age classes. It is also present in the south half of the RNP west and in the very shady RNP east, where it exhibits a leggy growth form. Other bog species present in the study area include bog-laurel, bog blueberry and velvet-leaved blueberry (*Vaccinium myrtilloides*). Bog-laurel is regionally rare, but is common in the study area (Photo 10.5).

Photo 10.5: Bog-laurel (Kalmia microphylla ssp. occidentalis). Photo: Rose Klinkenberg.

Photo 10.6: Round-leaved sundew is abundant in the DND property where a higher water table and periodic light fire maintain populations. This species can also grow on damp logs. Photo: Gary Lewis.

Sundew (Photo 10.6) is commonly found in the DND property, but is rare elsewhere in the study area. It occurs in wetter sites where the mat is thin and quaking. Three-way sedge (*Dulichium arundinaceum*), cottongrass (*Eriophorum chamissonis*), white beak-rush (*Rhynchospora alba*) and round-leaved sundew are abundant in the DND property in the small fen-like[4] area that parallels the small stream. Three-way sedge is also found in the streambed and some ditches. Bog cranberry is common in bog hollows, where it can form extensive mats. This species is present in the other properties, but is less abundant. Large cranberry (*Oxycoccus macrocarpus*) is also present and many patches of cranberry appear to be hybrids of the two species. In many areas, large and small-fruited plants occur side by side.

Yellow pond-lily (*Nuphar lutea* ssp. *polysepala*) (Photo 10.7) is found in small openings in the peat mat, and it pokes through the thinner mat in bog hollows in several locations. This species is also found in the perimeter ditch on the west side of the RNP west, parallel to the railway tracks. Salal is abundant in some sections of the RNP west and particularly in the RNP east where it forms dense low thickets in drier parts of the site. It is also found along the north-south access road in the DND property and adjacent areas.

Photo 10.7: Yellow-pond lilies (Nuphar lutea ssp. polysepala) poke through the peat mat and bog cranberries in the DND property. Photo: Brian Klinkenberg.

Running clubmoss (*Lycopodium clavatum*) is a bog-associated species that is often found in bog margins. It is infrequently found in both the RNP east and west, where it occurs on slightly elevated moist to mesic sites.

Cottonwoods (*Populus balsamifera* ssp. *trichocarpa*) occur in stands in the RNP west and east, along with red alder (*Alnus rubra*). The latter is particularly common in parts of the RNP east. The RNP east also supports hardhack thickets (*Spiraea*

[4] See Chapter 9 for details on this small wetland type.

douglasii) adjacent to the small willow wetland in the northeast corner, with similar thickets in the northwest corner of the DND property. Red osier dogwood (*Cornus stolonifera*) occurs throughout the study area in suitably moist to wet sites and cattails are found sporadically throughout the study area in all three properties.

In both the RNP east and west, several native non-bog species occur as common associates. These include red elderberry (*Sambucus racemosa* ssp. *pubens*), salmonberry (*Rubus spectabilis*), Saskatoon berry (*Amelanchier alnifolius*), Indian plum (*Oemleria cerasiformis*) and several ferns species, including lady fern (*Athyrium filix-femina*), sword fern (*Polystichum munitum*), bracken fern (*Pteridium aquilinum*), and deer fern (*Blechnum spicant*).

Other species found in the study area include western hemlock (*Tsuga heterophylla*), which occurs on low ridges in both the RNP east and west and scattered through the open bog. Trees found in the bog proper are usually stunted and can at first glance resemble mountain hemlock.

Species accounts for significant species in the study area are presented in Section 10.8.1 below.

10.6 Alien and Invasive Species in the Study Area

Worldwide, invasive species have become an important environmental issue. Invasive species are "the second leading cause of species endangerment and extinction, second only to habitat loss" (Poulin et al. 2005). Control and removal of invaders has become a focus for environmental groups and governments as these species alter ecosystems and disrupt species assemblages. Fortunately, public education about invaders is well established and there is strong public support for control.

In the Lower Mainland area, invaders are an important issue and have become the focus of provincial groups such as The Invasive Plant Council of British Columbia (IPC), and local groups such as the Greater Vancouver Invasive Plant Council (GVIP). The GVIPC lists the top invaders in our region and targets these for removal from natural areas (Table 10.2), and they strongly encourage the public not to use them in gardens. Eradication efforts by the GVIPC for removal of invasive species are already underway and include removals in Richmond at Iona Beach Regional Park and adjacent area, where Scotch broom has been a major target.

Table 10.2: Top twelve plant invaders in the Vancouver area. Source: GVIPC 2008.

English Common Name	Scientific Name
English holly	*Ilex aquifolium*
Yellow flag	*Iris pseudoacorus*
Himalayan blackberry	*Rubus discolor*
Japanese knotweed	*Polygonum* spp.
Purple loosestrife	*Lythrum salicaria*
False lamium	*Lamiastrum galeobdolon*
Periwinkle	*Vinca minor*
Daphne	Daphne laurel
Scotch broom	*Cytisus scoparius*
Giant hogweed	*Heracleum mantegazzianum*
Spartina	*Spartina anglica*
Policeman's helmet	Impatiens glandulifera

Table 10.3: Top invaders in the Lulu Island Bog

English Common Name	Scientific Name
European birch	*Betula pendula*
Highbush blueberry	*Vaccinium corymbosum*
Scotch heather	*Calluna vulgaris*
Himalayan blackberry	*Rubus discolor*
Evergreen blackberry	*Rubus laciniatus*
European mountain ash	*Sorbus aucuparia*
English holly	*Ilex aquifolium*

In the study area, invasive species are an important issue and ecosystem alteration resulting from these species is well underway. Of the top twelve invasive species identified in our region, the following six are found in the study area: periwinkle, English holly (Photo 10.8), Himalayan blackberry, Japanese knotweed, purple loosestrife, and Scotch broom. However, additional top priority invaders have been identified in the study area. These are primarily ecosystem-altering species that, in some cases, have overwhelmed the bog (e.g., birch). They play a role in shade generation that changes growing conditions for native bog species (e.g., birch and highbush blueberry), and some pose biological threats to native species through hybridization and genetic swamping or genetic pollution[5] (e.g., European mountain ash[6]) (Table 10.3). These species require a focused invasive species management

[5] Genetic pollution is undesirable gene flow into wild populations. This is an issue that threatens many of our native species. See for example http://www.montana.edu/~wwwbi/staff/creel/bio480/hybrid.pdf.
[6] European mountain ash hybridizes with the native mountain ash, *Sorbus sitchensis*.

program in order to move towards control. Wildlife-dispersed species should be an important focus in invasive species management, and point sources of introductions should be controlled where this is possible.

Photo 10.8: English holly (Ilex aquifolium), another top invader, is found in forested areas in the RNP east and west properties. Photo: Diane Williamson.

Invasive and alien species in the bog are annotated in the vascular plant list in Appendix D-4. Species accounts for the top four invasive species in the study area are presented in Section 10.8.2 below.

10.7 Planted Species

Many species have been planted in the wildlife garden in the RNP west over the years (Table 10.4). Planted species in the wildlife garden include alien species, native species cultivars, and species native elsewhere in the region but not native to the bog (Bauder 2005). Several invasive species were planted in the wildlife garden in the past, prior to awareness of the invasive species problem, including European mountain ash, English Holly, Evergreen blackberry and Himalayan blackberry.[7] Many planted species may be benign, however, and some, like Indian plum (*Oemleria cerasiformis*) and red-flowering currant (*Ribes sanguineum*), are locally native and occupy drier forested and semi-forested areas on their own. Red-osier dogwood (*Cornus stolonifera*) has been planted, but also occurs naturally in the study area.

[7] The wildlife garden has now been upgraded. Lusk (pers. comm. 2008) indicates that the city now endeavors to plant only native species wherever possible. However, many new noon-native species have been in the new garden.

Outside of the wildlife garden, Yellow-pond lily has been planted in the nature park pond and is still present there, but is native in the study area. Additional plantings have occurred in the RNP west outside of the wildlife garden. For example, pitcher plant (*Sarracenia purpurea*) was planted in the past as an attempted introduction. However, this was unsuccessful: Pitcher plant is native in bogs in northeastern BC, but is does not occur in our regional bogs because of unsuitable growing conditions.

Table 10.4: Planted Species in the Richmond Nature Park
Wildlife Garden List compiled by Kris Bauder, 2007.

- Bedstraw	- Oak sp.
- Bleeding hearts	- Oregon grape
- Bracken fern	- Periwinkle (*Vinca minor*)
- Buddleia	- Purple pea
- Columbine	- Pussy willow
- Cotoneaster	- Oregano?
- Daylilies	- Red flowering currant (white variety developed at UBC)
- Elderberry (Gold and Red)	- Red flowering currant (pink)
- English holly	- Red huckleberry
- English ivy	- Red-osier Dogwood
- Fireweed	- *Rhododendron* spp.
- Flowering dogwood (Eddies White Wonder)	- Salal
- Foxglove	- Salmonberry (including a double flowered variety)
- Fuchsia	- Saskatoonberry
- Juniper sp.	- Sedum sp.?
- Hawthorn (Ornamental)	- Snowberry
- Hazelnut sp.	- Sweet rocket?
- Highbush cranberry	- Sword fern
- Honeysuckle sp.	- Thistles
- Hops	- Vine maple
- Indian Plum	- Violets
- Kinnikinnick	- Virginia creeper
- Lupine sp.	- *Weigelia* sp.
- Mountain-ash	

10.8 Species Accounts

Species accounts are provided for both significant species in the study area and for invasive species.

10.8.1 Significant Species Accounts

Vancouver Island Beggarticks (*Bidens amplissima* Greene)

Global Status: G
Provincial Status: S3
SARA Status: Special Concern
BC Status: blue

Vancouver Island beggarticks (Photo 10.9) is a Pacific Northwest endemic species found globally only in British Columbia and adjacent Washington State (Figure 10.1 and Figure 10.2) (Klinkenberg and Klinkenberg 2000). Most of the world population is found in British Columbia, with only a few stations reported from Washington.

Photo 10.9: Vancouver Island beggarticks (Bidens amplissima). Photo: Brian Klinkenberg

In British Columbia this species is found only in the Georgia Depression Eco-province in the southwestern corner of the province, where it is reported from southern Vancouver Island north to Comox and in the lower Fraser Valley. It is found in wet spots, including pond, lake and stream margins, bogs and associated willow wetlands, marshes, tidal estuaries, and ditches.

Vancouver Island beggarticks is most commonly confused with nodding beggarticks (*Bidens cernua*). However, flowerheads on Vancouver Island beggarticks do not nod, and when in flower, are readily separated by seed morphology (Figure 10.3). This species can also be confused with three-parted beggarticks when flowers are not present. However, during the flowering period they are easily distinguishable: the flowers of three-parted beggartick lack yellow ray petals.

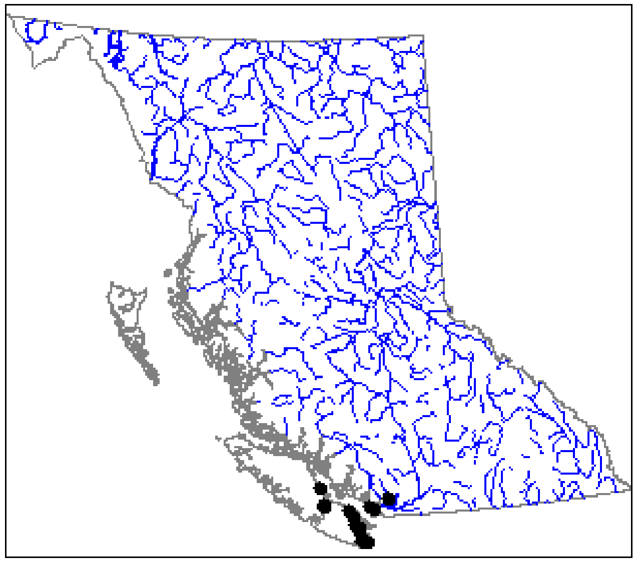

Figure 10.1: Distribution of Vancouver Island beggarticks (Bidens amplissima) in British Columbia. Source: E-Flora BC 2006.

Figure 10.2: Global distribution of Vancouver Island beggarticks (Bidens amplissima). Source: After Klinkenberg and Klinkenberg 2000.

Under the new species BC Conservation Framework that is currently being developed for the province[8], Vancouver Island beggarticks is one of the highest scoring species, if not the highest scoring species, for protection in the province (Fraser pers. comm. 2007). This evaluation is derived from several criteria including percentage of a

[8] This new system assesses provincial responsibility for species protection (Fraser 2007 pers. comm.).

species total range that is found in BC. *Bidens amplissima* has >90% of its global range in British Columbia.

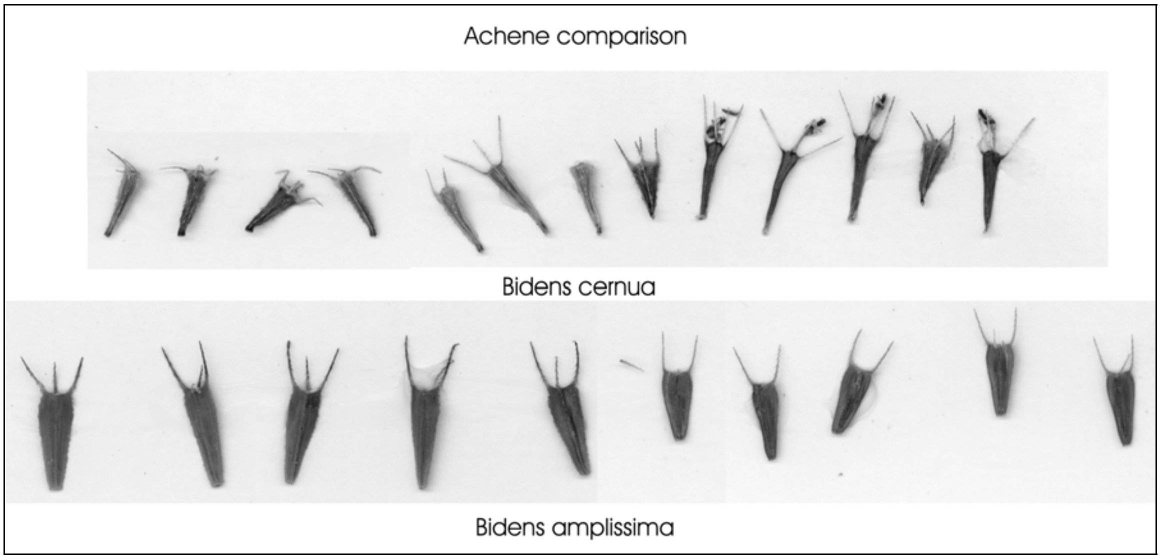

Figure 10.3: Seeds from Vancouver Island beggarticks and nodding beggarticks have different overall shape. Photo: Brian Klinkenberg.

Bog rosemary (*Andromeda polifolia* L.)

This species is uncommon in southwestern British Columbia (Figure 10.4), and in the past has been reported only from Burns Bog, Langley Bog and the Richmond Nature Park (Hebda et al. 2000). It is commonly found throughout the Lulu Island Bog, where it occurs at the southern limits of its range.

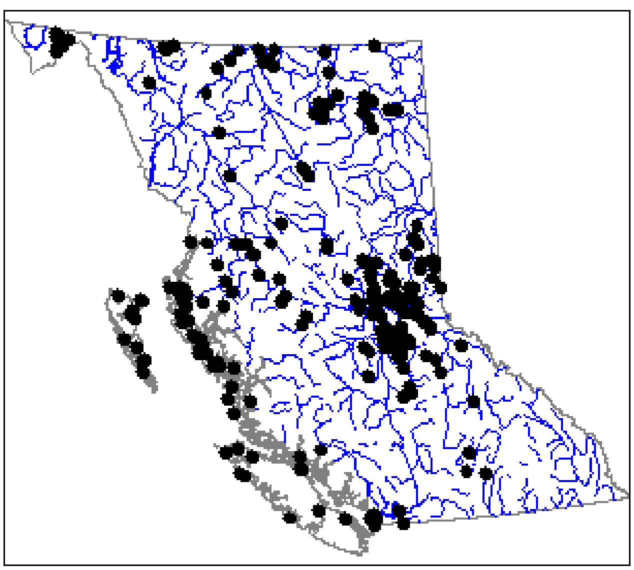

Figure 10.4: Distribution of bog-rosemary (Andromeda polifolia) in British Columbia. Source: E-Flora BC 2007.

Chamisso's cotton-grass (*Eriophorum chamissonis* C. A. Mey.)

Hebda et al. (2000: 183) report that, while this species ranges throughout BC (Figure 10.5), in our region it "was once widespread but now occurs only at Burns Bog and possibly at Richmond Nature Park" (as listed in Taylor 1973). During this survey, this species was found in the DND property. As with *Carex pauciflora*, this species is adversely impacted by drainage (Hebda et al. 2000), and its continued presence in the DND property may reflect the hydrological health of this property.

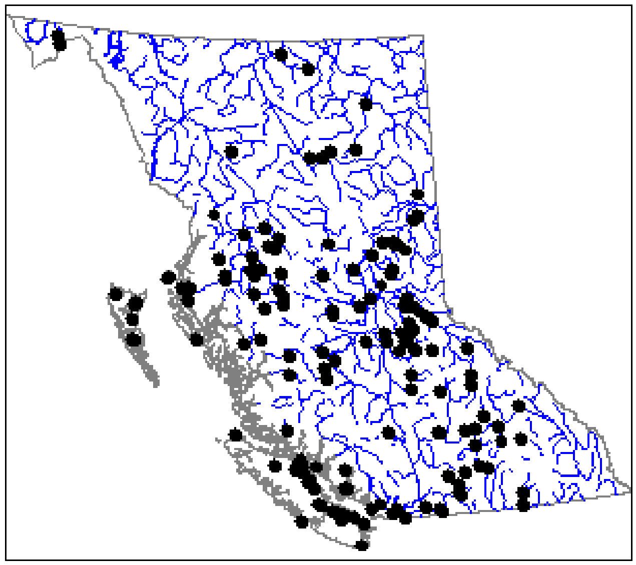

Figure 10.5: Distribution of Chamisso's cottongrass (Eriophorum chamissonis) in British Columbia. Source: E-Flora BC 2007.

Cloudberry (*Rubus chamaemorus L.*)

In British Columbia, cloudberry (Photo 10.10) is frequently found north of 55 degrees N (Figure 10.6) where it occurs as a dominant or common understorey species. However, it is infrequent to the south, including our region, where it reaches the southern limits of its distribution (Douglas et al. 1999). This is a regionally rare species.

Cloudberry is found in several habitats in our northern regions, including open and closed forests, bogs, muskegs, and open tussock tundra where it occurs as a dominant or co-dominant species (Coladonato 1993). In BC, this species ranges south to northern Vancouver Island, with sporadic sites occurring south of there, including in the Greater Vancouver Region where it is restricted to cold bog habitats. Taylor (1990) reports Burns Bog as containing the most southerly population in western North America.

Photo 10.10: Cloudberry (Rubus chamaemorus) re-sprouting over burned peat mat.
Photo: Brian Klinkenberg.

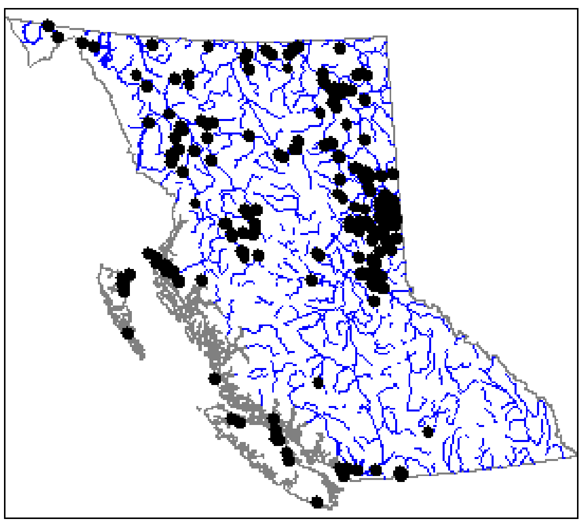

Figure 10.6: Distribution of cloudberry (Rubus chamaemorus) in British Columbia.
Source: E-Flora BC 2007.

Cloudberry is a shade tolerant species, and sprouts readily following fire (Coladonato 1993), and in the study area it is found abundantly in the DND property on previously burned sites, particularly on hummocks and in spots where Labrador tea has been killed or reduced by fire. This species is well known as a pioneer species that quickly moves in after a fire, although this may, in part, represent re-sprouting of dormant or semi-dormant plants. Cloudberry is frequent in the RNP east, where it is found on hummocks. It is also present in the RNP west, although in much reduced numbers, and relegated to only a few spots. This is a species that reaches its greatest percent cover in raised bogs (Coladonato 1993).

Few-flowered sedge (*Carex pauciflora* Lightf.)

Based on Hebda et al. (2000), the occurrence of this species in the DND property may be only the second record in our region (Figure 10.7). Because this species is sensitive to drainage and drying effects (Hebda et al. 2000), its continued presence in the bog may reflect the hydrological health of the DND property.

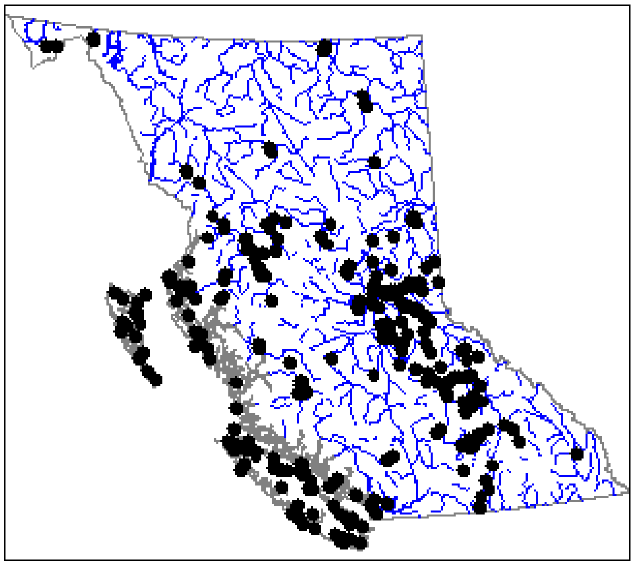

Figure 10.7: Distribution of few-flowered sedge (Carex pauciflora) in British Columbia. Source: E-Flora BC 2007.

Velvet-leaved blueberry (V*accinium myrtilloides* Michx.)

This species is found primarily in eastern BC and is rare in southwestern BC (Douglas et al. 1999) (Figure 10.8), where it occurs in the Fraser Lowland. It is found in both dry to mesic forests on sandy or rocky soils, and on hummocks in bogs.

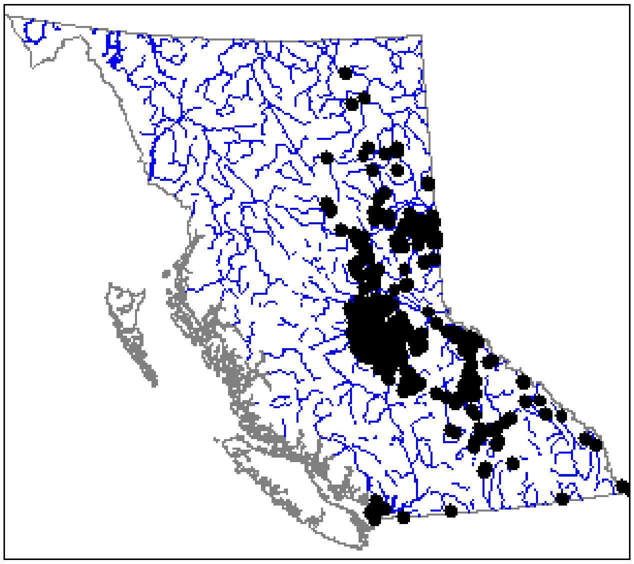

Figure 10.8: Distribution of velvet-leaved blueberry (Vaccinium myrtilloides) in British Columbia. Source: E-Flora BC 2007.

White beak-rush (*Rhynchospora alba* (L). Vahl.)

This regionally rare species (Figure 10.9) is reported from only three bogs in our region: Burns Bog (Madrone Consultants Ltd. 1999), Langley Bog (Douglas 1995; Douglas and Chapman 1998) and Richmond Nature Park (Taylor 1973) (Hebda et al. 2000). In this inventory, it is also reported from the DND property.

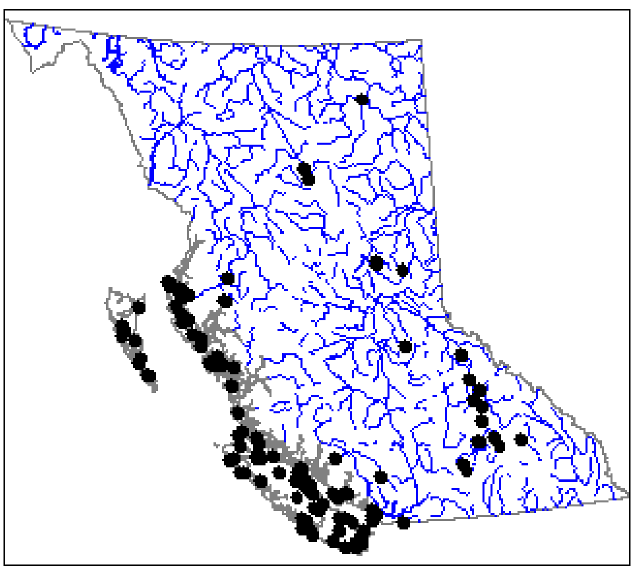

Figure 10.9: Distribution of White beak-rush (Rhynchospora alba) in British Columbia. Source: E-Flora BC 2007.

10.8.2 Invasive and Alien Species

European Birch (*Betula pendula Roth.*)

The Lulu Island Bog and other peatlands in Richmond are dominated[9] today by birch. Forming open to semi-closed canopies, this scrubby forest type is also found in other bogs in the region. The presence of birch in the Lulu Island Bog differs significantly from our bogs several decades ago, where dwarfed shore pines (*Pinus contorta* var. *contorta*) were the dominants in the tree layer (Photo 1.1). Birch is not a natural part of the Lulu Island Bog and is indicative of the drier growing conditions that are present as a result of drainage changes.

Identification of birch trees in the bog is challenging, as they appear to be a hybrid swarm. Some trees are recognizable as European birch (Photo 10.11) and a few as paper birch, but most show variable traits of these species and other birches that make identification difficult[10]. Lomer (pers. comm. 2007) indicates that the immaturity of many birch trees in the study area, and the great variability of key features, make identification bewildering. Reznicek (pers. comm. 2007) indicates that taxonomic work is needed to sort out the identification of birches generally, especially where hybrid swarms are present, and where there are several other species of birch (both native and non-native) present in the region. Birches are discussed in more detail in the footnote below[11].

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[9] Dominance in the study area is changing as a result of both die-off of the birch trees, and the effects of major windstorms over the last few years with resulting windthrow. Many previously forested areas are now open landscapes with sheared trees. This opening of the canopy will favour bog species and bog restoration if rewetting of the bog occurs.

[10] Birch species that could occur in the area include silver birch (*Betula pubescens*) and low birch (*Betula pumila* var. *glandulifera*).

[11] Variability of birches in our area is added to by the presence of other birches that may hybridize. Brayshaw (1976) discusses the presence of *Betula pubescens* in BC: "Introduced from Europe as an ornamental street tree, this species is occasionally seen growing in the peat lands of the Fraser River Delta and on southern Vancouver Island. On southern Vancouver Island it is accompanied by *B. pendula*, and intermediates between them, and by *B. papyrifera*." It is likely that this species is present, however no plants were observed in the study area that could be reliably identified as this species. What appears to be paper birch (*Betula papyrifera*) has been observed in the DND property, with some trees in the RNP west exhibiting characteristics of this species. The presence of paper birch in the study area is complicated in its own right. Brayshaw (1996) describes paper birch as "probably the most variable tree species in Canada" and provides insight into the taxonomic issues surrounding it. This species is well known for its easy hybridization with other birch species, and this could account in part for the morphological variation of birches in the study area. Paper birch exhibits considerable ecotopic variation, with six intergrading geographical varieties reported in Canada (Brayshaw 1976).

Photo 10.11: European birch (Betula pendula). Photo: Jamie Fenneman.

It is not known when the bog was first invaded by birch. Bell (1984) reports the presence of probable "hybrid birch" in the Richmond Nature Park in 1980, while Hanson (1940) reports a heavy invasion of the bog by western birch (reported as *Betula papyrifera*) as early as *circa* 1940. It is possible that this may actually have been invasion by European birch, as this species was collected on Lulu Island "in the peat bog" by Krajina in 1949 (UBC Herbarium collection—Krajina, 1949, Accession numbers V88005 and V8962). It may have arrived in the bog earlier than that. Hybridization may have occurred around that time or later. European birch has a predilection for bogs and marshes, and hybridizes easily.

European birch trees form a border around the perimeter of the three study area properties, with intrusions into the bog plant communities where it is abundant in the understorey and overstorey. In wetter sites, prevalence of this species is reduced and plants are much shorter. Birch produces a closed canopy in some part of the study area and reduces light levels reaching the *Sphagnum* mat and associated light-loving bog species.

Highbush or Swamp Blueberry (*Vaccinium corymbosum* L.)

Highbush blueberry (Photo 10.12) is a significant invasive species in our local bogs where it is spread from agricultural fields by birds and mammals. A shade intolerant species native to eastern North America that occurs in wet woods, bogs (where it can be a dominant species), edges of swamps and ponds, and occasionally in open acid sandy clearings (Soper and Heimburger 1982, Uchytil 1993b). It is a taxonomically complex species with at least 26 synonyms and many recognized varieties (Uchytil 1993b). Camp (1945) separated *V. corymbosum* into 12 species, however later treatments lumped these as a single species *V. corymbosum*. Soper and Heimburger (1982) recognize several varieties of *V. corymbosum* and include black highbush blueberry (*Vaccinium fuscatum* syn. *V. atrococcum*), a black-berried species[12], with *V. corymbosum*. However, other authors (Billington 1949) recognize *V. atrococcum* (syn *V. fuscatum*, *V. corymbosum* var. *atrococcum*) as a separate species.

Photo 10.12: Highbush blueberry (Vaccinium corymbosum) forms thickets in the Richmond Nature Park. Photo: Brian Klinkenberg.

Highbush blueberry ranges in height from nine to 12 feet (Billington 1949, Soper and Heimburger 1982, Uchytil 1993b). In the study area it can reach heights of 15 feet in shade. In sunlight, it forms a thick canopy that inhibits light penetration. It is abundant in the bog, with extensive growth and 100% dominance in parts of the RNP west and less abundant growth in the DND and RNP east. In the RNP east, growth is

[12] During plant inventory work in the DND property, we encountered a black-berried blueberry growing with *V. corymbosum*. This plant was not identified, but may represent an introduction of *V. fuscatum*. Further investigation of this is needed.

particularly thick to the east of the nature park pond, where low light levels and other factors have caused *Sphagnum* die off (see Chapter 22).

Highbush blueberry reproduces primarily by seed, rarely by rhizomes, and is easily dispersed by birds and mammals (Uchytil 1993b). Fire favours highbush blueberry and plays an important role in controlling trees and other shrubs that can shade out this species (Uchytil 1993b). While primarily distributed by seed, plants can sprout following fire (Uchytil 1993b).

Scotch Heather (*Calluna vulgaris* (L.) Hull)

Scotch heather is a fire following, introduced species from Europe that is now naturalized in eastern North America (Matthews 1993). In British Columbia, this species is generally rare in the lowlands zone in southwestern BC (Klinkenberg 2007), but it is an invader in peat areas. It is a low growing heath, reaching heights of 3.3 feet (Matthews 1993). It is a fire prone species that sprouts from stem bases following fire (Matthews 1993). In the DND property it is abundant (Photo 10.13) where small fires have been a frequent occurrence. It is scarce in the RNP west where it is reported only from an old burn site by the railway track but is abundant in the RNP east. Light to moderate fires may damage upper portions of the plant but do not damage stem bases or seeds. While this is a fire-following species, it cannot withstand hot fire and can, thus, be controlled by fire. In the study area, drier site conditions and periodic light fires may allow it to persist and increase in abundance in areas of recent fire. Heather is the third most common invasive plant species in the bog.

Photo 10.13: Scotch heather (Calluna vulgaris) is a dominant species in post-burn sites.
Photo: Brian Klinkenberg.

Controlling Scotch heather in the study area will be a challenge. Various methods have been used, including steam treatment (Norberg et al. 2001). This species is known to effectively exclude other vegetation and causes growth stagnation of conifer seedlings (Norberg et al. 2001).

English Holly (*Ilex aquifolium* L.)

English holly (Photo 10.8) is dioecious[13] broad-leaved evergreen perennial species with single or multiple stems that is grown ornamentally in the northwest US and Canada. It is native to the British Isles and Central Europe but is now naturalized in British Columbia, Washington, Oregon, California and Hawaii. English holly reproduces by seeds, layering and suckering. Introduced in BC for the small but active holly industry in BC, and in gardens as an ornamental, it has spread into mixed and coniferous forests, forest edges and hedgerows. It can grow as a dominant in forests, shading out groundlayer species and competing with native species for water, light and nutrients and is reported to suppress growth of native trees and shrubs. This species is readily dispersed by birds in our area and is targeted for removal in our region where it has become well established. It is one of the top twelve invasive species identified by the Greater Vancouver Invasive Species Council (2007).

In the study area this species is frequently encountered along nature park trails in the RNP west, and in forested/open forest areas in both the RNP east and west.

This species can be controlled by hand pulling of small trees and seedlings in moist sites, and cutting of larger trees. Because the tree will sprout from the base, repeated cuttings will be necessary but will eventually be successful.

10.9 Recommendations

Management activities in the study area should aim towards maintaining species health and diversity, and minimizing encroachments of alien species that would impact on bog ecology and species composition. Management in heavily disturbed sites should aim towards restoration of bog conditions and removal of invasive species. A general invasive species program should be initiated targeting the major ecosystem changing species. A “No Planting” list should be developed for the study area that particularly focuses on species that are easily dispersed by wind, or berried species that are easily dispersed by birds and other wildlife. Priority target species for removal and control should include Scotch heather, European birch, English holly, evergreen blackberry, Himalayan blackberry, and European mountain ash; Scotch

[13] Male and female flowers occur on separate plants.

broom, an incoming species, should be removed whenever it is encountered. These are significant ecosystem disrupters.

CHAPTER 11: BRYOPHYTES OF THE LULU ISLAND BOG

By Wilf Schofield

11.1 Introduction[1]

While mosses are widely distributed over the earth's surface, many mosses have special requirements. Some, for example, grow only on decayed animal waste, while some grow best in habitats with high illumination and humidity, such as wetlands. Many mosses flourish in wetlands, including the peat mosses – *Sphagnum* species. While many moss species occur in the Lulu Island Bog, it is the *Sphagnum* mosses that are the key to the bog ecosystem (Photo 11.1). Each of the many species of *Sphagnum* has a particular type of site in which it thrives. Some are confined to wet depressions in the bog, others to the drier margins. Still others tolerate only a certain amount of acidity and die if this is exceeded, and then are replaced by mosses that can tolerate the altered conditions.

Photo 11.1: Sphagnum pacificum. Photo: Brian Klinkenberg. ID: Wilf Schofield.

Sphagnum forms extensive quaking carpets in bogs and around lakes and ponds, especially in the boreal coniferous forest. Some species of *Sphagnum* are aquatic and float in the marginal waters of quiet bodies of water. As they grow, these mosses absorb chemical substances from the water, leaving it highly acidic. This acid water inhibits decay and permits few organisms to survive in it.

[1] This brief introduction is adapted from Schofield (1992)*: Some Common Mosses of British Columbia*. Royal British Columbia Museum Handbook.

In a natural setting, *Sphagnum* growth can inhibit the growth of forest trees. In some areas, the *Sphagnum* expands from an open bog into the floor of the adjacent forest. The expansion of the *Sphagnum* population means that the growing moss absorbs water from adjacent *Sphagnum* in the water. The whole population acts as an immense absorptive sponge as water moves from the waterbody or wet bog outward to the perimeter of the colony. If the perimeter invades a forest, the water brought to the forest floor can drown the roots of the trees and kill them. The death of the trees increases illumination at ground level and improves moss growth – the *Sphagnum* population expands further into the forest. The destruction of forests by the encroachment of *Sphagnum* bogs can be significant, particularly in northern BC.

Liverworts in general are widespread and can be abundant, but they are much less common than mosses (Schofield 2002). In peatlands, liverworts are often abundant (Schofield 2002). Searching for the bryophyte flora of a site requires searching on different substrates and at different heights (Photo 11.2).

Photo 11.2: Wilf Schofield exploring the willow wetland for bryophytes. Photo: Brian Klinkenberg.

11.2 Regional Perspective

The bryophytes (mosses and liverworts) of the Lulu Island Bog represent a fraction of the bryophytes that would have existed in the original extent of the (Greater) Lulu Island Bog prior to significant human disturbance. The peat mat in some sections of the bog is badly disturbed and considerably drier than it would have been in an undisturbed state. The mosses, upon which a living peatland depends, have died off in a good portion of the nature park property (RNP west and east), and in some spots

Sphagnum species are now confined to small surviving patches, resulting in a reduced diversity. Invasion by the aggressive highbush blueberry (*Vaccinium corymbosum)* is probably the main negative influence on these mosses, utilizing moisture as well as shading them out. Few peatland liverworts persist.

In spite of this, there are indications that the Lulu Island Bog ecosystem in general is still a viable ecosystem. Fourteen species of *Sphagnum* have been reported for the Fraser Lowlands region (Hebda et al. 2000), some of which are primarily coastal species (Schofield 1992). Of these, 11 are reported here for the Lulu Island Bog. Burns Bog supports thirteen species of *Sphagnum*, and Hebda et al. (2000) indicate that this represents 80% of the regional *Sphagnum* flora. A comparison of the mosses of the Fraser lowland, Burns Bog and the Lulu Island Bog is presented in Table 11.1.

Table 11.1: Sphagnum mosses of the Fraser Lowlands, Burns Bog, and the Lulu Island Bog. Source: Hebda et al. 2000.

	Fraser Lowlands	Burns Bog	Lulu Island Bog
S. angustifolium	x		
S. austinii	x	x	
S. capillifolium	x	x	x
S. cuspidatum	x	x	
S. fimbriatum	x	x	x
S. fuscum	x	x	x
S. henryense	x	x	x
S. magellanicum	x	x	x
S. mendocinum	x	x	x
S. pacificum	x	x	x
S. palustre	x	x	x
S. papillosum	x	x	x
S. squarrosum	x	x	x
S. tenellum	x	x	x

A checklist of bryophytes (mosses and liverworts) is provided in Appendix D-1.

11.2.1 Significant Species

A few sites in the Lulu Island Bog harbour some species otherwise rare or unknown elsewhere in the Lower Mainland, and not widely distributed elsewhere: the native mosses, *Orthotrichum pulchellum* and *Sanionia symmetrica*, both epiphytes and not characteristically peatland species. These are ecologically demanding species, being confined mainly to high humidity sites; these are supplied in the study area in a single area where shrubby cover, coupled with long-persistent standing water, provide ideal conditions. These species are of restricted distribution in North America (Figure 11.1 and Figure 11.2).

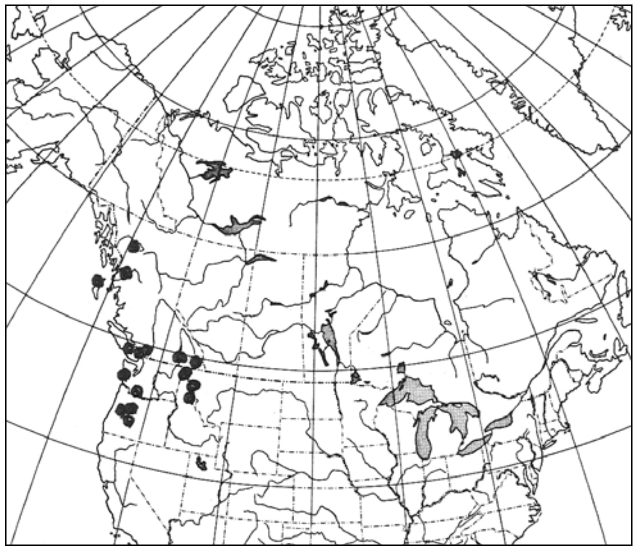

Figure 11.1: North American distribution of Orthotrichum pulchellum. Map: Wilf Schofield.

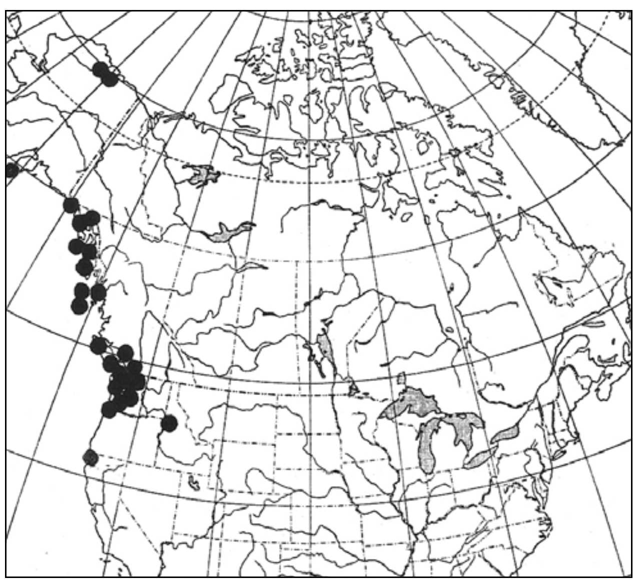

Figure 11.2: North American distribution of Saniona symmetrica. Map: Wilf Schofield.

11.2.2 Introduced Species

The history of the introduction of the moss *Campylopus introflexus* from the Southern Hemisphere remains mysterious. This represents one of the two Canadian localities: it is more richly represented in Burns Bog. The Richmond site is in the RNP west property near the nature house.

11.3 Importance of Protecting the Lulu Island Bog

The Lulu Island Bog is important to protect in spite of its disturbed condition. With protection and removal of invasive plants and animals, the human impacts can be lessened in time, which would make a return to healthy peatland possible. Without protection, the peatland is doomed. A dying peatland emits carbon dioxide and other greenhouse gases, adding to the problems of climatic change. A living peatland is a carbon sink; it absorbs carbon dioxide, thus reducing greenhouse gas emissions and reducing the rapidity of climatic change.

CHAPTER 12: FUNGI OF THE LULU ISLAND BOG

By Terry Taylor

12.1 Introduction

Fungi form an invisible web that ties together terrestrial ecosystems. These ecosystems could not exist without them. They can be grouped into three basic lifestyles—saprophytic, parasitic, and mycorrhizal. The saprophytic species are those that take up nutrients from downed wood, leaves and other organic debris and recycle their constituents back to the soil and air, making those components available for other living things. Parasitic species are those that take their nutrient requirements from organisms that are still living, and mycorrhizae are those fungi that form a mutually beneficial association with the roots of plants. Most plants depend upon these mycorrhizal fungi. Mycorrhizal fungi collect water and dissolved nutrients, delivering them to the roots to which they are attached. In return, those fungi take some of the sugars manufactured by the plant's leaves, and use them for their own sustenance.

Photo 12.1: Hoof fungus (Fomes fomentarius) is a parasite and a decay species found on birch.
Photo: Brian Klinkenberg.

Most fungi grow as mold threads, which are not easily distinguished from each other. The parts that enable us to identify them are usually the reproductive organs, which are often large enough to see without difficulty. Mushrooms are large examples of such reproductive structures. They produce spores that function as microscopic seeds. The big mushrooms are usually produced by mycorrhizal fungi. They are able to secure large amounts of carbohydrate from their associated trees, and are thus able to make large fruiting bodies. The small mushrooms are usually fruits of saprophytic species that are living on rotten wood or old leaves. Large bracket fungi that grow on living trees are examples of parasites (Photo 12.1).

12.2 The Lulu Island Bog

A survey of the macrofungi of the Lulu Island Bog was undertaken in 2002. Fungi had been surveyed in the RNP west in the early 1970's, but no formal inventory of the fungi has been undertaken in the RNP or adjacent boglands since that time.

12.3 Methods

The fungi were surveyed on six days during the spring, fall, and winter of 2002, and one day in the fall of 2004. The fungi are mostly terrestrial although there were also searches for wood decay species and leaf parasites. Surveys were conducted along the trail systems in each of the three properties and in off-trail areas. Fungi were primarily identified in the field with the help of a 16x lens. Arora (1986) was consulted to help identify unfamiliar specimens.

12.4 Results

Since mushrooms usually appear during the autumn rains, when there is sufficient moisture for their growth, there will be more of them during mild wet seasons than during dry ones. The survey year, 2002, had a dry autumn. Therefore, there were fewer species found than would be expected. In a more favourable year many more kinds than those identified in this report would be recorded. However, enough were located to show that the Lulu Island Bog is important for the conservation of Richmond's fungal biodiversity. Thirty four species were found in the RNP east, 29 in the RNP west, and 27 in the Department of National Defence lands. A species list of fungi in the study area may be found in Appendix D-3.

As mushrooms are less common in the nutrient-poor, wet conditions typical of boglands, it is not surprising that the mixed woodlands of the park's eastern property showed a slightly higher fungal diversity than the other sites. In all three areas the species encountered tended to be those associated with pine and birch trees, and the continued survival of those trees is, of course, necessary for the continued survival of the fungal biodiversity dependent upon them.

Amanita muscaria [var. *flavivolvata*], a mycorrhizal mushroom was found, in association with birch trees, in all three sites. Other birch mycorrhizal partners observed were *Lactarius glyciosmus, Paxillus involutus*, and *Leccinum scabrum*. Decay species found on birch wood include *Ganoderma applanatum, Fomes fomentarius, Trametes versicolor*, and *Xylaria hypoxylon* (Photo 12.1, Photo 12.2, and Photo 12.3). The *Trametes* is used medicinally in Japan.

Photo 12.2: Leccinum scabrum is a mycorrhizal partner of birch. Photo: Kent Brothers.

Photo 12.3: Paxillus involutus is also associated with birch in the bog. Photo: Brian Klinkenberg.

Lactarius rufus is mycorrhizally connected to pine. Also found on the pine trees are spherical galls caused by the rust fungus *Endocronartium harknessii*. These are only

found on two-needle pines, and form microhabitats for mosses and lichens not normally found on pine trees.
Again, it should be emphasized that the fungi found during this survey are species located during an autumn that was much drier than normal. There are many more fungi in the Lulu Island Bog than those recorded here. Also, several of them could only be identified to genus level. There may very well be other rare species present that would require detailed study before identification is possible.

12.3.1 Significant Fungi Species of the Lulu Island Bog

Amanita novinupta

The most significant finding in the bog was *Amanita novinupta*. This mycorrhizal species is extremely rare in British Columbia. It is closely related to *Amanita rubescens* of eastern North America, and was previously considered a form of that species. It is not recorded in *'Macrofungi of British Columbia*: *Requirements for Inventory'*, by Scott Redhead. This inventory by the BC Ministry of Forests Research Program lists the mushrooms reported for the province, as of 1997. It grows under a birch tree beside the nature house.

Daldinia concentrica

Another find of interest is *Daldinia concentrica*. This wood decay fungus is seldom encountered in our area.

CHAPTER 13: LICHENS OF THE LULU ISLAND BOG

By Terry Taylor

13.1 Introduction

Lichens are small plants that most people think of as mosses, if they think of them at all. However, they are not mosses, but members of a completely different group of organisms with a unique lifestyle. They can be ubiquitous, and grow in many different habitats – on trees, the ground, or rocks. They tend to live in drier sites than mosses do. Thus, whereas mosses usually grow on the moister parts of a tree, where water accumulates or flows, lichens tend to grow on the drier, overhanging part of the trunk, or exposed parts of branches in direct sunlight. On a geographical scale the same partitioning can be observed between the Lower Mainland and the Fraser Canyon. The coastal rainforests are dominated by mosses, whereas the drier interior forests have fewer mosses but many lichens (Photo 13.1).

Photo 13.1: Cladonia furcata is found in the Lulu Island Bog. Photo: Kent Brothers.

The pale colour of a lichen is a result of the colourless fungal tissue that constitutes over 80% of its volume. This tissue is an aggregation of microscopic mold threads. Embedded within these threads are the cells of an alga - a microscopic plant. The plant uses photosynthesis to make sugars, and some of these are taken by the fungus to build its own tissues. The mold in return protects the plant within it from predators, mechanical damage, and desiccation. Thus a lichen is not a single organism. It is a relationship between two organisms so closely connected and so dependent on each other that they grow and function as one individual. This symbiotic relationship has been referred to as the fungus that discovered agriculture.

There are three growth forms exhibited by lichens: crustose, foliose, and fruticose. The crustose form contains the greatest number of species and is structurally the simplest. This simplicity makes crustose species the most difficult to study and identify, as they usually produce a simple grey crust growing on rocks or tree trunks. Different species look the same or very similar, and chemical or microscopic techniques are often required in order to distinguish one species from another. For example, the pale patches on alder trees are not part of the bark, but various species of crustose lichens that are growing on that bark. Foliose forms are flat and leaflike. Like leaves, their flatness increases the surface area available for collecting sunlight. The fruticose species grow in the shape of small shrubs or hang like streamers from tree branches (Photo 13.2).

Photo 13.2: A variety of lichens are found in the RNP east property. Photo: Kent Brothers.

13.2 The Lulu Island Bog

A survey of the lichens of the Lulu Island Bog was undertaken in 2002. Lichens had been surveyed in the RNP west in the early 1970's, but no formal inventory of the lichens has been undertaken in the RNP or adjacent boglands since that time.

