

**Blurred Park Boundaries and the Spread of English Ivy (*Hedera helix* L.):
Case Studies from Greater Victoria, British Columbia**

by

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We accept this thesis as conforming
to the required standard

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ABSTRACT

This thesis examines the invasiveness of English ivy (*Hedera helix* L.; Araliaceae), an exotic horticultural species, in 14 near-urban parks in Greater Victoria, British Columbia. Using descriptive notes from field observations, the overall invasiveness of *H. helix* is assessed in each park, particularly near park boundaries. Land use associated with the fragmentation of natural habitat directly outside each park is characterised and related to invasion inside the park.

Only three of the 14 representative parks examined are not invaded by *H. helix*, and four are very extensively invaded. The analysis of administrative park boundaries supports the hypothesis that *H. helix* begins invasion inside park boundaries that are adjacent to established residential areas.

H. helix is found in moist forest communities of grand fir (*Abies grandis*), bigleaf maple (*Acer macrophyllum*) and western redcedar (*Thuja plicata*). Communities of Garry oak (*Quercus garryana*) with black hawthorn (*Crataegus douglasii*) and English hawthorn (*C. monogyna*) are heavily invaded and vulnerable to invasion. However, Douglas-fir (*Pseudotsuga menziesii*) forest communities are most heavily invaded and especially at risk of invasion. *H. helix* climbs at least 17 species of trees and tall shrubs, with Douglas-fir trees providing the tallest supports. Other areas in parks vulnerable to invasion by *H. helix* include woodlands with rich soils, slight canopy gaps, windthrown forest edges, park entranceways and accessways.

During the growth season, *H. helix* shoots were monitored in both heavily and less invaded sites. On average, shoots on the forest floor grew 22 cm per month, and on

host trees, shoots grew 17 cm per month. Another growth characteristic of *H. helix* is that where it is long established on host trees, its stems have radial growth rings viewable in cross-section. These rings are likely annual and sensitive to annual climatic variability.

The spread of an introduced liana, a plant form not present in the indigenous flora, has several implications for near-urban forest ecology including altered physical forest structure, hastened tree death and suppression of understory species (e.g. seedlings and shrub species such as salal - *Gaultheria shallon* and possibly red huckleberry - *Vaccinium parvifolium*). The increased concentration and range of exotic, horticultural species such as *H. helix*, in near-urban park and forest fragments, signifies that an exotic species management strategy is urgently needed for habitat and ecosystem conservation.

Examiners:

Dr. M.C.R. Edgell, Supervisor (Department of Geography, Chair)

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DEDICATION

This thesis is dedicated to individuals whose efforts help to preserve all sizes and types of natural areas and ecosystems.

TABLE OF CONTENTS

ABSTRACT	ii
ACKNOWLEDGEMENTS	iv
DEDICATION	v
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
REPRODUCTION OF COPYRIGHT MATERIAL	xii
CHAPTER 1: INTRODUCTION	
1.1 Research Questions.....	2
1.2 Background Influences on this Study	2
1.2.1 The Species of Human Habitat	4
1.3 This Study	5
1.4 Thesis Outline	6
CHAPTER 2: <i>HEDERA HELIX</i> (L.): BIOLOGY, DISTRIBUTION AND GENERAL ECOLOGY	
2.1 Biology.....	8
2.2 Major Taxa of the Genus <i>Hedera</i> : Native Range and Distribution	9
2.3 Ecology and Habitats of <i>Hedera helix</i>	11
2.4 <i>Hedera helix</i> : Distribution and Invasiveness in the New World	13
2.5 Local Distribution	16
CHAPTER 3: INVASIVE PLANTS IN NATURAL AREAS AND PARKS	
3.1 Context of Human-Introduced Biota	19
3.2 Threats to Natural Ecosystems from Introduced Plants.....	21
3.3 Scale and Status of the Problem of Invasive Plants	24
3.4 Factors that Influence Invasion of Ecosystems and Parks	25
3.4.1 Climate	26
3.4.2 Isolation.....	27
3.4.3 Disturbance	28
3.4.4 Plant Characteristics.....	29
3.4.5 Community, Habitat and Landscapes Types.....	30
3.4.6 Landscape/Habitat Fragmentation	31
3.4.7 Park Size and Shape.....	33
3.5 The Influence of Park Boundaries on Invasion.....	34
3.6 Convergence and Application of Literature: Definition of Study.....	37
3.7 Research Objectives.....	38
3.8 The Study Area	40

CHAPTER 4: METHODS

4.1 General Methodology	42
4.2 Park Selection	42
4.3 Analysis of Park Edge Types	45
4.4 Overall Park Fragmentation / Insularity	46
4.5 Other Variables Outside Parks	47
4.6 General Habitat and Vegetation Inside Park Boundary Zones	48
4.7 Characterisation and Comparison of Areas Invaded and Not Invaded by <i>H. helix</i>	49
4.7.1 Invaded Areas and General Methodology	49
4.7.2 Non-Invaded Areas	54
4.8 Discussion of Methodology	55
4.8.1 General Habitat and Dominant Vegetation inside Park Boundaries	55
4.8.2 Influence of Human Activities	57
4.8.3 Quadrat Sampling and Comparisons between Invaded and Non-Invaded Areas	57

CHAPTER 5: THE PARKS

5.1 Bear Hill and Elk-Beaver Lake Regional Parks	59
5.1.1 Dominant Vegetation and General Habitat of Park Boundaries	59
5.1.2 Invaded Park Boundaries	61
5.1.3 Characteristics of Invaded Areas	63
5.1.4 Characteristics of Non-Invaded Areas	65
5.1.5 Overall Invasion	66
5.2 Coles Bay Regional Park	67
5.2.1 Dominant Vegetation and General Habitat of Park Boundaries	68
5.2.2 Invaded Park Boundaries	69
5.2.3 Characteristics of Invaded Areas	69
5.2.4 Characteristics of Less Invaded Areas	71
5.2.5 Overall Invasion	72
5.3 Devonian Regional Park	73
5.4 Francis-King Regional Park	76
5.4.1 Dominant Vegetation, General Habitat and Invasion of Park Boundaries	77
5.4.2 Characteristics of Invaded Areas	77
5.4.3 Characteristics of Less Invaded and Non-Invaded Areas	79
5.4.4 Overall Invasion	80
5.5 Horth Hill Regional Park	81
5.5.1 Dominant Vegetation and General Habitat of Park Boundaries	82
5.5.2 Invaded and Non-Invaded Areas	82
5.6 Knockan Hill Park	84
5.6.1 Dominant Vegetation, General Habitat and Invasion of Park Boundaries	85
5.6.2 Characteristics of Invaded Park Boundaries	86
5.6.3 Characteristics of Less Invaded Areas	88
5.6.4 Overall Invasion	89

5.7 Lone Tree Hill and Mount Work Regional Parks.....	90
5.7.1 Dominant Vegetation and General Habitat of Park Boundaries	90
5.7.2 Characteristics of Non-Invaded Areas	91
5.7.3 Overall Invasion	93
5.8 Mill Hill Regional Park.....	94
5.8.1 Dominant Vegetation and General Habitat of Park Boundaries	94
5.8.2 Characteristics of Invaded Areas	95
5.8.3 Characteristics of Non-Invaded Areas	95
5.8.4 Overall Invasion	97
5.9 Mount Douglas Park	98
5.9.1 Dominant Vegetation and General Habitat of Park Boundaries	100
5.9.2 Invaded Park Boundaries	100
5.9.3 Characteristics of Heavily Invaded Areas.....	101
5.9.4 Characteristics of Non-Invaded and Becoming-Invaded Areas.....	103
5.9.5 Overall Invasion	105
5.10 Thetis Lake Regional Park.....	105
5.10.1 Dominant Vegetation, General Habitat and Invaded Park Boundaries.....	106
5.10.2 Invaded Areas.....	107
5.10.3 Characteristics of Less Invaded and Non-Invaded Areas	109
5.10.4 Overall Invasion	110
5.11 Uplands Park.....	111
5.11.1 Dominant Vegetation and General Habitat of Park Boundaries	111
5.11.2 Invaded Park Boundaries and Invaded Areas	112
5.11.3 Characteristics of Less Invaded and Non-Invaded Areas	115
5.11.4 Overall Invasion	116
5.12 Witty's Lagoon Regional Park	117
5.12.1 Dominant Vegetation, General Habitat and Invasion of Park Boundaries.....	119
5.12.2 Characteristics of Invaded Areas	120
5.12.3 Characteristics of Non-Invaded Areas	120
5.12.4 Overall Invasion	122