13.3 Methods

The lichens were surveyed on 5 days by the author during the spring and summer of 2002 and identified in the field with a 16x lens. Some specimens that were difficult to identify were collected and identified using Goward et al. (1994), McCune and Geiser (1997), Goward (1999), and Brodo et al. (2001). Most surveys were conducted along the trail systems in the study area, but off-trail sites were also studied.

13.4 Results

Lichens do not adapt well to urbanization. It destroys habitats in which they flourish and exposes them to increased air pollution, to which they are very sensitive. This is one reason there are generally fewer lichens on city trees than on trees outside urban areas. Since the level of sensitivity varies from one species to another, they have been used to monitor air pollution levels (Van Dobbin and ter Braak 1999, Nash and Gries 2002, Loppi et al. 2004).

In the past several decades, the City of Richmond has been experiencing rapid urban and industrial expansion, the abundance of lichens and number of lichen species has markedly declined. The first vegetation surveys of the Richmond Nature Park were conducted in 1972, at which time lichens were much more common and larger than at present. However, the park and the adjacent Department of National Defence (DND) lands still retain significant remnants of lichen biodiversity (Photo 13.3).

Photo 13.3: Coastal reindeer lichen (Cladonia portentosa) is found in the DND property.
Photo: Kent Brothers.

Seventeen lichen species were recorded in the RNP west, 21 in the RNP east, and 29 in the DND property. Although there has been a decrease in lichen species over the last 30 years, the study area is still important on a regional level for lichen conservation.

A checklist of the lichen species of the Lulu Island Bog is found in the Appendix D-2 of this report.

13.5 Discussion

No rare species were found during this survey. The species recorded were typical for the habitat types present in the study area. Appearances, however, may be deceptive. Crustose species were only tentatively identified using field methods and not studied microscopically. Rare species, not just rare lichens, tend to be more difficult to identify than common species. As they are rare, there is a greater possibility they will be unfamiliar, and will be overlooked or misidentified.

More detailed studies would undoubtedly reveal additional species not recorded during this survey. Comparisons with the lichens recorded in 1972 and those presently found in Burns Bog give some idea of the lichen flora that was likely present at a time when the Lulu Island Bog was larger and less polluted.

Another factor that probably contributes to the loss of lichen diversity is the increasing encroachment of domestic blueberry bushes in the bog. In summer a dense canopy of blueberry leaves casts shade over ground-dwelling lichens and mosses. During the autumn the leaves fall to the ground and serve to continue blocking the sunlight.

The greater number of species found in the DND property than in either section of the Richmond Nature Park shows the importance of that area for the preservation of lichen diversity in Richmond. Not only is it more species rich, but the DND land increases the area of the Lulu Island Bog by one third, and biodiversity for most organisms often increases with increasing area.

CHAPTER 14: AQUATIC INSECTS OF THE LULU ISLAND BOG

By Karen Needham and Rex Kenner

14.1 Introduction

Bogs are specialized aquatic habitats. Due to the presence of *Sphagnum* mosses, their waters are strongly acidic and low in dissolved nutrient content. Not surprisingly, few organisms can survive in these extreme conditions. However, several insect species have not only managed to survive, but thrive, in the acidic waters of bogs.

Photo 14.1: Paddle-tailed Darner (Aeshna palmata).
Photo: G. P. Doerksen, courtesy of the Royal British Columbia Museum.

To date, the only summary of aquatic insects[1] in bogs, fens, and marshes in Canada is Rosenberg and Danks (1987). Each chapter in their compilation covers a major insect group, summarizing the number of species by province and giving the general ecology for some. Most of the restricted species are confined to bogs rather than fens or marshes, owing to the specialized nature of bog habitats. For instance, of 107 species of aquatic *Coleoptera* found in bogs in Canada, 20 species (19%) are bog-restricted specialists. The greatest percentage of specialists is found in the *Odonata*, with 14 out of 63 species (22%) restricted to bogs.

[1] For a list of the terrestrial beetles found in the Richmond Nature Park (RNP west), see Appendix D-6.

Scudder (1994) brings together our current knowledge of the potentially rare and endangered freshwater and terrestrial invertebrates in British Columbia. Most of the species listed are insects, with aquatic specialists found mainly in bogs and hot springs.

Olerick (1983) documented a number of aquatic invertebrate samples from the Richmond Nature Park's west property for educational purposes, but there have been no formal aquatic invertebrate surveys in the study area. In a brief survey of the invertebrate fauna of Burns Bog (Kenner and Needham 1999), over 400 species were identified. Nine species reported from the bog are considered to be rare or potentially rare: two ground beetles (order *Coleoptera*, family *Carabidae*), two waterboatmen (order *Hemiptera*, family *Corixidae*), two butterflies (order *Lepidoptera*, family *Lycaenidae*), and three dragonflies (order *Odonata*, Families *Aeshnidae* and *Libellulidae*) (Photo 14.1, Photo 14.2, and Photo 14.3).

Photo 14.2: Kirby's Backswimmer (Notonecta kirbyi).
Photo: R.A. Cannings and M.B. Cooke, courtesy of the Royal British Columbia Museum.

However, in order to know what is truly rare, one must know what is common. Scudder's (1994) list serves to highlight gaps in our systematic knowledge. It is only for the better-studied groups that details are available. In addition, it is often difficult, if not impossible, to obtain keys for identifying species from lesser-known groups. The reality is that for most invertebrates, which make up 95% of the animal kingdom, we have no information on even their most basic biology. Clearly, further inventory work and research on collections is needed. Thus, studies such as the Lulu Island Bog inventory are crucial for adding to this knowledge, so that we are better able to place new discoveries in a regional and provincial context.

Photo 14.3: Cardinal Meadowhawk (Sympetrum illotum). Photo: Dave Ingram.

14.2 Methods

Aquatic habitats were sampled by sweeping standing water with heavy, steel-framed nets fitted with coarse mesh. Arthropods were removed from the nets by hand and transferred into 70% ethanol for transport back to the lab. To capture insects associated with *Sphagnum*, large mats of moss were placed on a metal sieve above a white plastic tray containing water. Insects would wriggle free of the moss and land in the water below, where they were removed and preserved as above. While sampling aquatic habitats, we also opportunistically captured flying insects using finer meshed aerial nets, and collected terrestrial arthropods using beating sheets on emergent or overhanging vegetation.

Voucher specimens for this study have been deposited at the Spencer Entomological Museum (SEM), Department of Zoology, University of British Columbia.

14.3 Results

A checklist of the insects of the Lulu Island Bog may be found in Appendix D-5 of this report. This checklist lists insects (primarily aquatic) collected on the

Department of National Defence (DND) lands, in the Richmond Nature Park (RNP west), and in the Richmond Nature Study Area (RNP east) for the 2002, 2003, 2004, and 2005 field seasons. In 2002, collections were made from May - October in the RNP west but only from May - July on the DND lands, since there was a lack of standing water after that time. In 2003, collections were conducted in June at the RNP west and in March and October on the DND lands. In 2004, one collection was made on the DND lands in May, and in 2005 one collection was made in RNP west in September.

It is important to note that an absence of a species from the checklist in one of the three locales does not necessarily mean that it is not there. Insects are mobile and have a variety of complex life histories, so any attempt to infer distributional patterns from a small data set over the short distances between these field sites could be misleading.

14.3.1 Significant Species Accounts

To date, a few notable species of insects have been identified on the DND lands or in the Richmond Nature Park:

Agonum belleri

A potentially rare ground beetle, (order Coleoptera, family Carabidae), was taken from the DND property in 2004. To date, only two specimens of this species exist in the Spencer Entomological Museum (SEM), and a database survey of five other major collections which contain BC material uncovered only a further 16 records, most from the Queen Charlotte Islands. A close relative, *Agonum mutatum*, was also found in the DND. Both of these beetles are exclusive to peat bogs.

Agabus verisimilis

This diving beetle, (order Coleoptera, family Dytiscidae), represents both a range extension and a habitat type expansion. It had previously only been known from subalpine habitats, mainly in the Rockies. One specimen that we discovered was under a wet log in the RNP East willow swamp. This was a teneral adult, showing evidence of breeding.

Hydaticus aruspex

This species (order Coleoptera, family Dytiscidae) belongs to a rare genus of diving beetles.

Cyphon exiguus
C. exiguus (order Coleoptera, family Scirtidae) is a rare beetle associated with marshes and bogs, and in Canada is found only in British Columbia.

Procloeon spp.
This specimen (order Ephemeroptera, family Baetidae) is an as-yet unidentified species, belonging to a rare genus of mayflies.

Cenocorixa blaisdelli
C. blaisdelli is a rare species of waterboatmen (order Hemiptera, family Corixidae), which in Canada is confined to extreme southwestern British Columbia.

Most of the odonate species recorded in this study are common and widespread in the Lower Mainland. However, several are of particular interest:

Beaverpond Baskettail
Epitheca canis
Of particular interest is the record for the Beaverpond Baskettail (order Odonata, family Corduliidae) at the pond in the northeast corner of Richmond Nature Park (Photo 14.4). This is the first record for this blue-listed species in Richmond. In the Lower Mainland, they are otherwise only known from Pitt Meadows, Colony Farm, and Surrey Bend (Kenner 2000).

Photo 14.4: Beaverpond Baskettail (Epitheca canis). Photo: Ian Lane.

Autumn Meadowhawk
Sympetrum vicinum

Also of note is the blue-listed Autumn Meadowhawk (Photo 14.5), which was collected in the fall of 2005 from the central pond at Richmond Nature Park. This species has previously been collected at Burns Bog, but this is the first record of it in Lulu Island Bog.

Although most of the dragonflies and damselflies in the Species List are listed only for Richmond Nature Park, this is, in part, a function of the fact that these species can be very difficult to catch away from their breeding habitat. At least four different species of dragonflies have been seen feeding in the DND Lands. The actual number of species using this area is likely much higher. However, it is improbable that any odonate species actually breeds in the DND on a continuing basis as it dries out too early in the summer. The lower number of records in the RNP East study area is also not surprising, since the heavy forest cover reduces its attractiveness for these sun-worshipping insects.

Photo 14.5: Autumn Meadowhawk (Sympetrum vicinum). Photo: Ian Lane.

CHAPTER 15: BUTTERFLIES OF THE LULU ISLAND BOG

By Don Benson

15.1 Introduction

A person interested in wildlife can see a lot of different kinds of birds in the Vancouver region, but not many different kinds of butterflies. For butterfly lovers, the sad fact is that in our area we don't have many different kinds of butterflies. The number and diversity of butterflies in the Okanagan Valley, for example, is high compared to the Vancouver region and coastal British Columbia in general (Guppy 2001). One of the reasons for this is that most natural habitats on the coast have been covered with coniferous forests for thousands of years. Most butterflies use grasses and herbaceous plants as larval foodplants and hence reach their greatest diversity in grassland communities like those in the Okanagan where there is a high diversity of herbaceous plants (Guppy 2001). Another reason is that the cool wet weather on the coast depresses butterfly abundance for those species that are present (Guppy 2001). A third reason is that the Coast Mountains act as a barrier, preventing colonization from the interior of British Columbia (Guppy 2001).

Although southeastern Vancouver Island is on the coast, it too has more butterflies than the Vancouver area. This is because southeastern Vancouver Island, like the Okanagan, has a drier climate and a greater diversity of grasses and herbaceous plants than the adjacent mainland. The Garry oak meadows and grassy knolls on southern Vancouver Island are wonderful places to view butterflies (Tatum 1986). Unfortunately we don't have anything like them in the Vancouver area. But we do have butterflies, and one place to look for them is in the Lulu Island Bog.

The Georgia Depression Ecoprovince or Georgia Basin defines the area in and around the Strait of Georgia. The Canadian portion of the Georgia Basin includes the Fraser Lowland, Sunshine Coast, Gulf Islands and the southeastern part of Vancouver Island (Campbell 1995). The Fraser Lowland Ecosection is the area containing the Fraser River delta, estuary, lowlands and associated uplands (Campbell 1995). Campbell (1995) lists 25 butterflies and 2 skippers as "those most likely to be seen in the Georgia Basin." The skippers and all but three of the butterflies on the Georgia Basin list are found in the Fraser Lowland. Another 25 species are grouped under the heading "Uncommon Butterflies, Georgia Basin." Few of the uncommon butterflies ever turn up in the Fraser Lowland; most are found on Vancouver Island or in mountain or subalpine habitats. A few occur as rare migrants.

Combining records compiled by Ashton (1992) and Perdichuk (1999), Kenner and Needham (1999) list 18 butterflies and two skippers for Burns Bog. Vandermoor's list (Vandermoor 2003) for Richmond includes 15 butterflies and two skippers. None of Vandermoor's records are for butterflies collected in the Lulu Island Bog (Vandermoor 2002-2007). In 2002 and 2003 I looked for butterflies in the Lulu Island Bog and found a total of nine butterflies and two skippers.

In this report the term "Lulu Island Bog" refers to the survey area rather than the original bog, which would have covered a much larger area. A considerable portion of the bog in the survey area has been eliminated to accommodate roads, railway track, park buildings and parking lots. As a result of these developments, a number of plants and butterflies are found in the survey area that would not have been part of the original bog flora and fauna.

15.2 Methods

The butterflies of the Lulu Island Bog were inventoried and assessed in 2002 and 2003. This was achieved by conducting fieldwork in the study area, a general literature review on butterflies of the region, and a review of species previously reported for the Richmond Nature Park and the Richmond area.

In 2002, I visited the study area 28 times between April 19 and September 22. In 2003, I visited the study area 18 times between April 30 and August 8. During fieldwork, butterflies were identified by sight only. Voucher specimens were not collected. Attempts were made to photograph butterflies, but with limited success.

Some parts of the survey area were visited much more frequently than other areas. Those areas that received the fewest visits were the wooded areas of the RNP, the west side of the DND and the RNP East.

15.3 Results

Table 15.1 is a list of the butterflies and skippers that I saw in the Lulu Island Bog in 2002 and 2003. A list of the butterflies of the Georgia Basin, Fraser Lowland, Richmond, Burns Bog and the Lulu Island Bog is included in the Appendix D-7 of this report. This list was compiled in order to show how the butterflies of the Lulu Island Bog fit into a regional framework. The species accounts contain information on abundance, flight times, locations and foodplants (the word "foodplant" refers to a plant that a caterpillar or butterfly larva feeds on). Ian Lane provided voucher photographs for three butterflies. Table 15.2 shows the species previously reported from the RNP by Harvey (1974). For a discussion of her findings see the Discussion section below.

Table 15.1: Observed Butterflies of the Lulu Island Bog

Scientific Name	Common Name
Hesperiidae	Skippers
Thymelicus lineola	European Skipper
Ochlodes sylvanoides	Woodland Skipper
Papilionidae	Swallowtails
Papilio rutulus	Western Tiger Swallowtail
Pieridae	Whites
Neophasia menapia	Pine White
Pieris rapae	Cabbage White
Lycaenidae	Gossamer Wings
Incisalia iroides	Western Elfin
Incisalia eryphon	Western Pine Elfin
Strymon melinus	Grey Hairstreak
Celastrina echo	Western Spring Azure
Nymphalidae	Brushfoots
Polygonia satyrus	Satyr Anglewing
Limenitis lorquini	Lorquin's Admiral

Table 15.2: Harvey's Butterfly Records for the Richmond Nature Park (1974)

Scientific Name	Common Name
Papilio turnus	Tiger Swallowtail
Pieris rapae	Cabbage White
Everes comytas	Eastern Tailed Blue
Nymphalis antiopa	Mourning Cloak
Vanessa cardui	Painted Lady
Vanessa atalanta	Red Admiral

15.3.1 Species Accounts

Abundance - Abundance in Survey Area
L - never more than one butterfly seen on a two to three hour visit
M - at least two and no more than nine butterflies seen on at least one visit
H - on at least one visit, 10 or more seen

Cabbage White *(Pieris rapae)*

Conservation Status: Not of concern. A widespread introduced exotic species.

Voucher: Sight only

Abundance: M

Flight Time: March to October

Foodplants: Wild radish (*Raphanus raphanistrum*) and other plants in the mustard family (Guppy and Shepard 2001).

Comments: Cabbage Whites are seen in many types of habitats, including bogs, meadows, woods, farms, vacant lots, and urban and suburban gardens. Despite the fact that wild radish and other plants in the mustard family are not common in the survey area, cabbage whites were often seen in the RNP parking lot, along the railway tracks and in the bog.

European Skipper *(Thymelicus lineola)*

Conservation Status: Not of concern; an introduced exotic species

Voucher: Sight only

Abundance: M

Flight Time: June and July

Foodplants: Grasses. Probable foodplant in the study area is colonial bentgrass (*Agrostis capillaris*), a common introduced weedy species found on disturbed sites.

Comments: The European Skipper is a recent introduction to our area. Guppy and Shepard (2001) write that it "was recorded in Burnaby in 1991, but may not yet be established in the Fraser Valley." It is listed in Campbell (1995) with uncommon butterflies of the Georgia Depression Ecoprovince. I have seen it at Boundary Bay and in the Alaksen National Wildlife Area in delta, in the Terra Nova Natural Area in Richmond, and at Cypress Bowl on the North Shore. In the survey area it was found along the railway tracks and in the grassy area in the Highway 99 corridor. It seems to be most common in areas where bentgrass is found.

Grey Hairstreak *(Strymon melinus)*

Conservation Status: Not of concern

Voucher: Photographs by Ian Lane

Abundance: M

Flight Time: April to September

Foodplants: A variety of plants including leaves of clovers (*Trifolium* spp.), salal flowers and berries (*Gaultheria shallon*) and pearly everlasting (*Anaphalis margaritacea*) (Tatum 2003, Guppy and Shepard 2001).

Comments: In the Lulu Island Bog there are two broods, with adults appearing in May and again in July. They are found along the Bog Forest Trail in the RNP and in the railway corridor. They occur in close association with salal and were often seen flying around the smaller shoots springing up next to the Bog Forest Trail and the railway tracks. They were also seen basking on salal leaves and nectaring on salal flowers. Cranberry flowers are a favourite source of nectar for the Grey Hairstreak, and I often saw them nectaring on cranberry flowers on the west side of the RNP in early to mid July. On July 17, 2003 I saw a Grey Hairstreak depositing eggs on salal along the Bog Forest Trail. It laid a single egg on the calyx of a salal flower that had dropped its corolla but had not yet begun to swell with the ripening fruit. David Blevins reared a Grey Hairstreak on salal berries. The full-grown caterpillar was eating one salal berry per day (Blevins 2003).

Lorquin's Admiral *(Limenitis lorquini)*

Conservation Status: Not of concern
Voucher: Sight only
Abundance: M
Flight Time: May to September
Foodplants: Primary foodplant at Burns Bog is hardhack (*Spiraea douglasii*); secondary foodplant at Burns Bog is birch (*Betula* sp.) (Ashton 2003).
Comments: Lorquin's Admirals prefer grassy areas next to shrubs or trees (Guppy and Shepard 2001). In July 2002 one Lorquin's Admiral was seen in the railway corridor. In early July 2003 two males were seen perching about 100 metres apart in the railway corridor. Lorquin's Admirals may be resident in the railway corridor where their foodplants (hardhack and birch) are abundant.

Pine White *(Neophasia menapia)*

Conservation Status: Not of concern
Voucher: Sight only
Abundance: M
Flight Time: July to September
Foodplants: Various conifers including Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) (Guppy and Shepard 2001). Probable foodplants at the RNP are Eastern white pine (*Pinus strobus*) and Scotch pine (*Pinus sylvestris*).

Comments: The Pine White (Photo 15.1) is the one butterfly found in the survey area that is not listed by either Vandermoor (2003a) or Kenner and Needham (1999). In the RNP Pine Whites are associated with the Eastern white pines (*Pinus strobus*) and Scotch pines (*Pinus sylvestris*) by the parking lot in front of the Nature House. Pine Whites were not seen near any of the shore pines in the Lulu Island Bog, so it is unlikely they are using the shore pines in the bog as foodplants. Pine Whites are common on the North Shore where their principal foodplant is Douglas-fir (Croft 1986).

Photo 15.1: Pine White (Neophasia menapia). Photo: Ian Lane.

Satyr Anglewing ***(Polygonia satyrus)***

Conservation Status: Not of concern

Voucher: Sight only

Abundance: M

Flight Time: February to November

Foodplant: Stinging nettle (*Urtica dioica*)

Comments: Satyr Anglewings (Photo 15.2) were seen on April 30, 2003 and on May 1, 2003. They were not seen again in 2003. Satyr Anglewings are woodland butterflies, and they prefer open deciduous forests that support stinging nettle (Guppy and Shepard 2001). In the RNP they were seen along wooded sections of the Time Trail and the Bog Forest Trail. They were also seen in RNP East. Stinging nettle is not found in the survey area, and the absence of a suitable food plant may be the reason why the Satyr Anglewings seen in 2003 did not stay very long.

Guppy and Shepard (2001) note that Satyr Anglewings could become a common suburban butterfly if patches of stinging nettle are allowed to grow on vacant land or unused areas of parks and gardens. The Satyr Anglewing is also called the Satyr Comma.

Photo 15.2: Satyr Anglewing (Polygonia satyrus). Photo: Ian Lane.

Western Elfin *(Incisalia iroides)*
Conservation Status: Not of concern
Voucher: Photographs by Ian Lane
Abundance: H
Flight Time: April to early July
Foodplants: Foodplants at Burns Bog are bog-laurel (*Kalmia microphylla*) and Labrador tea (*Rhododendron groenlandicum*) (Ashton 2003). Other foodplants in the Georgia Basin are salal (*Gaultheria shallon*) and arbutus (*Arbutus menziesii*) (Guppy and Shepard 2001).
Comments: Western Elfins are the most common butterflies in the Lulu Island Bog. On a walk on May 12, 2003 through the middle of the DND from Shell Road to No. 4 Road, I saw 12 Western Elfins. These were probably all males. In the Lulu Island Bog male Western Elfins perch on top of Labrador tea bushes and wait for females to fly by. They prefer open spaces where there are few trees and Labrador tea is dominant. On one occasion a Western Elfin was seen perching on a highbush blueberry in the birch-pine woodland in the southwest corner of the RNP. Some authors treat the Western Elfin as a subspecies of the Brown Elfin (*Callophrys augustinus*).

Western Pine Elfin *(Incisalia eryphon)*
Conservation Status: Not of concern
Voucher: Sight only
Abundance: L
Flight Time: April to June
Foodplants: Shore pine (*Pinus contorta* var. *contorta*)
Comments: The Western Pine Elfin appears to be extremely rare in the Lulu Island Bog. Ashton (1992) found that in 1991 and 1992 Western Pine Elfins were much less common in Burns Bog than Western Elfins. I saw only two in the Lulu Island Bog, one in 2002 and one in 2003. Both sightings were in the RNP.

Western Spring Azure *(Celastrina echo)*
Conservation Status: Not of concern.
Voucher: Photographs by Ian Lane.
Abundance: M
Flight Time: Mid May to the end of June
Foodplants: Hardhack (*Spiraea douglasii*)
Comments: Western Spring Azures are common and widespread in the survey area. In the Richmond area hardhack is the foodplant for Western Spring Azures. In the DND hardhack grows beside an old overgrown lane that runs in a north-south direction through the west side of the DND. It is also found in the birch hedgerow on the east side of the DND, on either side of the railway tracks, and in the RNP East. Each of these areas appears to have a resident population of Western Spring Azures associated with it. Females begin to lay their eggs on hardhack flower clusters in late May and early June, before the flowers have opened. The caterpillars feed on the flowers that start to bloom in mid June. Males often patrol for females in the bog, away from the areas with hardhack. On a few occasions Western Spring Azures were seen taking nectar from the flowers of bog-laurel and Labrador tea. Western Spring Azures appear to have a greater need to puddle, or take up minerals, than other butterflies in the survey area. They were seen puddling on the woodchip paths in the RNP (Griffith 2002a), on dog or coyote droppings in the DND, and on mud and gravel in the parking area of RNP East. Some authors treat the Western Spring Azure as a subspecies of the Spring Azure, *Celastrina ladon.*

Western Tiger Swallowtail ***(Papilio rutulus)***
Conservation Status: Not of concern
Voucher: Sight only
Abundance: M
Flight Time: June and July
Foodplants: Alder (*Alnus rubra*), birch (*Betula* sp.), black cottonwood, (*Populus balsamifera* ssp. *trichocarpa*), willow (*Salix* spp.) and others. Foodplant in Burns Bog is birch (Ashton 1992).
Comments: Adult Western Tiger Swallowtail butterflies are highly mobile and may be seen almost anywhere, including major thoroughfares and shopping centers. They are very common in residential areas because their foodplants (alders, birches and poplars) are common in or near residential areas (Guppy and Shepard 2001). In the survey area they were seen along the railway tracks, along Shell Road and in the RNP. Birches are one of the most common plants in the Lulu Island Bog, but I did not see Western Tiger Swallowtail caterpillars feeding on the birches in the bog, so I could not say for sure that the swallowtails I saw came from outside the bog or were part of a local population. Some that were seen high-tailing it down the railway tracks were probably just passing through, but others hovering around the birches in the wooded area behind the Nature House may have been females looking for a place to lay their eggs.

Woodland Skipper ***(Ochlodes sylvanoides)***
Conservation Status: Not of concern
Voucher: Sight only
Abundance: H
Flight Time: July and August
Foodplants: Grasses. Probable foodplant in the survey area is colonial bentgrass (*Agrostis capillaris*), a common introduced weedy species found on disturbed sites.
Comments: In the Lulu Island Bog Woodland Skippers are found in the grassy area in the Highway 99 corridor and along the railway tracks. In our area Woodland Skippers are always found in the same habitat as European Skippers, but they fly a bit later than European Skippers.

15.4 Discussion

Ashton (1992) found nine butterflies in Burns Bog (see Appendix D-7). This is half of the total on the Kenner and Needham (1999) list. The reason for the disparity is that Ashton listed resident butterflies only (resident butterflies are those that are present year round as eggs, larvae, pupae and adult butterflies) (Ashton 2003). Migrants, non-residents and skippers are not on his list. The Western Elfin, Western Pine Elfin, Grey Hairstreak and Reakirt's Copper (*Lycaena mariposa)* on Ashton's list are resident in the bog proper, as opposed to the edges of the bog. All but Reakirt's Copper were found in the Lulu Island Bog. The Western Spring Azure and Lorquin's Admiral, which Ashton found in the "inner southern edge" zone at Burns Bog, are also resident in the Lulu Island Bog. Ashton (1992) found the Western Tiger Swallowtail, Margined White, and Purplish Copper in the "outer southern edge" zone at Burns Bog. I did not see the Margined White or the Purplish Copper in the Lulu Island Bog. I have never seen a Margined White in Richmond or Delta, and I think they must be close to extinction in these areas. In Richmond there is a population of Purplish Coppers on Iona Island where their foodplants (Polygonum spp.) grow in abundance on a mountain of nitrogen-rich soil on the north side of the sewage plant. They can also be found at Boundary Bay where their probable food plant is a saltmarsh plant called orache (*Atriplex patula*).

In her pamphlet on the insects of the RNP, Harvey (1974) listed six butterflies (Table 15.2). The Tiger Swallowtail (*Papilio turnus*) on her list is undoubtedly the Western Tiger Swallowtail (*Papilio rutulus*). The tailed blue on her list is a puzzler. The Eastern Tailed Blue (*Everes comytas*) is not found in our area (Guppy and Shepard 2001). Its western look-alike, the Western Tailed Blue (*Everes amyntula*), is not normally found in bog habitat (Guppy and Shepard 2001). I did not see the Painted Lady (*Vanessa cardui*), Red Admiral (*Vanessa atalanta*), or Mourning Cloak (*Nymphalis antiopa*) in the Lulu Island Bog in 2002 and 2003, but they are common butterflies of the Fraser Lowlands (see Appendix D-7), and they could be expected to show up in the bog in years when their numbers are high. The year 2005 was just such a year. Painted Ladies and Mourning Cloaks, but not Red Admirals, were seen in great numbers all over the Lower Mainland in 2005. The Red Admiral has been pretty scarce in recent years, even in areas where its food plant (stinging nettle (*Urtica dioica*)) is found. If stinging nettle was planted in suitable areas around the bog (near the Nature House, in the Highway 99 corridor, along the railway tracks, and in the birch hedgerow by Shell Road, for example), the Red Admiral might become a permanent resident.

CHAPTER 16: MOTHS OF RICHMOND

By Rob Vandermoor

16.1 Introduction

Moths, like their better-known relatives the butterflies, share all of the same conservation issues. These range from habitat loss due to encroaching development, declining numbers from pesticide use and, one of the greatest conservation issues, the lack of available data for moths in general. Without this data it is extremely difficult to understand which moth species are disappearing, remaining steady or increasing in numbers. Therefore, the viability of certain species may be in jeopardy without us being aware of the situation.

Predation of moths is not much different from that of butterflies, with a few exceptions such as predation from bats due to the nocturnal nature of moths and the large amount of moths predated on by birds where they congregate after being attracted to artificial lights. Predation of moth species, like butterflies, is not at its greatest on the adult imago form but rather is greatest on the larval form (Vandermoor personal observations) where they fall victim to a host of predators. Some of these predators include species such as the common Yellow Jacket Wasps, Bald Faced Wasps, Ichneumon Wasps, Braconid Wasps, Tachinid Flies, birds, spiders, rodents and a bevy of others.

16.2 Moths on Lulu Island

No targeted moth inventory specific to the Lulu Island Bog was carried out for this biophysical inventory. However, a more general discussion of the moths found on Lulu Island is detailed here. The diversity of moth species on Richmond's Lulu Island is high, though the exact number of different species is unknown. The ratio of moths to butterflies in British Columbia is approximately 11:1, thus the number of moth species on Lulu Island could be as high as 200 (Lafontaine and Troubridge 1998). It is unclear how the diversity of moth species has changed on Lulu Island over time, as little data is available. Due to drastic habitat change on the island from the draining of vast portions of wetlands, habitat loss from encroaching development, and pesticide use, it is plausible that some moth species have already been extirpated.

Lulu Island is well represented by a diversity of moth species (Vandermoor personal observation and collection) and should have at least one if not many more species represented for each family of moths. The families Geometridae and Noctuidae, small to medium sized moths, represent the greatest proportion of moths commonly encountered. Many more families of moths are represented on the Island and these range from very small to very large species, the largest being *Antheraea polyphemus,* a moth of the family *Saturniidae* (Silk Moths). This extremely large and colourful moth has a 10-15 cm wingspan and can be most easily identified by its size and the large fake eyespot on the dorsal side of each hind wing. When startled, this moth will open its wings rapidly exposing these fake eyes in the hopes of scaring off its attacker or startling it long enough to make a getaway to safety. *Antheraea polyphemus* should be considered rare or uncommon on Lulu Island, however more and more records of this moth are being reported each year.

A few of Lulu Island's moth species are rarely seen but can be more easily found in the larval form. Two species in particular are the very colourful Garden Tiger Moth (*Arctia caja*) (Photo 16.1) and Isabella Tiger Moth (*Pyrrharctia isabella*). Unlike many other moths, the females of these two species are rarely attracted to artificial light (Oehlke n.d.) and therefore are not readily seen. The Isabella Tiger moth larva is the rust and black coloured short bristled haired larva (Woolly Bear caterpillar) that many of us see in the early to late fall walking across paths and roadways in search of a dry sheltered spot to hibernate over the winter. Once winter has passed and temperatures increase enough for these larvae to start moving again, they will begin to feed again on available food plants, generally plantain or dandelion. In late May to early June, these larvae will spin their cocoons and emerge approximately 2-3 weeks later as adult moths.

Photo 16.1: Female Garden Tiger Moth (Arctia caja). Photo: Stephen Ife.

Two other large sized moth species should be mentioned, as these are often encountered on Lulu Island at dusk around flower gardens. These two species are

White-lined Sphinx (*Hyles lineate*) and Gallium Sphinx (*Hyles gallii*). These large and colourful species have a 6-9 cm wingspan and are commonly referred to as hummingbird moths because the adult moths feed on the nectar of flowers. They can generally be seen at dusk buzzing in and out of flower heads in a hummingbird-like fashion, their wings beating extremely rapidly creating a tell-tale hummingbird buzzing sound. The large larvae of these species feed primarily on fireweed, which can be readily found growing sporadically along ditches, open fields and vacant lots.

Another very interesting little moth with an approximate wingspan of 3 cm is Langton's Forester (*Alypia langtoni*). This rather uncommon moth is unlike most other local moths in that it is only active during the day and is most fond of bright sunshine and hot temperatures. Also, unlike most other local moths, it is very sensitive to the habitat in which it can thrive. Langton's Foresters require a wind sheltered habitat normally along the edge of a riparian zone such as a blackberry thicket bordering the sheltered sunny side of a field or forest edge where its larval food plant, fireweed, is locally present. Due to this specialized requirement there has been a sharp decline in Langton's Foresters on Lulu Island because of habitat loss from industrial encroachment and urban sprawl.

The rarity of certain moth species on Lulu Island is only partially known due to the overall lack of species lists and field data. One such rarity would certainly be the day flying moth Yellow-banded Day Sphinx (*Proserpinus flavofasciata*). This extremely rare moth is only known on Lulu Island from one record – two late instar larvae were collected from fireweed, one of their common food plants (Vandermoor personal observation 1992). Other rarities may well exist, but much more study will be required before a clearer understanding of species' rarities can be made.

Geographically, Lulu Island's large bodies of water to the south and west make it prime for the influx of migrant moth species that at some point may become permanent residents here. To the immediate east there is little in the way of mountain ranges or other geographical impediments to stop the influx of species that normally would not be present in this area. It is not uncommon to hear reports of species normally thought only to be resident in areas far removed from here. The island still has several intact or partially intact bog systems that are unique and play host to an array of species that can virtually be found nowhere else on the island and with increased study. This could include moths that are also found nowhere else on Lulu Island.

The unique peat bog systems of Lulu Island are gold mines of varied plant, animal, amphibian and insect species and great effort should be made to keep them intact, as without these unique ecosystems species could be extirpated or become extinct without us ever realizing they were gone.

CHAPTER 17: AMPHIBIANS AND REPTILES OF THE LULU ISLAND BOG

By Colin Sanders, Aerin Jacob, M. Alexandra Reid and Neil Davis

17.1 Introduction

During this inventory, the study area properties – the Department of National Defence property (DND), Richmond Nature Park (RNP west) and Richmond Nature Study Area (RNP east) – were inventoried for the presence of reptiles and amphibians. Until now, there has not been any systematic study of reptile and amphibian species in the Lulu Island Bog. Bell's 1984 inventory work in the RNP west did not include surveys for reptiles or amphibians and no past survey work has been conducted in the DND or the RNP east. Until this present inventory, records of reptile and amphibian species in the two park properties were based solely on observations by park staff or visitors, and on incidental capture.

Information about amphibian and reptile use of bog habitats is limited (Knopp and Larkin 1999, Mazerolle 1999). In the Lulu Island Bog, many of the observations and captures come from the vicinity of the bog's semi-permanent waterbodies, which are not natural features of the bog. These aquatic habitats (the RNP west pond, the RNP east pond and the perimeter ditches) are limited, man-made, and were not historically present. The waterbodies have created additional habitat for amphibians and reptiles in the bog, many of which use aquatic environments for a portion of, or throughout, their life cycle. The ditches not only function as habitat but also as connections to other aquatic habitats and thus potential corridors for the movement and dispersal of amphibians and reptiles, including non-native species.

The Richmond Nature Park is occasionally a destination for unwanted amphibian and reptile pets, and these drop offs are responsible for the introduction of non-native species such as the Red-eared Pond Slider (*Trachemys scripta)*. Other non-native species such as the American Bullfrog (*Lithobates catesbeiana* syn. *Rana catesbeiana*) and Green Frog (*Lithobates clamitans* syn. *Rana clamitans*) are also present in the bog. The effects of these species on native amphibians and reptiles in the bog are not well understood. Hence, in addition to documenting the species present, this report also addresses some of the potential conservation concerns related to the presence of these non-native species in the bog.

17.2 Methods

A number of survey techniques were employed to ascertain the herpetological inventory of the RNP west, RNP east, and the DND lands between May and October 2002, and September and November 2004. The RNP east received the greatest amount of time-constrained intensive search with the aid of members from the Westcoast Society for the Protection and Conservation of Reptiles. The most commonly employed technique was visual encounter surveys conducted weekly in 2002 within two or three hours of sunrise to take advantage of when reptiles are more likely to be basking and less likely to have been disturbed by park visitors. Areas targeted by this technique included park trails, the park pond and other open bodies of water, the margins of open areas (the RNP parking lot, old roads in the DND lands, along the railroad corridor) and other key locations that would likely be utilized by reptiles and amphibians due to the habitat structure.

Auditory encounter surveys were also used in 2002 from early spring to mid-summer during dusk hours to record the occurrence of frogs that often eluded visual identification. A combination of drift fences (both linear and cross-shaped arrays[1]), pit traps and funnel traps were also utilized in 2002 and 2004. These were often set up around bodies of water and other potentially important microhabitats such as open patches in the forested parts of the DND lands, coniferous tree-dominated terrain (typical habitat for low altitude *Plethodontid* salamanders), around the ponds in the RNP west and the RNP east, and along the margins of the railway.

Larger bodies of water were sampled in 2002 for amphibian larvae using minnow traps baited with ground beef and algae pellets. For each trapping session, traps were monitored on a daily basis to reduce mortality, and were set for a week's duration.

During 2004, the DND property was further inventoried using black roofing tiles placed as artificial cover objects at the edges of openings where reptiles were judged likely to bask on or under them.

Lastly, discernible microhabitats were sampled with periodic time-constrained searches. This entailed an intensive half hour search in a 10 m X 10 m quadrat, looking under rocks, logs, loose bark, in rotten stumps, etc., for any reptile or amphibian inhabitants. These were conducted once in each of the spring, summer and fall seasons of 2002. Additional searches were conducted by volunteers from

[1] Provincial Resource Inventory Standards Committee (RISC) guidelines were followed for array trapping in 2004.

2003 – 2006 ditches and throughout the study area, in particular targeting moist hummocks.

17.3 Results

Of the 11 amphibians and seven reptile species known to inhabit the Fraser River delta, three amphibians and four reptiles were discovered in the three properties surveyed during this inventory.

There are two historical records of a fifth reptile in the bog - the Northern Alligator Lizard, both from the Richmond Nature Park. One record is from the mid-1980's and one is dated August 19, 1991 (Bauder pers. comm. 2007). These are the only observations for this species in Richmond (Klinkenberg and Klinkenberg 2001). Although Alligator Lizards are reported for the Lower Mainland (Friis pers. com. 2007; Matsuda pers. comm. 2007), and do occur in cooler habitats than other lizards (Friis pers. comm. 2007), it is possible that these records represent abandoned pets and thus are isolated occurrences (Photo 17.1). Of the seven species confirmed in the study area, three are introduced species that could potentially be affecting the status of not only the other indigenous amphibian and reptile species, but other organisms in the park as well.

Photo 17.1: Northern Alligator Lizard (Elgaria coerulea). Photo: Brian Klinkenberg.

17.3.1 Significant Species Accounts

Painted Turtle *(Chrysemys picta* Schneider, 1783)
BC Status: Blue-listed
Western Painted Turtles (*C. p. belli*, Gray, 1831) have been observed in the RNP west. The last sighting was in the summer of 2002 (Griffith pers. comm. 2005). There were no recorded sightings during the inventory. Whether its disappearance is attributable to predation, competition or removal by pet enthusiasts is uncertain. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed the Pacific Coast subspecies as endangered in April 2006, though it does not yet have an official status under the Species At Risk Act (SARA) (COSEWIC 2006, SARA 2006). COSEWIC cites major losses of wetlands and an increase in roads and development (habitat fragmentation) as the main causes of the subspecies' decline within its range, which includes southern Vancouver Island, the Lower Mainland, and parts of the Fraser Valley (COSEWIC 2006). The other BC subspecies, the Intermountain-Rocky Mountain population, located in parts of the southern interior and Kootenays, is also listed by COSEWIC, as a population of special concern (Blood and Macartney 1998, COSEWIC 2006).

17.3.2 Species Accounts

Pacific Chorus Frog *(Pseudacris regilla* Baird & Girard, 1852)
(Pacific Tree Frog, Western Oregon Treefrog)
BC Status: Yellow-listed
The Pacific Chorus Frog is an ubiquitous species found throughout most of the Lower Mainland and along the coast (Photo 17.2). Although it is Yellow-listed in BC and not considered threatened, its status within the bog is questionable. No individuals were ever seen or collected (whether adults, tadpoles or egg masses) during survey work in 2002 or 2004, and only a few calling males were ever heard at one time during that period. The frog's status in the bog is questionable because the lack of sizable choruses, combined with the overwhelming presence of introduced species, make it difficult to discern whether this species' population in the park is thriving on its own or represents a sink population being sustained by immigrants. Isolated pockets of calling males on the borders of RNP west, RNP east and the DND property are promising, but the lack of egg masses and tadpoles would seem to indicate that their foothold within the Lulu Island Bog is tenuous and dependent on supplementation from more viable populations. Survey work over multiple years would better determine if this is the case.

Photo 17.2: Pacific Chorus Frog (Pseudacris regilla). Photo: David Blevins.

American Bullfrog *(Lithobates catesbeiana* Shaw, 1802)
BC Status: Introduced (invasive)
The American Bullfrog is an introduced species in British Columbia that often preys upon and displaces other amphibian species and small animals (Corkran and Thoms 1996). Only two bullfrogs were observed in the RNP pond in 2002-2003, and no tadpoles were caught in collection traps from the pond. However, tadpoles were caught during fish trapping sessions in the perimeter ditches of the properties in the summer of 2003 (Davis and Cressey, this volume). Observers have noted more American Bullfrogs in the pond regularly in recent years (Sanders pers. obs. 2005-2006, Griffith pers. comm. 2006, Klinkenberg pers. comm. 2007), which may indicate a population increase. The lack of egg masses observed in the ditches and ponds may suggest that population increases are a result of immigration, likely via the system of ditches that connect the bog to other parts of Lulu Island. Increased numbers of bullfrogs may pose management concerns; some sources show that American Bullfrogs affect the native biodiversity at the sites they invade (Corkran and Thoms 1996), although their impacts may be complex (see, for example, Kiesecker et al. 2001) and multifaceted as they can function as prey items for other native species such as garter snakes (Klinkenberg pers. obs. 2007). An investigation of the species' effects on native wildlife in the park would be useful to direct management actions aimed at mitigating the negative impacts of this species.

Green Frog *(Lithobates clamitans* Latreille in Sonnini de Manoncourt & Latreille, 1801) (Yellow-throated Green Frog)
BC Status: Introduced (invasive)
The Green Frog is the most abundant frog found in the study area. Most commonly seen in the park pond almost year round, it is also frequently spotted in the ditches surrounding the RNP and DND lands. The Green Frog is an introduced species that, although no current evidence shows it to have a direct effect on other indigenous species, may displace native amphibian species through competition.

Red-eared Pond Slider *(Trachemys scripta* Schoepff, 1792)
BC Status: Yellow-listed
The Red-eared Pond Slider is an introduced species that is commonly found in the pond of the Richmond Nature Park in the Lulu Island Bog. The turtles' numbers in the park appear to be stable, likely due to natural reproduction and abandonment of unwanted pets balanced against poor winter survival and a ban on turtle sales in local pet stores (Bauder, pers. comm. 2007). In 2002, several females were found in June attempting to lay eggs on the south side of the RNP west property, demonstrating the viability of this small population. Several turtles in the pond had shell rot, which could be the result of poor water conditions endemically or introduced fungal, bacterial or viral infections.

Northern Alligator Lizard *(Elgaria coerulea* Wiegman, 1828)
BC Status: Yellow-listed
Although two records for Northern Alligator Lizard exist for the Lulu Island Bog, the natural occurrence of the species in the bog is unknown. The park is a drop off spot for abandoned pets, we cannot determine if these records represent natural occurrences. However, no specimens were found in 2002 or 2004.

This species is reported for much of southern BC, including eastern Vancouver Island and the Lower Mainland (Matsuda pers. comm. 2007), and is known to prefer cooler habitats (Friis pers comm. 2007).

Common Garter Snake *(Thamnophis sirtalis* Linnaeus, 1758)
BC Status: Yellow-listed
The Common Garter Snake is the most polymorphic of all *Thamnophis* species (Rossman et al. 1996), a fact that is readily apparent on summer morning walks along the trails of the Richmond Nature Park where many colour morphs have been observed. The most prominent morph seen in the park is the Valley Garter snake subspecies (*Thamnophis sirtalis fitchi*, Fox, 1951). Other forms are also present such as morphs closely resembling the subspecies *Thamnophis sirtalis pickeringii* (Baird and Girard, 1853), *T. s. sirtalis* (Linnaeus, 1758), *T. s. dorsalis* (Baird and Girard, 1853),

T. s. infernalis (Blainville, 1835) and *T. s. pallidulus* (Allen, 1899), as well as several morphs previously undescribed.

Griffith (pers. comm. 2002b) reports seeing, on several occasions, an all yellow morph, while one author (Sanders pers. obs. 2002) has repeatedly seen a distinctive morph possessing yellow ground colour with a random pattern of small black spots on the dorsal surface and tiny red speckling over the entire body. To confirm that these were two separate morphs, a specimen of the latter morph was caught and shown to Griffith, who indicated it was not the snake he had seen.

The common garter snake appears most commonly around the Richmond Nature Park (RNP west) pond. The highest density is observed during late spring/early summer when green frogs are undergoing metamorphosis, and observers can frequently spot the snakes preying upon froglets amongst the reeds.

Northwestern Garter Snake *(Thamnophis ordinoides* Baird & Girard, 1853)
BC Status: Yellow-listed
The Northwestern Garter Snake is also polymorphic, but within the RNP and DND lands it appears to show little variation. *T. ordinoides* does not appear to be as common within the park as *T. sirtalis*, and appears to show a distribution inversely correlated to *T. sirtalis*. Whereas *T. sirtalis* is most common around the pond and in boggy areas, *T. ordinoides* is most common in the drier, outlying areas, particularly in the DND property.

17.4 Discussion

Of the three amphibian species present in the park, two are introduced and the Pacific Chorus Frog population, although augmented by occasional releases of two or three frogs per year (Griffith pers. comm. 2007), appears to be a naturally sustained population. Of the five reptile species, one is introduced (Red-eared Slider) and one may be extirpated (Western Painted Turtle). Thus, of the reptiles, only the two garter snake species are native with probable enduring populations, while the occurrence of the Northern Alligator Lizard may or may not stem from isolated introductions.

The Western Terrestrial Garter Snake (*Thamnophis elegans* Baird & Girard, 1853) is usually common along shores on the coast, but less common inland (Sanders pers. obs. 2004). There are no verified records of this species in the Lulu Island Bog. No specimens were ever collected, and only fleeting glimpses of garter snakes closely resembled the Wandering Garter snake subspecies (*Thamnophis elegans elegans*, Baird and Girard, 1853) were recorded.

No salamanders or other BC native amphibians aside from the Pacific Chorus Frog were found in the inventory. This is unusual given the presence of salamanders and frogs in Burns Bog. The potential reasons for the lack of native amphibian records in the bog are unclear.

17.4.1 Conservation Concerns

Frogs

Concern for the status of frogs within the bog is mixed. While it is disconcerting that the only native frog is the Pacific Chorus Frog, the presence of Green Frogs probably functions as an important prey source, supporting the abundant garter snake populations in the bog. The potentially negative impacts of bullfrogs on other native species may make it advisable to remove bullfrogs from the park. However, considering how connected the park is to the Richmond drainage ditch system and that the drainage ditches are already an apparent haven for the bullfrogs, it is questionable whether such an endeavor is feasible on a long term scale unless addressed at a geographical scale beyond that of the study area.

Turtles

There is concern about the RNP pond becoming a sanctuary for unwanted pet amphibians and reptiles such as turtles. Many park visitors enjoy seeing turtles in the pond, but the park is meant to reflect the region's indigenous biodiversity, thus native turtles would be a more suitable viewing experience. This would require curtailing the illegal activity of unlicensed collecting of native species and the abandonment of non-native species within the park. We recommend that the current Red-ear Slider (*Trachemys scripta*) inhabitants be removed and native Western Painted Turtles (*Chrysemys picta*) be re-introduced to the pond. For this initiative to be sustainable, active measures must be taken to enforce park rules and educate users about native and introduced species. Initiatives such as placing educational signs around the pond outlining the park's interest in maintaining natural biodiversity, noting the fines for removal or abandonment of any animals, and providing a contact number for the Westcoast Society for the Protection and Conservation of Reptiles as an alternative for placing unwanted reptile pets may help ensure visitor compliance.

CHAPTER 18: MAMMALS OF THE LULU ISLAND BOG

By Neil Davis with contributions by Patrick Robinson and Bret Jagger

18.1 Introduction

Although it is a growing urban area, Lulu Island is still home to many species of mammals. Both large and small mammals were once abundant on Lulu Island. Historical records show that there was a resident population of Mule Deer on Lulu Island when the first settlers arrived (Kidd 1927). Black Bears were also occasionally observed swimming to the island to forage (Kidd 1927). Other early records cite elk on the island as well as other large mammals with large home ranges such as Cougars and Grey Wolves (Ross 1979). Smaller mammals such as American Mink, Beaver, Muskrat, Northern Flying Squirrels and rabbits are also recorded (Ross 1979, Klinkenberg and Klinkenberg 2001). However, as human settlement progressed, and agricultural and urban development increased on Lulu Island, habitat loss accelerated. Many large mammals such as bears, elk, cougars and wolves have disappeared from the island. Today, other than large wetlands such as Sturgeon Banks and the Iona spit, Lulu Island wildlife persists primarily in small fragments of habitat. Of these, the remnant Lulu Island Bog is one of the largest remaining natural areas. The bog now plays a key role in maintaining residual wildlife populations on Lulu Island through the provision of habitat and sanctuary in the midst of surrounding development, and its persistence is key for the survival of many animal species on the island.

Photo 18.1: Coyotes are regular residents of the bog. Photo: David Blevins.

Today, while most large mammals have disappeared from Lulu Island, Mule Deer and Coyotes are still present (Photo 18.1), and occur in the Lulu Island Bog. Columbian Black-tailed Deer are frequently sighted on the island, near or in the Richmond Nature Park properties, or the Department of National Defence (DND) property, and elsewhere. Deer tracks have been observed regularly in the bog, with fresh tracks observed as recently as October 2005 (Klinkenberg pers. comm. 2005, Griffith pers. comm. 2004). Frequent signs of Coyotes, such as scat and tracks, distinguish them as the largest natural predator in the study area.

Red Foxes (Photo 18.2) were observed in the nature park up until 1970 (Cooney et al. 1972), but there are no recent records. Beaver have a continuing presence on Lulu Island, with the presence of active beaver lodges at Garry Point and Green Slough, and in other locations proximal to the river (Klinkenberg and Klinkenberg 2001). Small mammals such as squirrels (Photo 18.3), moles, voles, mice and shrews generally have small enough home range requirements to permit the continued existence of populations on Lulu Island and in the study area.

Photo 18.2: Red Fox (Vulpes vulpes) has been extirpated on Lulu Island.
Photo: UBC Alex Fraser Research Forest, with permission.

Some species have not yet been confirmed in Richmond or on Lulu Island. The introduced Virginia Opossum, for example, is found throughout the Lower Mainland, and is found in the adjacent Municipality of Delta. However, this species is not yet reported for Richmond or Lulu Island (Klinkenberg pers. comm. 2007).

Photo 18.3: Douglas Squirrels are common in the bog, but rare elsewhere in Richmond due to loss of suitable forested habitats. Photo: David Blevins.

18.2 A Fragmented Bog

Natural areas on Lulu Island have become increasingly fragmented as a result of agricultural and urban development, and the bog is no exception. Scattered remnants of bog and bog forest are still found on the island adjacent to agricultural fields and along roadway edges. The largest remnants are those included in the study area, where the bog itself is fragmented into three properties separated by roadways and channelized watercourses. One effect of fragmentation is its influence on the movement of species between patches of habitat (Schtickzelle and Baguette 2003). For small mammals such as rodents and insectivores, roads, channelized watercourses and railway tracks can act as barriers or filters, preventing or restricting movement between habitat patches, respectively (Witt and Huntly 2001, McDonald and St. Clair 2004). Conversely, roads may actually provide coyotes corridors for movement (Tigas et al. 2002). For species at risk in this region, the implications of the bog as a refuge and as a fragmented habitat could be of particular importance. The Lulu Island Bog may be one of a small number of suitable habitats and natural areas remaining for such species.

18.3 Small Mammal Inventory

While the presence, historically or otherwise, of larger mammals on Lulu Island is reasonably well documented (see Table 18.2 below), the small mammal fauna of the Lulu Island Bog has never been thoroughly surveyed. Bell (1984) sampled briefly in the RNP west, and there are numerous recorded incidental sightings, photographs and captures of wildlife by park staff since the inception of the park. However, this inventory is the first to sample small mammals systematically (present/not detected) across all three properties that comprise the remnant Lulu Island Bog. The small mammal inventory focused on rodents, insectivores, and hares.

18.3.1 Targeted Species Inventory

In addition to general small mammal inventory, targeted surveys were conducted for species at risk that could potentially occur in the study area based on an assessment of habitats present in the bog, recent survey records, records from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Species At Risk Act (SARA) listings, the British Columbia Conservation Data Centre (BCCDC), and consultation with the British Columbia Ministry of Environment regional Species at Risk Biologist. Three target organisms were identified as possible residents based on their status, distribution, and habitat requirements:

- Pacific Water Shrew (*Sorex bendirii*)
- Red-backed Vole (*Clethrionomys*[1] *gapperi occidentalis*) (western subspecies)
- Washington Snowshoe Hare (*Lepus americanus washingtonii*)

All three targeted taxa are provincially red-listed which means they are candidates for listing as Endangered or Threatened. The Pacific Water Shrew is also federally listed by COSEWIC on Schedule 1 as Threatened. Snowshoe Hare and Red-backed Vole subspecies have not been federally assessed, but even if assessed, may be considered data deficient due to a lack of scientific information to use in the listing process. However, additional work on these species may significantly influence status designation. This project can contribute by providing much needed data. None of these organisms has ever been the subject of study in Richmond, thus information about their status on Lulu Island is very limited. Habitat in the bog qualifies as "high capability" for the threatened Pacific Water Shrew, based on the draft provincial habitat rating system (Craig 2003). Additionally, based on captures in Burns Bog and the occurrence of nearly identical habitat type in our study area, the Lulu Island Bog may also provide habitat for the western subspecies of the Red-backed Vole (Vennesland, pers. comm. 2005). Reported but unconfirmed sightings of Snowshoe Hares in the study area prompted interest in this species.

[1] Editor's Note: Nomenclature for this genus has recently been changed to *Myodes*

Southern Red-backed Vole, Western Subspecies ***(Clethrionomys gapperi occidentalis)***
BC Status: Red-listed
Federal Status: not presently listed
International Status: secure (NatureServe 2005)
Presence in survey area: not reported from Richmond
Habitat: prefer cool moist deciduous or coniferous forests. Use coarse woody debris and tree roots (Cannings et al. 1999).
Locally observed: records from Stanley Park and Burns Bog

The circumscription of *C. g. occidentalis* as a subspecies and separate taxon is derived from a description in 1890 based on qualitative traits of one specimen from Chehalis County, Washington (Merriam 1890 as cited in Fraker et al. 1999). Although the taxon's validity is questionable (Nagorsen 2000), scientists recommend it continue to be treated as a taxon at risk until taxonomic analysis proves otherwise. At the time of the small mammal inventory (2004), in accordance with this approach, the subspecies was treated as separate and at-risk. However, since the inventory's completion, unpublished DNA research by Amy Runck of Idaho State University has shown that while there are two widespread genetic groups of southern red-backed voles in southern BC, these are not consistent with the existence of a Lower Mainland subspecies 'occidentalis'.

The inventory was designed based on the understanding that the known distribution of *C. g. occidentalis* in BC was limited to the lower Fraser Valley, south of Burrard Inlet (Cannings et al. 1999). There were very few reported captures for this subspecies in BC. Two historical observations exist from animals caught in Point Grey and Stanley Park, each more than 50 years ago. More recently, in the summer of 1999, seven individuals were trapped in Burns Bog (Fraker et al 1999). The Lulu Island Bog remnants contain similar habitat to Burns Bog, and thus were approached as a potentially important habitat refuge.

Pacific Water Shrew ***(Sorex bendirii)***
BC Status: Red-listed
Federal Status: Threatened (SARA)
International Status: apparently secure (NatureServe 2005)
Presence in survey area: not reported in Richmond
Habitat: riparian specialist, associated with wet forests, marshes, areas adjacent to slow moving streams and channelized watercourses. Often in coniferous/mixed forested areas with abundant coarse woody debris (Craig and Vennesland 2005, Craig 2003).
Locally observed: reported in Vancouver, Delta and Surrey at low elevations, some in channelized watercourses.

The Pacific Water Shrew was federally listed as a Threatened species in 2000 under SARA, as recommended by COSEWIC. SARA provides protection for the animal and its critical habitat on federal lands. Protection under SARA is direct and immediate for areas of federal jurisdiction, and indirect for areas of provincial jurisdiction as SARA provides a "safety net" to ensure provinces provide equivalent protection. A recovery strategy for the species has been drafted (Craig and Vennesland in review). Provincial best management practices that include protocols for sampling and assessing habitat suitability are also available (Craig and Vennesland 2005).

The Pacific Water Shrew is known to date from only the farthest southwest corner of the province, extending as far eastward as Agassiz and north to the north shore of Burrard Inlet (Nagorsen 1996 as cited in Cannings et al. 1999) (Figure 18.1). The shrew is a semi-aquatic riparian species (WLAP 2004). Irrigation and channelized watercourses present throughout Lulu Island may act as vectors for movement and dispersal of the Pacific Water Shrew. The wooded riparian areas along the channelized watercourses that surround each of the properties in the study area rank as highly suitable habitat according to the draft provincial habitat rating system (Craig 2003).

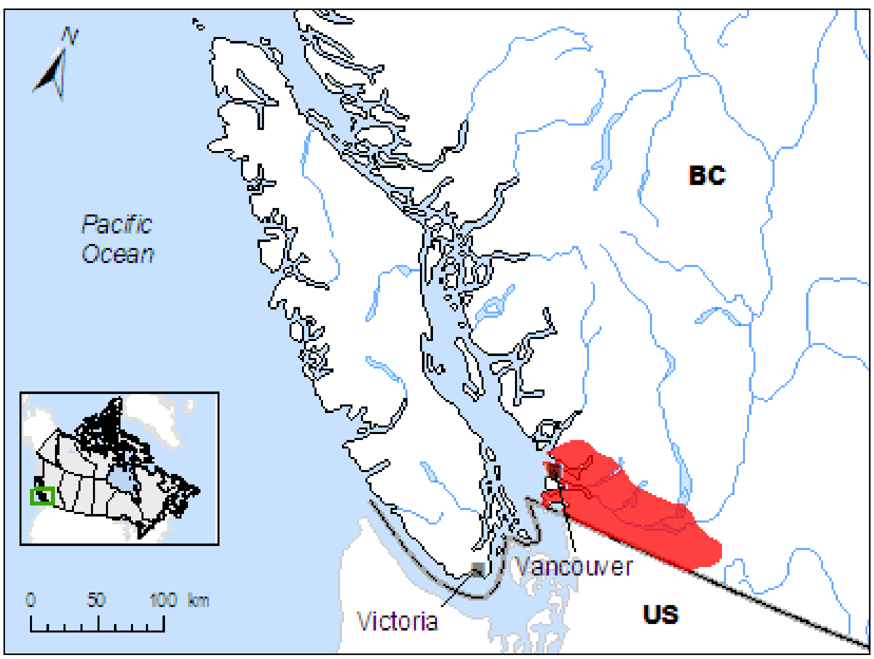

Figure 18.1: Pacific Water Shrew Canadian historical distribution map.
Source: Canadian Wildlife Service 2004 as cited by SARA 2005.

Washington Snowshoe Hare ***(Lepus americanus washingtonii)***

BC Status: Red-listed

Federal Status: subspecies not presently listed

International Status: apparently secure (NatureServe 2005)

Presence in study area: A Snowshoe Hare was reported in 1984 in the Richmond Nature Park inventory (Bell 1984), however the specimen from this study cannot be located and the record remains unconfirmed. Underhill (pers. comm. 2007) indicates that the specimen was found in the RNP east property, and was brought to Simon Fraser University for confirmation of the identification. Numerous subsequent reports exist for the park, some as recent as April 2001. A photo of a juvenile road-killed animal found in the fall of 2006 on the road at the edge of the RNP east was determined to be a "possible" Snowshoe Hare by Nagorsen (pers. comm. 2007).

Habitat: prefer dense coniferous/mixed forest with abundant understorey (Cannings et al. 1999, Sinclair pers. comm. 2004).

Locally observed: less than five known occurrences in region as of 1999 (Cannings et al. 1999), however there is recent confirmation of this species at Burnaby Lake Regional Park, with numerous sightings (Nagorsen pers. comm. 2007). Reports are restricted to the lower Fraser Valley (Nagorsen 1990 as cited in Cannings et al. 1999).

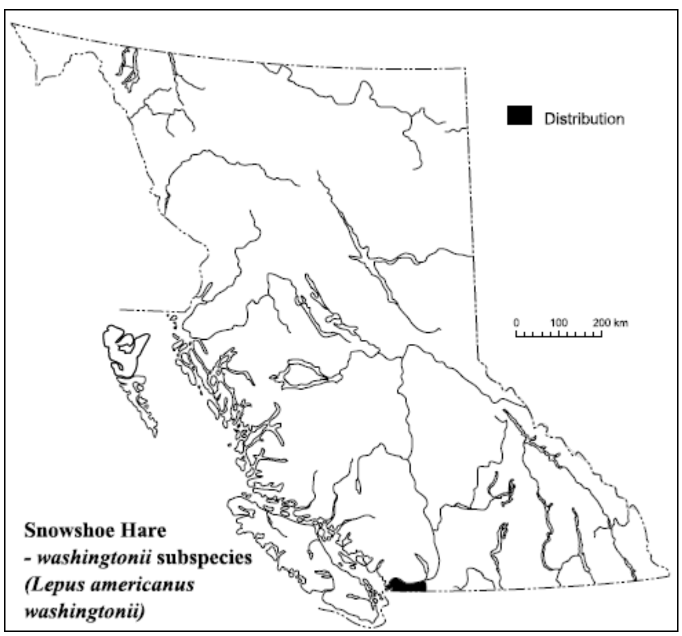

Figure 18.2: Washington Snowshoe Hare Canadian historical distribution map.
Source: Cannings et al. 1999.

This species, like the Southern Red-backed Vole and Pacific Water Shrew, has also been negatively affected because of a restricted range within a highly developed landscape (Cannings et al. 1999).

Also, like the Southern Red-backed Vole, the Washington subspecies' validity is uncertain (Cannings et al. 1999), but it is still treated as a taxon at risk in BC. Until recently, the hare was considered extirpated in this region, as there had been no confirmed records in the last thirty years (Nagorsen pers. comm. 2004). However, recent observations (Nagorsen pers. comm. 2004, Thunstrom pers. comm. 2004, Zevit pers. comm. 2005) indicate the species may still persist south of the Fraser River (Figure 18.2 and Photo 18.4).

Photo 18.4: Washington Snowshoe Hare (Lepus americanus washingtonii). Photo: Dave Nagorsen.

Notably, a Snowshoe Hare specimen was reported during the 1984 Richmond Nature Park inventory (Bell 1984), but this specimen has not been located and its identity remains unconfirmed. However, the thick understorey and food sources that the hare favours are abundant in the study area, and the area is known to host other lagomorph species including feral domestic rabbits and Eastern Cottontail (*Sylvilagus floridanus*) (Bell 1984).

18.4 Methods

18.4.1 Live Trapping

In March 2004, The Richmond Nature Park Society obtained a permit for live trapping of small mammals. Trapping began in early August 2004 and continued until early December 2004. Trapping methodology followed the guidelines set out by the Resources Inventory Standards Committee (RISC) and recovery team methods (e.g., for Pacific Water Shrew) wherever feasible (RISC 1998, Craig and Vennesland 2005).

The objective of the study was to survey and document the small mammal composition of the Lulu Island Bog. To achieve this objective, a general inventory for all species present and a targeted inventory for three at-risk species were carried out. Additionally, an owl pellet survey was conducted and scat, pellets, and bones were collected and examined for small mammal bones. Wherever possible, diagnostic bones and skulls were identified to gain information on small mammal species that may inhabit the park. Voles and shrews were examined most closely in an effort to determine the presence of the targeted Southern Red-backed Vole and Pacific Water Shrew.

Prior to fieldwork, habitat mapping was performed (Michalak 2004) in order to stratify the study site into broad habitat units for trapping based on preliminary vegetation mapping work completed by University of British Columbia Geography students (Mack 2000) and aerial photograph interpretation (Klinkenberg and Klinkenberg 2004). Trapping was planned to sample each of the habitat units for the general inventory, and to focus on the particular habitat units associated with each of the targeted inventory species. Seasonality and timing were also taken into consideration. Trap locations were marked using a Global Positioning System unit. A variety of trap types and associated methods were employed.

- Sherman and Longworth traps were arranged along transects to trap insectivores and rodents. Along each transect, Sherman or Longworth traps were placed every 15 to 20 metres, with two traps at each trap station. Transects consisted of five to 10 trap stations. Traps were set within one metre of each other and baited with peanut butter, whole oats, and a piece of carrot or apple to prevent dehydration in trapped animals. Cotton or pillow stuffing was also placed in each trap to provide bedding, and a cover board was put on top of each trap to alleviate animal discomfort due to extreme heat or rain soaking the traps. To discourage unwanted attention (predators and park visitors) and focus on habitat features favourable for small mammals, traps were concealed under low-lying shrub cover and along runways or downed wood wherever possible. Following a pre-baiting period of three to seven days with traps clipped or locked open, transects were checked and replenished for four to eight days each morning and afternoon. After October 18th 2004 traps were closed overnight to prevent mortality in colder temperatures.

- Pitfall traps were also used as another method of trapping insectivores and rodents. Plastic or black mesh sheeting was used as drift fencing to direct animals into the pitfall traps. Inverted two litre pop bottles and four litre ice cream buckets functioned as pitfalls. Drift fences were arranged as transects perpendicular to habitat features such as water bodies, with two traps dug near each end of the fence, or as x-arrays with traps dug at the centre and near the ends of each radiating arm. A small piece of Styrofoam was placed in each trap to provide refuge from accumulated rainfall, cotton supplied bedding and cover, and mealworms or wet dog food were added to provide sustenance.
- Tomahawk 205 traps were set for hares. The hare traps were placed in areas where there had previously been hare sightings by parks staff and volunteers, and in additional areas with suitable habitat along potential runways. Traps were baited with apple and/or carrot and covered with a board to discourage predation and shed rainfall.

Body length and tail length were measured for each trapped animal and photo documentation was taken for individuals that were difficult to identify or that were of special interest. Additional diagnostic measurements, such as hind foot length, were taken dependent on species and following Nagorsen (2002). Mortalities were noted and a subset of specimens was deposited at the Cowan Vertebrate Museum at the University of British Columbia.

18.4.1.1 General Inventory

Trapping was planned such that each of the habitat units would be sampled for the general inventory. Traps were placed in representative sections of each habitat unit based on a visual assessment of the habitat structure and potential species' life history traits (Nagorsen 1996, RISC 1998). Pitfall traps and transects of Sherman and/or Longworth traps were used to sample the units. Traps were set according to RISC (1998) standards in order to protect the animals from heat, sun or other exposure.

18.4.1.2 Targeted Inventory

Southern Red-backed Vole

All seven Southern Red-backed Voles caught in 1999 in Burns Bog were trapped in the same "Pine Woodland" habitat type, typified by Shore Pine (*Pinus contorta* var. *contorta*) and birch (*Betula pendula*) overstorey and a dense salal (*Gaultheria shallon*) understorey (Hebda et al. 2000, Robertson pers. comm. 2004). Other studies have also recorded higher abundances of Red-backed Voles in forest stands with more structurally diverse understoreys (Sullivan et al. 2001). Similar habitat exists in the RNP and trapping for the vole focused on these areas. Trapping for the vole began in August 2004, which is the recommended period because juveniles are dispersing (Nagorsen pers. comm. 2004).

Habitat units were used as guidelines for trap placements, but ultimately transects were placed based on finer scale ground-truthing of the park properties for the most suitable habitats/locations. Dense salal understorey and a significant canopy cover were used as indicators of habitat suitability, thus transects were laid under birch as well as pine canopy, where salal understorey was dominant. Because actual habitat preferences for this species are not yet fully defined, transects were also placed in habitats dominated by Labrador tea (*Rhododendron groenlandicum*) and bog blueberry (*Vaccinium uliginosum*) among patches of Shore pine (*Pinus contorta*), European birch (*Betula spp.*), shrubs and highbush blueberry (*Vaccinium corymbosum*).

Pacific Water Shrew

Knowledge of this species' life history and habitat use is limited. Trapping strategy and methods were adopted from Craig (2003), Craig (2003a) and in consultation with Michalak (2004) and Vennesland (pers. comm. 2004). Trapping focused around the permanent water bodies in the park, and prioritized those that were more likely connected with other waterways in Richmond. Pitfall traps and transect drift fences were set every 15 metres perpendicular to the water's edge. Where possible, fences coincided with habitat features such as coarse woody debris that the shrews may use as cover.

Pacific Water Shrews are endangered and, like all shrews, are susceptible to mortality in traps. To minimize the chances of mortality traps were checked at eight-hour intervals and closed during heavy rainfall. This followed permit requirements and provincial inventory guidelines (RISC 1998, Craig and Vennesland 2005).

Snowshoe Hare

Trapping for hares focused on areas of the study area where there had been recent sightings and other areas with habitat similar to those where there had been sightings. Traps were placed at the edges of openings and along runways under shrubs. Hare trap cages were placed in the RNP west and DND properties only.

18.4.2 Pellet and Scat Analysis

In order to complement live trapping for small mammals, pellet and scat analyses were also carried out. Samples were collected by Klinkenberg and MacQueen between July and October 2004 in the DND and the two park properties. The pellet survey focused on areas of the three properties with mature hemlock trees, plus incidental collections at other locations. Four time-constrained searches in these areas were conducted during July and August 2004. Pellets and scat were also collected incidentally in the three properties in conjunction with other mammal trapping efforts.

Small mammals that were identified in owl pellets or coyote scat cannot be directly linked to the study area due to the transient nature of these two predators. However it is likely that the predators are catching a portion of their prey items within the study area boundaries, as small mammals are common in the study area. Thus the pellet and scat analysis does augment the data collected by other means such as live trapping.

Pellets and scat were dissected and all bones were removed for identification. Skulls provide the most accurate means of identification and were the only bones used to identify to genus or species. The general dental formula was used to determine genus, and details of the cheek teeth, as outlined by Maser and Storm (1970), were used to determine species. Other bones aided in the enumeration of small mammals in the pellets or scat but were not used for identification beyond genus. A detailed summary of the pellet analysis is presented below.

18.5 Results

18.5.1 Live-trapping Results

Between July and December 2004, 44 000 trapping hours of effort were expended across the three properties and across the habitat units (Table 18.1). In total, 148 individuals comprising seven species were caught. Deer Mice and Vagrant Shrews were the most frequently caught species, accounting for 69% (102 of 148) of all captures (Table 18.2). None of the three targeted species was documented or confirmed by the small mammal inventory. However, the “possible” juvenile hare found as a road kill in 2006 immediately adjacent to the RNP east indicates further study is warranted.

Table 18.1: Trapping effort in each of the Lulu Island Bog properties

Property	Trap type	Hours
West	Sherman/Longworth	4400
	Hare traps	1896
	Pitfalls	7920
	Total	14216
East	Sherman/Longworth	8768
	Hare traps	0
	Pitfalls	3440
	Total	12208
DND	Sherman/Longworth	15016
	Hare traps	672
	Pitfalls	1888
	Total	**17576**
	Cumulative effort	**44000**

Table 18.2: Total species captures in each of the Lulu Island Bog properties

Species	Common name	# Captures			
		DND	RNPW	RNPE	Total
Sorex vagrans/monticolus	Vagrant/Dusky Shrew	33	19	16	68
Peromyscu maniculatus	Deer Mouse	8	0	26	34
Tamiasciurus douglasii	Douglas Squirrel	1	1	0	2
Microtus townsendii	Townsend's Vole	1	1	7	9
Vole spp.	unidentified vole	0	3	9	12
Sciurus carolinensis	Eastern Gray Squirrel	0	1	0	1
Rattus rattus	Black Rat	9	0	12	21
Mephitis mephitis	Striped Skunk	0	1	0	1
				Total	**148**

18.5.2 Species Accounts

Based on previous work by Klinkenberg and Klinkenberg (2002), and the results of this inventory, a checklist of the mammals of the Lulu Island Bog has been compiled and is presented in Appendix D-11. Accounts of species documented by the inventory are presented below.

Deer Mouse ***(Peromyscus maniculatus)***

A total of 34 Deer Mice were caught, 8 in the DND and 26 in the east property. The east is the most forested of the three properties, with a canopy of predominantly birch and smaller components of hemlock and pine. This species was caught almost exclusively in forested habitats dominated by birch, with low shrub cover dominated by salal. All 26 individuals in the east were caught in this habitat type, and of the 8 individuals caught in the DND, 5 were caught in this habitat type along the north edge of the property. This correlates closely with the results of the Burns Bog trapping, which found 69% of all Deer Mouse captures in mixed coniferous or deciduous forest habitats (Fraker et al. 1999). This species is abundant throughout most of North America across a range of habitat types (NatureServe 2004).

Vagrant/Dusky Shrew ***(Sorex vagrans vagrans / Sorex monticolus)***

The identification of most shrews is based on dental characteristics (Nagorsen 2002). Distinguishing the Vagrant Shrew from the Dusky Shrew (*Sorex monticolus*) is impractical with live animals in the field, thus judgment was reserved and individuals were recorded as Vagrant/Dusky Shrews. Vagrant/Dusky Shrews were found on all three properties, and were the most commonly caught species. The Vagrant Shrew is also reported in the 1984 inventory of the west property (Bell 1984). Both species are abundant provincially and in North America.

Townsend's Vole ***(Microtus townsendii)***

There were difficulties identifying some Townsend's Voles due to the challenges of visually distinguishing juvenile Townsend's from juvenile dark-pelaged Southern Red-backed Vole. Although the literature describes external distinguishing features such as dorsal pelage colouration and tail colouration (Nagorsen 2002), there were numerous cases where trapped animals could not be clearly defined by any external characteristics.

Weights and sizes of the two species overlap. In an analysis of specimens at the Cowan Vertebrate Museum, one confirmed specimen of *Clethrionomys gapperi occidentalis* in the collection exhibited somewhat uniform brown pelage typical of the Townsend's Vole instead of the reddish dorsal pelage that is a distinctive external characteristic of the Southern Red-backed Vole. Furthermore, some captured individuals identified as Townsend's Voles by their size, weight and colouration had white hairs on the underside of their tails, a distinguishing characteristic of the Southern Red-backed Vole (Nagorsen 2002). This raised further questions about certainty in specimen identification. Most of the individuals caught in the bog were of a size and weight feasible for either species. Twelve of the 21 voles caught could not be identified to species.

Two animals in particular—both caught in the RNP west property-- raised questions about identity and could not be confirmed visually by experts as either Townsend's Vole or Red-backed Vole (Photo 18.5 and Photo 18.6). Pellets and hair samples from one of these individuals were collected for DNA analysis and determined to be Townsend's Vole (see Appendix B). In light of this analysis, it is probable that the other voles that could not be identified to species were also Townsend's Voles.

Photo 18.5: Townsend's Vole, typical pelage. Photo: David Shackleton.

Voles were trapped most commonly (16 of 21 individuals) in the RNP east property. All of the Townsend's Voles caught in the RNP east property were in forested habitats with dense salal understorey, as were all of the unidentified voles caught in the east property. The individual caught in the DND was found in dense heather and Labrador tea habitat with scattered highbush blueberry and birch shrubs and lacking tree canopy. Townsend's Vole is generally more commonly associated with meadows, marshes, and other open habitats (NatureServe 2004). However, despite the availability of more open habitats in the study area, such as the areas dominated by heather, Labrador tea, highbush blueberry and native blueberry, Townsend's Vole in this study was found predominantly in forested habitats. This may be a result of several factors. First, more trapping hours were expended in forested habitats than in more open habitats because of the additional targeted species inventory and associated trap site choices. Second, it is also possible that the heath-dominated habitat does not provide suitable features or forage for this herbivore, and consequently, their use of heath habitat is limited.

Photo 18.6: Townsend's Vole, red pelage. ID determined by DNA analysis of fecal pellets.
Photo: R. Klinkenberg.

The occurrence of voles in habitat less preferred by Townsend's Vole contributed to the uncertainty of species identification. Forested habitats had been targeted as likely Southern Red-backed Vole habitat due to their similarity to the habitat type that all seven Southern Red-backed Voles were found in at Burns Bog.

The Townsend's Vole is abundant in BC and its range extends from BC through Washington and Oregon to California (NatureServe 2004).

Douglas' Squirrel ***(Tamiasciurus douglasii)***
Douglas' Squirrels are common in the west property and can be seen around the bird feeder. Two individuals were trapped, one in the DND and one in the west property. The species is common in BC and is also found in the western United States (US). It is typically found in coniferous forest habitats (NatureServe 2004).

Eastern Grey Squirrel ***(Sciurus carolinensis)***
The Eastern Grey Squirrel is native to eastern North America where it is common throughout its range (NatureServe 2004). It is an exotic species in western Canada and the western US, introduced to the Lower Mainland in 1914 in Stanley Park. Its range in the region has been growing since then. Park staff first began noticing the Eastern Grey Squirrel in the nature park approximately 9 years ago. Its population grew quickly in the park, and was commonly seen around the pond and bird feeder in the RNP west property. However, shortly after the completion of the small mammal surveys for this inventory, park management live-trapped Eastern Grey Squirrels and

relocated them away from the park in an effort to eliminate this invasive species from the park. Only one individual was caught in this survey in the RNP west property, although the species is suspected of having frequently visited the hare traps and taken bait without setting the traps off.

Black Rat *(Rattus rattus)*

The Black Rat is an introduced species often associated with ships, ports and other non-natural environments. It is also sometimes found in natural habitats. This species was trapped 18 times in the DND and east property. All but one of the captures occurred along edges of disturbed habitat. The nine captures in the DND occurred along the edges of the north south lane and the south edge of the park, and 11 of the 12 captures in the east occurred near the peripheral channelized watercourse that separates the park from Jacombs Road and the Richmond Auto Mall.

Striped Skunk *(Mephitis mephitis)*

One Striped Skunk was caught in a hare trap in the RNP west. The Striped Skunk is a common sight in the neighbourhoods of Richmond and Vancouver. It is common throughout much of North America and can exist in a range of habitat types.

18.5.3 Pellet and Scat Analysis *(by Patrick Robinson)*

Individuals of some owl species may have a favourite perch where they regurgitate pellets and this behaviour can result in several pellets at one location. Although owl pellets were often found in groups, each pellet was treated as an individual sample. There were a total of 36 (21 owl pellets, 14 coyote scat and one of unknown origin) individual samples. The majority of the skulls that were identifiable were in the Cricetidae family and sub-family Microtinae. Evidence of Microtinae was present in 16 of 36 samples and of those that were identifiable to species, all were Townsend's Voles. Four samples contained skeletal remains of members of the shrew family (Soricidae) however extensive damage to these skulls precluded identification to species. An individual in the Sciuridae family was identified by cheek teeth but could not be identified to species.

18.6 Discussion

18.6.1 Species at Risk

Bog habitat on Lulu Island has been impacted by agricultural and urban development. Associated activities such as drainage have shifted drier portions of the Lulu Island Bog towards successional bog forest habitat. Additionally, development on the island has facilitated colonization of the bog by forest plants and agricultural/horticultural cultivars such as European birch (producing a hybrid birch forest cover). Concurrent with this drying and invasion of the bog, continued development on Lulu Island has resulted in widespread natural habitat loss and fragmentation of remaining natural habitats. This fragmentation influences mammal movements and dispersal, and may effectively prohibit source/sink dynamics in the study area. Hence, it is possible that, although suitable habitats for the vole, shrew and hare are now present in the bog remnants, dispersal into these remnants may be non-existent, limited, or periodic because of fragmentation, habitat loss, and a lack of source populations nearby. Research has found that Red-backed Voles are poor colonizers of island habitats, with low immigration rates and low rates of successful colonization (Crowell 1973, Mills 1995).

It is important to recognize the limitations of this survey work, which may also account for the lack of evidence of some species. It is possible that the species are present in the study area but not detected in this survey. This has been demonstrated in other small mammal surveys in the Lower Mainland. For example, in a small mammal survey of 55 sites comprising 19 000 trap nights, Zuleta and Galindo-Leal (1994) did not catch any Southern Red-backed Voles and trapped only three Pacific Water Shrews. The trapping effort expended by Fraker et al. (1999) in Burns Bog did not result in any Pacific Water Shrew captures, even though owl pellet analysis identified a Pacific Water Shrew skull that may have come from the bog (Fraker et al. 1999). These results could have several important implications for the results of the Lulu Island Bog inventory. First, it may indicate that these species are rare within their ranges even in suitable habitats (Fraker et al. 1999). Second, in regards to the Pacific Water Shrew, existing trap types may not effectively capture the animal even when suitable habitats are targeted.

18.6.2 Pellets and Scat

Bones, feathers or fur were found in all but two of the pellet and scat samples, which suggests that small mammals and birds play a significant ecological role as prey items for predators.

The relative abundance of small mammal species identified in the pellet and scat analysis does not closely correspond with the trapping results. Deer Mice and Vagrant/Dusky Shrews, the two most commonly caught small mammals, are uncommon in the pellet and scat analysis results. This may be a result of several factors. Soricidae skulls are delicate and easily crushed, rendering them unidentifiable. It is likely that shrews are a prey item for coyotes and owls, but unlikely that their remains in pellets and scat are preserved in identifiable form. Furthermore, coyotes and owls are likely catching some of their small mammal prey outside of the study area boundaries. The relative abundance of small mammal species may differ outside the study area.

18.6.3 Recommendations

The Lulu Island Bog is used by populations or individuals of the majority of the mammal species known at this time in Richmond. Together, the three properties comprise the largest remnant upland natural area on Lulu Island. The remnant boglands are an important site for the preservation of wildlife on the island, and the City of Richmond has identified all three properties as Environmentally Sensitive Areas. Green spaces around Richmond are increasingly subject to development as the city grows, and remnant habitats such as the park and DND properties may become more important as refuges if the extent of green spaces continues to shrink. These properties warrant protection based on their significance in this regard.

Protected status for the DND property would ensure continuation of its capacity to sustain populations of numerous small mammals. It would also provide valuable habitat for larger mammals such as coyote and deer. These species need natural habitat refuges and use the DND property in conjunction with the park properties as part of larger home ranges. Anecdotal reports from DND staff of regular deer sightings on the property indicate that deer use the DND property more frequently than the park, which would provide further reason for the protection of this site.

Given the rarity of the three species at risk and the lack of suitable habitat in this highly developed region, preservation of the habitat that exists in the Lulu Island Bog is further warranted based on their potential presence. In particular, the presence of high or moderate capability habitat for the Pacific Water Shrew in the study area should result in the implementation of the habitat protection guidelines set out in the provincial draft of the Best Management Practices Guidelines (Craig and Vennesland 2005). As a SARA-listed threatened species, the federal and provincial governments have an obligation to ensure adherence to these protective measures for the animals and their critical habitat.

Craig and Vennesland's (2005) habitat protection guidelines that have relevance to the study area include recommended buffer zones up to 100 metres wide on each side of watercourses and wetlands that are suitable habitat or habitat capable of being suitable. Within the buffer zones, minimal low-impact disturbance such as walking trails are recommended. The guidelines also propose the restoration of low capability habitat to higher capability habitat. These measures are pertinent for the east channelized watercourse of the west property and the west channelized watercourse in the east property. The watercourse edges closest to the highway are dominated by invasive grasses and other species such as Himalayan blackberry (*Rubus discolor*) - a species that may not provide optimal habitat for Pacific Water Shrew. These are sites where restoration of native shrub and tree species would be suitable, or, at the least, where further disturbance such as grass mowing or clearing should be avoided to allow further re-vegetation of the riparian zone.

Roads, bridges and other crossings within suitable Pacific Water Shrew habitat are also discouraged. These incursions fragment habitat and facilitate the establishment of invasive species (Craig and Vennesland 2004). Where crossings cannot be avoided, the guidelines advocate the use of bridges instead of culverts. Bridges can be designed to leave buffers on either side of the waterbody.

The guidelines can help protect riparian and wetland habitat, increase or preserve the connectivity between habitats, and protect the waterbody and its ecological processes. These outcomes may be of benefit for many riparian and wetland species.

CHAPTER 19: BIRDS OF THE LULU ISLAND BOG

By Hugh Griffith

19.1 Introduction

The largest remnant of the once expansive Lulu Island Bog consists of three adjacent quarter-properties in north-central Richmond. These are the Richmond Nature Study Area (RNP east), the Richmond Nature Park proper (RNP west) and the Department of National Defence property (DND). The relatively large size of this remnant, and its location within a major north-south greenbelt (Highway 99 and adjacent farmlands and woodlots), make it an important site for resident and migrant bird species. In recent decades, the expanding human population of the City of Richmond has replaced other wild areas on Lulu Island, but the Lulu Island Bog remains a significant island of wildlife habitat, and a large stepping-stone in a green corridor that continues in some form south to Burns Bog and other important wildlife areas. The Georgia Basin Ecoprovince, which includes the Lower Mainland (Demarchi 1995), is under greater pressure from urban expansion than any other region in the province, rivaled only by urban growth in the South Okanagan Ecoprovince, and natural habitat necessary to maintain avian diversity in the region is disappearing at a great rate.

The vegetation of the study area creates structural variation, which is important to the maintenance of bird species diversity in bogs (Desrochers et al. 1998). An ecological inventory of the RNP west in 1983 (Bell 1984) listed only 22 species of birds, but cited insufficient time and recommended more extensive surveying. The present study is the first to survey and compare all three properties to provide a best assessment of the current state of birdlife of the Lulu Island Bog.

Starting in March 2002 bird surveys on the first Saturday of the month were carried out on all three properties as the availability of qualified birdwatchers allowed. Coincident with the time span of the survey, daily surveys at the RNP west were carried out by Michael Beck, most intensively during the breeding season (March-August).

19.2 Survey Method

The purpose of the bird counts was to determine which species occur in each property, at what time of year, and if any of the properties provide breeding, roosting or foraging habitat for species at risk. The methodology approximated Simple Point Counts along an Encounter Transect (RISC 1999), although in the Nature Park properties, dense brush made straight transects impractical and routes were chosen along established park trails, through all major vegetation groups. The data gathered primarily are “species present or not detected” and strictly speaking do not determine relative or absolute abundance of species. However, because detections were counted and tallied, rough estimates of species abundance were obtained.

Surveys consisted of 2-hour circuit walks by one or more experienced birdwatchers. Starting in March 2002, bird surveys were carried out on the first Saturday of the month. When possible, all three properties were surveyed simultaneously, starting at 9AM, but occasionally it was necessary to survey the properties sequentially. In some months, lack of skilled volunteers prevented the surveying of all three properties.

Birds were identified visually or by call. Presence of occupied nests, juveniles, or adults exhibiting nesting behaviour were recorded to determine probable nesting on site. Overflying birds were also recorded.

Routes comparable in length, which covered comparable areas, were decided upon for each site. Specifically, survey routes were as follows:

- ***Department of National Defence (DND).*** This survey was made along two transects of roughly 1 km length each. Transect 1 (east to west) began at the Shell Road entrance on the southeast side of the property, followed an old roadway for the first 100 m, then well- to poorly-defined trails through the bog to the midline tree-stand. From there, trails became difficult to find and heavy ground-shrub growth forced the transect line to take accessible directions trending northwest, emerging onto No. 4 Road along the northwest side of the DND property. Transect 2 went from the Canadian Forces station and trended along fairly well-defined trails directly east, paralleling the mostly European birch tree-line border along Alderbridge Way and approximately 200 metres south of that line. After following well-defined trails for approximately 1km, the route continued along an old road trending northwest to southeast for approximately 150 metres before turning directly east, eventually to emerge onto Shell Road near the northeast corner of the property.
- ***Richmond Nature Park (RNP west).*** The route consisted of the entire Bog Forest Trail, with the addition of the trail east through the forest to the No. 5 Road ditch, and the trail from the northwest corner of the Bog Forest Trail to the CPR rail line. This route covers all major vegetation zones of the property.
- ***Richmond Nature Study Area (RNP east).*** The single large ring trail was the survey route, and transects or skirts all major vegetation zones of the property.

19.3 Results

A summary of observations made during the bird surveys is presented in Appendix D-12. Including Michael Beck's almost-daily counts in the RNP west during the 2002 migratory and nesting seasons, 91 species of birds were observed in the Lulu Island Bog. Greater numbers are documented in the RNP west because of more available data and differences in habitat diversity and disturbance regimes from site to site. However, all three properties show a good diversity of bird species, and all three properties are used for foraging, roosting, and nesting (Photo 19.1).

Photo 19.1: Hooded Merganser is sometimes seen in the Nature Park pond. Photo: David Blevins.

19.3.1 Summary of the 2002/2003 Survey Data

19.3.1.1 Department of National Defence Property

Eight surveys were made. 2002: April 14, May 4, June 1, July 7, August 4, November 3, December 15; 2003: January 7. Forty-one species were observed. The most common species, in descending order of number of observations, were Song Sparrow, Black-capped Chickadee, Spotted Towhee, Northwestern Crow, Common Yellowthroat, Orange-crowned Warbler, American Robin and Golden-crowned Kinglet. Of these, Common Yellowthroat and Orange-crowned Warbler were only present in summer months (April-September). The others are year-round residents. Other migrant species include Rufous Hummingbird (April-July - note: no survey was done in March, when this species typically returns to the Lower Mainland), Willow Flycatcher (July -September), Barn Swallow (June-August), Hermit Thrush (a single sighting in May), Wilson's Warbler (May), White-crowned Sparrow (April), and Brown-Headed Cowbird (July).

19.3.1.2 Richmond Nature Park

Eleven monthly surveys were done. 2002: April 6, May 4, June 1, July 6, August 3, September 7, October 5, November 3, December 15; 2003: January 6, March 1. Fifty-five species were observed on survey days, and Michael Beck's observations increased the total to 90. The most common species, in descending order of number of observations, were Song Sparrow, Black-capped Chickadee and Spotted Towhee. Other species observed on every count, though in numbers less than 10 included Bewick's Wren, Winter Wren, Northwestern Crow, and Bushtit. Common summer species include Rufous Hummingbird, Orange-crowned Warbler, Common Yellowthroat, American Goldfinch (Photo 19.2) and Black-headed Grosbeak. Common winter species include Dark-eyed Junco, Golden-crowned Kinglet and Ruby-crowned Kinglet. Species not seen during monthly counts but reported by Michael Beck included: Killdeer (July 22 - over flight, Aug 6 - over flight), Solitary Sandpiper (August 6), Common Snipe (October 31), Blue-winged Teal (May 13, June 4), Common Merganser (2 immature on pond July 10), Northern Goshawk (April 20), Bald Eagle (April 20, May 11), Merlin (May 14), Black Swift (June 18, 2 individuals, June 25 a single bird, August 4, 4 individuals), Northern Rough-winged Swallow (May 14), Townsend's Solitaire (Sept 11, 3 individuals), Hutton's Vireo (April 20), Warbling Vireo (June 18,19, 24), MacGillivray's Warbler (May 15), Lincoln's Sparrow (Sept 11, 3 individuals), White-crowned Sparrow (April 27), Golden-crowned Sparrow (April 27)

Photo 19.2: American Goldfinches nest in the northwest corner of the RNP west.
Photo: David Blevins.

The observations from this study have been used to update the bird checklist used in the RNP west.

19.3.1.3 Richmond Nature Study Area

Thirty-six species were observed during seven monthly surveys. 2002: April 5, May 10, June 1, July 6, August 3, November 3, December 15; 2003: January 3. All species common to the forested areas of the RNP west (Song Sparrow, Black-capped Chickadee and Spotted Towhee, Winter Wren, Bewick's Wren) were similarly well represented in the RNP east, but observations of birds typical of open bog – such as Northern Harrier, swallow species, and Common Snipe – were lacking. No herons were reported. Mallard ducklings were observed in May 2002. The only raptors observed during counts were Bald Eagle and Red-tailed Hawk overflights.

19.4 Discussion

During this inventory, the greatest diversity of bird species was found in the RNP west. This can be attributed, in part, to a sampling bias, because this property has been under almost daily observation over many years whereas knowledge of the adjacent properties comes mostly from the present study. Additional surveys of the DND and the RNP east should be carried out to obtain fuller pictures of the avian life of those properties, especially during spring and fall migration, when transient species are observed.

Migrants such as warblers and tanagers would be expected to use these sites as stopovers, and relatively uncommon resident species, such as the Yellow-listed Hutton’s Vireo, various species of woodpecker, and species of owl known from the RNP west would also be expected to forage, roost or nest there. The non-appearance of these species on the Species List may be attributable to absence of data rather than non-occurrence. The habitat diversity and larger expanses of distinct habitat types in the RNP west may also contribute to the observed greater number of bird species in that property. The RNP west possesses a large, open pond, a very broad ditch on its eastern edge that is easily accessible to observers, and expansive areas of several distinct habitat types (open bog, bog forest, mixed deciduous forest containing significant stands of western hemlock), which are characterized by different avian assemblages.

The DND has a higher component of open bog, thus less structural diversity than the Nature Park properties. Its deciduous forest is patchy, and tends to follow road margins and the north-south roadway within the property. These forests would be expected to be more strongly influenced by edge effects than the Nature Park forests, including weather extremes, degree of insolation, and even increased cowbird nest parasitism (Robinson et al. 1995), all of which may decrease the value of DND woodlands as nest sites for forest birds.

Successional bog forest is more prevalent in the RNP east than in the RNP west. It supports a large component of birch-shore pine bog forest intermixed with relatively small open bog components. It should be noted, though, that in the extreme northeast corner there is a habitat unique to this property, a wetland containing willow, and surrounded by dense areas of hardhack. Apart from bird songs heard while passing, bird life from this vegetation community was not extensively surveyed during the bird census. It may be of special importance for bird species not found elsewhere in the bog - especially songbirds such as vireos and warblers that favour a dense understorey for nesting.

Photo 19.3: Wood Duck are occasionally observed in the Nature Park pond. Photo: David Blevins.

The ponds in both Nature Park properties were excavated from the peat mat during Nature Park development in the mid 1970s. In its early years, the pond in the RNP west was heavily used by waterfowl as foraging (encouraged by feeding by park visitors) and nesting habitat. Over time, the banks of both ponds have become overgrown by birch and highbush blueberry. Water surface areas have decreased due to bank slumping, aquatic plant growth, and build up of organic detritus. These factors are more significant in the RNP east than the RNP west (where the pond persists as an open *Sphagnum* pond) because active human intervention, as part of routine park maintenance, has slowed or to some extent reversed these processes. Never-the-less, in both properties, the ponds have become less attractive to waterfowl. Wood Ducks were common and nested near the pond in the RNP west until 1999, but now are only sporadically observed (Photo 19.3). The only waterfowl to have nested around the pond since 2000 are Mallard and Green-winged Teal (Griffith pers. obs. 2004). During late winter and early spring, the pond is visited by Green-winged Teal, Mallard, and small numbers of Hooded Mergansers. Because of lack of observations, the degree of use of the pond in the RNP east by waterfowl is not well known, although some nesting must occur as evidenced by the Mallard ducklings observed in May 2002. Wood Ducks have continued to be observed sporadically in the pond in the RNP east (Klinkenberg pers. comm. 2005).

The only species recorded by Bell (1984) not recorded in the present study in any property was Evening Grosbeak. This species is described as an uncommon to very common migrant and winter visitant, and uncommon to common summer visitant in the Georgia Depression Ecoprovince (Campbell et al. 2001). However, data from Christmas bird counts from this ecoprovince show a marked decrease in sightings in recent years compared to the 1980s, which may be related to the decline in western spruce budworm infestations in the Southern Interior Ecoprovince during this time (Campbell et al. 2001).

19.4.1 Species of Note in the Lulu Island Bog

Green Heron *(Butorides virescens)*
Provincial List: Blue Listed
Federal Status: not ranked
Provincial Status: S3S4B
Immature Green Herons were seen in late summer at the pond in the RNPW (2002: August 6, 9, 12-14, 15, 17, 22, 27, 30; September 10-12). Most sightings were of a single bird, but on August 15, 2002 there were 2 individuals.

Great Blue Heron, *fannini* subspecies *(Ardea herodias fannini)*
Provincial List: Blue Listed
Federal Status: Special Concern (May 1997)
Provincial Status: S3B,S4N
Because of the susceptibility to human disturbance, in addition to ongoing habitat loss, the non-migratory *fannini* (coastal) race of the Great Blue Heron is considered by COSEWIC to be of "special concern"(Butler 1997a). Sightings at the RNP west were scattered throughout the year, with a cluster of immature bird sightings in August and September. This species uses the pond as foraging habitat, feeding on frogs, tadpoles and possibly garter snakes. Individuals are easily spooked and are only seen when there are few human visitors in the Nature Park. Herons were not reported from the RNP east, and only one sighting (August survey) was recorded for the DND, although it is expected that open areas and ditches in and around those

properties provide fruitful year-round foraging habitat, especially during winter months when Great Blue Herons prey heavily on voles (Butler 1997b). Great Blue Herons forage widely throughout Lulu Island, and will use any ditch or private pond as a potential hunting area. As development continues and densifies, fewer useful water sources or grassy areas in which voles are prey will be available, and all manner of anthropogenic disturbance to herons on Lulu Island will increase (Photo 19.4).

Photo 19.4: Great Blue Heron is occasionally seen in the Nature Park pond. Photo: David Blevins.

Hawks, Eagles, Falcons *(Accipitridae)*

Some Hawks, Eagles and Falcons are Red or Blue-listed provincially (BC Conservation Data Centre 2005), and all are protected by the Migratory Bird Act so preservation of their foraging and breeding habitats should be a high priority. During summer, 2002, in the RNP west, a pair of Cooper's Hawks fledged 2 young near the south end of the Maintenance Trail. During the survey, apart from over flights, no raptors were observed in the RNP east. More recently, however, Cooper's Hawks have been seen and photographed, in July 2004 (Cressey pers. comm. 2004). In the August 2002 count, two adult and three juvenile Northern Harriers were seen in the DND, suggesting that a brood had been raised there that summer. The DND possesses appropriate open foraging areas and nesting sites, which include shrubs and small pines (Campbell et al. 1990). Individuals are frequently observed over the DND, RNP west and blueberry fields south of Westminster Highway during summer months (Griffith pers. comm. 2004). Other accipitrids that use these lands, seen during the survey period, include Peregrine, Merlin, Northern Goshawk, Rough-legged Hawk and Red-tailed Hawk.