CHAPTER 6: PARK FRAGMENTATION AND PARK EDGE TYPES

6.1 Park Edges in the Sample of Parks as a Whole	123
6.2 Park Size, Edge to Interior Ratios and Overall Invasion	125
6.3 Park Edge Types and Invasion of Ivy	126
6.4 Overall Occurrence of Ivy Outside Parks and Invasion.....	129

CHAPTER 7: COMPARISON OF INVADED AND NON-INVADED AREAS

7.1 Characteristics of Invaded Areas	131
7.1.1 Community Characteristics of Invaded Plots.....	138
7.1.2 Community Characteristics of Seedling Plots.....	141
7.2 Community Characteristics of Non-Invaded Areas	142
7.3 Comparison of Invaded, Seedling and Non-Invaded Plots.....	143
7.3.1 Dominant Vegetation Characteristics	146

CHAPTER 8: GROWTH OF IVY

8.1 Growth of Shoots	148
8.1.1 Method	149
8.1.2 Results and Discussion.....	150
8.2 Growth of Woody Stems	155

CHAPTER 9: DISCUSSION

9.1 Influence of Park Boundaries, Park Size, Park Shape and Park Fragmentation / Insularity on Invasion.....	160
9.2 Land Use Change and Landscape Transformation	163
9.3 General Habitats and Vegetation Communities of Parks Invaded by <i>H. helix</i>	164
9.4 Relationships between Ivy and Host Trees	165
9.5 Other Influences on Ivy's General Distribution	167
9.6 Growth of Ivy.....	1691

CHAPTER 10: IMPLICATIONS AND CONCLUSIONS

10.1 Implications for Conservation	173
10.2 Implications and Recommendations for Management	174
10.2.1 Methods for Controlling <i>Hedera helix</i> and other Invasive Plants.....	176
10.2.2 Legislative, Policy and Regulatory Instruments	178
10.2.3 Other Strategies and Recommendations	182
10.3 Implications for Further Research	186

SUMMARY AND CONCLUSION	190
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BIBLIOGRAPHY	192
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APPENDICES

1. Park Boundary Reconnaissance (Field Notes and Observations).....	206
2. Park Edge Types	222
3. Analysis of Park Boundary Segments by Edge Type	226
4. Raw Data: Ivy Host and Stem Data	228
5. Raw Data: Vegetation Cover Classes and General Habitat of Sampled Quadrats	235
6. Raw Data: Short term Horizontal and Vertical Shoot Elongation of <i>H. helix</i>	248
7. Photo Gallery	251

LIST OF TABLES

Table 4.1: Land-Use and Landscape Types for the Analysis of Park Edge Types.....	45
Table 4.2: Numbers and Types of Plots Sampled in Parks.....	51
Table 4.3: Plant Cover Classes	53
Table 5.1: Summary of Park Boundary Characteristics and Invasion: Bear Hill Regional Park	62
Table 5.2: Summary of Park Boundary Characteristics and Invasion: Elk-Beaver Lake Regional Park.....	63
Table 5.3: Plants in Non-Invaded Plots: Bear Hill Park	66
Table 5.4: Plants in Invaded and Non-Invaded Plots: Elk-Beaver Lake Park.....	66
Table 5.5: Summary of Park Boundary Characteristics and Invasion: Coles Bay Park..	71
Table 5.6: Plants (not including trees) in Plots: Coles Bay Park.....	72
Table 5.7: Plants in non-Invaded Plots: Devonian Regional Park.....	76
Table 5.8: Plants in Invaded Plots: Francis-King Park.....	79
Table 5.9: Plants in Seedling and Non-Invaded Plots From Francis-King Park	80
Table 5.10: Plants in Non-Invaded Plots: Horth Hill Regional Park.....	84
Table 5.11: Plants in Invaded Plots: Knockan Hill Park	88
Table 5.12: Plants in Non-Invaded Plots: Knockan Hill Park	89
Table 5.13: Plants in Non-Invaded Plots: Lone Tree Hill Park.....	93
Table 5.14: Plants in Non-Invaded Plots: Mount Work Park.....	93
Table 5.15: Plants in Non-Invaded Plots: Mill Hill Park.....	97
Table 5.16: Summary of Park Boundary Characteristics and Invasion (# = transect number): Mount Douglas Park.....	102
Table 5.17: Plants in Plots: Mount Douglas Park	102
Table 5.18: Plants in Invaded Plots: Thetis Lake Park	109
Table 5.19: Plants in Seedling and Non-Invaded Plots: Thetis Lake Park	110
Table 5.20: Plants in Invaded and Non-Invaded Plots: Uplands Park.....	116
Table 5.21: Plants in Invaded and Non-Invaded Plots at Witty's Lagoon Park	121
Table 6.1: Parks Ranked by Edge (Perimeter in m) to Interior (Area in ha).....	125
Table 6.2: Parks by Overall Invasion of <i>H. helix</i>	125
Table 6.3: Minimum Frequency of <i>H. helix</i> on Properties Adjacent to Parks.....	129
Table 7.1: Summary of Trees (≥ 35 cm) from Invaded Plots	132
Table 7.2: Trees from Invaded Plots by Condition and % Hosting Ivy.....	132
Table 7.3: Common Plants Found in Plots Invaded by Ivy	139
Table 7.4: Common Plants Found in Plots with Ivy Seedlings or Young Sprouts.....	141
Table 7.5: Common Plants Found in Plots (Fir and Garry Oak Forest) Containing No Ivy	142
Table 7.6: Summary of Tree, Canopy and Slope Characteristics by Type of Plot.....	144
Table 7.7: Percentage of Plots with Various Soil Qualities.....	145
Table 7.8: Mean Number and Proportion of Dominant Plant Species by Type of Plot	146
Table 7.9: Mean Number of Dominant Plant Species in Heavily Invaded Garry Oak Woodland	147