Barn Owl (western population) ***(Tyto alba)***
Provincial List: Blue Listed
Federal Status: Special Concern under SARA, listed May 2003
Provincial Status: S3

The western race of the Barn Owl, which has been observed in and near the RNP west and DND, depends heavily on Townsend's Vole (*Microtus townsendii)* in the Lower Mainland (Andrusiak and Cheng 1997). This prey species is one of the dominant small mammal species in the bog (see Chapter 18), thus these lands are important in the maintenance of this population. A second significant requirement for the Barn Owl is the presence of man-made structures, especially barns, as nesting sites. Barn Owls may breed in winter months, and at the northern extreme of their range, which includes the Lower Fraser Valley, the relative thermal protection provided within barns increases fledging success (Andrusiak and Cheng 1997). The Lulu Island Bog falls within provincial Agricultural Land Reserve, and surrounding farms probably provide nesting places. In combination with these sites, the DND-RNP lands would help sustain this population (Photo 19.5).

Photo 19.5: Barn Owl (Tyto alba). This species is frequently seen hunting in the bog. Photo: Fred Lang.

Western Screech-Owl ***(Otus kennicotti kennicotti)***

Provincial List: Blue Listed
Federal Status: Special Concern (May, 2002)
Provincial Status: S3

Michael Beck (pers. comm. 2000) recorded a single sighting of this Western Screech Owl sub-species in the RNP west property prior to this inventory (date uncertain), and an individual responded vocally to a taped owl call during a Nature Park public program in November 2003 (Griffith pers. obs. 2003). Richmond is within the breeding range of this species, and both the RNP east and RNP west properties have appropriate breeding and non-breeding habitat for this species. Habitat is described by Campbell et al. (1990) as open deciduous and coniferous woods at low elevations, usually near water. It is possible that these small, secretive owls reside in the bog.

Hutton's Vireo ***(Vireo huttoni)***

Provincial List: Yellow Listed
Federal Status: not ranked
Provincial Status: S4

This species is a resident in the Lulu Island Bog. It was likely once widely spread on Lulu Island when bog forest habitats occurred more frequently, but has been largely displaced by farmland and urban development. The Nature Park properties and DND may be a last viable habitat for this species on Lulu Island. Its breeding habitat includes coastal western hemlock with cedar and shore pine (Campbell et al. 1997), which closely describes parts of all three properties. It uses shrub understorey and prefers forest edges, where the shrub layer is thicker (Campbell et al. 1997). It is not known from urban or rural environments. It is known to nest in the mixed birch-western hemlock forests of the RNP west, and could be expected to nest within comparable habitats in the RNP east and the DND.

Band-tailed Pigeon ***(Columba fasciata)***

Provincial Status: Blue Listed
Federal Status: not ranked
Regional Status: S3S4B

This species was observed in the RNP west when blueberries were in fruit (August-September 2002). Its typical habitat includes lowlands in open sites bordered by tall conifers (Campbell et al. 1990). In the RNP west, they were seen in open bog, usually perched high in western hemlocks. Their appearance in the bog coincides with the migratory pattern of this species, from the interior to the coast in early autumn (Campbell et al.1990). It is reported as an uncommon to locally abundant resident on the South Coast (Campbell et al. 1990).

Pileated Woodpecker *(Dryocopus pileatus)*
Provincial Status: Yellow Listed
Federal Status: not ranked
Regional Status: S4S5B
This species is seen occasionally at the RNP west. It is not considered at risk but has the potential to become vulnerable under certain circumstances, particularly habitat degradation. This largest woodpecker species requires expansive areas of forest, on the order of 100 hectares or more per breeding pair, depending on the density of snags and decadent living trees with trunk diameters (at breast height) of at least 30 cm (Renkin and Wiggers 1993). It forages by excavating large holes, which then are used by other birds. For this reason it is regarded as a keystone species in the region (Aubry and Raley 2002). The Nature Park-DND lands provide potential nesting room for this species, and fresh excavations in the trunks of larger birches are still found, indicating its continued presence.

Barn Swallow *(Hirundo rustica)*
Provincial Status: Yellow List
Federal Status: not ranked
Regional Status: S4B
Barn Swallows are common summer aerial feeders over the open areas of the RNP west and the DND. Worldwide, a decline of this species has been noted in recent years. In Canada, Breeding Bird Survey data suggest Barn Swallows have experienced a 2.9% annual decline over the past 30 years. Decrease in Canada is accelerating, and had dropped by almost 5% a year by the end of the 1980s (Brown and Brown 1999). It is feared that Barn Swallows will be declared a threatened species in Canada within a decade (Bird Studies Canada 2004).

19.4.2 Overall significance of the Lulu Island Bog to birds

These properties comprise a significant forested green space in the centre of Lulu Island, and therefore contain important habitat for both resident and migrant species of birds (Photo 19.6 and Photo 19.7). Situated within the Pacific Flyway, they provide an important resting and feeding station for frugivorous (feeds primarily on fruit) and insectivorous (feeds primarily on insects) migrants, such as band-tailed pigeons, thrushes, tanagers and warblers, and also provide safe, daytime roosts for migrant and resident owls.

Photo 19.6: Barred Owls are frequently seen in the bog. Photo: Fred Lang.

The availability of small vertebrate prey provides food for raptors and herons, including provincially Blue-listed species. The most extensive open heath bog is found in the DND property. These are attractive foraging areas for aerial hunters, including Northern Harriers, and insectivores such as swallows, swifts, and potentially nighthawks. Nighthawks have not been observed, but due to the crepuscular habits (primarily active during the twilight hours) would not be expected to be flying at times when the surveys were done. The wetter areas of this property and the adjacent areas of the RNP west are also attractive to typical wetland species such as Common Yellowthroat and Common Snipe.

Historically the combined area of the bogs of Lulu Island surpassed the present area of the famous Burns Bog in our neighbouring community of Delta, and overall, the avian faunal compositions are very similar (see Hebda et al. 2000). However, several notable species found in Burns Bog do not occur in the Lulu Island Bog. There are small numbers of sandhill cranes breeding in Burns Bog, American Bitterns still occur, and it is heavily used by migrant waterfowl. Barn owls use the bog forest margins and hunt over the open bog (Hebda et al. 2000). The similarity in size of these two bogs, and their close proximity, suggest that some breeding species have been lost from Lulu Island due to conversion of bog habitat to farms and urbanization. As islands of bog habitat are reduced in area, the numbers of species able to use them decreases. Among the first lost are those that require large home ranges or distance from human disturbance. The Lulu Island Bog remains a vital habitat for avian life, but with any additional loss of area will become less useful and avian biodiversity will be expected to drop, especially among raptors, herons, and other species at risk.

Photo 19.7: Sapsuckers are frequently observed in the study area. Photo: Hugh Griffith.

19.4.3 Current Protection for Birds in Richmond

Presently all migratory species are protected under the Migratory Birds Convention Act, 1994, an international agreement that implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful. In addition, under the Provincial Wildlife Act, birds, eggs of birds, and nests containing eggs may not be killed, taken or disturbed. The nests of eagle, peregrine falcon, gyrfalcon, osprey, heron and burrowing owl species may not be disturbed even when vacant.

The provincially designated Red and Blue lists, determined and maintained by the BC Conservation Data Centre, specify provincial conservation priorities and should be consulted by municipal and other jurisdictions prior to modification or reduction of important wildlife habitat. Should these guidelines not be adhered to, and habitat of species deemed at risk under the federal Species at Risk Act of 2002 is endangered, federal legislation may be used to ensure protection of that/those species. The Species at Risk Act, as it applies to migratory birds, states:

"in the case of a species that is a species of migratory birds protected by the *Migratory Birds Convention Act, 1994*,

(i) on federal land or in the exclusive economic zone of Canada,

(A) identify habitat that is necessary for the survival or recovery of the species in the area to which the emergency order relates, and

(B) include provisions requiring the doing of things that protect the species and that habitat and provisions prohibiting activities that may adversely affect the species and that habitat, and

(ii) on land other than land referred to in subparagraph (i),

(A) identify habitat that is necessary for the survival or recovery of the species in the area to which the emergency order relates, and

(B) include provisions requiring the doing of things that protect the species and provisions prohibiting activities that may adversely affect the species and that habitat;"

Complete text is available at:
http://www.sararegistry.gc.ca/approach/act/default_e.cfm

CHAPTER 20: FISH OF THE LULU ISLAND BOG

By Neil Davis and Shannon Cressey

20.1 Introduction

There are approximately 70 fish taxa documented in British Columbia's freshwater environment (Clemens and Lindsey 1959). Of those, approximately 29 are resident or semi-resident in the waters in and around the City of Richmond, including Lulu Island (Naito 2004). These often occur in ditches, creeks and other wetland sites on Richmond's dyked islands. Included among these are species at risk, economically important species, and species of special interest to First Nations and recreational fishers such as salmon. This range of species makes inventorying the fish species on Lulu Island in the vicinity of the Lulu Island Bog important.

The first European settlers in Richmond and on Lulu Island were farmers who immediately set about clearing, dyking and draining Lulu Island (City of Richmond 2005). Dykes and drainage altered the distribution and nature of aquatic habitats on Lulu Island. Natural streams and sloughs that existed prior to settlement disappeared or were modified, replaced by a growing network of drainage channels flowing into the Fraser River to control the island's water levels and prevent flooding. Aquatic habitats in and around Lulu Island today primarily consist of this network of drainage channels and those outside the dykes associated with the Fraser River estuary (Naito 2004).

Lulu Island is divided into drainage catchments, each of which drains the network of waterways contained therein (Figure 20.1). Each drainage catchment is defined by the area that is contributing drainage to the associated water control structure under gravity conditions (Paller pers. comm. 2005). The catchments are drained by water control structures whose design and function vary. All of the catchments' water control structures allow water to flow out into the Fraser River via gravity. Lulu Island has varying elevation; approximately one quarter of Lulu Island is five metres or more above sea level, and the remaining three quarters are lower (Kidd 1979).

Most catchments have water control structures with one-way gates that are also designed to prevent the inflow of water from the Fraser River. However, there are a number of catchments with structures that are capable of opening to allow water in for irrigation from the Fraser River via gravity at high tide, and this has implications for the fish of Lulu Island. The No. 8 Road North catchment (Figure 20.1) is capable of pumping water in from the Fraser River in addition to allowing it to flow in and out via gravity. The pump intake is screened to prevent the uptake of debris or fish.

The Lulu Island Bog is drained by 4 catchments: Bath Slough; Highway 99; Shell Road North; and No. 4 Road North (Figure 20.1), none of which are designed to facilitate water intake. However, in general, catchments are not isolated from one another. Pipes and/or open channels may connect adjacent catchments, allowing water to flow between catchments in the event of blockage, conveyance system overcapacity, pump settings, or adjustments to water level control structures (Paller pers. comm. 2005). These interconnections minimize the risk of flooding, but also allow fish to make their way through the interconnecting systems. Waterways in the catchments consist of open channels or ditches and buried pipes and culverts. Although some of the waterways immediately surrounding the bog are open channels, a significant portion of the waterways in the four catchments that drain the bog are enclosed (Naito pers. comm. 2004).

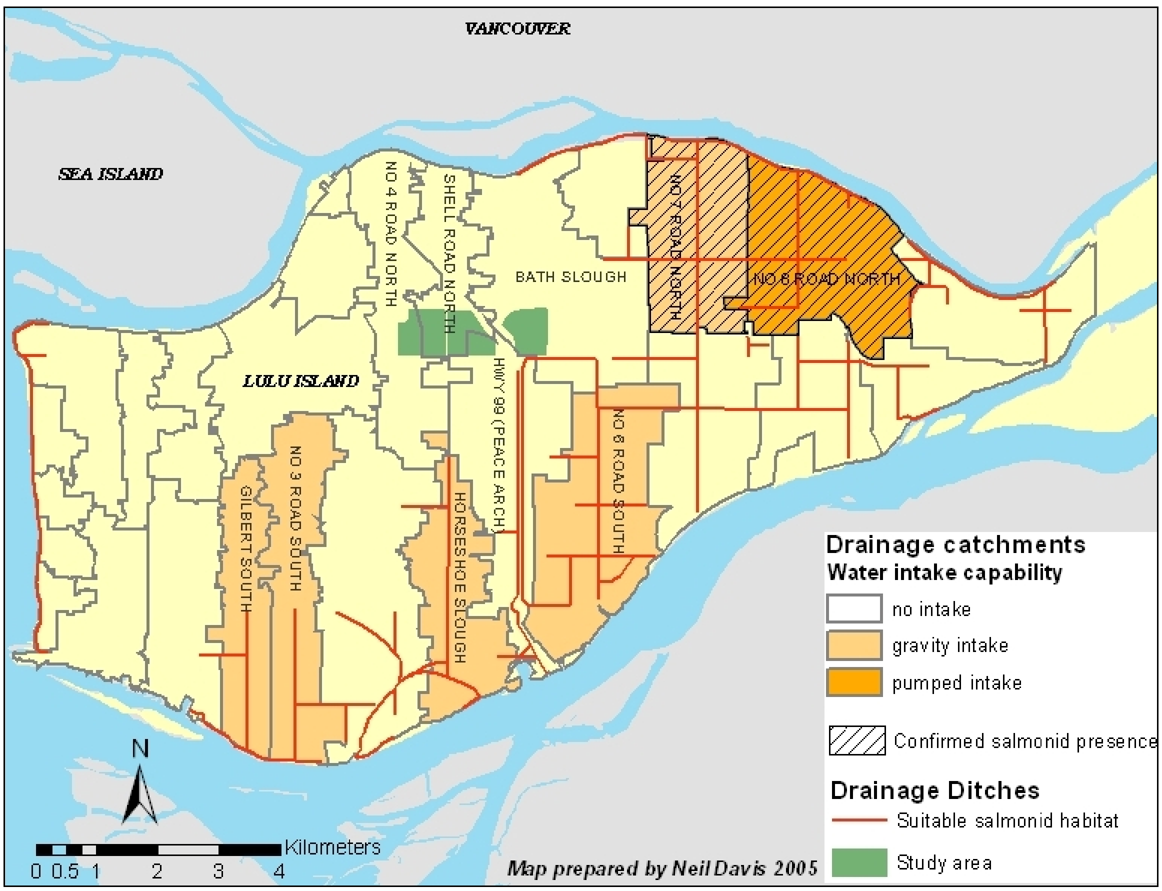

Figure 20.1: Lulu Island drainage catchments and salmonid habitat.
Source: City of Richmond 2004, Naito 2004.

To date, there has been very little inventory of the fish species present in Lulu Island's waterways. Two consulting firms, Beak Consultants and Integrated Resource Consultants (IRC), surveyed the No. 7 Road North, Cambie Road, and No. 8 Road North irrigation ditches on behalf of the City of Richmond in 1993 and 1994, respectively (Beak Consultants 1993, IRC 1994). These surveys recorded the presence of salmonids in the Cambie Road and No. 8 Road North irrigation ditches (Beak Consultants 1993, IRC 1994)[1]. Fisheries and Oceans Canada Habitat Biologist Brian Naito has also mapped the waterways on Lulu Island that may be potentially salmon-bearing based on the anticipated water quality (particularly in the springtime when salmonids are most likely to be present) and likelihood of their survival. The mapping is reflected in the "suitable salmonid habitat" identified in Figure 20.1. Extended lengths of enclosed waterways may decrease the likelihood of salmonid presence; past studies have shown fish to be less likely to move through enclosed waterways than open waterways (Warren and Pardew 1998).

Photo 20.1: Tiny seasonal stream that flows through the fen-like area in the DND property. Photo: Rose Klinkenberg.

Several different aquatic habitats are present in and around the Lulu Island Bog. In the DND property, a small fen-like area contains a small seasonally drying stream that is wet and flowing in winter (Klinkenberg pers. comm. 2005)Photo 20.1). There is a small, manmade pond in the southeast corner of the Richmond Nature Park (RNP west) and another man made pond in the Richmond Nature Study Area (RNP east).

[1] Fish species reported in these ditches were Three-spine Stickleback, Northern Squawfish, Carp, Brown Bullhead, Prickly Sculpin, Redside Shiner, Chinook Salmon (Beak Consultants 1993), Cutthroat Trout juveniles and Coho Salmon juveniles (Integrated Resource Consultants 1994).

The 3 bog properties also have peripheral drainage ditches that are dry in some summers and wet from precipitation and road runoff later in the fall, winter and early spring. There are also 2 larger drainage ditches that contain water throughout the year. They are located on the east side of the RNP west and the west side of the RNP east, and were built in the late 1950s in conjunction with the construction of Highway 99 which bisected the park's west and east properties.

20.2 Purpose

There has been no previous known effort to survey for fish species in and around the Lulu Island Bog, although ditches in Richmond have been surveyed by others and can support salmonid species (Naito pers. comm. 2004). This study aimed to carry out a presence/not detected survey of the open aquatic habitats of the Lulu Island Bog for the presence of fish species.

20.3 Methods

A literature search on drainage systems, significant species, and potential for fish occurrences was conducted. Particular attention was paid to the potential for occurrence of Red or Blue-listed species, or significant species such as salmonids. Water bodies were assessed for standing water and suitability during the dry season, and later during the wet season. Based on the seasonality of water presence, connectivity to other waterbodies and the amount of standing water, 3 ditches were targeted for sampling: the west ditch of the west park property, and the larger ditches located on the east side of the west property and the west side of the east property. The ditches surrounding the DND property did not contain sufficient standing water during the survey period and were not sampled.

20.3.1 Targeted Species

Based on the results of a literature search on recorded species in the area (Naito 2004), habitat preferences, and the connectivity of Lulu Island waterways, several species were targeted in the fish survey:

Brassy Minnow *(Hybognathus hankinsoni)*

BC status: Yellow-listed

Habitat: small, weedy, slow moving creeks or streams with sand gravel or mud bottoms. They can also be found in boggy lakes, sloughs, and ditches in brackish or in tidally influenced waters (BC Fish Facts 2004).

Locally observed: the Brassy Minnow's historical range includes the Fraser Lowland (BC Fish Facts 2004). Within Richmond, the Brassy Minnow occurs in the Fraser River (Northcote 1974).

At the outset of the inventory, the Brassy Minnow was Blue-listed (MELP 2004) and identified as an intermediate priority candidate for assessment on the COSEWIC candidate list (COSEWIC 2004). Recent surveys in the northern part of its BC range recorded a distribution more widespread than previously established. As a result of these surveys, its status was reassessed in 2004, and it is now Yellow-listed (MSRM 2004).

Coho salmon ***(Oncorhynchus kisutch)***

BC status: Yellow-listed

Habitat: Juveniles will remain in their natal stream for up to a year before migrating out to the ocean. These streams generally have small gravel substrate, low flow velocity and clean water. In the winter, to avoid high water flows the juveniles will often migrate into smaller tributaries and off-channel habitat. Ditches like those in the study area may offer habitat similar to low flow tributaries and off-channel habitat.

Locally observed: Coho salmon juveniles have been recorded in the No. 8 Road Irrigation Drainage Channel north of Highway 91 (IRC 1994), approximately 5 kilometres from the study area.

Chinook salmon ***(Oncorhynchus tshawytscha)***

BC status: Yellow-listed

Habitat: Chinook generally inhabit larger, deeper tributaries than Coho. The juveniles will move from the main river stem into smaller tributaries and seek cover under overhanging vegetation and cutbacks in the fall and winter. The two larger ditches in the study area provide overhanging vegetation and low water velocity that may be suitable for Chinook juveniles, and thus were targeted for sampling.

Locally observed: Chinook salmon juveniles have been recorded in the No. 8 Road Irrigation Drainage Channel north of Highway 91, as well as the Cambie Road Irrigation Drainage Channel north of Highway 91 (Beak Consultants 1993, IRC 1994).

20.3.2 Sampling Methods

Based on a literature search and input from a DFO fisheries biologist, the following sampling methodology was followed:

- Gee-type minnow traps were placed in 3 ditches surrounding the bog, in addition to other water level dependent locations;
- 7 traps were placed in the east ditch on the west property;
- 7 traps were placed in the west ditch on the east property;

- 2-3 traps were placed in the west ditch on the west property;
- Traps were set daily for 1 week/month from July to November, with the exception of August and September;
- When set, traps were checked every 4-5 hours. Although they have a maximum allowable soak time of 24 hours (RISC Fish Collection Standards 1997), they were checked more frequently to prevent fish mortalities due to possible low oxygen levels and high temperatures;
- Traps were baited with cat food or salmon roe. The bait was placed in a nylon stocking and wired to the side of the trap or in a film canister with holes punched throughout;
- Small rocks were placed in the traps to provide refuge and minimize predation among captured fish (RISC Fish Collection Standards 1997);
- Each species trapped was photo documented and recorded. Species of interest were measured and weighed. Specimens were released after measurement;
- After each trapping period all traps were removed so that they did not continue to fish indefinitely (RISC Fish Collection Standards 1997).

20.4 Results

2168 trapping hours were expended between July and December 2004. Threespine stickleback (*Gasterosteus aculeatus*) and Goldfish (*Carassius auratus*) (Table 20.1, Photo 20.2) were the only two fish species recorded in adjacent ditches. In total, 1082 Threespine Stickleback and 2 Goldfish were captured.

Table 20.1: Fish species of the Lulu Island Bog

Fish Species	**Location (Property/Ditch)**		
	West/West	West/East	East/West
Threespine Stickleback (*Gasterosteus aculeatus)*	0	205	877
Goldfish (*Carassius auratus)*	0	0	2
Total Fish Captured	0	205	879
Total Trap Hours	33	1207.5	927.5

Photo 20.2: Three-spine Sticklebacks and Bullfrog tadpole caught during fish surveying in the bog. Photo: Shannon Cressey.

20.4.1 Species Accounts

Threespine Stickleback *(Gasterosteus aculeatus)*

Conservation Status: not of concern.

Habitat: marine, brackish and freshwater; lakes, ponds, streams, and ditches.

Comments: Very widespread throughout BC. In Richmond they have been found in the No. 7 Road Irrigation Drainage Channel north of Highway 91, No. 8 Road Irrigation Drainage Channel north of Highway 91, Cambie Road Irrigation Drainage Channel north of Highway 91, Nelson Road and Westminster Highway Drainage Channel, and Westminster Highway between No. 7 Road and No. 8 Road (Naito 2004).

Goldfish *(Carassius auratus)*

Conservation Status: not of concern; a widespread introduced exotic species.

Habitat: prefer warm, shallow, muddy-bottomed lakes and ponds; spawn in weedy shallows (Carl et al. 1973).

Comments: Goldfish were introduced to BC from Asia and have become widespread since their introduction. In Richmond they have been found in the Nelson Road and Westminster Highway Drainage Channel, Westminster Highway between No. 7 Road and No. 8 Road, and No. 8 Road Irrigation Drainage Channel north of Highway 91 (Naito 2004).

20.5 Discussion

Several key factors influence the presence, or recorded presence, of fish species in the ditches around the perimeter of the Lulu Island Bog, including connectivity, channel enclosure, water quality, seasonality of water flows, seasonality of surveys, and climatic flux.

20.5.1 Connectivity

Connectivity of the study area waterbodies and their proximity to the Fraser River may both have an effect on fish species abundance and distribution. Salmonids, including Chinook, Coho and Cutthroat Trout, have been found in several irrigation drainage channels approximately 5 kilometres from the Richmond Nature Park. Other freshwater species, including the Largescale Sucker, Common Carp, Goldfish, Redside Shiner, Pike minnow, and Brown Bullhead have also been recorded in irrigation drainage channels (Naito 2004). Most of these species are recorded in drainage channels more proximal to the Fraser River than the study area. This may be due to a lack of surveys further inland, or there may be barriers or filters discouraging fish movement further from the river.

As mentioned, drainage catchments differentially allow water inflow and outflow. Drainage catchments that open to allow inflow are more likely to periodically or permanently host species from the Fraser River, as fish entry is presumably easier. However, catchments are not isolated from one another, and if suitable connecting habitat exists, fish may move between catchments. It is also possible for fish to directly enter catchments that do not open to allow inflow if they enter drainage control structures against the flow direction. The connectivity of the 2 year-round ditches to other waterways where the trapped fish were caught is not well understood. The ditches are the jurisdiction of the provincial Ministry of Transportation, whose drainage channels link with the city's drainage system (Smith pers. comm. 2005). The 2 ditches appear to connect to city drainage channels at No. 5 Road.

20.5.2 Enclosed Channels

The degree to which drainage channels in a catchment are enclosed may have significant effects on fish movement. Warren and Pardew (1998) found that fish movement through culverts was an order of magnitude lower than through open box channels or natural stream reaches. Hence, the enclosed drainage channels on Lulu Island may restrict fish movement between more suitable open channel habitats. The drainage catchments that drain the Lulu Island Bog contain extended lengths of enclosed channels. This has several implications. First, it may prevent fish species that directly enter those drainage catchments from reaching the ditches in the study area. Second, it may prevent fish species from adjacent catchments from moving into the ditches in the study area. In other words, though connecting channels may exist between catchments draining the bog and catchments with aforementioned fish species, the connecting channels may be largely enclosed, and thus, effectively act as barriers between or within catchments.

20.5.3 Water Quality

The quality of the water in and around the Lulu Island bog may also play a role in the fish species composition in the study area. Dissolved oxygen content and water temperature are two important factors that influence the suitability of aquatic environments for fishes (Hondzo and Stefan 1996) and may be pertinent in explaining the fish species composition in the study area.

Fish species have different tolerances to temperature and dissolved oxygen content. Beitinger et al. (2000) summarize research on the temperature tolerances of North American freshwater fishes. Threespine Stickleback and Goldfish and *Hybognathus placitus* (a relative of the Brassy Minnow) exhibit higher maximum temperature tolerances than salmonids such as Coho (Beitinger et al. 2000). During the summer months, the study area ditches may rise to sub-optimal or lethal temperatures for salmonids, but remain suitable for minnows (M.A. Whelen and Associates Ltd., as cited in Hebda et al. 2000), Threespine Stickleback and Goldfish. Increases in water temperature can lead to decreases in dissolved oxygen content (Morrill et al. 2005). Dissolved oxygen levels below 6.0 mg/l can cause stress or death in juvenile salmonids (CCME 1992, as cited in Hebda et al. 2000) (Sigma Environmental Consultants 1983, as cited in Hebda et al. 2000). Physical and chemical measurements in the No. 7 Road, No. 8 Road and Cambie Road irrigation ditches in 1993 and 1994 recorded low flow, water temperature as high as 23º C, dissolved oxygen content as low as 1.2 mg/L, and regular occurrence of dark leachate (Beak Consultants 1993, IRC 1994). IRC (1994) stated that high temperatures (15 - 20º C) and low dissolved oxygen content (1.2 - 9.5 mg/L) in the No. 8 Road ditch during June and July likely caused stress in fish populations present. It is reasonable to assume that the climate and flow conditions in the study area are similar to those of the irrigation ditches surveyed in 1993 and 1994. Dissolved oxygen content and water temperature may also be similar, and are likely strong selecting forces determining the species present in the study area.

Water flow in all of the study area ditches is very limited. There are no other apparent water mixing processes that might increase dissolved oxygen content in the water. The water volume in the ditches is limited, and in the two ditches that contain water throughout the year, water depth is shallowest during the summer. Consequently, water temperatures during hot spells in the summer months may become quite high and dissolved oxygen content may decrease to the point of causing stress or death in fishes. Although no measurements of water temperature and dissolved oxygen content were recorded for this study, trapping mortalities occurred only during July, not in the fall months. This further suggests that temperature and/or dissolved oxygen content are important factors in determining water quality in the study area ditches.

20.5.4 Seasonality of Water Flows

Salmonids, minnow, carp, or sculpin species may also be absent as a result of the seasonality of most of the perimeter ditches surrounding the Richmond Nature Park. As mentioned, there were only 2 ditches with permanent water in 2005. All of the other ditches were seasonal with water periodically or consistently present in the fall, winter and spring. Thus, species may periodically migrate to the study area ditches during wet periods, but without year-round habitat, be unable to survive.

20.5.5 Seasonality of Surveys and Climatic Variation

The seasonality of surveys may have also played a role in the species caught during the trapping period. Trapping was conducted in the summer and late fall. Some species may be more abundant at other times of year. For example, the probability of the presence of juvenile salmonids may be greatest in the spring after emergence.

Moreover, the presence, persistence and depth of water in the ditches around the study properties throughout each year are influenced by the weather. Had the fish surveys been conducted in another year with different availability of aquatic habitat, they may have yielded different results. Surveys conducted over several years would create a more representative picture of aquatic habitats in the bog.

CHAPTER 21: LAND SNAILS OF THE LULU ISLAND BOG

By Rose Klinkenberg

Inventory work in the Lulu Island Bog was carried out by volunteers from the Richmond Nature Park Society Ecology Committee. Field assessments were done on several faunal groups as well as on vascular and non-vascular plants. During this work, incidental observations of land snails (snails and slugs) were recorded, and shells were collected and photographed by John MacQueen, Hugh Griffiths and Rose Klinkenberg. Identifications from snail shells and from leaf litter samples were made by Robert Forsyth.

Based on photos of shells, and analysis of leaf litter from the bog, five species of slugs and five species of snails have been confirmed for the Lulu Island Bog (Photo 21.1, Photo 21.2 and Photo 21.3). A list of species is presented in the Appendix D-9. Nomenclature for land snails follows Forsyth (2004).

Photo 21.1: Grove Snail (Cepaea nemoralis). A common, introduced species of land snail.
Photo: Diane Williamson.

Of the 10 species recorded for the bog to date, four are native and six are introduced. No rare species of land snails have been documented. There are no doubt other species of land snails present in the bog. Continued inventory for new species should be undertaken and incidental observations encouraged.

The text "*Land Snails of British Columbia*" by Robert Forsyth provides a useful identification guide for BC land snails. Additionally, Robert's web site on land snails of BC provides a photo gallery of species for further assistance in identification (see http://www3.telus.net/rforsyth/gallery/index.htm).

Photo 21.2: Robust Lancetooth (Haplotrema vancouverense) is found in the study area and is a native, forest-dwelling species of land snail that is frequent in conifer forests. Photo: Robert Forsyth.

Photo 21.3: Grey Fieldslug (Deroceras reticulatum) is found in the study area and is one of the most common and widespread introduced species in BC (Forsyth 2004). Photo: Robert Forsyth.

PART III: EVALUATION, UNDERSTANDING AND THE FUTURE

CHAPTER 22: RESTORING THE LULU ISLAND BOG

By Danielle Cobbaert

22.1 Introduction

Historically, Lulu Island Bog was a domed bog with a raised surface near the centre and a high water table forming a groundwater mound. Domed bogs are typically surrounded by a lagg, which is a transition zone between the peat bog and adjacent mineral soils. The lagg is defined by unique vegetation, often shrubs such as willows, and intermediate hydrological and hydrochemical properties.

The Lulu Island Bog today is a fragment of the extensive bog that once covered much of Lulu Island, Richmond. Now it is comprised of three small parcels of land, each bounded by roadways and drained throughout the year, as well as tiny fragmented remnants bordering agricultural fields and adjacent subdivisions. Drainage has resulted in drying of the bog ecosystem, and the invasion of non-native plant species. This remnant bog has never been mined, and hence the peat mat has not been disturbed to a great extent. However, the drainage changes and invasion of non-native plants, and possibly the reduction of fire, have resulted in a shift away from open bog habitat in some portions of the study area--particularly the eastern portion--towards a bog forest (Photo 22.1). There has been a large die-off of *Sphagnum* mosses, particularly in areas of heavy growth by the invasive highbush blueberry (*Vaccinium corymbosum*) in the Richmond Nature Park (RNP west) property, and in access ways in the Department of Natural Defence (DND) property (Photo 22.2). Their die-off is significant. *Sphagnum* mosses are regarded as a keystone species in bogs because they actively produce peat, help to maintain acidic conditions and maintain a high water table (van Breeman, 1995). Hence the loss of *Sphagnum* signifies a loss of many critical bog functions.

A parallel gradient of bog conditions and associated vegetation types closely follows a slight east-west gradient in elevation and moisture regimes that are present in the three study area properties. The Richmond Nature Study Area (RNP east) is the driest of the three study properties, while the DND property is the wettest. These wetter conditions have resulted in the greatest retention of open bog. The RNP west sits in the middle of the gradient, supporting both bog forest, and portions of open heath bog in good condition.

While the drainage alterations are shifting the Lulu Island Bog towards a bog forest habitat in the east portions, this need not be a permanent situation. Current research shows that it is possible to restore bog ecosystems, even remnants such as this. Because this is not a mined bog, restoration would not require intensive “re-growing” of the peat. In many areas re-wetting the bog may be sufficient to revitalize the peat mat and lead to the spontaneous colonization of bog plant species and an associated decline in invasive species.

Photo 22.1: Danielle Cobbaert and Heather Williamson surveying the vegetation in the Lulu Island Bog. Photo: Karen Golinski.

Photo 22.2: Dead peat mat on access road, DND property. Photo: Brian Klinkenberg.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been disturbed, damaged or destroyed from human activities. It generally aims to restore an ecosystem to the historical state prior to modern human disturbance. Restoration of ecosystems is appropriate in protected areas where there is a long-term commitment to conservation of the natural systems, and where people and resources are in place to implement restoration measures and monitor their success (Society for Ecological Restoration Science and Policy Working Group 2002).

The objective of this chapter is to stimulate discussion on the potential for restoration of the remnants of the Lulu Island Bog. This discussion can contribute to a foundation for a comprehensive approach to designing a management plan for the bog. Understanding the nature and magnitude of disturbances is a necessary first step to developing effective management strategies. Suggestions are made about philosophical and practical considerations to aid in conservation and restoration management decisions.

22.2 Conservation Implications

From a regional perspective, bogs such as the Lulu Island Bog are rare and important to the landscape diversity of the Lower Mainland (Photo 22.3). The Lulu Island Bog is part of the Temperate Wetland Region, in which wetlands represent less than five percent of the total land area (National Wetlands Working Group, 1988). Added to this significance, the shore pine/*Sphagnum* moss community in the Lulu Island Bog is recognized as a provincially rare plant community by the British Columbia Conservation Data Centre (Golinski 2003). Efforts to conserve and restore what is remaining of the Lulu Island Bog will contribute significantly to the land area and diversity of wetland classes in the Lower Mainland.

Photo 22.3: The fen-like area in the DND property, which is sedge-dominated. Disturbed areas in the bog are balanced by areas like this that offer relatively undisturbed natural habitat. Photo: Brian Klinkenberg.

22.3 Disturbance Levels and Implications for Restoration

In analyzing disturbance in bogs with a view to restoration, bog ecologists have classified disturbance levels. These levels vary between very minor alterations of the natural functioning of the system to severe alteration of form and function (Table 22.1). Understanding the disturbance levels sets the stage for determining the degree of restoration and management that will be necessary to return a site to a more natural state.

The RNP east and southern half of the RNP west properties have characteristics of major disturbance. The vegetation is no longer characteristic of an open bog plant community and the upper peat layer is dry and decomposing. The dome shape and associated water mound characteristic of a raised bog are altered in these properties. Human impacts, including fragmentation, severe drainage activities, trampling, pond creation, fire regime alteration and the introduction of exotic species, have resulted in major changes in the vegetation and hydrologic regime.

Table 22.1: Classification of peatlands according to the level of disturbance. Source: Charman 2002.

Disturbance level	Characteristics
Natural	No influence of human activity at any time in the past. Initiation and development processes have proceeded naturally, ecology and hydrology unaffected by current human activity.
Minor disturbance	Some influence of humans in the distant past or very minor levels of recent or current disturbance. Peatlands retain same peatland type and form as they would have in the absence of disturbance.
Moderate disturbance	Disturbance levels in the past or present sufficient to alter the type or form of peatland. A functioning peatland is retained but its structure may be changed and the functions are altered.
Major disturbance	Human activity has altered the structure and form of the peatland. Changes have resulted in species impoverishment, major shifts in hydrology, and changes in the dominant species. Functions are significantly changed and compromised in one or more areas.
Severe disturbance	Damage has almost completely destroyed the original peatland and the existing peatland is entirely a result of human efforts to restore function and form to the site.

In the RNP east, the vegetation has shifted to bog forest associations dominated by pine (*Pinus contorta* var. *contorta*) and birch (*Betula pendula*) in much of the site, with a stand of western hemlock (*Tsuga heterophylla*) dominating along a low ridge in the western portion of the property. The understorey in the central portion of the site is dominated by Labrador tea (*Rhododendron groenlandicum*), bog laurel (*Kalmia microphylla*) and salal (*Gaultheria shallon*) with cloudberry (*Rubus chamaemorus)* and bog blueberry (*Vaccinium uliginosum*) a common associate on *Sphagnum* hummocks. This contrasts with the eastern portion of the property where a thick salal understorey under a birch canopy is present. Exotic species are frequent in areas of open canopy, and include highbush blueberry, Himalayan blackberry (*Rubus discolour*) and evergreen blackberry (*Rubus laciniatus*). In the northeast corner of the property, the vegetation shifts to a willow wetland, with proximal stands of hardhack (*Spiraea douglasii*). These areas may be a remnant of the historical lagg. Aerial photos indicate that this wetland area was once much larger and extended into an area now covered with agricultural fields.

The RNP west property follows a disturbance gradient – from major disturbance in the southeast corner to minor to moderate disturbance towards the western and northern portions. The southern half of the RNP west is more disturbed and altered than the north half of the property, with a high prevalence of tall highbush blueberry. The creation of the pond has altered the hydrologic regime and has likely influenced the peat mat die-off seen near the pond. Tap water added to the pond in the summer may also be affecting the nutrient status of the local area, which would have historically and ecologically relied on precipitation. The vegetation of the RNP property gradually transitions to treed bog in the centre to open heath bog towards the northern and western boundaries, indicative of less disturbed, wetter boggy conditions.

Despite these major disturbances, restoration of these sites to a bog ecosystem is still possible. There are still vast deposits of peat intact and the local climate supports bog ecosystems in the immediate vicinity. The drainage of the RNP properties is the chief disturbance that has damaged the bog ecosystem. Drastic measures in hydrological management are needed to reverse the current drainage and restore natural conditions that would allow peat-forming *Sphagnum* mosses to grow again. This requires maintaining surplus rainwater close to the bog surface for a considerable portion of the year. The groundwater table should reach the surface for most of the winter and in the summer it should not be deeper than 30-40 cm (Schouwenaars, 1993). Water management measures that will help maintain a high, stable water table include: blocking the ditches, creating inundated areas, creating dams parallel to the surface contours to hold surface water, and the removal of trees and shrubs to reduce evapotranspiration. Gates were installed on some of the drains in the RNP circa 1980, but were thought ineffective and are not currently used. Proper construction of gates to block these drainage canals would likely raise the water table and should be seriously considered.

Many trees and large shrubs are intolerant of saturated peat, and are likely to die off if the water table is sufficiently raised. Short term flooding of the site may hasten the death of many of these non-bog species. Many natural bog species are still present in the local area and may naturally re-colonize the sites once suitable hydrologic conditions are established. Facilitating natural colonization will help maintain local populations of natural bog vegetation communities that are relatively rare and regionally important.

There are several invasive alien plant species in the bog that may be problematic for restoration. Highbush blueberry in particular may be difficult to eradicate by simply raising the water table because their roots are quite resistant to flooding (Photo 22.4). The manual removal of such species may be necessary. Transplanting bog vegetation from donor sites should be attempted only if it becomes apparent that natural re-colonization is unlikely.

Photo 22.4: The Time Trail includes one of the wettest spots in the Nature Park, yet blueberry growth is thick. Photo: Brian Klinkenberg.

The DND boglands appear to show only minor to moderate disturbance levels. Taller birches form a band around the perimeter of the property. However, while highbush blueberry and birch trees are still present in the interior of the property, they are generally much shorter and less prevalent. With the exception of the disturbed habitat along the north-south access road and around other old access roads, the interior of the site still supports good bog habitat, with *Sphagnum* moss lawns and hummocks and characteristic bogs species such as Labrador tea, bog blueberry, cloudberry (*Rubus chamaemorus*), cottongrass (*Eriophorum spp.*) and sundews (*Drosera rotundifolia*). The DND property still appears to have characteristics of a domed bog with a raised centre higher than the surrounding roadways. The hydrological regime appears to be in good shape – the water table appears raised to the bog surface for most of the winter with water pooling in hummocks. However, water table draw down occurs in the summer, especially in July and August. Basic hydrological studies during the summer are recommended to determine if these areas are sufficiently wet or if some restorative measures are necessary.

However around the periphery of the DND property, especially near Shell Road, there are areas that are dense with non-native blueberries. Scotch heather (*Calluna vulgaris*) is present on the site, although its prevalence is generally lower than in the adjacent city-owned properties. Blueberry pickers disturb the native bog flora by trampling and creating trails and are responsible for frequent small fires in the DND property. Further disturbance has resulted from the use of the site by the military, where roadways and tower construction have directly impacted the bog. Toxic contamination of the site resulting from military use is an additional, less understood, disturbance. It appears that there is little lagg still present surrounding these properties. One or two of the larger ditches may be functioning as somewhat of a lagg. There is standing water in these larger ditches all year round and it supports *Polygonum amphibian* var. *emersum* and other aquatics that suggest it is quite alkaline.

The DND property and the northern portions of the RNP west property show only low to moderate levels of disturbance and they will therefore require less effort to restore. Several restoration measures may benefit the open heath bog areas, such as the manual removal of invasive species, improvements to the local hydrology, and improvements to the lagg area.

No detailed studies of the extent of fire and its impacts on vegetation have been undertaken in the Lulu Island Bog; however observations suggest that it may promote the establishment of bog vegetation. Many areas of the peat mat show signs of recent fire -- often leading to an upsurge in bog species such as sundew. Several studies have found increased biodiversity of bog vegetation following fire. Fire appears to suppress dominant late-successional species and encourages the growth of rhizomatous plants, herbs and grasses including rare species such as orchids. There also tends to be an increased prevalence of weeds post-fire (Photo 10.13), although they are generally found not to persist (Timmins 1992, Johnson 2001, Norton and De Lange 2003).

22.4 Historic Management and Restoration of the bog.

There is a history of restoration trials in the RNP properties, demonstrating that interest in restoration exists. In 1985, the Richmond Nature Park staff created the Bog Ecology Protection Zone (BEPZ) near the Time Trail in the RNP west property. Within the BEPZ, the Richmond Nature Park Society in cooperation with the Richmond Nature Park, carried out a series of initiatives to restore an open bog ecosystem dominated by native vegetation including:

- removal of birch trees and highbush blueberry shrubs;
- establishment of fixed plots to monitor the re-growth of birch and blueberry over several years;
- creation of two shallow ponds; and
- irrigation of one of the created ponds with a hose during the summer for several years, and the installation of piezometers to monitor ground water levels and flow paths within the BEPZ and between the two ponds.

From 1989 to 1991 near the south junction of the Pond Trail, further efforts were made to reduce the spread of invasive blueberries. The above and belowground portions of highbush blueberry plants were removed in small patches. These areas were then re-vegetated with *Sphagnum*, bog cranberry (*Oxycoccus oxycoccus)*, Labrador tea (*Rhododendron groenlandicum)* and bog-laurel (*Kalmia microphylla*). The transplantation of pitcher plants (*Sarracenia purpurea*)—a species not found in bogs in the Lower Mainland region and that is restricted in occurrence to northern BC—was also attempted, but was unsuccessful.

Informal monitoring of the BEPZ initiatives and observations by park staff concluded that these efforts did not result in appreciable long-term changes. The blueberry removals were time consuming and labour intensive, and the blueberries grew back quickly, particularly when the roots were not removed (Bauder pers. comm. 2005). The transplanted bog species at the sites of blueberry removals have partially recolonized these areas. While these recolonized patches still persist, blueberry re-growth appears likely to eventually overtake them. Piezometer readings in the BEPZ indicate that there is very little lateral movement of water between the two ponds resulting from irrigation. The water level in the bog has been dropping since at least the early 1990s, after water level monitoring began.

These attempts at restoration have not succeeded, most likely because the hydrologic conditions of the site are too dry to support the dominance of native bog species. Further attempts to remove invasive species and transplant bog vegetation are likely to be met with defeat unless efforts are made to restore the hydrological regime.

22.5 Recommendations

If restoration efforts are to be successful, a comprehensive management plan needs to be adopted. It is recommended that an ecological advisory committee with scientific expertise be set up to assist with the development of a Lulu Island Bog management plan. Efforts should be made to link up with scientists from universities, government and other local bog conservation groups to incorporate expertise and to ensure a rigorous scientific management plan is adopted.

Attempts to restore the bog should be carefully designed and monitored using scientific methods. This will allow the effectiveness of various techniques to be assessed and lead to quicker and more prescriptive protocol development. One key point is to ensure that a scientific design is put into place with proper controls. If a decision is made to block ditches then ideally the hydrologic regime of a ditch that isn't blocked and one that is blocked should be monitored and the results compared (and ideally there would be several replicates of each although this is often not possible). The same applies to the removal of blueberry bushes. Several plots of blueberries should be removed and several plots of the same size and characteristics should be identified and left uncut. The vegetation community of the cut and uncut plots should then be periodically monitored with a consistent protocol and statistically compared to determine whether the restoration treatment was successful. Various treatments could also be tested, such as the complete removal of blueberry bushes including roots, cutting only the above ground portion, and cutting 30 cm above the ground.

One critical step towards bog restoration is avoiding the introduction of non-native species. Alien plants can easily spread and may prove difficult to eradicate once they become established. Currently the park's wildlife garden is a source of introduced alien species. Any future work on this garden should avoid planting non-native species and focus only on establishing native species. This will promote a natural state and prevent potentially costly restoration measures at a later date.

The adoption of a comprehensive management plan would ensure that all aspects of bog restoration are considered and integrated including hydrology, plant community dynamics, wildlife, alien species control, and human values. **The order and timing of key restoration actions may be critical for restoration success** and could be incorporated into a bog restoration plan. For example, restoration measures to re-wet the bog should occur before efforts are made to remove the invasive blueberries. The environmental conditions must be suitable for native bog plants to grow otherwise exotic species are likely to re-colonize the site.

CHAPTER 23: RESULTS AND KEY FINDINGS

By Rose Klinkenberg and Neil Davis

23.1 Introduction

The inventory of the Lulu Island Bog has documented some surprising results. First, the bog continues to support bog species typical of bogs in this region, including habitat specialists[1]. Second, this tiny bog supports relatively high species numbers for its size, rivaling Burns Bog, which is a much larger bog that incorporates a greater range of bog and wetland habitats (Table 23.1). Third, in spite of disturbance and its urban setting, the Lulu Island Bog continues to support a viable and representative bog ecosystem and associated plant communities, and supports substantial wildlife populations. Fourth, the bog supports several rare, threatened and endangered species including several SARA-listed species.

Table 23.1: Species totals for the Lulu Island Bog

Vascular Plant species	143	Aquatic Insect species	76
Fungi species	82	Land Snails and Slugs	10
Lichen species	39	Amphibian and Reptile species	7
Moss species	64	Mammal species	19
Sphagnum species	11	Bird species	91
Liverwort species	14	Fish species	2
Butterfly species	11	Tick species	1

More specifically,

- Bog ecosystem functions and processes persist in parts of the study area. It is also a significant natural area and wildlife preserve in Richmond. This is despite (1) its small size, (2) considerable water table reduction, (3) associated vegetation succession in the drier sites, and (4) heavy invasions of species such birch, highbush blueberry and Scotch heather. The persistence of its ecological functions is indicated by the continued presence of live, actively growing *Sphagnum* moss in areas where drainage effects are minimal, the persistence of representative bog plant associations, and the continued presence of the expected suite of representative bog species;
- The bog supports many bog specialist and wetland species and several rare or endangered species (Photo 23.1), including several that are listed under SARA.

[1] Species that are restricted to specialized growing conditions, conditions that are often unique or rare. This includes the cold acidic waters of bogs.

Federally-listed species at risk include: Vancouver Island Beggarticks[2], Barn Owl (western subpopulation), and Great Blue Heron (*fannini* subspecies). The bog also hosts an endangered (provincially red-listed) plant association. Additional significant species may be present, and may be documented in future inventory work;

Photo 23.1: Northern Harriers are often seen hunting in the DND property. For species like this the study area offers invaluable habitat for both roosting and feeding. Photo: David Blevins.

- In spite of disturbance and drainage effects, the bog continues to be colder than the surrounding landscape, as evidenced by observations of late lying snow patches and isolated fog. Because of this, it continues to provide key habitat for many bog specialists that require colder conditions - species and plant associations more typical of northern regions;
- The bog continues to function as a refuge for local populations of wildlife species, including small mammals, large mammals, and birds;
- Because of the high loss of other natural areas in the landscape, the bog provides an "island' of habitat, functioning as a stepping-stone for species movement on Lulu Island, such as for birds during migration periods;
- The Lulu Island Bog provides a readily accessible representation of bog ecosystems in BC, particularly through the trail system and interpretive programs of the Richmond Nature Park.

[2] Under the proposed new BC Conservation Framework (currently under development December 2007) that denotes provincial responsibility for protection of species at risk in BC, *Bidens amplissima* is one of the highest scoring species, if not the highest scoring species, for protection in the province (Fraser pers. comm. 2007).

The inventory work strongly suggests that while the bog ecosystem continues to function, it is significantly impacted by invasive and alien species. The urban setting and altered conditions have resulted in increased representation of alien species, some of which are ecosystem altering. Management that reduces the invasion of alien species is necessary to preserve a bog ecosystem in the study area.

23.1.1 Plant Species

The number of plant species present in the Lulu Island Bog compares favourably to Burns Bog, which is a much larger site (Table 23.2). It continues to support most of the complement of true bog species typical of bogs in the Lower Mainland, with little species loss. Several specific results are surprising. For example, more mosses have been reported in the Lulu Island Bog than for Burns Bog. Similarly, more lichen species have been found in the Lulu Island Bog than in Burns Bog. Interestingly, although the Lulu Island Bog is a fragment of its former size, and while drainage has been significantly altered, it supports almost as many species of *Sphagnum* mosses as Burns Bog. These findings may reflect one or several of three things: greater inventory search time in the Lulu Island Bog, the continued viability and function of this small remnant bog ecosystem, or the variety of vegetation community types present in the Lulu Island Bog (see Chapter 9).

Table 23.2: Comparison of the numbers of plant species: Burns Bog and the Lulu Island Bog.

	Burns Bog	Lulu Island Bog
Vascular Plants	188[3]	143[4]
Mosses	41	64
Sphagnum	14	11
Liverworts	16	14
Lichens	26	39
Macrofungi	94	82

23.1.2 Plant Communities

Plant community representation within the Lulu Island Bog is dispersed across all three properties, and no one property offers identical representation of all plant communities. Quality and areal representation varies from property to property, with drier successional communities, such as bog forest, well represented in the Richmond Nature Study Area (RNP east), a mix of open heath bog and bog forest represented in

[3] Of the 188 vascular plant species reported in Burns Bog in the Burns Bog Review, 58% were native and 41% were alien (Hebda et al. 2000).

[4] Of the 143 vascular plant species reported in the Lulu Island Bog to date 64 (or 44%) are alien species.

the Richmond Nature Park (RNP west), and primarily open heath bog represented in the Department of National Defence (DND) property. The distribution of plant communities follows a moisture gradient from east (driest) to west (wettest), with the DND property representing the wettest and hence better quality bog, and the RNP east primarily[5] representing the driest and most successional bog forest and other forest communities. This gradient of plant communities follows a natural moisture gradient. The DND property is wettest because of its role as a catchment area, as evidenced by the continued presence on the site of an historical, seasonally intermittent, stream.

The best examples of typical raised bog communities (Shore Pine-*Sphagnum*, Labrador tea heath, and representation of bog lawns and hummocks) are found in the DND property, with additional representation found in the north half of the RNP west. The RNP east, which supported open bog and natural openings in the peat mat as recently as 1970, has dried considerably because of drainage changes, resulting in successional bog forest and other wet forested communities. However, substantial representation of bog species continues, including the presence of several *Sphagnum* species, Cloudberry, and Labrador tea.

The RNP east also supports an area of willow wetland and hardhack thickets on mineral soils, distinct from the adjacent peat communities. A similar hardhack association is found in the northwest corner of the DND property.

23.1.3 Animal Species

Similar to plant communities, the fauna documented on each of the three properties were somewhat different, with some faunal groups much more differentiated between properties than others. For example, whereas all but one mammal species documented were common to two or all three properties, aquatic insects were strongly differentiated between the three properties (Appendix D-5). Differences in the faunal species documented for each property are likely the result of two things. First, as some faunal groups are largely influenced by the habitats created by plant communities present on a site, the differences in dominant plant communities on each property likely played an important role. Second, the different sampling efforts on each property coupled with the chance involved in capturing mobile, sometimes hidden, fauna undoubtedly caused surveyors to miss species in some properties that they do in fact inhabit.

[5] The RNP east site supports a small triangular area of willow wetland in the northeast corner. Drainage in this area requires investigation but may reflect a distinct hydrology.

23.1.4 Significant Species

The following rare or endangered species were documented in the Lulu Island Bog (Table 23.3 and Table 23.4):

- **Barn Owl (*Tyto alba*)** (western sub-population): This sub-population is listed on Schedule 1 under SARA[6] as a species of Special Concern. It is provincially blue-listed. Individuals use the Lulu Island Bog as hunting territory and possibly as roosting areas and can be observed in the DND property and in the RNP west. The Barn Owl has also been observed foraging in the DFO (Garden City) lands, west of No. 4 Road;
- **Great Blue Heron (*Ardea herodias fannini*):** Local populations use the Nature Park pond (RNP west) and perimeter ditches for hunting.
- **Vancouver Island beggarticks *(Bidens amplissima)*:** This is a nationally rare plant species listed on Schedule 1 under SARA as a species of special concern. It is provincially blue-listed. It occurs in the west property of the RNP west, in the park pond and in the perimeter ditch along No. 5 Road. Population numbers of this species fluctuate dramatically from year to year, in some years occurring in the hundreds while in other years few or no plants appear. This is an annual seed-bank dependent species. Seed banks in the nature park pond and perimeter ditches require protection if the population is to persist in the park (Photo 23.2);
- **Beaverpond Baskettail *(Epitheca canis)*:** This species is a provincially blue-listed species of dragonfly. It occurs in the RNP west. This is the only recorded occurrence of this dragonfly species in Richmond;
- A number of other rare aquatic insects were also identified in the bog, including: ***Cenocorixa blaisdelli, Cyphon exiguous, Hydaticus aruspex***, and ***Agonum belleri.*** Of these species, *Agonum belleri* is associated with bogs, and *Cyphon exiguous,* found only in BC, is associated with bogs and marshes. *Cenocorixa blaisdelli* is confined to the very southwest of BC within Canada. These species are candidates for COSEWIC status assessments;
- ***Amanita novinupta***: This mycorrhizal species of macro-fungi is extremely rare in BC. It is closely related to *Amanita rubescens* of eastern North America, and was previously considered a form of that species. It is not recorded in *'Macrofungi of British Columbia: Requirements for Inventory'* (Redhead 1997), which lists all fungi reported in BC up to 1997. This species was found in the RNP west.
- ***Orthotrichum pulchellum* and *Sanionia symmetrica***: These epiphytic mosses are both rare in the Lower Mainland, and are found in one area of the bog in the DND. The site of occurrence has shrubby cover and standing water.

[6] Federal Species At Risk Act (SARA), which regulates Species at Risk found on federal lands

Photo 23.2: Vancouver Island Beggarticks (Bidens amplissima) is one of the most significant species found in the study area. Photo: Brian Klinkenberg.

Table 23.3: SARA-listed species confirmed in the Lulu Island Bog

Species	Status	Properties of Occurrence
Barn Owl (*Tyto alba*) (western population)	Global Status: G5 Federal Status: Special Concern (SARA Schedule 1) Provincial Status: S3 BC List: Blue Listed	RNP west and DND (observed in early morning on park trails, and at dusk hunting, possibly roosting). Also observed several times foraging over the DFO lands (Garden City Lands, immediately west of DND).
Great Blue Heron (*Ardea herodias fannini)* (*fannini* sub-species)	Global Status: G5T4 Federal Status: Special Concern (SARA Schedule 3) Provincial Status: S3B, S4N BC List: Blue Listed	RNP west (park pond and east perimeter ditch)
Vancouver Island Beggarticks (*Bidens amplissima*) [7]	Global Status: G3 Federal Status: Special Concern (SARA Schedule 1) Provincial Status: S3 BC List: Blue Endemic to BC and WA.	RNP west (park pond and east perimeter ditch).

Table 23.4: SARA-listed species - unconfirmed, but potentially present in the bog

Species	Status	Properties of Occurrence
Pacific Water Shrew (*Sorex bendirii*)	Global Status: G4 Federal Status: Threatened (SARA Schedule 1) Provincial Status: S BC List: Red	The DND property and the Richmond Nature Park are considered highly suitable habitat for this species, although no animals have been captured.
Washington Snowshoe Hare (*Lepus americanus washingtonii*)[8]	Federal Status: Unlisted Provincial Status: S BC List: Red	Sightings reported from study area, however present occurrence is as yet unconfirmed. Bell, 1984 reported the species as present based on a specimen observation. A roadkill juvenile animal found adjacent to the RNP east property in Sept. 2006 was identified as a “possible” Snowshoe Hare (Nagorsen pers. comm. 2007).

[7] Recently ranked as one of the top species in BC for provincial attention (Fraser pers. comm. 2007).
[8] This species has not been evaluated at the federal level, by COSEWIC, because it is data deficient. However, data is now being compiled on it.

CHAPTER 24: EVALUATION - THE IMPORTANCE OF BEING A BOG

By Neil Davis

24.1 Introduction

In conducting this inventory, we sought not only to document the biophysical components of the bog, but also to assess its significance and role as a natural area and a contributor to regional biodiversity, and to examine how those roles are currently protected. This section analyzes the findings of the inventory and explores these topics. It is guided by several specific questions. First, what picture of the bog's significance and conservation value emerges from the cumulative findings of the inventory when considered together? Second, what are the major issues that threaten the persistence of the bog ecosystem? Third, how are the individual and emergent findings situated and significant in the regional context of natural areas protection and biodiversity conservation initiatives? Lastly, what are the protective measures that are in place, or that are relevant, for the bog, and what does this imply for management of the study area?

In assessing the Lulu Island Bog, we recognize that the inventory work documented in this report represents a "snapshot in time". That is, results primarily reflect observations based on surveys conducted during the inventory period[1]. In some instances, they represent findings made from a single year of surveys. In these instances, results are dependent upon the seasonal and annual variations encountered during the survey period and are limited by the intensity of surveys conducted by project biologists. More intensive or continued survey work is needed for some groups in order to fully document the diversity and species abundances in the bog. This snapshot may or may not reflect the true biodiversity of each property. Further survey work in different years would no doubt add significantly to the diversity of some taxa in the bog. However, overall this "snapshot" provides a valuable insight into the diversity of the bog and its role as a significant natural area.

24.2 Significance of the Lulu Island Bog

A number of important roles for the Lulu Island Bog emerge from a synthesized analysis of the inventory results, grouped under three broad headings: 1) ecological importance, 2) educational importance, and 3) historical importance. While the species present in a bog and the bog habitat itself are important both intrinsically and for the natural spaces they provide in an urban setting, the bog is also important historically and educationally as part of the local community.

[1] Some chapters also summarize historical observations in the bog.

24.2.1 Ecological Importance

The ecological importance of the Lulu Island Bog is multi-faceted. The bog is part of the Pacific Flyway for migrating birds, it is an uncommon habitat in the region, it supports rare and endangered species and plant communities, and it can play a regional role in long-term carbon storage. It is also the largest remaining representation of the bogs that once covered more than one-third of Lulu Island and is pivotal in sustaining the island's wildlife populations.

24.2.1.1 Pacific Flyway

The bog is significant beyond its borders as a stopover for migrating birds on the Pacific Flyway. The Pacific Flyway is one of four major north-south migration pathways on the North American continent. The Migratory Bird Convention Act of 1918 vests Canada with the responsibility to protect and conserve migratory birds as part of an international convention with the United States (Russia, Japan and Mexico have since become additional parties to the convention). Subsequent flyway conservation efforts have recognized the importance of "stopover" habitat along the flyways that provides migrants with an opportunity to rest and feed. There are several important migration stopover sites in and around Lulu Island including the Lulu Island Bog. Almost 100 bird species have been recorded in the Richmond Nature Park (which is monitored each year), approximately 60 of which are migratory in some or all years (Griffith pers. comm. 2005). The bog offers a variety of open and forested habitats for migrating birds in the largest non-coastal natural space in Richmond, making it a valuable stopover site.

24.2.1.2 Uncommon Ecosystems: Regional Prevalence and Health of Bogs

Bogs are uncommon in the regional landscape (Hebda 2000). The Lulu Island Bog lies in the Temperate Wetland Region, in which wetlands represent less than 5% of the total land area (National Wetlands Working Group 1988). Moreover, bogs in the Lower Mainland have declined as a result of several factors such as peat mining, drainage, urban and agricultural development, and ecological succession. Most of these factors continue to threaten Lower Mainland bogs and remnant boglands.

As illustrated in the vascular plant chapter of this report, many of the species associated with bogs are specialists adapted to the unique bog environment, and are not found outside bog ecosystems. This has important implications in terms of biodiversity at the municipal and regional landscape level. The study area is the largest remaining remnant of the historical Greater and Lesser Lulu Island Bogs, situated in largely urbanized surroundings. It is also the only remnant that hosts open bog habitat. There is no alternative site in Richmond that can be conserved as a representation of this ecosystem. As a result, development of the study area or continued ecological succession will result in the loss of plant and animal populations from Lulu Island. Bog specialists, with specialized habitat needs, are among the most vulnerable to extirpation because they cannot persist in non-bog environments. Extirpation of bog species in the study area may equate to extirpation on Lulu Island.

24.2.1.3 Rare and Endangered Species, Habitats and Plant Communities

The remnant Lulu Island Bog, while small in size compared to its original extent, or compared with Burns Bog, nevertheless supports viable representation of bog ecosystem and associated bog specialists such as Labrador tea, bog-rosemary, and cloudberry. These regionally rare species and habitat specialists are found only in bogs, and, in the Lower Mainland, approach the southern limits of their range in North America. Peripheral populations of species have been shown to have high significance in biodiversity protection because of the genetic diversity and strength that they represent for the species and its long-term survival (see, for example, Lessica and Allendorf 1995, Channell and Lomolino 2000, Channell 2004, Hampe and Reny 2005). This makes protection of bog habitats important for protection of the bog specialists that inhabit them.

In addition to the importance of the bog for protection of peripheral populations, it also supports rare species. The Lulu Island Bog is home to, or supports, several provincially and federally rare, threatened, or endangered species such as Vancouver Island beggarticks and Lower Mainland populations of the Barn Owl. The bog is also listed as possible habitat for the SARA-listed Pacific Water Shrew. Several rare and endangered species and genera of insects were also reported in this inventory (see Chapter 23).

The bog also supports the provincially red-listed *Pinus contorta-Sphagnum* (CDF) plant community, and a regionally rare fen-like community – the only one reported for Lulu Island. Protection of rare habitats and their associated species is a priority in biodiversity protection in order to protect the ecological web they support. Loss of rare species in an ecosystem is correlated with increased vulnerability of the system to invasive species (Lyons and Schwartz 2001).

24.2.1.4 Wildlife Refuge

More generally, the study area is significant as a natural space for wildlife. It hosts bog and bog forest habitat that is a refuge for many species of wildlife beyond those dependent on bogs, but dependent on relatively undisturbed, natural spaces. Migrating birds and large mammals such as deer and coyotes use the study area as nesting/denning, foraging, and resting habitat, as evidenced by sightings, scat, and the discovery of den sites. Other remnant natural areas of Lulu Island that provided deer habitat have recently been developed, such as the area adjacent to the municipal dump along Lulu Island's south shore. As areas like this disappear, the study area becomes increasingly important as refuge for these large wildlife species on the island. The degree to which the study area remains connected to other habitats by natural corridors may also play a part in determining the prospects of a sustainable deer population on the island.

24.2.1.5 Carbon Storage

Peat bogs play a significant global role in carbon storage, an important element of mitigating climate change (see Chapter 3 for more detail). They act as carbon reservoirs that store a disproportionately large amount of the world's pool of soil carbon. The Lulu Island Bog can sequester carbon, removing it from the atmosphere and storing it in the dead, undecayed organic matter characteristic of peatlands, thus acting as an active carbon sink[2]. The stored carbon would otherwise be released into the atmosphere as carbon dioxide, one of the gases principally responsible for climate change. Bogs are more likely to serve these functions where their ecological integrity is effectively maintained: development or alteration of peatlands can have a significant negative impact on their carbon storage capacity, and can change them from sinks to sources of carbon. For example, drainage leads to the oxidation of the peat layer and the accelerated release of carbon dioxide, methane and other greenhouse gases into the atmosphere (Kusler 1999). Proposed strategies to meet Kyoto Protocol stipulations for protecting and enhancing greenhouse gas sinks and reservoirs have included blocking drainage in bogs and maintaining or restoring the hydrological regime. This can serve to reduce carbon release and preserve their function as carbon sinks and reservoirs. This strategy can be a cheaper method of carbon storage than other proposals such as afforestation[3]. Moreover, blocking drainage in bogs can have other positive outcomes such as improved ecological health of bog ecosystems and the conservation of the biodiversity therein.

24.2.2 Educational Importance

Natural areas play a significant role in public environmental education, especially with respect to the public's understanding of biodiversity and its conservation. The remnant Lulu Island Bog is the only spot in Richmond, and one of only a few in the Lower Mainland, where one can easily visit an example of the region's bogs and develop an understanding of these unique ecosystems and their associated representative, rare or endangered species. The Richmond Nature Park component of the study area plays a particularly important role in outdoor education, indeed this was part of the park's purpose when it was established in 1970. Aside from self-

[2] A carbon sink is a carbon reservoir that is increasing in size, thereby sequestering more carbon than it releases.

[3] Afforestation is the conversion of previously unforested lands to forested lands.

guided, easily accessible trails that host between 80,000 – 100,000 visitors each year, the Richmond Nature Park Society delivers an environmental education program to elementary school groups, reaching approximately 5,600 children annually. The Nature House in the park also has a variety of displays and information about the park, bogs and wildlife, and the Richmond Nature Park staff deliver numerous interpretive programs and community events throughout the year.

24.2.3 Historical Importance

Historically, bogs covered much of the landscape of Lulu Island. The presence of bogs affected European settlement patterns and transportation routes on Lulu Island, and the colder than normal temperatures found in bogs produced the fogs that are well described for the area. The Lulu Island Bog was historically an open landscape, lacking tall trees, and dominated primarily by small, stunted pine trees, heath and *Sphagnum* (Figure 7.2). Most of the Lulu Island Bogs were cleared and converted to blueberry and cranberry farming, and in some areas, subdivisions and industrial development have recently sprung up. Peat underlies many farms, and also underlies many new subdivisions and areas of industrial development.

Prior to European settlement, bog fires were used by First Nations people as a way to reduce shrub and tree growth, and to encourage crops of wild cranberries and bog blueberries (Cairns 1973). Harvesting blueberries and cranberries in the bog is an activity that continues even today when, in July and August, blueberry pickers descend on the area - particularly the DND property - armed with buckets and bags. These blueberry pickers inadvertently continue early management practices, as discarded cigarette butts continue to trigger small fires in some sections of the bog, and act to rejuvenate the bog. These fires are of varying intensity, and may affect only upper woody vegetation, significantly reducing growth and, sometimes, killing trees and shrubs. They may also burn into the peat itself, removing the top layer, and allowing for a flush of growth by species such as wild cranberry and sundews.

24.3 Threats

24.3.1 Drainage

There are numerous phenomena that threaten the persistence of an open bog ecosystem within the study area, but several stand out as the most important. Foremost, the changes to the bog's hydrological conditions caused by drainage appear to be at the root of many of the other threats to the Lulu Island Bog. The amount, retention and distribution of water are of fundamental importance to the formation and persistence of raised bogs, thus a lack or loss of water can often lead to bog degradation (Charman 2002). The three properties have been drained by ditches that have grown in number and cumulative length since the DND acquired their property in 1944 and the Richmond Nature Park was established in 1970. The construction of Highway 99 in the mid 1970s bisected the Richmond Nature Park and significantly augmented drainage. Drainage lowers the bog groundwater table which facilitates the drying and shrinking of peat and negatively alters the wet, acidic, low nutrient growing conditions that provide a competitive advantage for native bog specialist species such as *Sphagnum* mosses, Labrador tea, bog-laurel, and bog blueberry (see Chapter 2 for more detail). Consequently, non-bog plant species (both native and non-native) have established in greater abundance over an increasingly large proportion of the study area with the passage of time (Figure 24.1, Figure 24.2, and Figure 24.3). The establishment of these species has moved the study area away from an open bog structure. Dense, high shrub cover and tree canopy now exist to varying extents in all three properties. Moreover, these changes have also crowded out and replaced bog species – the presence of dense shrub layers of blueberry cultivars is strongly correlated with extensive die-off of the underlying *Sphagnum* groundlayer.

Figure 24.1: The Study Area in 1948, prior to purchase of land by the DND. The single homestead is the only development in the study area. Source: Province of British Columbia 1948.

Figure 24.2: The study area in 1976, after construction of Highway 99 but prior to the building of the East-West Connector. Source: Province of British Columbia 1976.

Figure 24.3: The study area in the mid-1990s. Map Source: Land Data BC 1999.

These effects in the study area are not a recent discovery: the Richmond Rod and Gun Club's original 1968 proposal for a park at the site of the Richmond Nature Park stated that groundwater levels were lowest at the property's perimeter adjacent to the ditches, where tree growth was most vigorous. In contrast, the groundwater levels were highest in the middle of the bog, where bog vegetation was found in abundance and trees were sparse and stunted (Jagger, this volume). The history (Chapter 7) and impact (Chapter 8) of drainage as well as the current hydrological state (Chapter 5) of the study area are addressed in more detail elsewhere in this report.

24.3.2 Introduced and Invasive Species

Introduced and invasive species are the second primary threat to the Lulu Island Bog. Because of its urban location (and consequent vulnerability to garden species), fragmentation, proximity to agricultural lands (and consequent vulnerability to cultivated species), drainage that leads to drying of the bog, and plantings of non-native species, the site is both subject and susceptible to invasions from numerous sources.

Invasions are evident in all three properties, but there is a noticeably higher influx and prevalence in the RNP west. Additionally, while invasions are generally widespread throughout bog habitat in all three properties (e.g., highbush blueberry, birch, mountain-ash), there is a noticeable prevalence of invasives along some sections of the nature park trails. The nature park wildlife garden may also be a point source of introduced species. Non-native invasive species that have been planted include dead nettle (*Lamium amplexicaule*), periwinkle (*Vinca minor*), English holly (*Ilex aquifolium*), Hops (*Humulus lupulus*), and English ivy (*Hedera helix*), though English holly and periwinkle pre-date the garden. Scotch broom (*Cytisus scoparius*) is now present in the nature park properties. Scotch broom, periwinkle, English holly and English ivy have been identified as some of the invasive species of the most concern in the Lower Mainland. They are being targeted by cooperative initiatives against invasive plant species by several groups and agencies, including non-governmental organizations (the Invasive Plant Council of British Columbia and the Greater Vancouver Invasive Plant Council), regional bodies (Metro Vancouver) and local governments.

Past small-scale attempts to eradicate invasive species in the Richmond Nature Park have not been effective in maintaining or restoring open bog habitat dominated by native species. One likely reason for the limited success of these attempts, and, more broadly, the continued in-growth of invasive and introduced species, is the changing conditions in the bog. The water level in the bog has been dropping since at least the early 1990s, shortly after water level monitoring began. Drier conditions are favourable for introduced species such as birch and highbush blueberry, the in-growth of native species like salal, and rapid succession and growth of shore pine. Passive management that does not alter the hydrological conditions in the bog will result in the continued expansion of introduced and invasive species and an evolution away from an open bog community.

24.4 Evaluation of the Conservation Value of the Study Area

Table 24.1: Important factors for selecting and prioritizing wetlands for conservation, in approximate order of importance. Modified from Keddy (2000).

Factors especially applicable to the Lulu Island Bog are bolded.

Factor	Comments
Area	Ecological values and functions increase with area.
Naturalness	Minimal alteration to natural patterns and processes.
Representation	**Serves as Richmond's only example of an important ecosystem type.**
Significance	**Regional importance: small and shrinking existing area of this ecosystem type in Lower Mainland, only a handful of isolated examples protected elsewhere in region.**
Rare species	**Regionally and provincially significant species present.**
Richness	Supports many species.
Productivity	Good production of commercial species (high production may reduce diversity and rare species).
Hydrological functions	Central to maintaining a bog ecosystem.
Social functions	**Education, recreation, historical relevance.**
Carrier functions	**Contribution to global life support systems: carbon storage.**
Food production	Harvesting of species for human/livestock consumption.
Special functions	**Migratory stopover.**
Potential	**Potential for restoration to recover lost values and functions (see Chapter 22).**
Prospects	Probability of long-term survival: future threats, buffer zones, possibilities for expansion, patrons, supporting organizations.
Corridors	**Existing connections to other protected areas or site itself is a corridor.**
Science function	**Published work on site, existing use by scientists, existing research station, potential for future research.**

Identifying the significant roles played by the Lulu Island Bog and the issues the bog faces facilitates an explicit evaluation of the conservation value of the bog remnants as protected sites. Such an evaluation can act as a tool for management and land use decision-making. It can also contribute to a foundation for comparing the benefits of protecting these properties against the benefits of protecting other sites, or against the benefits of developing portions for other uses.

Table 24.1 provides an overview of important factors for selecting wetlands for conservation and locates the roles of the bog (outlined in the preceding sections) within a more comprehensive and prioritized list of key roles (referred to as ‘factors’ in the table). It is important to recognize the table as only an abbreviated summary, and to recognize that the characterization of the bog’s roles in the table represents a snapshot in time. For example, with a commitment to planning for long-term conservation, the ‘prospects’ for the Lulu Island Bog would improve which in turn could restore the bog’s ‘hydrological functions’. Conversely, if nothing is done or there are management/land use decisions that adversely affect bog structure and function, the study area will evolve away from a bog ecosystem and many of the important roles it currently plays will likely diminish.

24.5 Regional Context

24.5.1 Wetland Habitat Representation in Richmond

In Richmond, biodiversity protection is critical to the health of the Fraser Delta and the globally significant wildlife systems that it supports. Richmond’s natural areas play a key role in this, including Sturgeon Banks, Terra Nova, and the islands in the south arm of the Fraser River.

Because of their location in the delta, ecosystems in Richmond, with one or two exceptions (such as the Iona Island dunes), are primarily comprised of wetland systems, including bogs, marshes, and riverine meadows. Protection of these wetlands falls to various agencies with different areas of responsibility, including the Canadian Wildlife Service, the Department of Fisheries and Oceans, and Metro Vancouver. These agencies, and other non-governmental agencies (NGOs) such as the Nature Conservancy of Canada (NCC), have collectively worked towards estuary protection under the Pacific Estuary Conservation Program. Protected sites include Swishwash Island (NCC-owned), Sturgeon Banks (provincial wildlife management area), South Arm Marshes (federal wildlife management area), and Iona Beach (Metro Vancouver Regional Park). The Municipality of Richmond has also contributed towards green space growth and protection of key natural areas that lie within the municipality and the delta with the purchase of the Terra Nova lands, the purchase and protection of the Northeast Bog Forest, and procurement and protection of portions of the Lulu Island Bog (the city-owned RNP west and RNP east).

There are, however, gaps in natural areas protection in Richmond, and some key ecosystems remain unrepresented within municipal protected areas. This includes two critical components represented in the study area: intact, high quality Shore Pine-*Sphagnum* plant community (red-listed in BC) representing heath bog, and open fen-like habitat (regionally rare). The DND lands provide the only representation of regionally rare fen-like habitat and the best example of open heath bog in Richmond.

24.5.2 Regional Conservation Initiatives

At the regional level, the study area is part of the “green zone” within the Livable Region Strategic Plan, which is Metro Vancouver’s regional growth strategy. The “green zone” is designated to protect the region’s natural assets such as watersheds, ecologically important areas, major parks and farmland. Metro Vancouver is also creating a Biodiversity Conservation Strategy. The areas identified in the green zone are intended to play a central role in conserving biodiversity within this strategy (GVRD 2005). The Biodiversity Conservation Strategy aims to “understand, identify and conserve” a diversity of natural habitats and life-sustaining ecosystem functions within Metro Vancouver (GVRD 2005). As natural and green spaces, green zone areas are the best suited to serve these functions.

One highlighted aspect of this strategy is the conservation of hotspots, reservoirs, corridors and sensitive areas (GVRD 2005). The Lulu Island Bog fills several of these roles; it is one of the major upland reservoirs of plant and animal species within Richmond, and as one of the region’s few remaining bogs, it is also a regional reservoir of species and communities particular to bog ecosystems. Anecdotal observations also suggest that the bog provides key connection corridors for wildlife movement and dispersal within Richmond. Its location as a large node linked to numerous surrounding green spaces supports these observations.

24.6 Protection Measures

24.6.1 Richmond Land Use Designations and Policies

The properties that comprise the study area are designated Environmentally Sensitive Areas (ESAs) in Richmond (Figure 24.4). However, recognition of the properties as ESAs does not provide them with formal, long-term protection. An ESA designation in the municipality affords the area some protection during the municipal review process for development permits by virtue of Bylaw 5746, but it does not preclude any site development (City of Richmond 2005). ESA status means that the ecological role of a property is given consideration by city planners during review of development applications and efforts are made to reduce or prevent impact (Brownlee pers. comm. 2005). Guidelines for managing development proposals in sites adjacent to ESAs, in order to minimize impact on key natural areas, have also been developed (City of Richmond 2005). However, many of the parcels of land identified as ESAs are privately owned, and their status as ESAs can be affected by changes in land use that are the result of private landowner choices. Indeed, the total area of ESAs in Richmond has shrunk in recent years as private lands designated as ESAs have been developed. This phenomenon can be documented by analyzing time series of aerial photos for land use changes in conjunction with an analysis of Geographic Information System map layers for ESAs developed by the City of Richmond Planning Department. It is clear that the status of the current network of ESAs in the municipality is precarious given the ongoing development pressures of a growing city (Figure 24.5).

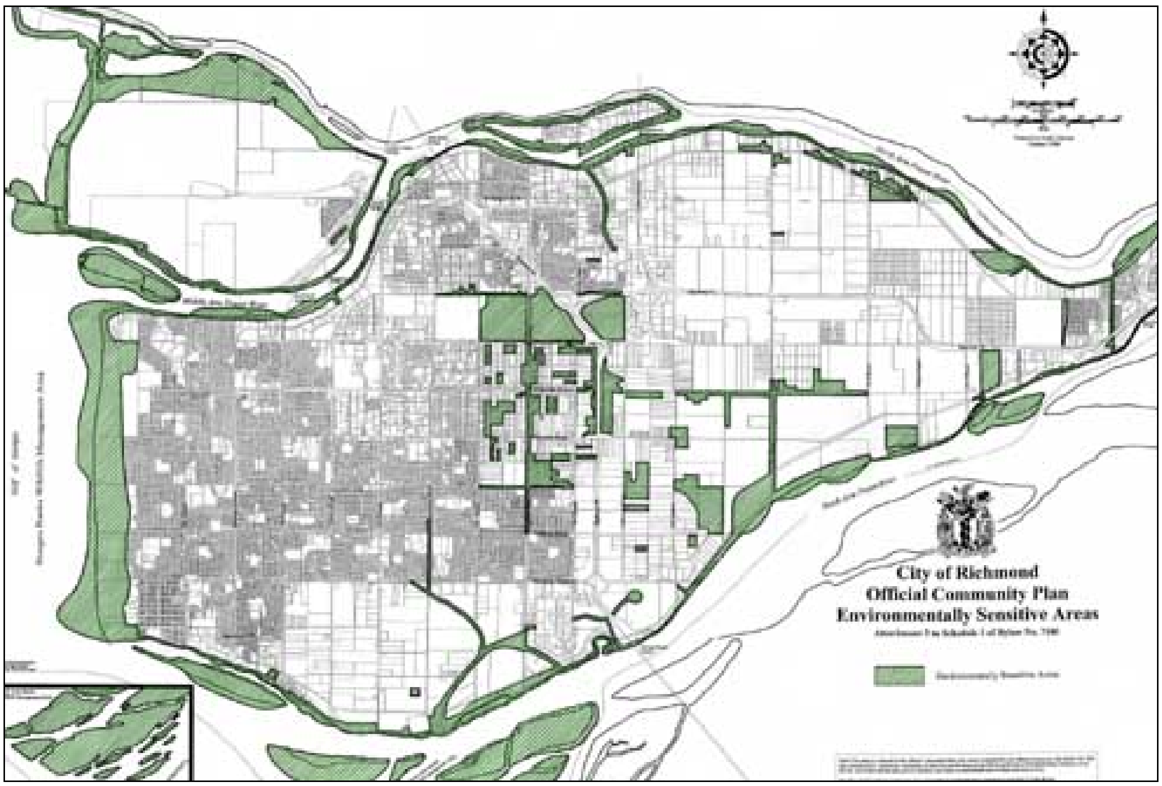

Figure 24.4: Environmentally Sensitive Areas in Richmond. Green highlighted areas also serve to show the connectivity of the study area to other bog remnants, and, ultimately to the river - a major corridor of wildlife movement. Source: Richmond Official Community Plan.

The two Nature Park properties are municipally owned, which presents the city with a comparatively straightforward opportunity to permanently protect the properties. The possibility of protection for the DND property is more complex. Though it is designated as an ESA, its owner, the Department of National Defence, has considered surplusing the property putting it up for sale (Goulden pers. comm. 2003-2007, Lemieux. pers. comm. 2005). Evaluation of the property continues in December 2007.

Of the three properties, the DND property supports the best and largest representation of open bog. Protection of the site would help preserve the integrity of several regionally rare ecosystems. However, because the land is not owned by the municipality, its future, especially in the face of surplusing by the military, is uncertain.

Figure 24.5: Land use and Environmentally Sensitive Areas of Richmond.
Source: City of Richmond Planning Department.

The study area properties are also part of the provincial Agricultural Land Reserve (ALR)[4], a provincial zone in which agriculture is given priority of land use, based on provincial legislation. This zoning takes precedence over, but does not replace other

[4]As per the Agricultural Land Commission website, "The Agricultural Land Reserve (ALR) is provincial zoning in which agriculture is recognized as the priority use. ALR lands comprise those lands within BC that have the potential for agricultural production. [In these] lands, farming is encouraged and non-agricultural uses are controlled. The Agricultural Land Reserve takes precedence over, but does not replace other legislation and bylaws that may apply to the land" (Agricultural Land Commission 2007). ALR legislation does not supercede federal Species at Risk legislation (Brownlee pers. comm. 2007).

legislation and bylaws that may apply (Agricultural Land Commission 2007). Developing ALR lands for other uses requires an application process subject to review to determine whether the land should be removed from the ALR. While there is strong pressure to retain lands in the ALR, zoning can be changed. Thus, the restrictions on the uses and development of ALR lands provide, in effect, a measure of protection from certain forms of development for the study area properties, but are not definitive.

As part of Richmond's effort to conserve natural areas, the city encourages the restoration and creation of green spaces when development disturbs and/or removes natural areas (City of Richmond 2005). While this policy is an important component of environmental planning, it is worth noting that it is not sufficient to sustain natural areas and the species that inhabit them, for several reasons. First, there can be a lapse between the loss of the former natural space and the physical creation of a new green space, creating a discontinuity in the availability of habitat for species occupying affected areas. Second, compensatory spaces may not necessarily be designed to provide the same habitat types or quality, or connectivity, as the former natural space. Third, even in instances where compensatory spaces are designed to create similar habitat, it would be many years before new green space developments mature to the point where they will provide the same structure and function that the former mature habitat did previously, if ever. The mature, raised bog ecosystem of the study area took thousands of years to develop under favourable conditions. Taking into account the factors that are detrimental to the bog ecosystems and that are directly relevant to the study area, such as drainage and the prevalence of introduced and invasive species, it is unrealistic to expect effective compensation for the loss of any portion of this habitat. It follows that if Richmond intends to sustain the diversity of natural areas currently present in the city, then this translates into the retention and enhanced protection of the Lulu Island Bog, not a more flexible arrangement that allows for development in the study area with compensatory new sites set aside elsewhere.

24.6.2 Species Protection Legislation

The implementation of federal endangered species legislation in 2005 (the Canadian Species at Risk Act—SARA) has implications for the study area. SARA provides threatened and endangered species and their habitats automatic protection on federally owned lands such as the DND property. Protection efforts are also encouraged for provincial and municipal lands.

Barn Owl (western subspecies)

The provincially blue-listed Barn Owl is also listed by SARA as a species of Special Concern. The Barn Owl selects for open fields and wet meadows as foraging habitat, and preys on small mammals such as voles, shrews, and mice (BCCCDC 2005). Barn Owls are frequently observed hunting over the bog and in the immediate area (Griffith pers. comm. 2007). Studies have reported significant positive correlation between the quantity and quality of foraging habitat and nesting activity (BCCDC 2005). Thus, an area like the Lulu Island Bog, with relatively undisturbed large open meadows and small mammal populations can play a role as foraging habitat for Barn Owls and also support nesting activity in the area. The Barn Owl is granted limited protection in British Columbia by Section 34 of the provincial Wildlife Act, which prohibits the taking of eggs, nestlings or nesting adults or destroying active nests (SARA 2004). This may not directly affect the study area because there are no known nests. However, the study area is of critical importance as foraging habitat. Foraging habitat for Barns Owls and other raptors has declined in Richmond over the last few years as grassy open areas have been developed throughout the island. This increases the importance of the open bog for population maintenance. Measures in the study area may include, but are not limited to:

- vegetation management planning, specifically, management to limit tree and shrub growth and maintain the natural openness of the bog;
- establishment of one or more nest boxes for Barn Owls

Great Blue Heron

The Great Blue Heron is a provincially blue-listed species, and is listed under SARA as a species of Special Concern. The Great Blue Heron is granted limited protection in British Columbia by Section 34 of the provincial Wildlife Act, which prohibits the taking of eggs, nestlings or nesting adults, or destroying active nests. As with Barn Owls, this may not directly affect the study area because there is no known heronry[5] present. However, Great Blue Herons have been observed in the RNP west foraging in the Nature Park pond, and has been flushed from open areas of the DND property where it may be foraging. Foraging habitat for this species is often on land, with voles making up a significant percentage of their diet (Seattle Audubon Society 2005-06). Open foraging habitat that supports significant vole populations has declined in Richmond and Lulu Island over the last few years, which increases the importance of the open bog for heron population maintenance. The number of herons breeding in an area is directly related to the amount of feeding habitat available to them (Canadian Wildlife Service and Canadian Wildlife Federation 2008). In this respect, the study area's foraging habitat supports local breeding colonies. Management measures in the study area that retain open heath bog habitat will likely benefit herons by maintaining prey populations of voles and other small mammals.

[5] A colonial nesting site comprised of multiple stick nests, usually located near water.

Pacific Water Shrew

Portions of the study area are recognized as highly suitable habitat for the Pacific Water Shrew (see Chapter 18) which is classified by the Committee for the Status of Endangered Wildlife in Canada (COSEWIC) as an endangered species, and officially listed by SARA as threatened. Even in the absence of confirmation of the presence of the animal in the study area, suitable habitat is recommended for protection in the Pacific Water Shrew Recovery Strategy (Craig and Vennesland 2004). Habitat protection objectives for the Pacific Water Shrew include minimizing disturbance around water bodies (such as ditches) and restoring potential habitat to suitable condition (Craig and Vennesland 2004). Measures in the study area may include, but are not limited to:

- Mowing/weeding restrictions—in the riparian zone and adjacent areas to preserve cover and minimize disturbance;
- Foot path restrictions—for example, no dogs on trails or no trails in riparian zones to minimize traffic in highly suitable Pacific Water Shrew habitat;
- Buffer maintenance—preserving natural spaces that separate habitat from roadways to mitigate the disturbance caused by vehicle traffic;
- Clearance of invasive species—invasive species like Himalayan blackberry growing in riparian areas create low habitat suitability for the Pacific Water Shrew. Blackberry removal and the planting of native shrub and tree species and coarse woody debris placements can provide higher suitability habitat.

Vancouver Island beggarticks

Vancouver Island beggarticks is also a Schedule 1, SARA-listed species (Special Concern). It has also been evaluated as one of the highest scoring species in the province, if not the highest, under the new proposed provincial Conservation Framework (Fraser pers. comm. 2007). The presence of Vancouver Island beggarticks in the Nature Park pond and west perimeter drainage ditch (RNP west) is important, as the park constitutes a protected site for the species. This means that pond and ditch management in the nature park should follow provincial Best Management Practices for the species (Klinkenberg and Klinkenberg 2006). This would include:

- Protection of the critical habitat for the species in the nature park;
- Protection of the seed bank for the species in the pond and ditch, which is critical for survival of the species in periods of low recruitment;
- Maintenance of natural water fluctuation levels in order to allow both germination and seed set for the species;
- Control of invasives species in these aquatic habitats.

Washington Snowshoe Hare

The Washington Snowshoe Hare is red-listed in the province, but has not yet been assessed federally by COSEWIC. Recent confirmation of the species in Burnaby

(Nagorsen pers. comm. 2007) and elsewhere in the region indicate that it is still present, so assessment is needed. This species has unconfirmed reports from both the RNP west and the RNP east. The report by Bell (1984) was from the RNP east, with a specimen sent to Simon Fraser University[6], and the recent (2006) roadkill of a possible juvenile hare (photo documentation, Klinkenberg 2006) was found on the roadway perimeter of the RNP east property. Several sightings in the RNP west have been reported by Griffith (pers. comm. 2002 to 2007). Habitat in the RNP east and in the more forested sections of the RNP west match habitat descriptions for the species (Sinclair pers. comm. 2007), and may be critical for the continued presence of this species on Lulu Island. Habitat management in the bog should give this due consideration.

Other Species

Several rare species are found in the study area that have not yet been evaluated by COSEWIC, but that may be assigned official status in the future. These include several species of aquatic insects identified in Chapter 14.

The presence of SARA-listed species and highly suitable habitat for provincially and federally listed species in the study area has the potential to restrict activity and development. If municipal and federal management agencies are to play a positive role in the protection of species at risk, they can adhere to recovery strategy recommendations (where applicable) and consult findings about habitat demands in the scientific literature for each species of concern.

24.6.3 Existing Protection for Study Area Properties

Richmond Nature Park properties: While owned by the city of Richmond, the two Richmond Nature Park properties are not currently formally protected as "park". They fall within several designations and/or zoning categories that allow limited use, but can be changed. They are "protected" as follows:

- They are located in the Agricultural Land Reserve;
- They are listed in the Official Community Plan (OCP) as "Open and Public Space Use";
- They are also listed in the OCP as "Environmentally Sensitive Areas";
- Additionally, both parcels comprising the Nature Park are designated in the OCP as "Conservation Area" which is defined as "Areas considered environmentally sensitive … whose protection has been secured by legal

[6] The specimen has not been found for confirmation.

means (dedication, public acquisition, legislation, Order-in-Council, etc.), or by a long-term policy commitment by a senior level of government";

- Both properties are zoned as "school and public use".

While these mechanisms show a strong interest in protecting the park properties, they may still permit some approved site development. Zoning can always be changed and, as is presently being considered for the Richmond DFO (Department of Fisheries and Oceans) lands (located immediately to the west of the DND lands), properties can be rezoned and removed from the ALR[7]. Generally, the mechanisms in place may not be strong enough to withstand future development proposals. Establishment of the city-owned park properties as a Nature Reserve is important to the long-term preservation of the bog ecosystem.

The Department of National Defence Property: This property is federally owned land. While it is effectively protected from development while it is federally owned, and hence unaffected by zoning designations, if it were to be surplused and sold, the current zoning designations would allow protection as follows:

- It sits in the Provincial Agricultural Land Reserve and is zoned by the City of Richmond as Agricultural District (AG1). The zoning district includes the following uses: a one family dwelling, agriculture, peat extraction and processing, horse-riding academy, farm-based winery, animal hospital, and more;
- Richmond's OCP designates the site as "Public and Open Space Use" which is defined as "those areas of the City where the principal use is public or private recreation, parks, schools, religious facilities, public administration and City works, transportation, utilities, health care facilities, or other institutions";
- The site is also designated in the OCP as an Environmentally Sensitive Area which requires a development permit prior to commencement of certain types of development activities.

As above, while these zoning categories offer some protection at present, they do not offer long-term protection. The current federal status of the land provides protection for SARA-listed species that use or inhabit the property, and this status should be retained. A change in ownership, unless it is land transfer to another federal agency, would remove this protection. At that point, unless additional conservation measures are put in place by the City of Richmond, or achieved by the DND in partnership with the city or a stewardship group, the site would be open to some development.

[7] The DFO lands currently sit in the Agricultural Land Reserve. Application to remove them from the reserve was turned down in 2007. However, at the moment of writing, this is being appealed.

CHAPTER 25: RECOMMENDATIONS

By Rose Klinkenberg and Neil Davis

25.1 Introduction

Maintaining local natural areas is an important step in the protection and conservation of biodiversity. In this report, we have studied and evaluated a component of local biodiversity—the Lulu Island Bog—with the aim of developing baseline information on the site, evaluating its role in the region, and ultimately making recommendations on the conservation needs of this ecosystem remnant. The three properties that comprise the study area are small, and they are fragments of what was once a much larger ecosystem covering a large part of Lulu Island. However, they continue to fill a critical role in providing habitat for wildlife species and offer good representation of the once larger bog ecosystem.

In light of this, recommendations for the bog have been compiled. These cover key issues for the bog, including management and research needs. A summary of overarching recommendations is provided, followed by detailed discussion of specific recommendations. We recognize that implementation of these recommendations would require a collaborative partnership initiative between the City of Richmond, the Department of National Defence (DND), and the Richmond Nature Park Society, and other stakeholders, aimed at promoting protection and stewardship of the Lulu Island Bog.

25.2 Summary of Recommendations:

The four main recommendations that have emerged as a result of this study are:

1. **Protect the Lulu Island Bog** using stronger protection mechanisms than are currently in place. The study area should be established as a nature reserve.

2. **Develop an integrated ecosystem management plan for the bog** that includes a vegetation management plan (including bog restoration planning and invasive plant species management), a wildlife management plan (including species at risk management), and a research agenda to address knowledge gaps and guide restoration, and long-term monitoring to inform management.

3. **Develop an environmental impact assessment process** to evaluate impacts on the bog ecosystem and species for any works undertaken in the bog, and in the immediate surrounding area where this would influence the bog ecosystem.

4. **Organize a discussion forum aimed at establishing a process and framework for carrying out the above recommendations.** This should include:
    a. establishment of a long term interagency steering committee that would guide the processes, and
    b. the establishment of an operationally-focused implementation team to carry out the direction laid out by the steering committee.

25.3 Discussion

The City of Richmond's Parks Master Plan states that the "stewardship of all resources is a priority, as is the protection of urban parks, open spaces and natural areas (City of Richmond 2005d). It also indicates Richmond's support for natural areas: "As stewards of Richmond's open spaces including parks, trails, natural areas and farmland the City is committed to protecting the value and quality of the natural assets [of the city] and to further enhancing the blue/green interface" (City of Richmond 2005d: 55). Part of the Parks and Open Space Strategy for the city includes the preservation "of natural areas for their ecological, recreational and educational values" (City of Richmond 2005d: 56).

Under this umbrella of city stewardship and master planning, and based on our evaluation, we recommend the following actions for the Lulu Island Bog:

25.3.1 Protect the Remnant Lulu Island Bog

a) **Increase protection: use stronger protection mechanisms for all three properties that go beyond existing zoning and legislation**

Achieve stronger protection for all three properties in the study area by exploring the options available to ensure their long-term survival as natural areas within Richmond. This should include both municipal initiatives to provide protection through zoning and legislative measures, and municipal/federal initiatives to develop stewardship agreements[1] for all three properties. The establishment of a joint federal-municipal nature reserve achieved through land transfer of the DND property to Environment Canada (for example) and new municipal legislation is strongly recommended. There are precedents for establishment of joint nature reserves involving DND lands and land transfers[2]. Under such an agreement,

[1] This is often a joint partnership approach to land management that can include agreements to protect and manage a site for its conservation values, to limit development or to restore ecosystems.
[2] One example of the successful establishment of a nature reserve involving more than one landowner is the Blue Heron Nature Reserve in Chilliwack. This site was partly owned by the Department of National Defence and the municipality. The DND land ownership was transferred to Environment

zoning within the nature reserve would accommodate the current interpretive use in the Richmond Nature Park properties allowing continuance of current interpretive activities and enrichment of those activities through added ecological components.

b) **Size matters: protect all three properties**

In protecting the Lulu Island Bog, and, ideally, establishing it as a nature reserve, all three properties are critical for maintaining regional and municipal wildlife populations. Conservation biologists have studied the role of size in the protection of natural areas and their associated wildlife components. Although size is not the only important criterion for nature reserves, the results of these studies have clearly shown that "bigger is better". The larger the area protected, the more likely wildlife populations are to persist, and the better a natural area can function ecologically. Ecological function depends not only upon retaining the species complements that inhabit natural areas, but also depends upon ensuring that the needs of these species are directly met. Individually, each of the bog properties supports components of the bog ecosystem, but are not large enough alone to sustain all species of wildlife that are currently found in the area; some of these species require the larger size and diversity of habitats provided by all three properties, while other require habitats found in only one of the properties. Maintaining larger sizes of reserves helps to protect and buffer them from adjacent land use, and helps reduce the impacts of edge effects (moisture reductions, drying of soils, and invasive species), particularly in core areas.

25.3.2 Develop an integrated ecosystem management plan for the bog

There is a strong need for an integrated approach to bog ecosystem management in the Lulu Island Bog because of interconnected hydrology; overlapping invasive species problems and overlapping wildlife populations in the properties in the study area that dynamically interact. An integrated approach would embrace ecosystem preservation through bog restoration, maintenance of associated wildlife populations, reestablishment of vegetation communities, and would ultimately enhance this resource for wildlife viewing and green space use by Richmond and Lower Mainland residents. An ecosystem management plan for the bog fits with the current intent of the City of Richmond to develop a resource management plan for each asset (open space), and to develop a natural areas strategy for all of Richmond commencing in 2008 (City of Richmond 2005d; Redpath pers. comm. 2007).

Canada for management, and this was followed by a stewardship agreement between Environment Canada and the municipality. The site is both federally and municipally owned with an agreement for the municipality to manage the whole site (Golden, pers. comm. 2007).