LIST OF FIGURES

Figure 4.1: Parks Selected in the Study Area	44
Figure 5.1: Sampling Locations and Park Boundaries at Bear Hill Regional Park (above) and Elk-Beaver Lake Regional Park below	60
Figure 5.2: Sampling Locations, Elk-Beaver Lake Regional Park	64
Figure 5.3: Coles Bay Regional Park.....	70
Figure 5.4: Devonian Regional Park.....	74
Figure 5.5: Francis-King Regional Park	78
Figure 5.6: Horth Hill Regional Park.....	83
Figure 5.7: Knockan Hill Park	87
Figure 5.8: Lone Tree Hill Regional Park	92
Figure 5.9: Mill Hill Regional Park	96
Figure 5.10: Mount Douglas Park.....	99
Figure 5.11: Thetis Lake Regional Park	108
Figure 5.12: Uplands Park	114
Figure 5.13: Witty's Lagoon Regional Park.....	118
Figure 6.1: Park Edge: Interior by Overall Invasion.....	126
Figure 6.2: Park Edge Types.....	127
Figure 6.3: Minimum Frequency of <i>H. helix</i> on Properties Adjacent to Parks and Overall Park Invasion	130
Figure 7.1: Maximum Height of Climbing Ivy on Host Trees in Invaded Plots	133
Figure 7.2: Frequency Distribution for Height of Juvenile Ivy on Host Trees.....	134
Figure 7.3: Frequency Distribution for Height of Reproductive Ivy on Host Trees.....	135
Figure 7.4: Size of Ivy on Host Trees	135
Figure 7.5: Height of Ivy by Host Trees	136
Figure 7.6: Height of Ivy on Douglas-fir	137
Figure 7.7: Height of Ivy on Grand Fir.....	137
Figure 7.8: Height of Ivy on Garry Oak	138
Figure 7.9: Proportion of Plots by Aspect	145
Figure 8.1: Rate of Ivy Shoot Elongation by Site and Period.....	153
Figure 8.2: Weather Data and Mean Total Shoot Growth (All Sites)	154
Figure 8.3: Simplified Cross Section of Ring-Bearing Tree Versus <i>H. helix</i> Stem.....	156
Figure 8.4: Cross Section of one Ivy Ring.....	157
Figure 8.5: Rings in Stem Samples of Ivy	159

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Bear Hill Regional Park		Mill Hill, Francis-King and Thetis Lake Regional Parks
1992	15BCB92139 No.35 and 15BCB92134 No.38	1997 15BCC97001 No.17
		1956 BC1235 Nos. 55 and 56
Coles Bay Regional Park		Knockan Hill Park
1992	15BCB92134 No. 97	1997 15BCC97001 No.45
1955	BC2144 No.97	
Devonian and Witty's Lagoon Regional Parks		Lone Tree Hill Regional Park
1980s	BC7767 No.144	1997 15BCC97001 No. 1
1951	BC1238 No.89	
Elk-Beaver Lake Regional Park		Mount Douglas Park
1997	15BCC97001 No.42	1992 15BCB 92139 No.140
1955	BC2144 No.100	1955 BC2144 No.79
Horth Hill Regional Park		Uplands Park
1992	15BCB92134 No.94	1997 15BCC97001 No.76
1955	BC2144 No.97	