An integrated ecosystem management plan should address:

- overall vegetation management in the Lulu Island Bog, including bog restoration and invasive species control;
- overall wildlife management in the bog, including invasive species control and enhancement and/or maintenance of the natural wildlife habitat attributes of the site;
- establishment of vegetation monitoring, as a part of baseline data gathering, to assess change over time, and to assist research;
- establishment of long-term monitoring in order to aid management;
- connectivity between the study area and other natural or "covered" areas in order to allow for population migrations;
- coordination of research and management activities so that actions are not taken that may have negative consequences (e.g., removing large highbush blueberries before rewetting of the bog is carried out will leave behind an open disturbed area that will favour further invasion by alien species. Removals should be done post rewetting in order to favour wetland/bog species rather than alien species).

An integrated ecosystem management approach will also allow for protection and management of common species as well as species at risk, and for rare plant communities. Management approaches for species at risk should follow provincial Best Management Practices guidelines for SARA listed species. In initiating an integrated ecosystem management plan, a simple set of ecological health indicators should be established to guide work and determine end points (following, for example, Keddy (2000). These indicators should be:

- Ecologically meaningful: closely related to maintenance of essential environmental processes and ecosystem functions.
- Macro-scale: measuring the state of entire systems or key processes rather than small pieces or selected species.
- Pragmatic: guided by measurable or empirical attributes of systems rather than conceptual or theoretical concepts and notions.
- Sensitive: quick response to stresses and perturbations, to minimize lag and provide maximum response times for decision makers.
- Simple: easy to measure and inexpensive.

a) Vegetation management, bog restoration and invasive plant species - all properties

The Lulu Island Bog presently exists in a degraded condition and will continue to decline as a result of changes to hydrology and extensive drainage of the site. Active restoration must take place to preserve bog ecosystem processes. This will require vegetation management and restoration of the hydrological regime3. The aim of this work should be to preserve and restore healthy bog conditions in the three properties4 and control invasive species. These two go hand in hand: The wetter the bog, the fewer the invasive species. Also, where appropriate, vegetation management should aim to minimize impact by site users. Particular attention will need to be paid to the RNP west property, where significant die-off of the living Sphagnum mat has occurred, and where visitor usage has some impact on the bog. Presently, park trails are widening where standing water accumulates during periods of high rainfall and park visitors skirt the wet areas by moving through adjacent higher ground. In the DND property, where trail development is unmanaged, trails have also "braided" or multiplied in some areas. The widening and proliferation of trails results in vegetation trampling and, where traffic is high enough, kills vegetation and reduces the extent of living bog. Vegetation management measures in the study area should include, but not be limited to:

- bog restoration measures that should include restoration of high water table levels by rewetting[5] the bog and on-going management of high water levels[6];
- invasive species management that should include development of an invasive species management plan, with targeted removal and control of ecosystem-altering species such as European birch, highbush blueberry, Scotch Heather, English holly, European mountain-ash, Himalayan blackberry, evergreen blackberry and Scotch broom, a species that is now appearing in the bog;
- a prohibition on the use of non-native species in the bog, instead working with species native to the local area as an alternative in plantings. Attention should be paid to eco-types used in order to retain ecological fitness;
- minimization of disturbance pathways that allow influxes of invasive species;
- the development of mitigation strategies for invasives control following site operations that result in disturbance to the substrate that favour invasive species;
- input should be sought from invasive plant species specialists in our region such as the Greater Vancouver Invasive Plant Council. They could provide

[3] In this instance this would be restoration to a hydrological condition that allows peat mat formation, and re-establishment of raised bog processes, where the acrotelm is reestablished.

[4] See Chapter 22 for a discussion on bog restoration. Based on Cobbaert's review in this chapter, restoration is feasible in all three properties.

[5] Rewetting of the bog can be accomplished in several ways: reduce or eliminate drainage from the bog and restore the natural raised bog processes; divert storm water run-off to increase water levels (Redpath pers. comm. 2007), etc. Each method would require evaluation to assess suitability and ecological impact.

[6] Levels required to initiate and maintain raised bog conditions.

insight and direction in invasive plant species management and assist in the development of an invasive species management program;
- visitor management that includes the establishment of boardwalks (particularly in the RNP west property) to reduce trampling in sensitive areas and prevent trail widening;
- specific management for species at risk in the study area.

Bog restoration requirements include additional research in the bog, as follows:
- Bog hydrology: While it is evident from the data collected that there are patterns in the response of vegetation communities in the bog to precipitation input, it is difficult to fully assess these without a more substantial data set. Because the hydrology of the bog is considered the central factor in the overall health of the existing ecosystem, a hydrological study should be pursued with a more focused effort to learn about the hydrology of the bog. If further hydrological work is conducted, the Burns Bog hydrological study conducted as part of the Burns Bog Review in 2000 could be used as a framework. Further hydrology work should focus on groundwater chemistry and groundwater flow;
- Water chemistry analyses: Water chemistry studies of the bog are needed before management begins. This would provide baseline information against which future management actions can be judged, and would allow more specific insight into changes that have occurred in the bog. This information, compared against water chemistry in Burns Bog and other regional bogs, would provide a guideline for restoration;
- Fire effects: The historical and recent fire events of Lulu Island Bog have not been well documented and require further study. It is clear that these have influence on ecological communities, with the level of influence dependent upon the heat and duration of the fire. In some instances, the peat mat is burned down and adjacent trees die off, and in other instances, where fires are light and quick, trees sustain light damage while shrubs may be destroyed. Fire as a management tool can control woody plant growth. Further research should evaluate the role of fire in bog management and restoration. Fire is widely used elsewhere to rejuvenate ecosystems (e.g., Norton and Lange 2003), even in urban environments.

b) Wildlife Management - all properties

The Lulu Island Bog is used by many of the wildlife species found in Richmond today, including all of the mammal species on Lulu Island. Together, the three properties comprise the largest non-coastal natural area on Lulu Island and, as such, are critical to the island's wildlife populations. As green spaces in Richmond and the Fraser delta continue to shrink, management of the bog to maintain wildlife components is important.

Protected status for the DND property would ensure continuation of its capacity to sustain populations of numerous small mammals. It would also provide valuable habitat for larger mammals such as coyote and deer. These species need natural habitat refuges and use the DND property in conjunction with the park properties as part of larger home ranges. Anecdotal reports from DND staff of regular deer sightings on the property indicate that deer use the DND property more frequently than the park, which would provide further reason for the protection of this site.

A Wildlife Management Plan for the study area should include the following:

- general management for wildlife habitat in order to support the complement of species currently found in the site, including maintenance of dead trees, snags and brush piles;
- invasive species assessment and management where needed;
- targeted management for provincial and federal species at risk and their specialized habitat needs. This includes specific management for Great Blue Heron, Barn Owl, Pacific Water Shrew, and Snowshoe Hare. Management should follow provincial Best Management Practices Guidelines;
- additional species surveys, including:
    - continued inventory for Pacific Water Shrew and Snowshoe Hare. While live trapping for these species was carried out during the inventory, more live trapping is needed to determine or confirm presence in the bog. There is limited understanding of their distribution and habitat use in general, and any data that could be compiled would be an important contribution to the provincial knowledge-base;
    - continued inventory of insect fauna and new inventory for other wildlife groups. The inventory of insect fauna in the bog was limited to aquatic insects and butterflies. Other groups such as ants, bees and wasps should be studied in order to provide comprehensive baseline data. Arachnids (spiders and ticks) should also be surveyed. Such data will be useful in assessing change in the bog over time, particularly if restoration work begins, and would be an important contribution to the study of bogs;
    - targeted inventory for moth species in the bog. This faunal group was not inventoried in the bog, although a perspective on moths of Richmond is provided.

Some specific recommendations for species at risk management include:

- follow provincial 'Best Management Practices' for species at risk in BC. These documents, developed by the BC Ministry of Environment, provide management guidelines for species at risk in the province that are species-specific;
- nesting boxes for Barn Owl. Many old barns have come down in Richmond in recent years, and this species is in jeopardy in the region. Barn Owls regularly use the boglands (particularly the RNP east and west properties, the DND property, and the DFO[7] property) for hunting and are frequently seen along the roadways around the bog. Setting up Barn Owl nest boxes will significantly aid their populations;
- retention of brush piles for the Washington Snowshoe Hare. Although the Washington Snowshoe Hare has not been confirmed in the park, it is possible that it is present. Numerous sightings and one photo of a "possible" Snowshoe Hare warrant proactive measures to retain habitat for this species in the study area;
- management of suitable habitat for Pacific Water Shrew. Based on provincial guidelines, the bog is a potential Pacific Water Shrew habitat, and management should be proactive for this species. Craig and Vennesland (2004) provide habitat protection guidelines for the Pacific Water Shrew that are relevant to the study area;
- management of water bodies and open meadows in the study area where Great Blue Heron forage. Because this species faces shrinking habitat in Richmond for foraging, particularly winter foraging, development and disturbance around open water bodies and open meadows in the study area should be minimized. This includes the open ditches and ponds (RNP west) and the *Sphagnum* pond in the RNP east. The present fencing around the nature park pond is an effective means of minimizing disturbance from park visitors and should be retained. Notably, this pond also provides foraging ground for Green Heron (*Butorides virescens*), which is a blue-listed species in BC.

c) Other ecological considerations

Management planning for wildlife species in the study area should take into consideration metapopulation dynamics and species dispersal and recruitment. This should include consideration of other bog or natural areas remnants in the area that can act as corridors for wildlife movement. Connectivity is an important consideration in the establishment of wildlife reserves and maintenance of their health and viability.

[7] Now referred to as the Garden City lands.

25.3.3 Develop an Environmental Impact Assessment Process for the Bog - All Properties and Adjacent Land Areas

An environmental impact assessment procedure should be established for all properties in the study area and in the immediate surrounding area in order to minimize impacts on the bog ecosystem, species at risk in the bog, and other rare and sensitive species and habitats. This process should assess, but not be restricted to, the following activities and their impacts on species and habitats:

- direct impacts to sensitive species and species at risk and their habitats in the bog resulting from any management and construction activities in the nature park properties or in the DND property. This would include pond management activities, trail management activities and site use;
- indirect impacts of work, such as increased disturbance to the site, that allows further influx of invasive species or results in a decline in species at risk habitat;
- impacts of work outside the study area that could impact on the bog. In particular, activities that would alter site hydrology and result in changes to the bog ecosystem and ultimately the species that inhabit it.

A critical part of impact assessment would be the review of activities outside the study area that would have potential impacts on the bog, such as drainage or hydrological changes. The zone of concern for impact assessment outside of the bog will be primarily hydrologically driven, and the depth of this zone should be determined by a hydrologist who can determine an appropriate buffer zone based on this.

Additionally, mitigation methods should be developed for disturbance activities that result in, for example, an influx of invasive species into the bog. An invasive species influx will commonly occur where the substrate is disturbed or cleared. Mitigation methods could include the use of landscape cloth to prevent immediate invasive species establishment, immediate removal of invasives as they germinate, etc. This component may be addressed both under impact assessment and remediation, under general ecosystem management that includes invasive species management.

As part of the need to minimize impacts on species at risk and their critical habitat, and to assist in the impact assessment process, mapping should be undertaken showing species locations, critical habitat, and seasonal areas of occupation. This mapping will help guide operational activities in the bog.

25.3.4 Organize a Discussion Forum Aimed at Establishing a Process and Framework for Carrying Out the Above Recommendations.

In order to implement the recommendations outlined above, we recommend that the City of Richmond initiate an interagency discussion forum or meeting to review the recommendations in this report and to explore the needs and options for implementation. This forum should be comprised of representation from the City of Richmond (parks planning and city planning), the Richmond Nature Park, the Richmond Nature Park Society, the Department of National Defence, and other groups and individuals interested in the conservation of the bog or its role in outdoor education and interpretation. Discussion should include, but not be limited to:

- the **process** and **structure** through which recommendations could be planned and implemented. Two institutional components seem relevant:
    - a longer-term interagency steering committee that would guide the processes outlined in the above recommendations and provide direction to an implementation team (described below). This steering committee would have a strategic, 'overseer' role in guiding protection initiatives and restoration initiatives for the three properties. It would be comprised of municipal and federal representatives, NGO representatives, and other key individuals;
    - the establishment of an operationally-focused implementation team to carry out the direction laid out by the steering committee. This team would likely consist of representatives from the government agencies mentioned above and the RNPS, but should also be sure to involve technical advisors including biologists, hydrologists, and planners.
- The **substantive policies** and **procedures** that the steering committee should be considering to guide conservation and restoration of the bog. These include:
    - the steps required to move the study area properties towards nature reserve status;
    - vehicles for stewardship agreements and management partnerships for federal and municipal lands, such as federal-municipal management agreements;
    - the development of stronger legislation to protect all three properties of the Lulu Island Bog;
    - the steps needed to implement an integrated ecosystem management process for the bog and surrounding area that would include management needs on both federal and municipal lands;
    - development of a work plan for implementing the recommendations, inclusive of a budget, potential funding options, timeline, project schedules, and task assignments.

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PART IV: APPENDICES

APPENDIX A

A Student Evaluation of the Plant Biodiversity of the Richmond Nature Park Bog: Effects of Human Disturbance and Invasive Species [1]

By Lori D. Daniels, Polly Ng and Josephine Epp, UBC Department of Geography

A.1 Introduction

The Lulu Island bogs (Greater Lulu Island Bog and Lesser Lulu Island Bog) once occupied up to one third of Lulu Island (Jagger 2003), the largest island in Richmond, British Columbia. Agricultural and urban development on Lulu Island has since reduced the area of the bogs by 95% (Klinkenberg and Klinkenberg 2003), leaving only two small remnants of each of the once much larger boglands. One of these remnants, the present day Lulu Island Bog, is represented by the two Richmond Nature Park properties and the adjacent Department of National Defence lands. The Lulu Island Bog, like other relict bogs in the Lower Mainland, plays an important role in the hydrology of the region and provides essential habitat for many species. The bog habitat present here includes a provincially rare plant community, the shore pine-*Sphagnum* moss plant community (British Columbia Conservation Data Centre 2006). Because of the essential role that the Lulu Island Bog plays in the ecology and hydrology of Lulu Island, and the municipality of Richmond, it is important to understand the extent to which the bog has been altered by human disturbances. This understanding will help guide future restoration efforts.

In this study, we focused on the portion of the Lulu Island Bog that lies within the Richmond Nature Park. The objectives of the study were to quantify variation in plant diversity and to determine the effects of human disturbances and invasion of exotic species (Photo A.1) on biodiversity within the Park. We compare four different plant communities at six sites, each with a unique disturbance history. In each community, we determined species composition and calculated four indices of biodiversity: richness, dominance, diversity and uncertainty.

A.2 Study Area

The Richmond Nature Park (west property - RNP west) is located at 11851 Westminster Highway in the City of Richmond at approximately latitude 49° 05' and longitude 123° 10' (Centre for Topographic Information 2003). The 200 acres that

[1] This study was prepared as a class project by Geography students of the University of British Columbia (Geog. 207 and Geog. 307). As such, species identifications are based on local field guides and are not always accurate. Please interpret the results accordingly.

constitute the Park are protected under the Provincial Agricultural Land Reserve. Fieldwork was carried out at six different sites that represent the different plant communities of the Park as mapped by Mack (2000).

Photo A.1: Geography student Janneke Lade working on the bog vegetation study. Photo: Ashley Horne.

Site 1, in the Birch-Western Hemlock-Sword Fern forest community (Mack 2000), is located near the road and is characterized by a canopy approximately 16 to 20m in height that consists of western hemlock (*Tsuga heterophylla*) and birch (*Betula pendula*). The shrub layer is 2 to 3m tall and consists of red elderberry (*Sambucus racemosa* ssp *pubens*), and English holly (*Ilex aquifolium*). The understorey is short and consists primarily of salal (*Gaultheria shallon*), sword fern (*Polystichum munitum*), and trailing blackberry (*Rubus ursinus*). The forest floor is covered by leaf litter and moss. The hemlock forest was strongly disturbed by the introduction of mineral soils deposited near the area in the 1970s during the construction of the Massey Tunnel.

Site 2 was located in the ecotone between the Birch-Western Hemlock-Sword Fern forest community and the Shore Pine-Labrador Tea-*Sphagnum* treed bog community (Mack 2000). Site 2 has a much more open and shorter (10 to 12m) canopy than the hemlock-dominated forest and the dominant tree species is shore pine (*Pinus contorta*). The dense shrub layer is dominated by invasive highbush blueberries

(*Vaccinium corymbosum*), approximately 2m in height, with a shorter layer of salal and Labrador tea (*Rhododendron groenlandicum*).

Further into the bog, Site 3 is part of the Shore Pine-Labrador Tea-*Sphagnum* treed bog community (Mack 2000) that has been restored by removing highbush blueberry from the shrub layer. The few shore pine trees, along with the occasional birch, are sparsely distributed at the site so the canopy is open. Labrador tea and bog-laurel (*Kalmia microphylla*) are abundant. The terrain is varied because of the presence of *Sphagnum* hummocks.

In comparison with the restored treed bog community, Site 4 is more heavily invaded by blueberries in the shrub layer, though the Labrador tea is also taller than at Site 3. The *Sphagnum* hummocks are less defined and shore pine trees were more prevalent than in the restored treed bog community.

Site 5 is the Birch-Sword Fern forest community (Mack 2000) and is dominated by a tall, moderately dense canopy of birch and an understory of salal and highbush blueberry. It is situated close to the train tracks running down Shell Road and is also close to the perimeter of the park.

Site 6 is the Cultivated (highbush) Blueberries-Labrador Tea heath bog community (Mack 2000) or blueberry desert[2], which is a highly disturbed site characterised by a dense shrub layer almost entirely dominated by highbush blueberry. Very few native bog species grow among the blueberry bushes, although small wet depressions harbour carnivorous sundew plants (*Drosera rotundifolia*) and cranberries (both the native *Vaccinium oxycoccus* and the introduced *V. macrocarpon*, and hybrids). For the most part, however, the peat has died in this community as a result of dense shading by the blueberries, and drying of the bog resulting from drainage.

A.3 Methods

Fieldwork was conducted by students from the Department of Geography at the University of British Columbia on October 27, 2001, and on October 26, 2002. Data were collected from six plots at each of the six sites. Plots were 20m apart and 20m from the access trail, along transects perpendicular to the trail. At study Site 6, the plots were 20m apart but less than 5m from the access trail. Each plot consisted of a

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[2] The 'blueberry desert' is an artificial plant community type dominated by cultivated blueberry (*Vaccinium corymbosum*) and lacking understorey species. The peat mat in these areas has died, probably as a result of increased shade beneath the dense blueberry growth, and decreased available water. Please refer to Chapter 9 in this report for further details on vegetation communities in the bog.

1m x 1m quadrat was nested within a 5m x 5m quadrat. The species and percent cover of plants with heights >30cm were sampled in the $25m^2$ quadrats and plants with height ≤30cm were sampled in the $1m^2$ quadrats. Species >30cm tall were identified and percent cover was estimated. We differentiated *Sphagnum* according to its position on hummocks, in depressions, or in standing water.

Increment cores were extracted from the base of selected western hemlock at Site 2, shore pine at Site 3, and a large western hemlock known as the "Owl Tree" to estimate the ages of trees in the Park (Photo A.2).

Photo A.2: Lori Daniels coring the "Owl Tree" in the RNP west. The tree was established c. 1945. Photo: Brian Klinkenberg.

Species richness and three indices of biodiversity were calculated for each plot and averaged for each site. Simpson's index quantifies dominance (C) and diversity (D) of species in a community using the following equations (MacDonald 2003):

$$C = \sum (p_i)^2 \qquad [1]$$

where C measures dominance and p_i is the proportion of all individuals that belong to species i. Dominance is a measure of the evenness among species in a community. Since higher species abundances influence the calculation more than species with low abundance, a low C-value indicates the species in a study site were evenly distributed (Krebs 2001).

$$D = 1-C \qquad [2]$$

where D measures diversity. Diversity is negatively related to dominance. Therefore, when dominance of a site is low then diversity is high, indicating a high degree of biodiversity (Krebs 2001).

Uncertainty or information in the community was measured using the Shannon-Wiener index (H') (MacDonald 2003):

$$H' = -\sum (p_i)(\ln p_i) \qquad [3]$$

where H' ranges from 0 to 7 and measures uncertainty, or the amount of information, and p_i is the proportion of all individuals that belong to species i. High values of uncertainty indicate the variable communities that are unpredictable, contain large amounts of information or complexity, and a high degree of biodiversity (Krebs 2001, MacDonald 2003).

Species richness, dominance, diversity, and uncertainty were visually and statistically compared among study sites. We used analysis of variance (ANOVA) to test for significant differences in mean values of the biodiversity indices among the six study sites. For indices with significant variation, Tukey's pairwise multiple comparisons test was conducted to determine which sites differed from the others. Statistical tests were considered significant at the $\propto = 0.05$ level.

A.3.1 Limitations

As a class project (Photo A.3), a significant limitation of this project is the lack of familiarity with plant species identifications, in particular with bryophyte identification. As a result, some species that are discussed in this section are unverified, have not yet been confirmed as occurring in the Lulu Island Bog, and were not reported during the inventory by other botanists. This influences the accuracy of this work. However, studies such as this by biogeography students is a learning process in plant geography studies, and results must be taken in that light.

Photo A.3: UBC Geography 207 Class, 2002, in the bog. Photo: Lori Daniels.

A.4 Results

We observed 36 species of plants in the study plots, including mosses, ferns, herbs, shrubs and trees, plus *Sphagnum* moss and fungi (Table A.1). Species richness was greatest in the Birch-Western Hemlock-Sword Fern forest community (Site 1, 23 species), followed by the ecotone between Sites 1 and 3 (Site 2, 18 species), Birch-Sword Fern forest community, Shore Pine-Labrador Tea-*Sphagnum* treed bog community (Sites 3 and 4, 13 and 14 species respectively) and least in the Cultivated Blueberry-Labrador Tea heath bog community (n =5). Species native to the bog were present at the majority of sites (Table A.1). *Sphagnum* moss was found at all sites. Labrador tea and shore pine were present at all sites except Site 1. Bog blueberry (*Vaccinium uliginosum*) and bog-laurel were distributed less extensively, with the former absent from Sites 1 and 6 and the latter absent from Sites 1, 5, and 6. Three non-bog species were present at five of six study sites. Salal was absent from Site 6; birch, from Site 4; and highbush blueberry from Site 1. Fourteen species, including many ferns and shrubs, were present at Site 1 only.

Within study areas, up to 10 or 12 species were present in individual plots at Sites 1 to 4 (Figure A.1). Plots at Site 6 included only two to five species. Richness was most variable among plots at Sites 2 and 3. Mean species richness was highest at Site 4 and lowest at Site 6 (Table A.2). Species richness at Site 6 was significantly lower than richness at Sites 1 to 4 but not different from Site 5 ($p = 0.004$, Table A.2).

Based on percent cover, different species dominated each study site and the relative abundance of the dominant species varied between plots within sites. At Site 1, western hemlock and birch dominated. Labrador tea and salal dominated at Site 2. At both Sites 3 and 4, Labrador tea and *Sphagnum* moss on hummocks were dominant. Birch and salal dominated at Site 5. At Site 6, highbush blueberry dominated. When the plant community of each site was assessed, dominance (C) was lowest at Site 4, highest at Site 6, and most variable at Sites 1 and 6 (Figure A.2). Sites 1, 2, 3, and 5 had similar, relatively low mean values for dominance (Table A.2). Dominance at Site 6 was significantly greater than all other sites ($p<0.001$, Table A.2).

Results for diversity (D) were opposite to those of dominance (C), since diversity is inversely related to dominance. Diversity was lowest at Site 6 and highest at Site 4 (Figure A.3, Table A.2). All other sites had relatively high values of diversity similar to Site 4. Diversity of Site 6 was significantly lower than the diversity of all other sites ($p<0.001$, Table A.2).

Uncertainty (H') was significantly lower at Site 6 than all other sites (Figure A.4, Table A.2), as Site 6 was strongly dominated by highbush blueberry. Site 4 had the highest mean value for uncertainty, with similar mean values for all other sites.

The "Owl Tree", the largest hemlock tree in the Park, and the shore pine at Site 2 established about 1945 to 1949. The hemlocks at Site 1 established in the early 1970s.

Table A.1: Presence-absences of species in the six study sites in Richmond Nature Park. Common names are bolded for species that are true bog species.

Species		Study Site Number					
Latin Name	Common Name	1	2	3	4	5	6
Andromeda polifolia	**bog-rosemary**		✓				
Athyrium felix-femina	lady fern	✓					
Betula pendula	birch	✓	✓		✓	✓	✓
Blechnum spicant	deer fern	✓					
Brachythecium frigidum	golden short-capsuled moss	✓		✓			
Dicranum spp.	**wind-blown moss**	✓		✓	✓		
Dryopteris austriaca	spiny shield fern	✓					
Eurhynchium oreganum	**fern moss**	✓	✓	✓	✓	✓	
Gaultheria shallon	salal	✓	✓	✓	✓	✓	
Hylocomium splendens	**step moss**	✓	✓	✓	✓	✓	
Ilex aquifolium	English holly	✓					
Isothecium stoloniferum	**thread moss**		✓			✓	
Kalmia microphylla	**bog-laurel**		✓	✓	✓		
Kindbergia oregana	Oregon beaked moss					✓	
Pinus contorta	**shore pine**		✓	✓	✓	✓	✓
Pleurozium schreberi	red-stemmed feather moss						
Polystichum munitum	sword fern	✓					
Polytrichum spp.	**tree moss**	✓		✓	✓		
Pteridium aquilinum	bracken fern	✓					
Rhamnus purshiana	buckthorn	✓					
Rhododendron groenlandicum	**Labrador tea**		✓	✓	✓	✓	✓
Rhytidiadelphus loreus	lanky moss	✓					
Rhytidiadelphus squarrosus	bent-leaf moss	✓					
Rubus laciniatus	evergreen blackberry		✓				
Rubus procerus	Himalayan blackberry	✓					
Rubus spectabilis	salmonberry	✓					
Rubus ursinus	trailing blackberry	✓					
Sambucus racemosa ssp. *pubens*	coast red elderberry	✓					
Sorbus acuparia	mountain-ash	✓					
Sphagnum spp. – depressions	***Sphagnum* moss**	✓					
Sphagnum spp. – hummocks	***Sphagnum* moss**	✓	✓	✓	✓	✓	✓

Species		Study Site Number					
Latin Name	**Common Name**	**1**	**2**	**3**	**4**	**5**	**6**
Sphagnum spp. - standing water	***Sphagnum* moss**				✓		
Spirea douglasii	hardhack					✓	
Tsuga heterophylla	western hemlock	✓	✓				
Vaccinium corymbosum	highbush blueberry		✓	✓	✓	✓	✓
Vaccinium macrocarpon	large cranberry		✓				
Vaccinium myrtilloides	**velvet-leaf blueberry**		✓	✓		✓	
Vaccinium oxycoccus	**small cranberry**		✓		✓		
Vaccinium uliginusum	**bog blueberry**		✓	✓	✓	✓	
	fungi	✓	✓			✓	
Total number of species		**23**	**18**	**13**	**14**	**14**	**5**

Table A.2: Statistical comparison of four measures of biodiversity among the six study sites in the Richmond Nature Park.

Biodiversity Index	Mean (variance)						Calculated F-statistic	P-value
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6		
Richness (N)	8.3 (3.5)	7.7 (12.3)	8.0 (5.2)	8.5 (3.5)	6.7 (1.9)	3.7 (1.1)	4.4	0.004
Dominance (C)	0.30 (0.025)	0.23 (0.007)	0.23 (0.003)	0.19 (0.001)	0.29 (0.004)	0.79 (0.010)	35.6	<0.001
Diversity (D)	0.70 (0.025)	0.77 (0.007)	0.77 (0.003)	0.81 (0.001)	0.71 (0.004)	0.21 (0.010)	35.5	<0.001
Uncertainty (H')	0.19 (0.171)	0.32 (0.172)	0.23 (0.081)	0.33 (0.041)	0.22 (0.023)	0.09 (0.045)	16.4	<0.001

Note: Figure A.1, Figure A.2, Figure A.3, and Figure A.4 displays the 6 plots that were sampled per study area; richness was equal in some plots, indicated by a single point.

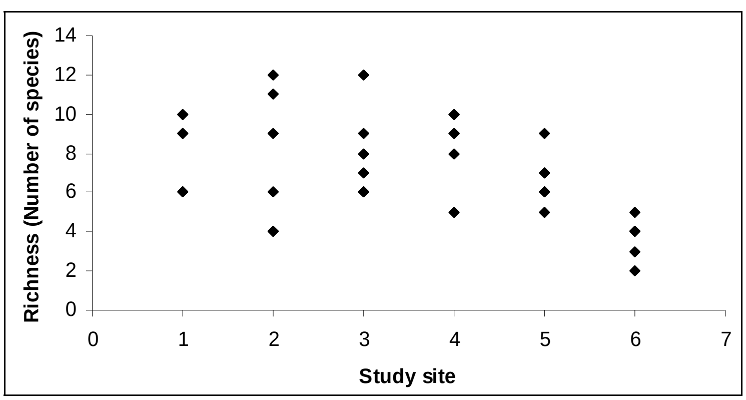

Figure A.1: Species richness in six study areas in Richmond Nature Park.

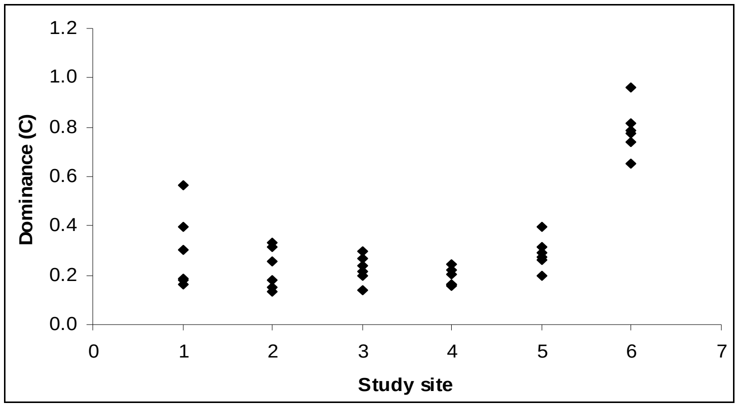

Figure A.2: Dominance in six study areas in Richmond Nature Park.

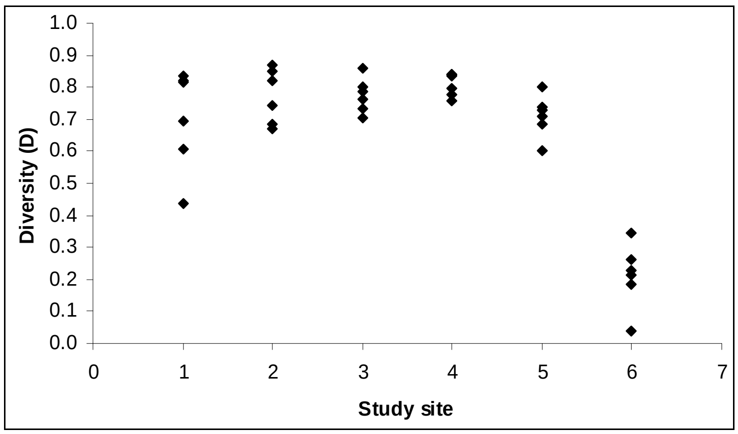

Figure A.3: Diversity in six study areas in Richmond Nature Park.

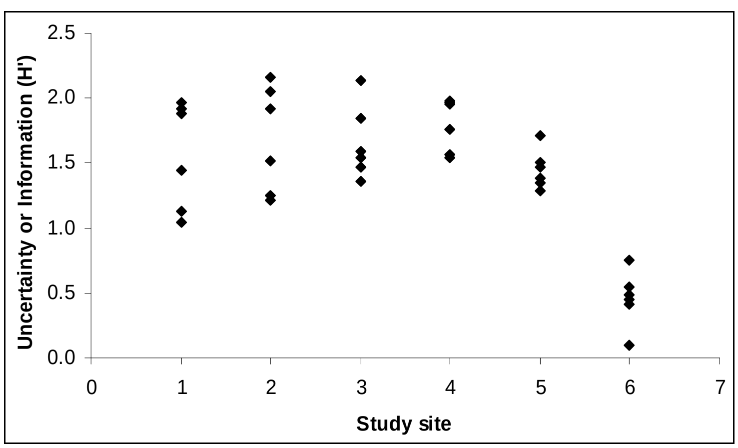

Figure A.4: Uncertainty or information in six study areas in Richmond Nature Park.

A.5 Discussion

Comparison of multiple indices of biodiversity indicated biodiversity was affected by disturbance, invasion of exotic species, and invasion by species not normally part of the bog flora (e.g., western hemlock trees and sword fern). Overall, high levels of disturbance and species invasion have increased species richness – the number of species present in the bog communities. Negative consequences of this change in species composition included reduced evenness of the distribution of individuals among species and increased dominance of non-native species in the Richmond Nature Park. Different types of disturbance in the park have had unique effects on biodiversity because each type of disturbance changed the physical environment to various degrees, which in turn changes community composition and structure through the responses of individual species. Therefore, the biodiversity of the plant communities at each site has been uniquely influenced by the types and severity of disturbances that occurred nearby, and the consequential changes in nutrient, moisture, and light availability.

The creation of drainage ditches around the perimeter of the park has changed the hydrology, substrate quality, and nutrient availability of the area. The most severe changes occur in areas near the park's periphery, namely in the Birch-Western Hemlock-Sword Fern and Birch-Sword Fern forest communities (Sites 1 and 5, respectively). The drainage ditches increased surface water run-off and lowered the water table, drying the peat substrate (see Chapters 8, 22). The peat layers also become compacted as a result of increased rates of aerobic decomposition, which decreased permeability and substrate porosity (see Chapters 8, 22). Drainage increases rates of mineralization, which increase nitrogen and phosphorous, but leach highly soluble potassium from the substrate (see Chapters 8, 22). As a result of these processes, areas disturbed by drainage ditches have less moisture and more nutrients than the wet, nutrient-poor conditions characteristic of *Sphagnum*-dominated bogs. Under these conditions, birch and western hemlock have established and have grown much taller than the small-stature shore pines usually found in treed regional bog communities. The moderately high levels of species richness and evenness exhibited by the Birch-Sword Fern forest community could possibly be attributed to succession at the site, in which the original bog community is gradually being replaced by birch and other species that are better adapted to the changes caused by drainage. A number of native bog species can still be found in the birch forest, but birch currently dominates the canopy, altering the amount of light reaching the shrub and forest floor strata and most likely influencing moisture levels and temperature.

In addition to the impacts of drainage ditches, mineral-rich sediments from the construction of the Massey Tunnel were deposited on Site 1, which is currently a hemlock-dominated forest. Increment cores from the hemlock trees indicated they were established in the early 1970s, soon after the soil was disturbed. Post-disturbance succession has resulted in the Birch-Western Hemlock-Sword Fern forest community, which is highly distinct from the communities of the other five study sites. Fourteen species were found exclusively at Site 1. Bog blueberry, shore pine, and Labrador tea were conspicuously absent from this site though they were present in all or most of the other sites.

Site 2 is the ecotone between the Birch-Western Hemlock-Sword Fern forest community (Site 1) and the Shore Pine-Labrador Tea-*Sphagnum* treed bog community (Site 3). Site 2 includes physical and biological characteristics of both the forest and treed bog communities. For example, the cover of western hemlock and birch were low compared with Site 1, but the cover of shore pine was much greater. In contrast, evergreen blackberry (*Rubus laciniatus*), an invasive species that signifies disturbed conditions and drying, was present only at Site 2. Given the environmental heterogeneity within the ecotone, species from both the forest and treed bog communities coexist. Therefore, we observed high levels of diversity and low levels of dominance. Three species, large cranberry, bog-rosemary, and evergreen blackberry, were found exclusively at Site 2. Although this observation could be an artefact of sampling, an alternate explanation for the presence of these unique species is that a high level of environmental heterogeneity created unique conditions favourable for the establishment of these species.

The two sites in the Shore Pine-Labrador Tea-*Sphagnum* treed bog community located near the north-central part of the Park may have been the least disturbed sites by virtue of the buffering effect between the core and disturbed edges of the bog. It is interesting to compare the restored site (Site 3) to the adjacent treed bog (Site 4). Species richness was similar at the two sites (13 and 14 species at Sites 3 and 4, respectively), with eleven species in common. Species were more evenly distributed in the treed bog than at the restored sites. At the restoration site, volunteers had removed highbush blueberry manually. However, it had regenerated resulting in cover values of 0 to 25% in individual sample plots. Presence of the regenerating highbush blueberry decreased evenness and diversity and increased dominance in the restored treed bog. The treed bog (Site 4) was dominated by native bog species including *Sphagnum* spp., Labrador tea, bog blueberry, and shore pine. These species were relatively evenly distributed and the percent cover of highbush blueberry was less than 8% in each sample plot and birch was present in only one plot. As a result, mean values of species richness, diversity and uncertainty were greatest in the bog forest and dominance was lowest. Qualitatively, the treed bog had the highest biodiversity of the six communities examined in this study. However, the quantitative differences in the biodiversity indices were not statistically significant, with the exception of the blueberry desert.

The lowest levels of species richness, diversity and uncertainty were measured at Site 6. The dominance of highbush blueberry, which grows as a high bush that shades out native species (Klinkenberg 2000), is responsible for low species richness and diversity at this site. Other parts of the Park have been susceptible to invasion, as highbush blueberry grows best on *Sphagnum* hummocks or raised bogs with moist, acidic, and well-aerated organic soils and in full sunlight (Uchytil 1993). Also, highbush blueberry withstands extended periods of flooding, which are common in natural bogs. Because it tolerates only low degrees of shade (Uchytil 1993), the only places in the Park where highbush blueberry is virtually absent is beneath the closed canopy of the Birch-Western Hemlock-Sword Fern forest community.

A.6 Conclusion

Over the past century, the biodiversity of Richmond Nature Park has been negatively affected by several anthropogenic activities. Direct disturbances such as the deposition of mineral-rich silt from the construction of the Massey Tunnel, creation of drainage ditches around the periphery of the park, and introduction of exotic species have altered soil nutrient availability, hydrological regimes, and other abiotic factors (see Chapters 8, 22). These changes have allowed non-bog species to invade and dominate parts of the bog ecosystem (Jagger 2003). While disturbance and introduction of exotic species have increased species richness, they have reduced the biodiversity of the bog community by dominating and excluding native bog species from some areas of the Park. The most extreme example of the impacts of invasion by an exotic species is the blueberry desert. Highbush blueberry has aggressively out-competed native bog species such as *Sphagnum* mosses, Labrador tea, bog blueberry, cranberry, and shore pine by shading out smaller plants and by monopolizing space. Dominance by highbush blueberry has had significant negative impacts on biodiversity in many areas of the park. Along the edges of the park, Birch-Western Hemlock-Sword Fern and Birch-Sword Fern forest communities dominate where disturbance to the soil has been most extensive. Although rich in species, these forest communities differ in composition from the less-disturbed treed bog communities in the interior of the park. Biodiversity, indicated by high values of diversity and uncertainty and low dominance by individual species, was greatest in the treed bog forest north of the trails in the Park, followed by the restored treed bog forest near the centre of the park. Although low in species richness, the species within the communities were relatively evenly distributed and included low abundances of exotic, invasive species. We conclude that the biodiversity measured at these sites is the best estimation of the level of biodiversity that once was present in the Greater Lulu Island Bog.

APPENDIX B

Provincially Endangered *Pinus contorta-Sphagnum* Community

Map and data prepared by Karen Golinski (2002)

Figure B.1. Dashed lines on the air photo of the DND property indicate the areas occupied by the Pinus contorta-Sphagnum community in 2002. Locations of the two plots or relevés sampled by Karen Golinski are indicated with arrows.

Table B.1: Relevé data, Pinus contorta- Sphagnum association (CDFmm), DND property.
Data collected September 12, 2002 by Karen Golinski with Kevin Mack.

Site ND		
Relevé Number	05	06
Plot Size (m2)	ca. 100	ca. 100
Microtopographic Unit1	hu	hu
Vascular Spp./ Relevé	7	11
Bryophyte Spp./ Relevé	7	8
Lichen Spp./ Relevé	1	3?
Vascular Plant Cover (%)	65	70
Bryophyte Cover (%)	98	98
Lichen Cover (%)	+	1
Species Percent Cover	2	
Pinus contorta var. *contorta*	1	+
Vaccinium corymbosum	2	2
Betula pendula	-	+
Vaccinium uliginosum	20	20
Calluna vulgaris	25	15
Rhododendron groenlandicum	15	10
Kalmia microphylla ssp. *occidentalis*	15	2
Vaccinium oxycoccos	10	5
Andromeda polifolia	-	+
Rubus chamaemorus	-	+
Carex pauciflora	-	+
Sphagnum capillifolium	90	90
Polytrichum strictum	2	1
Eurhynchium oreganum	-	1
Aulacomnium palustre	+	+
Sphagnum papillosum	+	+
Pleurozium schreberi	+	-
Sphagnum pacificum	+	-
Dicranum scoparium	-	+
Rhytidiadelphus triquetris	-	+
Mylia anomala	-	+
Cladina portentosa ssp. pacifica	1	1
Cladonia squamosa 3	+	+
Cladonia spp.	-	+

1 microtopographic unit: “hu” = hummocks
2 “+” = <1%
3 tentative identification; lichen specimens collected but not yet identified

APPENDIX C

Fecal Pellet Analysis in Species Identification: Identifying Voles in the Lulu Island Bog.

By Chris Sears

C.1 Introduction

As part of the Lulu Island Bog inventory a small mammal survey was conducted. This survey targeted one species that is currently listed under the federal Species at Risk Act (the Pacific Water Shrew) and two species that are considered data deficient, but potentially could be listed under the act in the future - the Western Red-backed Vole (*Clethrionomys gapperi* spp. *occidentalis*)[1] and Snowshoe Hare (*Lepus americanus washingtonii*). During live-trapping, some voles were identifiable as Townsend's Vole (*Microtus townsendii*) and not the targeted Western Red-backed Vole. However, several voles were of uncertain identity as their morphological features overlapped those of the Townsend's Vole and the Western Red-backed Vole. This ambiguity was important to resolve as identification of the animals was considered an important component of the inventory.

To undertake an inventory of any species at risk one must deal with intrinsic legal issues under Canada's Species at Risk Act (SARA). Legal issues revolve around the need to take vouchers in the form of skins and skulls. Vouchers are necessary as many small mammals can only be reliably identified by characteristics of the skull and teeth. Killing a member of a species that may be endangered in order to identify it has legal ramifications and requires special permits and expertise. Under SARA, harming a listed species is not permitted. Due to the potential presence of a federally listed species, the Pacific Water Shrew, our trapping permits for the inventory did not permit killing of animals, and required that all animals be released. This meant that identification of ambiguous animals had to be dealt with in other ways. Fecal pellet analysis was identified as a potential solution to the challenge of identification. As explained below, one can obtain DNA from fecal pellets and use molecular techniques to identify the animal that produced it to species. This eliminated our need to take voucher specimens and resolved any issues regarding identification based on skull characteristics or on cryptic or overlapping morphological characteristics.

[1] See chapter 18 for a discussion of the Red-backed Vole.

C.2 Background

DNA barcoding is a somewhat controversial means of placing an unknown organism into a species. It is controversial because it appears to take emphasis and funding away from organismal biology and because some have claimed that the procedure can be applied to all branches of the tree of life. DNA is a molecule that holds all of the information to build living things. DNA molecules are made up of very long chains of four different molecules called nucleic acids. Molecular biologists are able to determine the identity and order of these nucleic acids along a DNA molecule. This is called a DNA sequence. In animal cells, DNA is found in two structures. Most DNA is found in the nucleus and is inherited from both maternal and paternal parents. However, there is also DNA contained within the mitochondria and these organelles are inherited from the mother only. Each cell has many mitochondria and each mitochondria has its own piece of circular DNA called mtDNA. Mitochondria are the engines of a cell that convert food energy into usable energy. DNA contains regions that code for the building blocks of life. These regions are called genes. Genes are generally stable parts of a DNA molecule because any changes in the nucleic acid sequence of the gene will often result in building blocks that do not work properly. When the building blocks do not work properly the animal will most likely die before it can pass on its genes or it will not be very successful at passing on its genes. As a result, there is not much sequence variation in a gene within a species. DNA barcoding argues that all members of a species will share a similar DNA sequence for a given gene and will have a dissimilar DNA sequence when compared to other species. This means that all one has to do in order to place an animal into a species is to get the sequence for a gene and determine to which species it is most similar. For a review of this technique see Hebert et al. (2004).

Using mtDNA has its advantages and disadvantages. The main advantages of using mtDNA are that it is abundant and it lacks many confounding phenomena associated with nuclear DNA. mtDNA it inherited only from the mother so it gives a clear picture of evolutionary history above the level of species. However, below the level of species, at the population level, the web-like relationships between individuals is invisible when using mtDNA. When working below the level of species one must work with the biparentally inherited nuclear genomes to get the full picture. To this end researchers usually use nuclear DNA markers such as microsatellites or AFLP's. These techniques were unnecessary for this study. They would have been necessary if there was potential for gene flow between Townsend's Vole and Red-backed Vole. Gene flow between species is called lateral gene flow and the spread of a genome from one species into a different species is called introgression. Plants are much better at this than animals so botanists are used to dealing with these phenomena, but it is relatively rare in animals. Given that these two taxa are in different genera and the genetic distance between them is great, the probability of lateral gene flow and subsequent introgression occurring between them is highly unlikely. In this case DNA barcoding using mtDNA was appropriate.

C.3 Methods

C.3.1 Collection

Fecal pellets were collected from an ambiguous animal (hereafter referred to as the Lulu Island Bog [LIB] animal) and deposited into cryo-tubes. Within 2 hours of collection, the cryo-tubes were put into a -80°C freezer. Pellets were shipped in the cryo-tubes packed on dry ice to Adrian Kovack, Assistant Professor in the Department of Natural Resources at the University of New Hampshire. She extracted DNA from the pellets using a Qiagen- QIAamp DNA Stool Mini Kit (catalog # 51504), and confirmed the presence of mammal DNA by running a PCR using a universal mammal primer (PCR and primers will be explained below). She then shipped the DNA back to me at the University of British Columbia (UBC) packed on dry ice.

C.3.2 Primer Design

In order to obtain a DNA sequence for a gene of interest, two molecules are designed that will find the gene along the very long DNA molecule, and help make many copies of it. The molecules designed to help do this are called a primer pair. To design a primer pair, DNA sequences are analyzed for a gene of a species of interest or related species. Molecular biologists usually use a mitochondrial gene called cytochome oxidase B (cytB) or cytochome oxidase C (cytC) for DNA barcoding in mammals. I obtained sequences for cytB from GenBank of Southern Red-backed Voles (*Clethrionomys gapperi*) and Townsend's Vole (*Microtus townsendii*) and aligned these sequences manually using Se-Al Carbon. The aligned sequences were imported into Amplify 3X along with previously designed primers from Smith and Patton (1993). Amplify 3X is a computer program that simulates how well a primer will find and amplify a region of interest. The primers were modified to optimize amplification of cytB in *C. gapperi* and *M. townsendii*. The primer sequences are given in Table C.1.

Table C.1: Primers used for amplification and sequencing of cytochrome B gene of the Lulu Island Bog animal.

Primer	Sequence (5' to 3')
MVZ 03A	TGC CCC ATC AAA CAT CTC ATC
MVZ 16H	AGG AAR TAT CAY TCT GGT TTR ATG

C.3.3 PCR

To get many copies of cytB, I mixed the primer pair with the LIB mammal DNA along with an enzyme and a combination of various chemicals. This combination was put onto a thermal-cycler to create many, many copies of the cytB gene. This process is called Polymerase Chain Reaction or PCR. The thermal-cycler profile was as follows: 35 cycles [94°C (10s), annealing at 48 °C (15s), extension at 72 °C (45s)].

C.3.4 Sequencing

The next step was to determine the sequence of nucleotides of the amplified cytB gene. This was done by adding just one primer to a different mixture of much more expensive chemicals and put back onto the thermal-cycler on a different profile. The final product was sent to an automated sequencer that determined the DNA sequence of what was amplified during PCR.

C.3.5 Blast Search

This sequence was manually edited and trimmed in Se-Al Carbon, uploaded into GenBank and a blast search was conducted. The blast search compared this sequence to all sequences in a very large database in order to determine the most similar sequence.

C.3.6 Phylogenetic Analysis

CytB sequences for *M. townsendii* (GenBank accession number 163906), *M. canicadus* (GenBank accession number 163892), *M. californicus* (GenBank accession number 163891.1), *M. montanus* (GenBank accession number 119280), *M. pennsylvanicus* (GenBank accession number 119279), *Arvicola terrestris* (GenBank accession number 275106), and *C. gapperi* (GenBank accession number 309434) were downloaded from GenBank and manually aligned and trimmed using Se-Al Carbon. These aligned sequences were exported to PAUP 4.0b and a phylogenetic analysis was conducted using parsimony.

C.4 Results

C.4.1 PCR

After several failed attempts, the PCR reaction worked using the above thermal-cycler profile. I obtained a weak band containing about 27ng/μl of DNA (See Figure C.1 for an image of the gel).

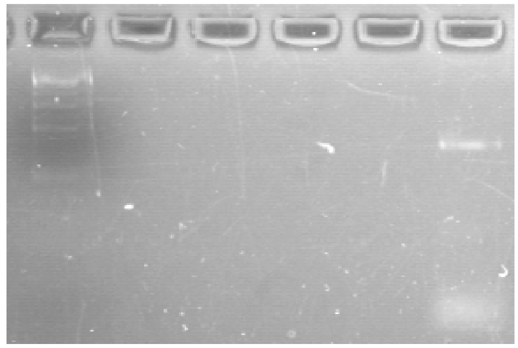

Figure C.1: Ethidium bromide stained agarose gel showing faint PCR band of cytB from the Lulu Island Bog animal, Richmond, British Columbia, Canada.

C.4.2 Sequencing

The sequence results are shown in Table C.2.

Table C.2: DNA sequence of a 339 base pair region of cytB obtained from a small mammal from the Lulu Island Bog, Richmond, British Columbia, Canada.

5’ACGGAATTTACTACGGCTCTTATAACATAATCGAAACATGGAACATAGGAATCATCCTA CTATTCGCTGTTATAGCAACAGCATTCATAGGCTATGTACTCCCATGAGGACAAATATCAT TCTGAGGGGCCACAGTAATCACAAATCTCCTATCAGCCATCCCCTATATCGGCACAACACT AGTAGAATGAATTTGAGGGGGCTTCTCAGTAGATAAAGCTACCCTCACGCGATTCTTCGC CTTCCACTTCA

C.4.3 Blast Search

A blast search determined that the Lulu Island Bog animal was most closely related to Townsend’s Vole. See Table C.3 for the first three results of the blast search.

Table C.3. First three results of a GenBank blast search of a partial cytB DNA sequence obtained from the Lulu Island Bog animal, Richmond, British Columbia, Canada.

gi|6690576|gb|AF163906.1|AF163906	Microtus townsendii cytochr...	628	2e-177
gi|9695297|gb|AF163892.1|AF163892	Microtus canicaudus cytochr...	529	2e-147
gi|5478485|gb|AF119280.1|AF119280	Microtus montanus cytochrom...	458	5e-126

C.4.4 Phylogenetic Analysis

The LIB animal is found in a well supported split (89% bootstrap value) in the phylogram with *M. townsendii* and is separated from *C. gapperi* by several dozen nucleotide changes. See Figure C.2 for the result of the phylogenetic analysis.

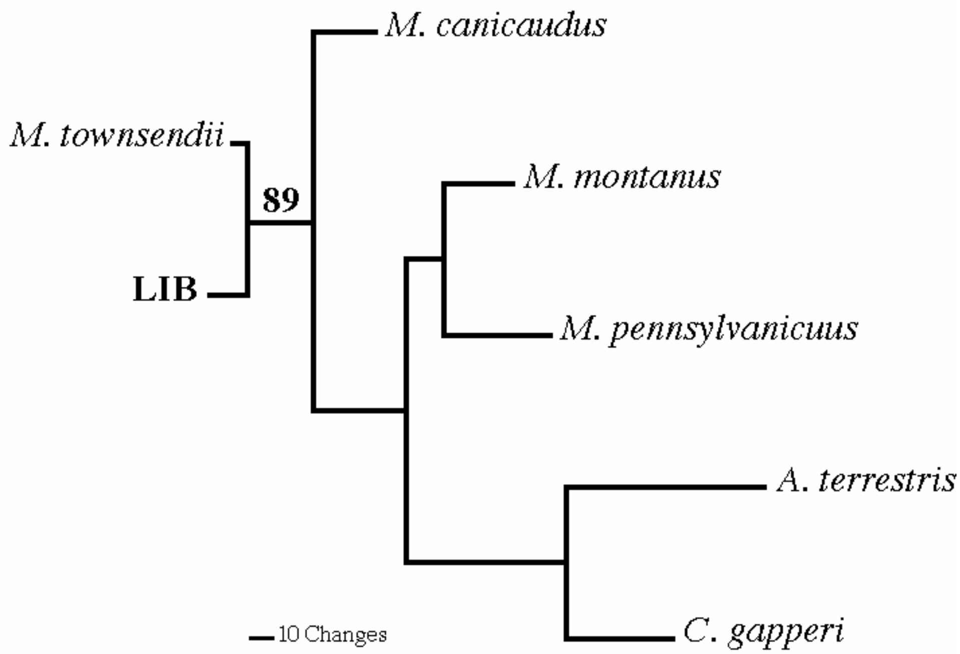

Figure C.2: Unrooted phylogram of Microtus, Clethrionomys and Arvicola generated from cytochome B sequence data. LIB denotes the animal from the Lulu Island Bog, Richmond, British Columbia, Canada. Number above branch is bootstrap value.

C.5 Conclusion

The blast search and phylogram show that the animal in question in the Lulu Island Bog was *M. townsendii* and that it is clearly not *C. gapperi*. In this case, DNA barcoding has proved useful, demonstrating that it may have a place in future small mammal surveys.

APPENDIX D

Appendix D-1: Bryophytes[1] of the Lulu Island Bog

By Wilf Schofield

S = Schofield[2] Br = Brothers I = Ingram + = photo record
G = Golinski[3] T = Taylor 2002, Taylor 1970 B = Bell, 1984 * = voucher, UBC
Comments Source: Schofield (1992). Some Common Mosses of British Columbia

Mosses

Latin Name	Authority	DND	RNP West	RNP East	Comments
Antitrichia curtipendula	(Hedw.) Brid.		T, I *	S, Br+	Common on trunks of trees.
Atrichum undulatum	(Hedw.) P. Beauv.		T, I*	S, Br+	Mineral soil.
Aulacomnium androgynum	(Hedw.) Schwaegr.	S	I, Br+*	S	Usually on decaying wood of stumps or logs or on peat-like turf.
Aulacomnium palustre	(Hedw.) Schwaegr.	S, G	T, I*	S, Br+	Frequent on swampy, boggy or seepage sites.
Brachythecium albicans	(Hedw.) B. S. G.		T		Terrestrial.
Brachythecium asperrimum	(Mitt.) Sull.		*I	S	On branches and trunks of trees and shrubs of somewhat open forests.
Bryum capillare	Hedw.		S		Open sites, usually on mineral soil or cliff crevices; also on concrete or stone walls.
Buckiella undulate (syn. *Plagiothecium undulatum)*	(Hedw.) Ireland		T, I, Br+*	S,	Rotten logs, humus, etc.
Calliergon stramineum	(Brid.) Kindb.	S			In open rich fens, swamps, marshy lakeshores, seepy depressions and bog hummocks.
Campylopus fragilis	(Brid.) B.S.G.	S		S	On disturbed peat banks. It is abundant locally in DND area.

[1] Selected photos of bryophytes found in the Lulu Island Bog may be viewed at http://www.geog.ubc.ca/richmond/city/bryophytesphotos.html.
[2] This study.
[3] This study.

Latin Name	Authority	DND	RNP West	RNP East	Comments
Campylopus introflexus			S		Found only in Burns Bog and RNP bog. This is a southern hemisphere species that has been introduced into Europe as well. It is also in western USA. First noted in BC by Terry Taylor.
Ceratodon purpureus	(Hedw.) Brid.	S	T, B		Sunny, usually sterile or disturbed soil. Common in urban areas.
Dicranella cerviculata	(Hedw.) Schimp.	S*	I*		Peat banks.
Dicranella heteromalla	(Hedw.) Schimp.		T	S, Br+	On banks of mineral soil in some-what shaded sites, forest margins.
Dicranoweisia cirrata	(Hedw.) Lindb. *ex* Milde	S*	I+*, B	S	Usually on tree trunks or wood.
Dicranum fuscescens	Sm.		T, I*,B		On wood and humus, occasionally epiphytic.
Dicranum scoparium	Hedw.	S, G	T, I *,B	S, Br+	On rotten logs, exposed cliff edges, sometimes forest floor and tree trunks.
Dicranum tauricum	Sapeh.		S, I*, B		Most commonly on rotten logs in coniferous forests.
Dicranum undulatum	Schrad. *ex* Brid.		I*		Peatland hummocks.
Drepanocladus exannulatus	(B.S.G.) Warnst.	S			In swamps, peatland, submerged to floating in quiet pools.
Eurhynchium oreganum	(Sull.) Jaeg.	T, G	T, I*	S	Terrestrial and logs.
Eurhynchium praelongum	(Hedw.)Schimp		T	S, Br+	Terrestrial and logs.
Funaria hygrometrica	Hedw.		T, B		On bare disturbed soil, especially frequent in burn sites.
Homalothecium fulgescens	(Mitt. *ex* C. Muell.) Lawt.		I*	S, Br+	Often on living tree trunks.
Homalothecium nuttallii	(Wils.) Jaeg. & Sauerb.			S	Ususally epiphytic, and most frequent on perpendicular surfaces.
Hylocomium splendens	(Hedw.) B.S.G.	S	S, *I, B	S, BR+	Usually terrestrial or on decaying logs.
Hypnum circinale	Hook.		T, *I, B	S, BR+	On tree trunks, logs.
Isothecium stoloniferum	Brid.		T, *I	S	Epiphytic on tree trunks and branches, commonly in humid forests.

Latin Name	Authority	DND	RNP West	RNP East	Comments
Neckera douglasii	Hook.		T, *I		Most commonly epiphytic on trunks and branches of trees.
Orthotrichum consimile	Mitt.		T, *I		Epiphytic on twigs and tree trunks.
Orthotrichum lyellii	Hook. & Tayl.		T	S	Epiphytic on living trees.
Orthotrichum pulchellum	Brunt. *ex* Winch. & Gateh.	S			Often epiphytic, also on rocks.
Orthotrichum striatum	Hedw.		S, *I		Usually tree trunks.
Plagiothecium denticulatum	(Hedw.) B.S.G.		T		Most frequent on cliffs, but also on tree bases.
Plagiothecium laetum	B.S.G.			S, BR+	Commonly on rotten logs, also on soil and cliffs.
Pleurozium schreberi	(Brid.) Mitt.	S, G	T, *I, B	S, BR+	On sterile litter, occasionally tree bases and in bogs.
Pohlia nutans	(Hedw.) Lindb.	S	T, *T, B	S	Humus soil and rotten logs.
Polytrichum commune	Hedw.		T, B		Common on organic soils in moist sites.
Polytrichum formosum	Hedw.			S, BR+	Margins of peatlands and on forest floor.
Polytrichum juniperinum	Hedw.		T, *I, B	S, BR+	Dry, sterile soil.
Polytrichum strictum	Brid.	S, G	T, *I	S	Peatlands, invading *Sphagnum* or on peat.
Pseudoleskea stenophylla				S	Epiphytic on tree trunks.
Pseudotaxiphyllum elegans	(Brid.) Iwats.		*S	S, br+	Mineral soil, tree trunks, rock faces.
Racomitrium canescens	(Hedw.) Brid.	S	S		Open, dry, sandy soil.
Rhizomnium glabrescens	(Kindb.) Kop.		T, B	S, BR+	Rotten logs in coniferous forests.
Rhytidiadelphus loreus	(Hedw.) Warnst.		T, *I, B	S	Rotten logs, forest floors, usually in humid coniferous forests.
Rhytidiadelphus squarrosus	(Hedw.) Warnst.		*I		Common weed in lawns.
Rhytidiadelphus triquetrus	(Hedw.) Warnst.	S, G	T, *I, B	S	Usually well drained sites in coniferous forests, also bouders and logs, occasional on tree trunks.

Latin Name	Authority	DND	RNP West	RNP East	Comments
Sanionia uncinata var. symmetrica	(Ren. & Card) Hedonas - var. Crum & Anderson	S			Epiphytic.
Scleropodium cespitans	(C. Muell) L. Koch			S	Epiphytic.
Sphagnum capillifolium	(Erhr.) Hedw.	G	G*	S, I+*, B+	Frequent in bogs, flourishes in better-drained sites. Some (deeper red) specimens occur in wetter depressions.
Sphagnum fimbriatum	Wils. *in* Wils. & Hook. f.		G*		Better drained hummocks, peatland margin.
Sphagnum fuscum	(Schimp.) Klinggr.	G*	G*		Better drained peatland.
Sphagnum henryense	Warnst.		S		Hummocks and damp areas in peatlands.
Sphagnum magellanicum	Brid.	S*	G*		Hummocks in peatlands.
Sphagnum mendocinum	Sull. & Lesq. *ex* Sull.	S*	G*		Wet areas in peatland.
Sphagnum pacificum	Flatberg	S*, G	S	S, br+	Both wet and well drained peatland.
Sphagnum palustre	L.	S*			Bog margins.
Sphagnum papillosum	Lindb.	S*, G	B, G*	S, br+	Open peatland hummocks.
Sphagnum squarrosum	Crome		G*	S	Primarily a woodland species, tolerant of some shade, swampy or seepage sites or near watercourses.
Sphagnum tenellum	(Brid.) Pers. *ex* Brid.	S*	G*		Nutrient rich areas of peatlands.
Tetraphis pellucida	Hedw.		T	S, BR+	Decomposing stumps and logs of coniferous trees, also peaty banks.
Ulota obtusiuscula	C. Muell. & Kindb. *ex* Mac. & Kinb.			S	Epiphytic on tree trunks.

Liverworts

Comments Source: Schofield (2002), Field Guide to Liverwort Genera of Pacific North America.

Species Name	Authority	DND	RNP West	RNP East	Comments
Calypogeia azurea	Stotler & Crotz			S	On organic or mineral soil, rotten logs, sometimes growing in peatlands.
Calypogeia muelleriana	(Schiffn.) Müll. Frib.			S	On organic or mineral soil, rotten logs, sometimes growing in peatlands.
Cephalozia bicuspidata	(L.) Dum.			S, BR+	On rotten logs, wet soil, peat, and living trees.
Gymnocolea inflata	(Huds.) Dum		S		This species is found in damp depressions at bog margins.
Lepidozia reptans	(L.) Dumort		T		This species is most frequent in shaded sites on rotten logs or stumps; some species arefound on moist soil.
Lophocolea bidentata	(L.) Dumort		*I		Epiphytes on living trees, rotten logs, on mineral soil in shaded to relatively open sites.
Lophozia sp.	L.		S		Rotten logs, rocks, in humid sites.
Mylia anomala	(Hook.) S. Gray	G	*I	S, BR+	In *Sphagnum* bogs on the coast.
Porella cordaeana	(Hub.) Moore		*I	S	On boulders and outcrops, also commonly epiphytic, including on red alder.
Porella navicularis	(Lehm. et Lindenb.) Lindb.			S	Commonly epiphytic, including on alder, also on boulders and outcrops.
Ptilidium californicum	(Aust.) Underw			S	Mainly epiphytic.
Ptilidium pulcherrimum	(G. Web.) Hampe			S	Rotten logs, tree bases.
Radula complanata	(L.) Dum.		*I		Epiphytic, also on rock surfaces, and terrestrial among other plants, especially in humid conditions.
Scapania bolanderi	(K. Mull.) Frye et Clark		*I	S, BR+	Primarily an epiphyte on living trees.

Appendix D-2: Lichens of the Lulu Island Bog, 2006

By Terry Taylor

T = Taylor[4], B = Brothers[5], BE = Bell[6], G=Golinski[7]

Species Name	Authority	Common Name	DND	RNP West	RNP East	Comments
Candelaria concolor	(Dickson) B. Stein.	Candleflame lichen	T, B+			Common, yellow, on urban trees.
Candelariella sp.				T		
Candelariella sp. (C. vitellina?)		Goldspeck lichen	T	T		
Cetraria orbata	(Nyl.) Fink.	Variable wrinkle lichen	T			
Cladina portentosa ssp. pacifica	(Dufour) Follmann (Ahti) Ahti	Maritime reindeer lichen	T, B+, G			More common on rock bluffs. Closely related to lichen caribou eat.
Cladonia chlorophaea	(Sommerf.) Sprengel.	Mealy pixie cup	T	B	T	Most conspicuous lichens in the bog.
Cladonia carrassensis				BE	B	
Cladonia cornuta	(L.) Hoffm.	Bighorn cladonia	T			
Cladonia fimbriata	(L.) Fr.	Trumpet lichen	T	T, B+	T	
Cladonia furcata	(Hudson) Schrader.	Many-forked cladonia	T, B+			
Cladonia gracilis	(L.) Willd.	Smooth cladonia		T		
Cladonia macilenta	Hoffm.	Lipstick powderhorn	T	T	T	Red reproductive structure containing an antibiotic, rhodocladonic acid.
Cladonia ochrochlora	Floerke	Smooth-footed powderhorn	T	T	T	
Cladonia pyxidata	(L.) Hoffm.	Pebbled pixie cup	T, B+		T	
Cladonia squamosa	Hoffm.	Dragon cladonia	G	T, B+	T	
Cladonia spp.			G			
Evernia prunastri	(L.) Ach.	Oakmoss lichen	T	T	T	As a perfume stabilizer.
Hypogymnia inactiva	(Krog) Ohlsson.	Mottled tube lichen			T	Hollow inside.

[4] This study.
[5] This study.
[6] Reported by Bell 1984.
[7] This study.

Species Name	Authority	Common Name	DND	RNP West	RNP East	Comments
Hypogymnia physodes	(L.) Nyl.	Monk's-hood lichen	T	BE	T	
Hypogymnia tubulosa	(Schaerer) Hav.	Powder-headed tube lichen	T			
Icmadophila ericetorum?		Candy lichen			T	
Lecanora sp. 1 (L. circumborealis?).		Rim lichen	T, B+			
Lecanora sp. 2 (L. symmicta?)		Rim lichen	T			
Lecanora sp. 3.		Rim lichen	T			
Lecidea sp?		Disk lichen	T		T	
Lepraria sp.		Dust lichen		T	T	Dusty gray coatings on shaded branches. Grows in dry places and uses water vapor.
Melanelia subaurifera	(Nyl.) Essl.	Abraded camouflage lichen	T	T		
Menegazzia terebrata	(Hoffm.) Massal.	Treeflute	T		T	Hollow inside, holes on top for air exchange.
Parmelia hygrophila	Goward & Ahti.	Western shield lichen	T	T	T	
Parmelia saxatilis	(L.) Ach.	Salted shield lichen			T	
Parmeliopsis ambigua	(Wulfen in Jacq.) Nyl.	Green starburst lichen			T	
Parmeliopsis hyperopta	(Ach.) Arnold.	Gray starburst lichen	T		T	
Parmotrema arnoldii	(Du Rietz) Hale.	Powdered ruffle lichen	T			
Pertusaria sp.		Wart lichen	T			
Physcia tenella	(Scop.) DC in Lam. & DC.	Fringed rosette lichen		T	T	
Platismatia glauca	(L.) Culb. & C. Culb.	Ragbag	T	T		Very common on deciduous trees.
Ramalina farinacea	(L.) Ach.	Dotted line	T			
Usnea subfloridana	Stirton.	Beard lichen	T	T	T	Shaped like a shrub.
Usnea sp.			T			
Xanthoria ramulosa	(Tuck.) Herre.	Pin-cushion sunburst lichen	T, B+		T	Orange, favors nutrient rich sites, e.g. deciduous trees with bird droppings

Appendix D-3: Fungi[8] of the Lulu Island Bog, 2006

By Terry Taylor

Species Name	Common Name	DND	RNP West	RNP East	Comments
*Amanita muscaria*var. var. *flavivolvata* L. ex Fr. Hook	Fly agaric	X	X	X	Especially numerous under birch beside Shell Road.
Amanita novinupta Tulloss & J. Lindgr.	New Bride Blusher		X		Under birches behind nature house. Rare in BC. Oct. 14, 2002.
Amanita vaginata group	Grisette		X		May be *A. fulva,* or undescribed. Colour does not match *A. fulva* nor *A. contricta*. With *Betula pendula.*
Calocera cornea (Batsch) Fr.			X		
Clavulina cristata *(Fr. Schroet.)*	Crested coral	X			
Clitocybe spp.	Funnel cap	X			Cream colour. Beside Alderbridge Way.
Collybia spp.	Coin cap		X		A gray spp. With flat cap. On rotten wood. No odour.
Collybia spp. Probably *C. confluens.*	Coin cap	X		X	Small. Clustered. Furfuraceous stem. In bark mulch.
Collybia dryophila (Bull. ex Fr.) Kum	Oak-loving coin cap		X		
Coprinus atramentarius (Bull. ex Fr.) Fr.	Inky cap	X			
Coprinus lagopus (Fr.) Fr.	Woolly inky cap	X	X	X	On old mulch of trail.
Corticiaceae spp.*?*				X	
Cortinarius spp.	Web cap		X		Brown cap.
Cortinarius spp.	Web cap	X			Subgenus *Myxacium*. White, viscid stem. Yellow-brown, viscid cap.
Crepidotus spp.	Stumpfoot	X		X	A soft white spp. On birch twigs.
Cronartium ribicola ? J.C. Fischer ex Rabh	White pine blister rust		X		The resinosis on the trunks of the white pines beside the parking lot is probably due to this spp.
Cyathus striatus (Huds.) Willd. per Pers.	Splash cups		X		

[8] Selected photos of the fungi of the Lulu Island Bog may be viewed at http://www.geog.ubc.ca/richmond/city/inventoryphotogalleryfungi.html.

Species Name	Common Name	DND	RNP West	RNP East	Comments
Daldinia concentrica Cesati & de Notaris	Carbon balls		X		
Endocronartium harknessii (J.P. Moore) Y.Hiratsuka	Western gall rust	X	X	X	Rust fungus galls on shore pine.
Entoloma spp. 1	Pinkgill		X	X	A large pale brown species.
Entoloma spp. 2	Pinkgill		X		
Entoloma spp. 3	Pinkgill	X			A large brown species. Beside Alderbridge Way.
Fomes fomentarius (L. ex Fr.) Kickx.	Tinder fungus	X	X		On birch.
Galerina spp.	Skullcap		X		A tall spp. with narrow cap. Oct. 14, 2002.
Galerina spp.	Skullcap			X	Large caps. In *G. autumnalis* group.
Ganoderma applanatum (Pers. ex S. F. Gray) Pat.	Artist fungus			X	
Hebeloma spp.	Poison pie			X	Radish odour.
Helvella lacunosa Afz. ex Fr.	Black elfin saddle	X			
Hohenbuehelia spp.*?*		X			Light brown above, white below, shoehorn shaped.
Hydnellum spp.	Tooth mushroom	X			Young and white.
Hymenoscyphus spp.*?*			X		A tiny cream cup fungus on *Rubus laciniatus*.
*Hypholoma fasciculare (*syn. *Naematoloma fasciculare)* (Huds. ex Fr.) Kumm	Sulfur top	X	X	X	
Hypoderma gaultheriae?			X	X	Black fungus in necrotic zones of *Gaultheria* leaves.
Hypomyces chrysospermus Tul.	Golden hypomyces	X	X	X	Mycoparasite on *Paxillus*.
Inocybe spp.	Fiberhead		X		White cap with umbo and striations. Small. Under birch and pine near parking lot. Oct. 25, 2002.
Inocybe spp.	Fiberhead		X		Brown cap. Umbo. In *Spagnum*. Oct. 14, 2002.
Inocybe spp.	Fiberhead			X	A small brown spp. with umbo.
Laccaria laccata (Scop. ex Fr.) Cooke	Deceiver	X	X		

Species Name	Common Name	DND	RNP West	RNP East	Comments
Lactarius spp.	Milky cap	X		X	Large cream spp., possibly *L. trivialis*.
Lactarius glyciosmus (Fr.) Fr.	Coconut milky cap	X	X	X	With birch. Coconut odour.
Lactarius luculentus Smith & Hesler.	Orange milky cap	X	X	X	
Lactarius rufus (Fr.) Fr	Red hot milky cap		X	X	
Lactarius torminosus (Fr.) S.F.G.	Pink-fringed milky cap	X			With birch.
Leccinum scabrum (Fr.) S.F. Gray.	Birch bolete	X	X	X	With birch.
Lepiota atrodisca Zel.	Black-eyed parasol		X		
Lophodermium pinastri (Schrader ex Fries) Chevalier				X	Parasite on shore pine needles.
Macrocystidia cucumis (Pers. ex Fr.) Heim	Cucumber-scented mushroom		X		On birch leaf mulch near nature house.
Melampsora occidentalis Jacks	Conifer-cottonwood rust	X			Rust fungus on cottonwood leaves. Beside Alderbridge Way.
Melampsoridium betulinum Kleb.	Birch rust	X	X	X	Rust fungus on birch leaves.
Mollisia spp. (Fries) Karsten			X	X	On rotten wood. Oct. 14, 2002.
Mycena spp.	Fairy helmet	X	X	X	A gray spp. In sec. Typicae.
Mycena epipterygia (Fr.) S.F. Gray	Yellow stalk fairy helmet	X			
Oligoporus spp.	Cheese polypore		X		
Omphalina ericetorum (Fr.) M. Lange	Lichen agaric	X	X		
Panellus serotinus (Fr.) Kuehner	Winter oyster mushroom		X		On birch log.
Paxillus involutus (Batsch ex Fr.) Fr.	Inrolled paxillus	X	X	X	
Penicillium spp.?		X			A blue mold on *Paxillus*.
Pholiota terrestris Overholts	Ground scalecap	X	X	X	
Pholiota spp.	Scalecap			X	Yellow. In bark mulch.
Phycomyces spp.				X	On dog feces. A common spp. on this substrate.

Species Name	Common Name	DND	RNP West	RNP East	Comments
Pluteus cervinus (Schaeff. ex Fr.) Kumm	Deer mushroom			X	On old wood chips.
Russula sp.	Brittlegill			X	A small white *R. albidula*-like species.
Russula emetica (Schaeff. ex Fr.) S.F. Gray.	Sickener	X		X	There is some belief that our local taxa is actually *R. bicolor.*
Russula placita group	Pleasing brittlegill		X		
Russula rosacea group	Rosy brittlegill			X	Rose cap and stem.
Russula spp.	Brittlegill			X	Pale brown cap, white stem, mild taste.
Schizophyllum commune Fr. ex Fr.	Splitgill			X	On cut log.
Scleroderma spp.	Earthball		X	X	
Stemonitis spp.	Chocolate tube slime mold		X		
Stereum spp.	Parchment fungus	X			
Stereum hirsutum (Willd. ex Fr.) S.F. Gray.	False turkey tail		X	X	On birch twigs.
Stropharia aeruginosa (Curt. ex Fr.) Quel	Green Stropharia	X			
Suillus umbonatus Dick & Snell			X		
Thelephora terrestris Fr.	Common fiber vase	X			
Trametes spp.				X	More hairy and zones indistinct. May be immature *T. versicolor.*
Trametes versicolor (L. ex Fr.) Pil.	Turkey tail	X	X	X	
Trichaptum abietinum (Dickson: Fr.) Ryvarden	Violet-pored bracket fungus			X	
Tricholoma spp.	Cavalier		X		Under white pines near parking lot. Rusty cap. Probably close to *T. pessundatum.*
Tricholoma spp.	Cavalier	X			Olive color. Mealy odor. Under birch beside Alderbridge Way.
Tricholoma spp.	Cavalier		X		Pale brown cap
Tyromyces spp.	Cheese polypore	X		X	
Xylaria hypoxylon (L. ex Hooker) Grev.	Carbon antlers		X	X	

Appendix D-4: Vascular Plants of the Lulu Island Bog, 2006

By Rose Klinkenberg and Brian Klinkenberg

This checklist of the vascular plants of the Lulu Island Bog has been compiled from several sources: fieldwork by the authors from 1999-2004, contributions by other botanists (Benson pers. comm. 2003-2005, Ingram pers. comm. 2003, MacQueen 2004) and from previous work in the bog (Bell 1984, Benson 2003, Golinski 2003, Lomer et al. 2001, Taylor et al. 2002, Taylor 1973). A total of 139 species have been reported to date, however, there are undoubtedly additional alien species present, and the numbers of these will increase if the bog continues to dry out.

Nomenclature follows Douglas et al. 1998-2002. Voucher specimens will be deposited at the UBC herbarium while some vouchers are retained in the Richmond Nature Park herbarium. Note: + SARA-listed (P) Planted

Scientific Name	Common Name	DND	RNP West	RNP East	Origin Status
Aceraceae					
Acer macrophyllum Pursh.	big-leaf maple		x		native
Apiaceae					
Anthriscus sylvestris (L.) Hoffman.	wild chervil		x		alien
Oenanthe sarmentosa Presl.	water parsley		x		native
Aquifoliaceae					
Ilex aquifolium L.	English holly	x	x	x	alien
Asteraceae					
Achillea millefolium	common yarrow		x		alien
Anaphalis margaritaceae (L.) Benth. & Hook	pearly everlasting	x	x		native
Bidens amplissima Greene	Vancouver Is. beggarticks		x		native +
Bidens cernua L.	nodding beggarticks		x		native
Bidens frondosa L.	common beggarticks		x		alien
Bidens tripartita L.	three-parted beggarticks		x		alien
Cirsium arvense (L.) Scop.	Canada thistle		x		alien
Cirsium vulgare (Savi) Tenore	bull thistle		x		alien
Gnaphalium uliginosum L.	marsh cudweed		x		alien
Hypochaeris radicata L.	hairy cat's ear		x		alien
Lactuca biennis (Moench) Fern.	tall blue lettuce		x		native
Lactuca canadensis L.	Canada lettuce		x		alien
Lactuca muralis (L.) Fresn.	wall lettuce		x		alien

Scientific Name	Common Name	DND	RNP West	RNP East	Origin Status
Lapsana communis L.	nipplewort		x		alien
Leontodon autumnalis L.	fall dandelion		x		alien
Senecio vulgaris L.	common groundsel		x		alien
Solidago canadensis L.	Canada goldenrod		x		native
Taraxcum officinale Webber	common dandelion		x		alien
Betulaceae					
Alnus rubra Bong.	Red alder	x	x	x	native
Betula papyrifera[9] Marsh	paper birch	x	x		native
Betula pendula Ehrh.	European birch	x	x	x	alien
Blechnaceae					
Blechnum spicant (L.) Roth	deer fern	x	x	x	native
Brassicaceae					
Draba verna L.	whitlow grass		x		alien
Raphanus raphanistrum L.	radish		x		alien
Sisymbrium officinale (L.) Scop.	hedge mustard		x		alien
Callitrichaceae					
Callitriche stagnalis Scop.	pond water starwort		x	x	alien
Caprifoliaceae					
Lonicera ciliosa (Pursh) D. C.	trumpet honeysuckle		x		native
Lonicera involucrata (Richards) Banks	black twinberry		x	x	native
Sambucus racemosa L. *ssp. pubens* (Mich.) House	coastal red elderberry		x		native
Caryophyllaceae					
Cerastium fontanum ssp. *triviale* L.	mouse-eared chickweed		x		alien
Sagina apetala Ard.	pearlwort	x			alien
Stellaria calycantha (Ledeb.) Bong.	northern stellaria		x		native
Stellaria media (L.) Vill.	common chickweed		x		alien
Convolvulaceae					
Convolvulus sepium L.	common morning-glory	x	x	x	alien
Cornaceae					
Cornus canadensis L.	bunchberry		x		native
Cornus nuttallii Aug. ex T.&G	western flowering dogwood	x			native
Cornus stolonifera Mich. (syn. *C. sericea* in part)	red-osier dogwood	x	x		native
Cyperaceae					

[9] Please refer to Chapter 10 for a discussion about birches in the study area.

Scientific Name	Common Name	DND	RNP West	RNP East	Origin Status
Carex canescens L.	grey sedge	x	x	x	native
Carex pauciflora[10] Lightf.	few-flowered sedge	x			native
Dulichium arundinaceum (L.) Britt	three-way sedge	x	x		native
Eleocharis palustris (L. Roem. & Schult) Link	common spike-rush	x	x		native
Eriophorum chamissonis[11] C.A. Mey	Chamisso's cottongrass	x	x		native
Rhynchospora alba[12] (L.) Vahl.	white beak-rush	x	x		native
Scirpus atrocinctus Fern.	woolgrass	x	x		native
Scirpus microcarpus J. and K. Presl.	small-flowered bulrush	x	x		native
Dennstaedtiaceae					
Pteridium aquilinum (L.) Kuhn.	bracken fern	x	x	x	native
Droseraceae					
Drosera rotundifolia L.	round-leaved sundew	x	x	x	native
Dryopteridaceae					
Athyrium felix-femina var. *cyclosorum* (L.) Roth.	lady fern	x	x	x	native
Dryopteris carthusiana (Vil.) H.P. Fuchs	spinulose woodfern	x	x	x	native
Polystichum munitum (Kaulf.) K.B.Presl.	sword fern	x	x	x	native
Equisetaceae					
Equisetum arvense L.	field horsetail	x	x	x	native
Ericaceae					
Andromeda polifolia L.	bog-rosemary	x	x	x	native
Calluna vulgaris (L.) Hull	Scotch heather	x	x	x	alien
Gaultheria shallon Pursh.	salal	x	x	x	native
Kalmia microphylla (Hook.) Heller	western bog-laurel	x	x	x	native
Oxycoccus macrocarpus L.	large cranberry	x	x	x	alien
Oxycoccus oxycoccus (L.) McM.	bog cranberry	x	x	x	native
Rhododendron groenlandicum Oeder	Labrador tea	x	x	x	native
Vaccinium corymbosum L.	highbush blueberry	x	x	x	alien[13]
*Vaccinium myrtilloides (*Michx.)	Velvet leaved blueberry	x	x	x	native
Vaccinium parvifolium Sm.	red huckleberry			x	native

[10] Until now, this species was known only from Burns Bog (Hebda et al. 2000)

[11] Previously reported only from Burns Bog and RNP (Hebda et al. 2000), now reported from DND.

[12] This species is previously reported only from Burns Bog, Langley Bog and the Richmond Nature Park (Hebda et al. 2000). It is now reported from the DND property.

[13] Native to eastern North America

Scientific Name	Common Name	DND	RNP West	RNP East	Origin Status
Vaccinium uliginosum L.	bog blueberry	x	x	x	native
Fabaceae					
Cytisus scoparius (L.) Link	Scotch broom		x		alien
Melilotus alba Desr.	white sweet clover	x	x	x	alien
Trifolium pratense L.	red clover	x	x		alien
Trifolium repens L.	white clover		x		alien
Fagaceae					
Quercus robur L.	English oak		x		alien
Geraniaceae					
Geranium robertianum L.	herb-robert		x	x	alien
Juncus effusus L.	common rush	x	x		native
Juncus tenuis L.	slender rush	x	x		native
Grossulariaceae					
Ribes sanguinium L.	flowering currant		x	x	native
Lemnaceae					
Lemna minor L.	duckweed		x		native
Lycopodiaceae					
Lycopodium clavatum L.	running club-moss		x		native
Lythraceae					
Lythrum salicaria L.	purple loosestrife	x	x	x	alien
Nymphaceae					
Nuphar lutea ssp. *polysepala* Engelm.	yellow pond-lily		x		native
Onagraceae					
Epilobium angustifolium L.	fireweed		x		native
Pinaceae					
Pinus contorta va*r. contorta* Dougl. ex. Loud.	shore pine	x	x	x	native
Pinus monticola (Dougl.) ex. D. Don	western white pine		x		native (P)
Pinus nigra Arnold	European black pine		x		alien (P)
Pinus sp. L.	eastern white pine		x		alien (P)
Pinus sylvestris	Scotch Pine		x		alien (P)
Pseudotsuga menziesii Michx.	Douglas-fir		x	x	native (P)
Thuja plicata Donn	western red cedar		x	x	native
Tsuga heterophylla (Raf.) Sarg.	western hemlock		x	x	native
Plantaginaceae					
Plantago lanceolata L.	English plantain		x	x	alien
Plantago major L.	common plantain		x		alien

Scientific Name	Common Name	DND	RNP West	RNP East	Origin Status
Poaceae					
Agrostis capillaris L.	colonial bentgrass		x		alien
Agrostis stonolifera L.	creeping bentgrass		x		alien
Alopecurus pratensis L.	meadow foxtail		x		alien
Anthoxanthum odoratum L.	sweet vernal grass		x		alien
Dactylis glomerata L.	orchard grass		x		alien
Festruca rubra L.	red fescue		x		native
Holcus lanatus L.	velvet-grass		x		alien
Holcus mollis L.	Creeping velvet-grass		x		alien
Phalaris arundinacea L.	reed canary-grass	x	x	x	native
Poa compressa L.	Canada bluegrass		x		native
Polygonaceae					
Polygonum amphibian var. *emersum* L.	water smartweed			x	native
Polygonum aviculare L.	common knotweed		x		alien
Polygonum convolvulus L.	black bindweed		x		alien
Polygonum persicaria L.	spotted lady's thumb		x		alien
Rumex acetosella L.	sheep sorrel		x		alien
Rumex obtusifolius L.	bitter dock		x		alien
Polypodiaceae					
Polypodium glycyrrhiza DC. Eaton	licorice fern		x		native
Primulaceae					
Lysimachia thyrsiflora L.	tufted loosestrife		x		native
Trientalis arctica Fisch.	northern starflower		x		native
Ranunculaceae					
Ranunculus acris L.	meadow / tall buttercup		x	x	alien
Ranunculus repens L.	creeping buttercup		x	x	alien
Rhamnaceae					
Rhamnus purshiana DC.	cascara		x	x	native
Rosaceae					
Amelanchier alnifolia Nutt.	Saskatoon berry	x	x	x	native
Amelanchier lamarckii F. G. Schroeder	snowy mespilus		x		alien (P)
Crataegus monogyna Jacq.	common hawthorn		x	x	alien
Fragaria chiloensis (L.) Duch.	coastal strawberry		x		native
Fragaria virginiana Dusch.	wild strawberry		x		native
Geum macrophyllum Willd.	large-leaved avens	x	x	x	native

Scientific Name	Common Name	DND	RNP West	RNP East	Origin Status
Malus fusca (Raf.) Schneld.	Pacific crab apple		x		native
Malus pumila Mill	cultivated apple		x	x	alien
Oemleria cerasiformis (H. & A.) Landon	Indian plum		x	x	native
Potentilla pacifica Howell	silverweed		x	x	native
Prunus laurocerasus L.	cherry laurel			x	alien
Rosa rugosa Thunb.	rugosa rose		x	x	alien
Rubus discolor Weihe and Nees	Himalayan blackberry	x	x	x	alien
Rubus chamaemorus L.	cloudberry	x	x	x	native
Rubus laciniatus Willd.	evergreen blackberry	x	x	x	alien
Rubus parviflorus Nutt.	thimbleberry		x	x	native
Rubus spectabilis Pursh.	salmonbeerry	x	x	x	native
Rubus ursinus ssp. *macropetalis* (Dougl. ex. Hook) Taylor & MacBryde	trailing blackberry		x	x	native
Sorbus aucuparia L.	European mountain-ash	x	x	x	alien
Spiraea douglasii var. *douglasii* Hook.	hardhack	*x*	x	x	native
Rubiaceae					
Galium aparine L.	cleavers		x	x	native
Galium trifidum L. var. *pacificum*	small bedstraw		x		native
Salicaceae					
Populus alba L.	silver poplar		x		alien
Populus balsamifera ssp. trichocarpa (T. & G.) Brayshaw	black cottonwood	x	x	x	native
Populus tremuloides Michx.	trembling aspen			x	native
Salix lucida Muhl. *var. lasiandra* (Bentham)	Pacific willow		x	x	native
Salix sitchensis Sanson ex. Boon	Sitka willow		x	x	native
Scrophulariaceae					
Digitalis purpurea L.	foxglove		x		alien, invasive
Veronica beccabunga ssp. *Americana* (Raf.) Sellers L.	European speedwell		x		native
Veronica serpyllifolia var. *serpyllifolia* L.	thyme-leaved speedwell		x		alien
Typhaceae					
Typha latifolia L.	wide-leaved cattail	x	x	x	native

Appendix D-5: Aquatic Insects of the Lulu Island Bog

By Karen Needham and Rex Kenner

			DND	RNP West	RNP East
Order Coleoptera					
	Family Cantharidae	*Podabrus* sp.	x	x	
	Family Carabidae	*Agonum belleri*	x		
		Agonum mutatum	x		
		Bembidion incrematum	x		
		Bembidion versicolor	x		
		Bradycellus conformis			x
		Bradycellus lecontei			x
		Dyschirius globulosus	x		
		Loricera decempunctata		x	
		Pterostichus algidus		x	
		Pterostichus amethystinus		x	
		Pterostichus herculaneus	x	x	
		Scaphinotus marginatus		x	
	Family Chryosomelidae	*Crepidodera nana*	x		
	Family Coccinellidae	*Chilocorus tricyclus*	x		
		Coccinella septempunctata	x		
		Cycloneda polita	x		
	Family Dytiscidae	*Acilius abbreviatus*		x	
		Agabus anthracinus		x	
		Agabus confertus	x		
		Agabus discors	x		
		Agabus lutosus	x	x	
		Agabus smithi	x		
		Agabus strigulosus			x
		Agabus verisimilis	x		x
		Agabus sp.	x		
		Dytiscus sp.		x	x
		Hydaticus aruspex		x	
		Hydroporus longiusculus	x		
		Hydroporus mannerheimi			x
		Hydroporus tademus			x
		Hydroporus tristis	x		x
		Hygrotus sayi		x	

			DND	RNP West	RNP East
		Ilybius quadrimaculatus		x	
		Neoclypeodytes ornatellus			x
		Sanfilippodytes terminalis	x		x
	Family Gyrinidae	*Gyrinus picipes*		x	
	Family Heteroceridae	*Lanternarius brunneus*	x		
	Family Hydraenidae	*Hydraena* sp.	x		
	Family Hydrophilidae	*Anacaena limbata*	x	x	x
		Berosus fraternus	x		
		Cymbiodyta acuminata			x
		Cymbiodyta pacifica		x	
		Cymbiodyta vindicata			x
		Enochrus californicus	x		
		Enochrus hamiltoni	x	x	x
		Helophorus sempervarians	x		
		Hydrobius fuscipes	x	x	x
		Tropisternus lateralis marginatus	x		
	Family Lathridiidae	*Melanophthalma americana*	x		
	Family Scirtidae	*Cyphon exiguus*			x
	Family Silphidae	*Nicrophorus defodiens*		x	
	Family Staphylinidae				x
Order Diptera					
	Family Chironomidae				x
	Family Culicidae				x
	Family Scathophagidae		x		
Order Ephemeroptera					
	Family Baetidae	*Procloeon* sp.		x	
Order Hemiptera					
	Family Acanthosomatidae	*Elasmostethus cruciatus*	x		
	Family Belostomatidae	*Lethocerus americanus*		x	
	Family Corixidae	*Callicorixa vulnerata*		x	x
		Cenocorixa blaisdelli		x	
		Hesperocorixa atopodonta		x	
		Hesperocorixa michiganensis	x		
		Sigara omani		x	
	Family Gerridae	*Gerris buenoi*	x		
		Gerris incurvatus		x	
		Limnoporus notabilis	x	x	
	Family Lygaeidae	*Kleidocerys resedae resedae*	x		

			DND	RNP West	RNP East
	Family Miridae	*Ceratocapsus apicatus*	x		
	Family Nabidae	*Nabis rufusculus*	x		
	Family Notonectidae	*Notonecta kirbyi*		x	
		Notonecta undulata		x	
Order Hymenoptera					
	Family Formicidae		x		
	Family Ichneumonidae	*Therion morio*	x		
Order Odonata					
	Family Aeshnidae	*Aeshna californica*		x	
		Aeshna multicolor		x	
		Aeshna palmata		x	
		Aeshna umbrosa		x	
	Family Coenagrionidae	*Enallagma* sp.		x	
		Ischnura cervula		x	
		Ischnura erratica		x	
	Family Corduliidae	*Epitheca canis*		x	
	Family Lestidae	*Lestes congener*		x	
	Family Libellulidae	*Libellula lydia*		x	
		Libellula quadrimaculata		x	x
		Sympetrum illotum		x	
		Sympetrum vicinum		x	
Order Trichoptera					
	Family Brachycentridae		x		
	Family Limnephilidae	*Glyphopsyche irrorata*			x

	DND	RNP West	RNP East
Total # of Species	39	44	22
Total # of Families	18	16	10
# of Unique Species	29	34	13

Appendix D-6: Terrestrial Coleoptera (Beetles) of Richmond Nature Park: A Partial List 2006

By Dr. L. M. Humble

Since 1995, Dr. L.M. Humble of the Canadian Forest Service of Natural Resources Canada has operated baited multiple funnel traps on a discontinuous basis in the Richmond Nature Park as part of a detection program for invasive species in urban areas. Since that time more than 20,000 beetle specimens have been collected from the park. While the detection program is focused on development of detection tools for and early detection of bark and wood-boring species of beetles in the families Anobiidae, Bostrichidae, Buprestidae, Cerambycidae, Curculionidae, Oedemeridae, Platypodidae and Scolytidae moving in international trade, beetle species from other families are occasionally captured. It should be noted that the majority of non-target beetle species captured in the traps have not been identified to species, thus this list is only a partial list of the beetles captured in multiple funnel traps.

Family	Species
Agyrtidae	*Necrophilus hydrophiloides*
Anobiidae	*Ernobius punctulatus*
Anobiidae	*Hadrobregmus quadrulus*
Anobiidae	*Hemicoelus gibbicollis*
Buprestidae	*Agrilus anxius*
Buprestidae	*Anthaxia aeneogaster*
Buprestidae	*Melanophila drummondi*
Cantharidae	*Podabrus piniphilus*
Carabidae	*Porotachys bisulcatus*
Cerambycidae	*Asemum striatum*
Cerambycidae	*Grammoptera subargentata*
Cerambycidae	*Leptalia macilenta*
Cerambycidae	*Monochamus clamator*
Cerambycidae	*Phymatodes aeneus*
Cerambycidae	*Xestoleptura crassipes*
Chrysomelidae	*Altica prasina*
Ciidae	*Cis americanus*
Ciidae	*Cis fuscipes*
Ciidae	*Plesiocis* spp.
Cleridae	*Enoclerus eximius*
Cleridae	*Thanasimus undatulus*
Coccinellidae	*Calvia quatorodecimguttata*
Coccinellidae	*Coccinella septempuntata*
Coccinellidae	*Cycloneda polita*
Coccinellidae	*Harmonía axyridis*
Coccinellidae	*Mulsantina* spp.
Coccinellidae	*Psyllobora* spp.
Coccinellidae	*Scymnus nebulosus*
Colydiidae	*Lasconotus* spp.
Colydiidae	*Namunaria pacificus*
Cucujidae	*Pediacus depressus*
Curculionidae	*Cossonus pacificus*
Curculionidae	*Dryophthorus americanus*
Curculionidae	*Larinus planus*
Curculionidae	*Pissodes fasciatus*
Curculionidae	*Tychius picirostris*
Curculionidae	*Tychius stephensi*
Dermestidae	*Anthrenus verbasci*
Elateridae	*Ampedus* spp.
Elateridae	*Megapenthes* spp.
Lampyridae	*Pyropyga nigricans*
Lathridiidae	*Aridius nodifer*
Lathridiidae	*Lathridius* spp.
Lathridiidae	*Melanophthalma* spp.
Lucanidae	*Platycerus oregonensis*
Melandryidae	*Melandrya striata*
Nitidulidae	*Epuraea* spp.
Nitidulidae	*Meligethes nigrescens*
Oedemeridae	*Nacerdes melanura*
Ptilidae	*Acrotrichis* spp.
Pyrochroidae	*Dendroides ephemeroides*
Rhizophagidae	*Rhizophagus dimidiatus*
Salpingidae	*Rhinosimus viridiaeneus*
Scirtidae	*Cyphon brevicollis*
Scirtidae	*Cyphon variabilis*
Scolytidae	*Dendroctonus pseudotsugae*
Scolytidae	*Dendroctonus valens*
Scolytidae	*Gnathotrichus sulcatus*
Scolytidae	*Hylastes nigrinus*
Scolytidae	*Hylocurus hirtellus*
Scolytidae	*Hylurgops porosus*
Scolytidae	*Hylurgops reticulatus*
Scolytidae	*Hylurgops rugipennis*
rugipennis	
Scolytidae	*Ips mexicanus*
Scolytidae	*Orthotomicus caelatus*
Scolytidae	*Phloeosinus punctatus*
punctatus	
Scolytidae	*Pityophthorus* spp.
Scolytidae	*Procryphalus utahensis*
Scolytidae	*Pseudohylesinus tsugae*
Scolytidae	*Trypodendron betulae*
Scolytidae	*Trypodendron lineatum*
Scolytidae	*Xyleborinus saxeseni*
Scolytidae	*Xyleborus dispar*
Scraptidae	*Anaspis rufa*
Silphidae	*Nicrophorus defodiens*
Staphylinidae	*Amischa* spp.
Staphylinidae	*Bolitobius kremeri*
Staphylinidae	*Eusphalerum pothos*
Staphylinidae	*Philonthus tenuicornis*
Staphylinidae	*Xantholinus linearis*
Tenebrionidae	*Corticeus* spp.
Throscidae	*Pactopus horni*
Throscidae	*Trixagus* spp.

Appendix D-7: Butterflies of the Lulu Island Bog

By Don Benson

Lulu Island Bog Species List 2002-2004 (Benson)

Scientific Name	Common Name
Hesperiidae	Skippers
Thymelicus lineola	*European Skipper*
Ochlodes sylvanoides	*Woodland Skipper*
Papilionidae	Swallowtails
Papilio rutulus	*Western Tiger Swallowtail*
Pierdae	Whites
Neophasia menapia	*Pine White*
Pieris rapae	*Cabbage White*
Lycaenidae	Gossamer wings
Incisalia iroides	*Western Elfin*
Incisalia eryphon	*Western Pine Elfin*
Strymon melinus	*Grey Hairstreak*
Celastrina echo	*Western Spring Azure*
Nymphalidae	Brushfoots
Polygonia satyrus	*Satyr Anglewing*
Limenitis lorquini	*Lorquin's Admiral*

Harvey's Butterfly Records for the Richmond Nature Park (1974)

Scientific Name	Common Name
Papilio turnus	Tiger Swallowtail
Pieris rapae	Cabbage White
Everes comytas	Eastern Tailed Blue
Nymphalis antiopa	Mourning Cloak
Vanessa cardui	Painted Lady
Vanessa atalanta	Red Admiral

Butterflies of the Georgia Basin, Fraser Lowland, Richmond, Burns Bog and Lulu Island Bog (see next page)

FL: Fraser Lowland: Campbell 1995
RMD: Richmond (not including the Lulu Island Bog): Vandermoor, 2003a.
BB1: Burns Bog: Kenner and Needham, 1999
BB2: Burns Bog: Ashton, 1992
LIB: Lulu Island Bog

Common Butterflies, Georgia Basin (Campbell 1995)

Species Name	Common Name	FL	RMD	BB1	BB2	LIB
Pyrgus ruralis	Two-banded Checkered Skipper	X				
Ochlodes sylvanoides	Woodland Skipper	X		X		X
Papilio zelicaon	Anise Swallowtail	X	X			
Papilio rutulus	Western Tiger Swallowtail	X	X	X	X	X
Pterourus eurymedon	Pale Swallowtail	X				
Neophasia menapia	Pine White	X				X
Anthocharis sara	Orange Tip	X				
Pieris rapae	Cabbage Butterfly	X	X	X		X
Pieris marginalis	Margined White	X	X	X	X	
Lycaena helloides	Purplish Copper	X	X	X	X	
Lycaena mariposa	Reakirt's Copper	X		X	X	
Mitoura rosneri	Cedar Hairstreak	X				
Incisalia iroides	Western Elfin	X	X	X	X	X
Incisalia eryphon	Western Pine Elfin	X		X	X	X
Strymon melinus	Grey Hairstreak	X		X	X	X
Loranthomitoura johnsoni	Johnson's Hairstreak	X				
Celastrina echo	Western Spring Azure	X	X	X	X	X
Polygonia satyrus	Satyr Anglewing	X	X	X		X
Nymphalis antiopa	Mourning Cloak	X	X			
Aglais milberti	Milbert's Tortoiseshell	X	X	X		
Vanessa cardui	Painted Lady	X	X	X		
Vanessa annabella	West Coast Lady	X	X	X		
Vanessa atalanta	Red Admiral	X	X	X		
Phyciodes mylitta	Mylitta Crescent			X		
Limenitis lorquini	Lorquin's Admiral	X	X	X	X	X
Coenonympha tullia	Northern Ringlet	X				
Cercyonis pegala	Common Woodnymph					

Uncommon Butterflies, Georgia Basin (partial list)

Species Name	Common Name	FL	RMD	BB1	BB2	LIB
Thymelicus lineola	European Skipper	X	X	X		X
Incisalia mossii	Moss's Elfin	X		X		
Nymphalis californica	California Tortoiseshell	X	X			
Everes amyntula	Western Tailed Blue	X		X		
Carterocephalus palaemon	Arctic Skipper	X	X			

Appendix D-8: A Partial List of the Moths of the Lulu Island, 2006[1]

By Rob Vandermoor

Author's Overview

The following annotated species list for Lulu Island is compiled from information contained in the following references:

- Covell 1984
- Natural Resources Canada 2003
- British Columbia Cranberry Growers Association 2000
- Natural Resources Canada 2004
- Vandermoor (collections, various dates)

The list below is a list of species documented only from these references; other species may be documented but were not included on this list. Overall, this partial list may reflect only a small fraction of the moth species that currently can be found on Lulu Island. A comprehensive, systematic study is needed to more clearly understand the species diversity of moths on the Island, in particular in those areas such as intact and semi-intact peat bog systems that are deemed sensitive or threatened. The checklist is organized alphabetically by family.

[1] Note that this list is for Lulu Island, and is not specific to the Lulu Island Bog.

Annotated Species Checklist

Family	Species Name	Common Name
Arctiidae	*Arctia caja*	Garden Tiger Moth
	Phragmatobia fuliginosa	Ruby Tiger Moth
	Spilosoma virginica	Virginian Tiger Moth
	Pyrrharctia Isabella	Isabella Tiger Moth
	Lophocampa argentata	Silver Spotted Tiger Moth
Geometridae	*Ennomos magnaria*	Maple Spanworm Moth
	Biston betularia	Pepper and Salt Geometer Moth
	Plagodis phlogosaria	Scorched Wing Moth
	Rheumaptera hastate	Spear Marked Black
	Xanthorhoe labradorensis	Labrador Carpet Moth
	Operophthera brumata	Winter Moth
Noctuidae	*Eurois occulta*	No common name
	Ochropleura implecta	Flame Shouldered Dart Moth
	Zotheca tranquilla	No common name
	Catocala junctura	Joined Underwing Moth
	Catocala unijuga	Once Married Underwing Moth
	Alypia langtoni	Langton's Forester Moth
	Acronicta lepusculina	Cottonwood Dagger Moth
	Xylena nupera	American Swordgrass Moth
	Plusia putnami	Putnam's Looper Moth
	Autographa pseudogamma	No common name
	Orthosia *hibisci*	Speckled Green Fruitworm Moth
	Melanchra picta	Zebra Caterpillar Moth
	Euxoa Olivia	No common name
	Scoliopteryx libatrix	Herald Moth
Nodontidae	*Schizura ipimoeae*	Morning Glory Prominent Moth
	Pheosia portlandia	No common name
Pterophoridae	*Emmelina monodactyla*	Plume Moth
Pyralidae	*Eurrhypara hortulata*	Small Magpie Moth
Saturniidae	*Antherea polyphemus*	Polyphemus Moth
Sphingidae	*Hyles lineata*	Five lined Sphinx Moth
	Hyles galli	Bedstraw Hawk Moth
	Smerinthus cerisyi	One-eyed Sphinx Moth
	Paonias excaecatus	Blinded Sphinx Moth
	Proserpinus flavofasciata	Yellow-banded Day Sphinx Moth
Thyatiridae	*Drepana arcuata*	Arched Hooktip Moth
Sesiidae	*Bembecia marginata*	Raspberry Crown Borer Moth

Species Accounts

FAMILY ARCTIIDAE

Garden Tiger Moth *(Arctia caja)*

Medium sized moth with a wingspan of 5-7 cm. This is our most colourful local moth, with deep rich hues of light chocolate brown, bright orange, steel blue, blood red and creamy white. This species, like many species of the Arctiidae family, is extremely variable in colour and pattern, which makes them very popular with collectors. The larvae are extremely hairy and feed on a wide variety of plants and shrubs; dandelion, plantain and common tansy being some of their favourites. They hibernate over winter as early instar larvae and then begin feeding as temperatures warm. They spin their cocoons in early to mid June and emerge as adult moths in late June to mid July. *Arctia caja* should be considered locally rare or uncommon, as very few records exist from the Island.

Ruby Tiger Moth *(Phragmatobia fuliginosa)*

Small to medium sized moth with a wingspan of 2-3 cm. Ruby Tiger has washed out hues of light red colouring throughout. The larvae are hairy and generally light brown in colour but can more uncommonly be dark brown in colour. Larval food plants are extremely varied but as with many Arctiidae; dandelion and plantain are favourites. The Ruby tiger is probably much more common than local records would indicate as this moth is rarely attracted to artificial light and is much more frequently encountered as larvae. Unlike many Arctiidae this species larvae hibernate as last instar larvae rather then early instar larvae. These larvae begin feeding early, once temperatures increase, making this species of Arctiidae one of the earliest species to emerge as adult moths in late April to early May.

Virginian Tiger Moth *(Spilosoma virginica)*

Medium sized moth with a wingspan of 3-5 cm. The overall colour is white with a light sprinkling of black dots on both the fore and hind wings. The abdomen is white with rusty orange coloured shading and a sprinkling of black spots. The larvae feed on an extremely wide variety of plants, shrubs and flowers. The larvae are extremely hairy and vary in colour from creamy white to yellow brown. These larvae are often encountered feeding in flower gardens were the larvae could cause a substantial amount of damage and are often considered garden pests. This moth is relatively common in early spring.

Isabella Tiger Moth *(Pyrrharctia Isabella)*
Medium sized moth with a wingspan of 4-6 cm. Overall colouring is diffused shades of orange, yellow and pink. The larvae, commonly referred to as “Woolly Bears”, are the rust and black coloured short bristle haired larvae that are commonly encountered in late August and early September wandering across roads and pathways in search of a winter hibernating location. These larvae feed on a wide variety of plants; in particular plantain and dandelion. When handling these larvae with bare hands caution should be exercised as these short bristled hairs are easily shed and commonly become embedded in the handler’s skin. These hairs have a mild toxin and when embedded in a person’s skin the affected area can become mildly swollen and itchy. This is believed to be a defence mechanism and is not uncommon among certain species of larvae; these types of toxic hairs are referred to as “urcitating”. A common false misconception concerning the colour of these larvae is the more black colouring they have the more severe the winter will be. This is entirely false and simply a reflection of the colour variances between specimens. This is a common species in our area but the adult imago moth is rarely seen partially due to not being overly attracted to lights and for other reasons not yet understood.

Silver Spotted Tiger Moth *(Lophocampa argentata)*
Medium-sized moth with a wingspan approximately 4 cm. Larvae feed particularly on needles of Douglas-fir and over winter as third or fourth instar. Larvae feed sporadically throughout the winter in 10 to 20 cm long silken tents. Larval feeding increases in early spring (March-April) as the weather warms. By mid-April the larvae leave their silken nests and feed solitarily for another 2 to 3 weeks. During May and June the mature larvae are often observed wandering on the ground as they seek out sheltered locations in which to spin cocoons and pupate. Adult moths emerge from mid July to mid August. Although relatively common the adult moths are only occasionally seen.

FAMILY GEOMETRIDAE

Maple Spanworm Moth *(Ennomos magnaria)*
A medium sized moth with a wingspan of about 4-6 cm. Adult moths have diffuse colours of yellow-orange with rust coloured spotted shading towards the outer margin of the heavily scalloped fore and hind wings. Larvae of the Maple Spanworm moth are part of a large group of larvae commonly referred to as “Inchworms” or “Loopers”. This name is derived from their walking motion - the back half of their body “inches” forward first and is then followed by the front half in a “looping” motion. Larvae feed on a wide variety of deciduous trees, but in our area, poplar and cottonwood would be their favourites. In other parts of Canada and the United States this species can cause significant damage to trees and is considered to be a forest pest.

Pepper and Salt Geometer Moth *(Biston betularia)*
A medium sized moth with a wingspan of about 4-4.5 cm. Although not uncommon, this moth is rarely seen. The common name "Pepper and Salt" refers to the overall colouring, which is black and white and appears to have been sprinkled with pepper and salt. Larval food plants are varied but locally, birch is likely their main larval food source. In Europe this moth is very common and much study has been done on the effects air pollution has on the colouring of this moth. European Pepper and Salt moths seem to take on a darker colour where air pollution is greatest.

Scorched Wing Moth (Subfamily *Ennominae Plagodis phlogosaria)*
A small moth averaging about a 2 cm wingspan, its colouring is rich orange-brown. Larvae feed on a variety of tree foliage including willow, alder and birch. The adult moths are readily attracted to artificial light and at times can be found in abundance.

Spear Marked Black (Subfamily Larentiinae *Rheumaptera hastate)*
A small moth of 2.5–3.5 cm, the Spear Marked Black is uncommon on Lulu Island-Richmond and can only be found in the local pine forests and peat bogs. Outside of the island this species is relatively common. Typically a day flying moth, it can be seen flying in wet overcast to bright sunshine weather conditions. The base colouring of this moth is black with a white diagonal band running across the forewings, which resemble spear points hence the common name "Spear Marked Black". The larvae of the Spear Marked Black feeds on species of birch and Bog Myrtle (*Myrica gale*); birch being common to the area, however Bog Myrtle is not currently listed on the checklist of vascular plants for the RNP or DND properties.

Labrador Carpet Moth (Subfamily Larentiinae *Xanthorhoe labradorensis)*
A rather non-descript pale brown-grey moth with an average wingspan of about 2-2.5 cm. Local larval food source is likely hemlock. Moths are often found where they have been attracted to artificial light.

Winter Moth (Subfamily Oenochrominae *Operophthera brumata)*
A small drab grey-brown coloured moth with a wingspan of about 2-3 cm. *Operophthera brumata* is a non-native species that was introduced from Europe into Nova Scotia in 1949. This moth is now fairly wide spread across North America where it causes significant damage to a wide range of forest and ornamental trees and shrubs. The larvae feed in the spring, and pupate in late summer and early fall. Adult moth emergence takes place in the depth of winter, and large numbers of the male moths can be seen flying from mid October to late November. The adult female moths have only very small nubs for wings and are completely flightless.

FAMILY NOCTUIDAE

No common name (*Eurois occulta)*
Medium sized moth with a wingspan of 5-6 cm, generally grey in colour with two white blotches on the mid costa of the forewing. Larvae over-winter as partly grown larvae. Larvae are present from April to June and pupation occurs June to July. Adult moths are in flight from July to September. Principal larval food sources are western red cedar and may also include blueberry. Larvae of this family are often referred to as cutworms.

Flame Shouldered Dart Moth *(Ochropleura implecta)*
Medium sized moth with 4-5 cm wingspan. The larvae of this moth caused economic damage on dry-pick cranberry farms in Richmond in 1997 and 1998. Adult moths fly, mate, and lay eggs from mid-May until late June, and again from late July until late August. Larvae feed at night and are particularly fond of berries. They partially consume both unripe and ripe cranberries in July and August.

No common name *(Zotheca tranquilla)*
A pretty moth with a wingspan of about 3.5 cm. The forewing is white with a green median band and thin wavy basal and post median lines; the hind wing is white. Larvae feed exclusively on Elderberry (*Sambucus racemosa* ssp. *pubens*).

Joined Underwing Moth *(Catocala juncture)*
Large sized moth with a wingspan of 7-8 cm. Size and colour are very much the same as the below *Catocala unijuga.* Underwing moths are very popular with collectors mostly due to their generally bright coloured hind winds. As with the genus of many moths, identification can be very difficult and this genus Catocala is no exception. Many of these “Underwing” moths are very similar in colour and pattern and require an expert to make a positive identification.

Once Married Underwing Moth *(Catocala unijuga)*
Large sized moth with a wingspan of 6-8 cm. In North America this genus Catocala is well represented, but on Lulu Island this genus is represented only by a few species. The term “Underwing” refers to the generally bright coloured hind wings of this genus as compared to the generally drab coloured forewings. *Catocala unijuga* hind wing colouring is a vivid salmon colour where as the forewings are a cryptic mix of grey and white. Underwing moths are not readily found on the island but there are years where they could occasionally be found attracted to artificial light. When disturbed from their resting spot Underwing moths become spooked easily and fly away with reckless abandon. The larvae of Underwings are masters of camouflage; when not feeding they cling inline with a twig where they virtually disappear. These

larvae have rows of soft diffuse hairs sticking out horizontally from their bodies that helps camouflage them by blending their sharp body lines with that of their background. Larvae feed on a variety of tree foliage, locally willow and poplar being some of the favourites.

Langton's Forester Moth (Subfamily Agaristinae *Alypia langtoni)*
A very interesting little moth with an approximate wingspan of 3 cm. This rather uncommon moth is unlike most other local moths in that it is only active during the day and is most fond of bright sunshine and hot temperatures. Also, unlike most other local moths, it is very sensitive to the habitat in which it can thrive. Langton's Foresters require a wind-sheltered habitat, normally along the edge of a riparian zone such as a blackberry thicket bordering the sheltered sunny side of a field or forest edge, where its larval food plant, fireweed, is locally present. Due to this specialized requirement there has been a sharp decline in Langton's Foresters on Lulu Island because of habitat loss from industrial encroachment and urban sprawl.

Cottonwood Dagger Moth (Subfamily Arconictinae *Acronicta lepusculina)*
Medium sized moth with a wingspan of 4-5 cm. Colouring is ash grey throughout with faint white streaks running across the forewings. Local larval food plants would include birch, cottonwood, willow and poplar.

American Swordgrass Moth (Subfamily Cuculliinae *Xylena nupera)*
A medium sized moth with a wingspan of 3-5 cm. The overall colouring is various shades of brown and creamy white. When resting, this moth folds its wings back and flat against its body giving the illusion that it is a piece of wood or other form of dead vegetation. Larvae feed on various plants and tree foliage- locally, willow, poplar, alder and blueberry are popular. This moth hibernates as an adult, and flies from early April to early June.

Putnam's Looper Moth (Subfamily Euteliinae *Plusia putnami)*
A small moth with a wingspan of 3-3.5 cm, Putnam's Looper is a pretty little moth with a forewing base colour of brown-orange. It can be readily identified by small bright silver coloured triangles on the forewings. This moth is often encountered where attracted to artificial light. The larvae feed on grasses and sedges.

No common name (Subfamily Euteliinae *Autographa pseudogamma)*
With a small wingspan of between 1.5-2 cm, this moth has a rather non-descript dark to light grey colouring. One easily identified marker is the silver coloured "Y" mark located near the middle portion of the outer costa of the forewing; occasionally this moth is referred to as the "Silver Y" moth. The hind wings are often semi-opaque with a shiny lustre. These moths are often encountered on hot sunny days while walking through open fields where the moths can be found nectaring on a variety of flowers, particularly dandelion blossoms. Larvae feed on a variety of small plants, clover being one of their local favourites.

Speckled Green Fruit worm Moth (Subfamily Hadeninae *Orthosia hibisci)*
A small to medium sized moth with a wingspan of about 3-4 cm. The principal hosts plants are spruce, Douglas-fir, willow and birch. This moth can also be serious pests of apple orchards and vegetable gardens.

Zebra Caterpillar Moth (Subfamily Hadeninae *Melanchra picta)*
Adult moths are reddish-brown and grey with a wingspan of about 2.5-4 cm. The larvae are easily distinguished by two bright yellow stripes running along each side of the body and separated by alternating black and white stripes running around the body. The legs and head are red. These larvae can be found defoliating a variety of broadleaf field and vegetable crops, ornamental trees and flowers. It is generally not considered to be a serious pest.

No common name (Subfamily Noctuinae *Euxoa Olivia)*
This medium sized moth has a wingspan of about 4 cm and has medium grey coloured forewings and very light semi-opaque coloured hind wings. Larvae are part of a family whose larvae are commonly referred to as cutworms.

Herald Moth (Subfamily Scoliopteryginae *Scoliopteryx libatrix)*
This species has a wingspan of approximately 3.5-4.5 cm. One of only a few local moths with heavily scalloped forewings. Larvae feed on foliage of poplars and willows.

FAMILY NOTODONTIDAE

Morning Glory Prominent Moth *(Schizura ipimoeae)*
Small to medium sized moth with a wingspan of 3.5-4.5 cm. Adult moths are highly variable in both colouring and patterning but are generally grey-brown with dark brown-black streaks near the outer portions of the fore and hind wings. Locally larvae feed on birch, maple, morning glory and others.

No common name *(Pheosia portlandia)*

A large moth with a wingspan of about 6.5 cm. The overall colouring is red-brown and is common in wet coastal forests. These moths fly from early spring to early fall. Larvae feed on the foliage of willow, aspen, and poplar and are some of only a few larvae outside of Sphingidae to have a caudal horn. A caudal horn is a horn-like protuberance located on the dorsal side of the rear of the larvae. I could not cite any specific information for the use of this horn and believe it has no particular use.

FAMILY PTEROPHORIDAE

Plume Moth (Subfamily Pterophorinae *Emmelina monodactyla)*

A small unusual moth with a wingspan of 1.5-2.5 cm. This moth is commonly referred to as a "Plume" moth due to the wing venation structure, which resembles feather plumes. Due to this unusual wing structure it appears that this moth has five wings per side, but in fact only has the regular two per side. The forewing is structured to look as though it has two and the hind wing is structured to look as though it has three. The adult moths of this subfamily are highly attracted to artificial lighting and when at rest, hold their wings out horizontally from their body taking on the shape of the letter "T" and therefore are sometimes referred to as "T" moths. Larvae may feed locally on the foliage of Morning Glory.

FAMILY PYRALIDAE

Small Magpie Moth *(Eurrhypara hortulata)*

A pretty little moth with a wingspan of about 3 cm. The larvae feed on common stinging nettle (*Urtica dioica).* Larvae leave the food plant in search of pupation locations and oddly enough, often end up finding their way into houses where they successfully pupate and ultimately emerge as moths.

FAMILY SATURNIIDAE

Polyphemus Moth *(Antherea polyphemus)*

A large colourful moth averaging a wingspan of 10-15 cm. The large green, essentially hairless, larvae feed on a wide variety of tree foliage; locally, hawthorn and maple are preferred. This moth is locally uncommon but sightings have generally increased over the last several years.

FAMILY SPHINGIDAE

Five lined Sphinx Moth ***(Hyles lineate)***
A large sized moth with a wingspan of approximately 6-9 cm. *Hyles lineata* has bright colours of brown, pink, black and white. The common name "Five Lined" refers to the five white lines running horizontally across the dorsal side of the forewings. This is one of two local species of sphinx moths that are commonly referred to as hummingbird moths because the adult moths feed on the nectar of flowers. They can generally be seen at dusk buzzing in and out of flower heads in a hummingbird-like fashion, their wings beating extremely rapidly, creating that tell-tale hummingbird buzzing sound. The large larvae of these species feed primarily on fireweed, which can be readily found growing sporadically along ditches, open fields and vacant lots. This moth is commonly seen during the months of July and August. *Hyles lineata* moths can on rare occasions be seen feeding on the nectar of flowers during the day.

Galium Sphinx or Bedstraw Hawk Moth ***(Hyles galli)***
Large sized moth of 6-7 cm having much the same colouring as the above Five Lined Sphinx but without as much cryptic patterning. *Hyles Galli* has in years past been very difficult to locate on the Island but over the last 10-15 years has become much less uncommon. Larvae feed on fireweed and over winter as pupae in the ground were they spin very loose silken cocoons.

One-Eyed Sphinx Moth ***(Smerinthus cerisyi)***
Large moth with a wingspan of 6-9 cm. Identification is made reasonably easily due to its large size and the fact that it is the only sphinx moth species in our area with a black central pupil on the fake eyespot of the dorsal side of the hind wing. Larvae feed on the foliage of several species of willow trees and also that of cottonwood and poplar.

Blinded Sphinx Moth ***(Paonias excaecatus)***
Large moth with a wingspan of 6-9 cm. Identification is made easily as this is the only sphinx moth in our area with the outer margin of the fore and hind wings being scalloped. The common name "Blinded Sphinx" refers to the pupil-less eyespot on the hind wings. Locally larvae of this species feed on birch and poplar. The adult moths of this species are rarely seen and have been documented on the Island from less than 10 sightings.

Yellow-Banded Day Sphinx Moth *(Proserpinus flavofasciata)*
Medium sized moth with a wingspan of 4-5 cm. Known only from two sightings of the larvae feeding on fireweed; this is possibly the most rare moth on the Island. *Proserpinus flavofasciata* is part of a small group of sphinx moths commonly referred to as "Bee hawks". *Proserpinus flavofasciata* flies only during the day and prefers bright sunshine and hot temperatures; adult moths nectar particularly on dandelion blossoms. This appears to be our only species of "Bee hawk" on the Island and is the first of the local Sphingidae to emerge as adult moths, possibly as early as mid April.

FAMILY THAYATIRIDAE

Arched Hooktip Moth (Subfamily Drepaninae *Drepana arcuata)*
Small to medium sized moth with a wingspan of 2.5-4 cm. Locally not often encountered, this moth has very distinctive arched forewing tips which gives it its common name "Arched Hooktip".

FAMILY SESIIDAE

Raspberry Crown Borer Moth *(Bembecia marginata)*
The adult moths are Yellow Jacket Wasp mimics and could easily be confused with a wasp. The wingspan is 3-4 cm. Adult moths fly during the day and can often be seen in raspberry fields or blackberry thickets from late May to mid June. Each female moth lives about a week and lays some 100 eggs singly on the undersides of the berry leaves. The eggs hatch into larvae and crawl down to the base of the cane and form an over-wintering cell inside the stem of the plant. The life cycle requires two full years for development into an adult moth. In some areas of Canada and the United States these larvae cause considerable damage to raspberry crops although on Lulu Island I believe this moth to be rather uncommon.

Appendix D-9: Land Snails of the Lulu Island Bog 2004-2006

By Rose Klinkenberg

All identifications by Robert Forsyth

Family	Species	Common Name	DND	RNP West	RNP East	Comment
Arionidae	*Arion rufus* (Linnaeus, 1758)	Chocolate Arion	x	x	x	introduced
	Arion hortensis (Férussac 1819) species group	Garden Arion (slug)		x		introduced
	Ariolimax columbianus (Gould in A. Binney, 1851)	Pacific Bananaslug	x	x	x	native
Agriolimacidae	*Derocerus reticulatum* (Müller, 1774)	Grey Fieldslug		x		introduced
Haplotrematidae	*Haplotrema vancouverense* (I. Lea, 1839)	Robust Lancetooth (snail)	x	x		native
Helicidae	*Cepaea nemoralis* (Linnaeus, 1758)	Grovesnail		x		introduced
Limacidae	*Limax maximus* (Linnaeus, 1758)	Giant Gardenslug		X		introduced
Polygyridae	*Vespericola columbianus* (I. Lea, 1839)	Northwest Oregonian (snail)	x	x		native
Punctidae	*Punctum randolphii* (Dall, 1895)	Conical Spot (snail)		x		native
Pristilomatidae	*Vitrea contracta* (Westerlund, 1871)	Contracted Glass-snail		x		introduced

Appendix D-10: Reptiles and Amphibians of the Lulu Island Bog 2002-2006

By Colin Sanders

N – Not encountered
R - Rare (< 5 individuals encountered)
U - Uncommon (5-20 individuals encountered)
C - Common (> 20 individuals encountered)
E – Extirpated
Q – Questionable

	DND	RNP West	RNP East
Amphibians			
Order Anura			
Family Hylidae			
Pseudacris regilla (Pacific Chorus Frog)	U	R	U
Family Ranidae			
Lithobates catesbeiana (American Bullfrog)	R	R	R
Lithobates clamitans (Green Frog)	U	U	C
Reptiles			
Order Testudines			
Family Emydidae			
Chrysemys picta (Painted turtle)	N	N	E
Trachemys scripta (Red-eared Pond Slider)	N	U	N
Order Squamata			
Family Anguidae			
Elgaria coerulea (Northern Alligator Lizard)	N	N	Q
Family Colubridae			
Thamnophis sirtalis (Common Garter)	U	N	C
Thamnophis ordinoides (Northwestern Garter)	C	N	C

Appendix D-11: Mammals of the Lulu Island Bog 2007

By Rose Klinkenberg and Neil Davis

Nomenclature primarily follows Wilson and Reeder 2005

Scientific Name	Common Name	Observer	Notes
Canis latrans	Coyote	Klinkenberg 1999, Griffith 1999-2004	There are frequent signs and occasional observations of coyotes in the nature park and DND property.
Castor canadensis	Beaver	MacQueen 2004	Evidence of past beaver activity is present along the east perimeter channelized watercourse of the nature park (RNP west).
Lepus americanus washingtonii	Washington Snowshoe Hare	Bell 1984, Griffith 1998-2001	This species is unconfirmed in the Lulu Island Bog. It was reported in the bog by Bell, 1984, however the specimen has not been re-located. A photo of a young roadkill animal (2006) was determined to be a "possible" snowshoe hare by Nagorsen (pers. comm. 2007). Several unconfirmed hare sightings are Wash reported in the RNP east and RNP west.
Mephitis mephitis	Striped Skunk	MacQueen and Griffth 2004	Trapped 2004.
Microtus townsendii	Townsend's Vole	MacQueen 2004, Davis 2004	Trapped. ID by Shawn Hilton, photo ID by Dave Nagorsen, DNA confirmation from fecal pellets by Chris Sears.
Mustela erminea	Short-tailed Weasel	Cooney et al. 1972, Griffith 1999, 2003, Bauder 2006.	Bauder reports numerous sightings from 1984 - present, mostly in the spring and summer, including a mating pair in spring 1997.
Mustela vison	Mink	Bauder 2005	Observed in August 2005 by Bauder on boardwalk in RNP west.
Myotis lucifugus	Little Brown Bat	Bauder 2006	Documented sightings in past few years by park staff. Sightings concentrated in spring and summer.

Scientific Name	Common Name	Observer	Notes
Odocoileus hemionus	Black-tailed Deer	Cooney et al. 1972, Griffith 2004	Tracks have been observed in the DND property, 2004, 2006, 2007 (Klinkenberg), deer have been observed and photographed in the RNP west (2007), tracks have been observed in the RNP east (2005-2007).
Odonatra zibethicus	Common Muskrat	Bell 1984, Cooney et al. 1972, Klinkenberg 2003, MacQueen 2004	This species has been sighted frequently in the nature park pond, and in the east perimeter channelized watercourse.
Peromyscus maniculatus	Deer Mouse	Bell 1984, Cooney et al. 1972.	Trapped by Bell 1984, MacQueen 2004, Davis 2004.
Procyon lotor	Raccoon	Griffith 2006	Regular observed visitor to the park.
Rattus rattus	Black Rat	Davis 2004	Trapped in DND and RNP east by Davis (2004).
Rattus norvegicus	Norway Rat	Bauder 2006	Frequently observed around the Nature House.
Scapanus orarius	Coast Mole	Bell 1984, Cooney et al. 1972	Evidence of this species is present along the park trails.
Sciurus carolinensis	Eastern Gray Squirrel	Klinkenberg 2002-2006	Frequent around the nature centre. Introduced in the region.
Sorex vagrans / Sorex monticolus	Vagrant/Dusky Shrew	Cooney et al. 1972, Bell 1984, MacQueen 2004	Trapped. ID by John MacQueen and Neil Davis, photo by MacQueen 2004. Lack of visible distinguishing features between species makes field ID difficult.
Sylvilagus floridanus	Eastern Cottontail	Bell 1984, Cooney et al. 1972, MacQueen 2004	This species has been confirmed in the bog. Numerous sightings and photos.
Tamiasciurus douglasii	Douglas Squirrel	Bell 1984, Cooney et al. 1972.	Frequent around the nature centre.

Note: A report of White-footed Mouse in earlier park studies is no doubt an error and was most likely a Deer Mouse.

Appendix D-12: Birds of Lulu Island 2002-2003

By Hugh Griffith

Based on monthly surveys and data by Michael Beck

N = known or believed to nest in the bog
O = occasional sighting, usually during migration
O/F = over flights only

R = year-round resident
S = summer resident
W = winter resident

Species order and nomenclature follow the AOU Checklist of American Birds, 7th Edition (1998).

Species	DND	RNP West	RNP East
Double-crested Cormorant		O/F	
Great Blue Heron	O	O	
Green Heron		O	
Canada Goose		O/F	
Trumpeter Swan		O, O/F	
Wood Duck		O	
Mallard	N	R, N	N
Blue-winged Teal		O	
Green-winged Teal		S, N	
Hooded Merganser		W	
Common Merganser		O	
Bald Eagle		O/F	O/F
Northern Harrier	S, N	S, N	
Sharp-shinned Hawk		O	
Cooper's Hawk		R, N	R, N
Northern Goshawk		O	
Red-tailed Hawk		R	R
Rough-legged Hawk		W	
Merlin		O	
Killdeer		O/F	
Common Snipe	O	W	
Solitary Sandpiper		O	
Glaucous-winged Gull	O/F	O/F	O/F
Rock Dove	R	R	R
Band-tailed Pigeon		O	
Mourning Dove		R	
Common Barn Owl		O	
Great Horned Owl		O/R	

Species	DND	RNP West	RNP East
Barred Owl		O	O/R
Short-eared Owl		O	
Black Swift	O, O/F	O, O/F	
Rufous Hummingbird	S, N	S, N	N
Belted Kingfisher		O	
Downy Woodpecker	R	R	R
Hairy Woodpecker		O	
Northern Flicker	R	R, N?	R
Pileated Woodpecker		O	
Red-breasted Sapsucker		W	
Western Wood-pewee		S	
Willow Flycatcher	S, N?	S, N?	S, N?
Pacific-slope Flycatcher		S, N?	S, N?
Northwestern Crow		R, N	R
Common Raven		O	
Tree Swallow	S	S, N	
Violet-green Swallow		S, N	
Barn Swallow	S	S	S
Northern Rough-winged Swallow		O	
Black-capped Chickadee	R	R, N	R
Bushtit	R	R, N	R
Red-breasted Nuthatch		O	
Brown Creeper		W	W
Bewick's Wren	R, N	R, N	R
Winter Wren	R, N	R, N	R
Golden-crowned Kinglet	W	W	W
Ruby-crowned Kinglet	W	W	W
Townsend's Solitaire		O	

Species	DND	RNP West	RNP East
Swainson's Thrush		S, N	S, N?
Hermit Thrush	O	O	
American Robin	R, N	R, N	R, N
Varied Thrush	W	W	W
European Starling	R	R, N	
Cedar Waxwing	S, N	S, N	S, N?
Hutton's Vireo		R, N	R, N?
Warbling Vireo		S	
Orange-crowned Warbler	S, N	S, N	S, N
Yellow Warbler		S, N?	S
Yellow-rumped Warbler		S	S
Black-throated Gray Warbler		O	
Townsend's Warbler		O	
Common Yellowthroat	S, N	S, N	
MacGillivray's Warbler		O	
Wilson's Warbler	S	S	
Western Tanager		O	
Winter Wren	R, N	R, N	R
Golden-crowned Kinglet	W	W	W
Ruby-crowned Kinglet	W	W	W
Townsend's Solitaire		O	
Swainson's Thrush		S, N	S, N?
Hermit Thrush	O	O	
American Robin	R, N	R, N	R, N
Varied Thrush	W	W	W
European Starling	R	R, N	
Cedar Waxwing	S, N	S, N	S, N?
Hutton's Vireo		R, N	R, N?

Species	DND	RNP West	RNP East
Warbling Vireo		S	
Orange-crowned Warbler	S, N	S, N	S, N
Yellow Warbler		S, N?	S
Yellow-rumped Warbler		S	S
Black-throated Gray Warbler		O	
Townsend's Warbler		O	
Common Yellowthroat	S, N	S, N	
MacGillivray's Warbler		O	
Wilson's Warbler	S	S	
Western Tanager		O	
Black-headed Grosbeak	S, N?	S, N	S, N?
Spotted Towhee	R, N	R, N	R, N
Fox Sparrow	W	W	W
Song Sparrow	R, N	R, N	R, N
White-crowned Sparrow	O	O	
Golden-crowned Sparrow		O	
Lincoln's Sparrow		O?	
Dark-eyed Junco	W	W	W
Brewer's Blackbird	O	O?	
Brown-headed Cowbird	S, N?	S, N?	
House Finch	R	R, N	R, N?
Purple Finch		O	
Red Crossbill		O	O
Pine Siskin	O	O	O
American Goldfinch	R, N?	R, N	R
Lazuli Bunting		O	
House Sparrow	R	R	R

Appendix D-13: Additional Species Documented in the Lulu Island Bog

Scientific name	Common name	Notes
Ixodes sp.	Pacific Black-legged Ticks	Many Pacific Black-legged Ticks were recovered from small mammals during trapping. [1]

[1] Specimens were sent to the BC Centre for Disease Control for analysis to determine if they carried the Lyme Disease bacterium *Borrelia burgdorferi*.

GLOSSARY

Acrotelm: the uppermost active layer of an undamaged bog, a soil layer; it forms the highly oxygenated surface layer within which water levels fluctuate and main water movement occurs.

Alien Species: species not native to an area.

Bryophyte: non-vascular, non-flowering, small type of land plant that produces spores instead of seeds.

Bog: An area having a wet, spongy, acidic substrate composed chiefly of *Sphagnum* moss and peat in which characteristic shrubs and herbs and sometimes trees usually grow. Also called peat bog; ombrogenous peatlands that receive their surface water only from precipitation and have low water flow.

Catotelm: a soil layer in a bog; the lower anaerobic layer of a peat bog; the anoxic inactive layer; comprises most of the bog.

Colour morph: a colour variant of a species, frequently found in garter snakes in the bog.

DNA barcoding: a taxonomic method which uses a short genetic marker in an organism's mitochondrial DNA to quickly and easily identify it as belonging to a particular species.

Ecosystem: interacting ecological units comprised of abiotic factors (air, water, rocks, energy) and biotic factors (plants, animals, and microorganisms).

Fen: a type of wetland fed by surface and/or groundwater, often characterized by sedge and/or moss species, usually less acidic than bog; wetlands characterized by continuous sources of calcareous ground water; peat-forming wetlands that receive nutrients from sources other than precipitation; fens range from "poor" fens to more nutrient rich fens, and can range from slightly acidic to acidic.

Heath: heaths plants are those in the Heath family or Ericaceae, and include familiar species such as rhododendrons, Labrador tea, bog-rosemary and blueberries; a heath is a shrubland habitat dominated by heaths – low growing woody vegetation on infertile acidic soils.

Hummocks: raised areas in a peat bog dominated by *Sphagnum* mosses.

Hydrology: the study of water movement, distribution and quality.

Invasive Species: species (often alien species) that invade an area or region where they are not native, often outcompeting native species, dominating vegetation communities, and altering ecosystems.

Insectivore: an animal that eats mainly insects.

Lawns or hollows: depressions in a peat bog where the water table is close to the surface, dominated by *Sphagnum* mosses.

Lowland raised bog: a peatland ecosystem that develops primarily, but not exclusively, in lowland areas such as the head of estuaries, along river flood-plains and in topographic depressions; continued accrual of peat elevates the bog surface above regional groundwater levels to form a gently-curving dome from which the term 'raised' bog is derived.

Mire: an area of wet soggy, muddy ground, a bog; a general term that includes all peat-forming ecosystems.

Ombrotrophic: A vegetation type nourished only by rain.

Pacific Flyway: a major north/south route of travel for migratory birds, extending from Alaska to Patagonia.

Peatlands: can refer to bogs, muskeg, fens; can refer to area of peat deposits where natural communities have been removed, such as cranberry fields.

Plant Community: an assemblage of plants, or group of plants species, occurring together at any point in time.

Polymerase chain reaction (PCR): a molecular biology technique for enzymatically replicating DNA without using a living organism.

Phylogenetic tree: is a tree showing the evolutionary interrelationships among species that are believed to share a common ancestor.

Phylogram: a phylogenetic tree that explicitly represents the number of character changes through its branch lengths.

Treed bog: A type of ericaceous shrub bog with a 10 to 25% cover of trees at least 135 cm tall.

Wetland: this is the collective terms for marshes, bogs, swamps and similar areas. They can occur in flat areas, or depressions, at any elevation

ABOUT THE AUTHORS

Lori Bartley, B. A.

Lori Bartley was the School Program Coordinator for the Richmond Nature Park Society for over 10 years. She now works for Metro Vancouver Regional Parks as an Acting Park Interpretation Leader. She has a Bachelor of Arts from the University of Manitoba. She is First Nations Cree originally from Manitoba and has been a student of nature her entire life.

Don Benson

Don Benson is a naturalist with a special interest in botany. He became interested in the butterflies of Richmond as a result of his participation, with other members of the Vancouver Natural History Society and the Richmond Parks Department in a Terra Nova Natural Area native plant enhancement project.

Danielle Cobbaert, M. Sc., Ph. D. (abd)

Danielle Cobbaert is a PhD candidate in Ecology at the University of Alberta. Her research focuses on the effects of nutrients and predators on controlling the ecosystem state of shallow water wetlands in boreal Alberta. She completed her Master of Science with the Peatland Ecology Research Group at Laval University on the restoration of a fen plant community on peat-mined sites. Originally from Delta, BC, Danielle continues to be interested in the conservation and restoration of wetlands in BC.

Shannon Cressey

Shannon Cressey has a Technical Diploma from BCIT in Fish, Wildlife and Recreation and a B.Sc. in Wildlife and Fisheries Management from UNBC. Her field experience includes mallard nest searching, plant (non-timber forest product) inventories, stream impact mapping, an estuary productivity study which included beach seining for juvenile salmon and phytoplankton and zooplankton collection and most recently working on a biophysical inventory for the Richmond Nature Park conducting breeding bird surveys, small mammal trapping, and fish trapping. In addition to field experience, Shannon has experience in environmental education and interpretation, and in coordinating, designing and delivering both school and public programs for a variety of agencies, including Metro Vancouver Parks.

Lori Daniels, M. Sc., Ph. D.

Lori Daniels is an Assistant Professor of Geography at the University of British Columbia. Her research applies dendroecological (tree ring) methods to investigate vegetation dynamics of temperate forests of North and South America, particularly in the context of natural disturbance, climate variation and human impacts on the environment. Her interests in conservation and natural resource management complement her expertise in forest ecology and biogeography. As a result, much of her work is applied research conducted in collaboration with NGOs, government agencies and private companies. Current projects with graduate students include investigations of coastal old-growth forests, the ecological role of large woody debris in streams, and fire regimes in mountain forests.

Neil Davis, M. Sc.

Neil holds an M.Sc in marine resources governance from the University of British Columbia. Over the past 10 years, he has worked in a variety of capacities related to resource management, conservation, and ecology. He is presently the Project Coordinator for the BC Marine Conservation Analysis, a collaborative initiative that seeks to identify and map areas of high conservation value and areas important to human use in Canada's Pacific Ocean for the purposes of supporting marine planning decisions.

Hugh Griffith, M. Sc., Ph. D.

Hugh is a broadly trained zoologist who has conducted research programs in crustacean and reptilian systematics, functional vertebrate morphology, and island species conservation. He is a former Nature Park Assistant at the Richmond Nature Park, and has worked as a naturalist for the former GVRD.

Aerin Jacob, B. Sc., Ph. D. candidate

Aerin Jacob graduated from the University of British Columbia in 2004 with a B.Sc. in Ecology. She has worked as a wildlife biologist in Africa, Canada, Alaska and Mexico researching threats to endangered species, carnivore and ungulate behaviour and population dynamics, and the effects of landscape fragmentation on wildlife. Currently, Aerin studies ecosystem restoration in African tropical rainforests as a PhD student at McGill University.

Bret Jagger, B. Sc., Dipl. Tech.

Bret Jagger is a North Vancouver-based environmental scientist (biology) with Trow Associates Inc., and a graduate of the Wildlife Biology program at the University of Guelph. He works in fisheries science on the Bering Sea and Western Pacific, and in environmental science (biology) throughout the Lower Mainland of BC. He is an avid taxonomist, with particular interest in biodiversity studies and family *Dolichopodidae* ('Doli' Flies). He has assisted with the inventory of the Lulu Island Bog since 2003.

Rex Kenner, Ph. D.

From an early age, Rex knew he was going to be a chemist. He duly completed a B.Sc. in Professional Chemistry at Northwestern State University of Louisiana and a Ph.D. in Physical Chemistry at Michigan State University and came to the University of British Columbia (UBC) as a Postdoctoral Fellow. Six years later he was off to Germany where he blew small molecules apart with high-powered lasers and Australia where he spent three years studying the chemistry of the ozone hole. Upon returning to Vancouver he decided to get a life and turned to biology. He began by expanding his interest in birds and volunteering in the Cowan Vertebrate Museum at UBC. Along the way he discovered dragonflies and moved down the hall and started volunteering in the Spencer Entomological Museum. Eventually things came full circle and he was hired by UBC as curator of the Cowan Vertebrate Museum although his principle interest and research is still in the realm of insects.

Rex has been involved in public outreach and education since turning to biology. He has done a number of environmental surveys including the Burns Bog Environmental Assessment in 1999, surveys for rare dragonflies for the Conservation Data Centre in Victoria and he spent three months banding birds at Long Point. He has a number of publications based on his insect research.

Brian Klinkenberg, O. L. S., M. Sc., Ph. D.

Brian is an Associate Professor of Geography at the University of British Columbia. He specializes in spatial analysis, GIS science, and biogeography. His research has included a study of the coincidence of rare species and landforms in the Carolinian Zone of Canada, and the biogeography of the Erie Islands. In British Columbia, he has worked on predictive mapping of rare species habitats in the Chilliwack Valley, and remote sensing applications in natural areas restoration in the Queen Charlotte Islands. He is author of several scientific papers on biogeography and is author or co-author of COSEWIC[1] status reports, national recovery strategies for several species at risk, and guidelines for inventory and monitoring of rare species. Brian is presently a

[1] COSEWIC: Committee on the Status of Endangered Wildlife in Canada.

member of the National Recovery Teams for Streambank Lupine and Phantom Orchid, and is a member of the Conservation Committee of the Canadian Botanical Association. He is project coordinator and editor for E-Flora BC (eflora.bc.ca) and E-Fauna BC (efauna.bc.ca), the online biogeographic atlases of the flora and fauna of British Columbia.

Rose Klinkenberg, B. Sc.

Rose is a graduate of the Ecology and Field Biology program at the University of Toronto. She worked for many years as an ecologist and regional botanist for the Ontario Ministry of Natural Resources conducting life science surveys, vegetation surveys, permanent plot sampling, natural areas evaluations, environmental impact assessments, and endangered species assessments. She has coordinated natural areas surveys in Ontario, and is author or co-author of numerous life science inventory reports, vegetation management plans, COSEWIC status reports and recovery strategies for species at risk. She is presently assisting with the development of E-Flora BC and E-Fauna BC, the biogeographic atlases of the flora and fauna of British Columbia. Rose is a past director of the Richmond Nature Park Society and a founding member of the Association of Field Botanists of Ontario. She is presently a member of the Conservation Committee of the Canadian Botanical Association.

Margaret North, M. Sc.

Margaret retired from UBC Geography Department in 2000. Her specialty within the broad field of geography is vegetation mapping. Her research areas have been located in Alberta and British Columbia. She has specialised in floodplain vegetation, using historical records to examine the vegetation that existed in the Lower Fraser before European settlement, and using aerial photos to study changes in the vegetation of the Peace River downstream from the Bennett dam.

Karen Needham, M. Sc.

Karen is the curator of the Spencer Entomological Museum and a lecturer in the Department of Zoology at UBC. Her specialty is aquatic insects, mainly *Heteroptera* and *Ephemeroptera*. She has published an identification guide to larval mayflies of BC and has conducted aquatic insects biodiversity surveys at both Burns Bog and Lulu Island Bog. Karen is also active in public education involving entomology. Over the years, she has hosted an insect segment on the Discovery Channel, run identification workshops and training sessions at parks and schools, and in 2001 published a children's book on aquatic insects for beginning readers. Karen has been a member and a director of the Entomological Society of BC for many years, and is currently their president.

Colin Sanders, B. Sc. H, M. Sc. (Abd).

Colin is a M.Sc. candidate in the Department of Zoology, University of British Columbia. He has studied and worked with reptiles for many years, both in Canada and South America.

Wilf Schofield, M. Sc., Ph. D., D. Sc. (Honorary).

Wilf Schofield has been a professor of botany at the University of British Columbia since 1960. He is one of North America's foremost bryologists and is the author of the award-winning textbook, Introduction to Bryology. He is also author of Some Common Mosses of British Columbia, A Field Guide to Liverwort Genera of Pacific North America and is co-author of An Evolutionary Survey of the Plant Kingdom, Non-Vascular Plants: An Evolutionary Survey, and Plant Diversity: An Evolutionary Approach.

Chris Sears, B. Sc., Ph. D. (Abd).

Chris obtained his B.Sc. in botany-plant science at the University of New Brunswick, and is presently completing his Ph.D. in botany at the University of British Columbia. He is interested in the taxonomy and evolutionary relationships within allopolyploid complexes. This interest has led him to study such systems in ferns (*Polystichum*), orchids (*Platanthera*), and hawks-beards (*Crepis*). Chris is an avid birder, botanist and naturalist, and is presently Director of a wholesale walking and wildlife-viewing firm, Fundy West Inc. He is co-author of three COSEWIC status reports, two articles published in the primary literature, and is sole author on a third. He sat on the Advisory Committee for E-Flora BC and is a former director of the Richmond Nature Park Society.

Terry Taylor, B. A., B. L. S.

Terry Taylor has been hiking the woodlands and mountains studying local ecology and botany for over 30 years. Present activities include ecological and botanical consulting, presentations for conservation and naturalist groups, and article writing for a number of publications. Recent work has included collecting soil and lichen samples for an antibiotics research project at the University of British Columbia. In 2003, Terry received the Queen's Jubilee Medal for nature education. He is a past director of the Richmond Nature Park Society.

Rob Vandermoor

Rob Vandermoor is a lepidopterist and has been studying and collecting butterflies and moths in BC since 1965, when at the age of 7, a friend gave him a butterfly net and an insect display case. Then, once his son, Ryan, turned four, they both began countless trips all over British Columbia in the search for specimens and field data. Their collecting has focused on all families of butterflies and moths that occur in British Columbia. Their primary goal is to represent the Lepidoptera of British Columbia in the form of a voucher collection and to supplement this collection with detailed field notes wherever possible. Eventually they would like to donate this collection to a worthy BC museum.

Rachel Wiersma, B. A.

Rachel Wiersma is a Planning Assistant at the University of British Columbia and a GIS specialist. She previously worked on the pilot project for the internet mapping portion for E-Flora BC, edited the Burns Bog Comprehensive Guide for the Burns Bog Conservation Society, and worked at the BC Ministry of Transportation and the Institute of Urban Ecology. She graduated from UBC with a BA in Geography and the BCIT Advanced Diploma Program in GIS.

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RICHMOND

Nature Park

SOCIETY