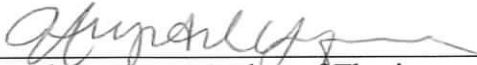
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 Krystal Larocque, Author of Thesis

CHAPTER 1: INTRODUCTION

The establishment of a park should represent success in preserving and protecting a natural area from the short-term interests of human use and development. However, the long-term preservation of species and ecosystems is neither simple nor does it necessarily follow park creation. Just as life forms and the biosphere have evolved to depend upon the process of exchange for their existence and renewal, habitats and species within parks rely upon abiotic and biotic exchanges with the outside environment for their long-term survival. Dependent upon and influenced by what is outside, a park is also vulnerable to exchanges that may alter or threaten its habitats, fauna and vegetation. Given that humanised landscape increasingly comprises the environment outside parks, it is important to study the exchange of plants linked to human habitation and the ways in which these species enter parks and protected areas.

The boundary of a park may be viewed as a permeable filter that allows for the exchange of species and ecosystem processes, as well as being a critical interface that separates a park from outside human habitat and human activities. Forman (1995:96) believes that the cellular membrane, with its various filtering functions, serves as a useful model to understand landscape boundaries including those that delimit parks. A literature has developed attempting to determine what attributes of parks offer the greatest amount of protection and resiliency against invasive species, like the search for attributes of organisms that enable them to resist invading pathogens and internal structural damage.

Parks that are most difficult to buffer from human activity are those in the near-urban¹ environment. This thesis examines the relationship between land use, habitat and the establishment of a horticultural species, English ivy (*Hedera helix* L.), hereafter referred to as ivy, in a sample of near-urban parks within Greater Victoria. Ivy was selected for study because of its prevalence, its connection to human activity, its low citation in the literature as an invasive plant and because of increasing concern about the spread and threats of invasive horticultural plants. The purpose of this research is to gather basic information about the ecology and habitats of ivy and the ways in which human landscapes may affect the spread and success of this species in near-urban parks.

1.1 Research Questions

Two major questions guide the research: (1) What are some of the characteristics of near-urban parks that influence their invasion by ivy? (2) What are some of the characteristics of areas that ivy invades and areas that it does not invade? In answering these questions, the types of parks and internal park habitats that are either prone to or resistant to invasion may be determined for the purposes of conservation, future urban and park design and ecosystem management.

1.2 Background Influences on this Study

Population growth has led to a rapid conversion of natural areas into urbanised, human habitat. Influenced largely by European culture, Canada's natural ecosystems have been the recipients of numerous European plants. On the southwest coast, Greater

¹ The term near-urban refers to developed (e.g. residential or sub-urban), undeveloped and natural areas (e.g. municipal and regional parks) that are found within a metropolitan area (similar to the 'peri-urban' environment). Near-urban parks refer to regional and municipal parks in this study.

< Victoria's characteristically mild climate and British culture have encouraged the introduction of vegetation originating from north Europe as well as the re-creation of European-style gardens. Ivy is among the many popular north-European species that feature prominently in gardens on south Vancouver Island. As the nature parks of south Vancouver Island are very highly treasured, horticultural plant species that invade park ecosystems are a growing conservation problem.>

Concerns about the growing human footprint on the environment provide general justification for this study. For example, Our Common Future (World Commission on Environment and Development 1987) articulated the multidisciplinary concept of "sustainable development" which urged integration of ecology with economic and urban development. The fields of conservation biology, biogeography and landscape ecology have focused significant attention on the dynamics of remaining natural landscapes including threats to species in and outside nature reserves. Many of these ecological threats have not been successfully translated into widespread public awareness, compared to the more generalised human impacts on the environment such as those articulated in Our Common Future. For instance, chemical pollution and habitat destruction from urban development have captured considerable media and public attention whereas the impact of invasive species has largely been overlooked² (Coblentz 1990).

² Coblentz (1990) groups human impacts on the environment into: (1) adverse resource use such as over-fishing, destructive forestry or agriculture, paving habitat for shopping malls or draining wetlands; (2) pollution (chemical, nuclear, nutrient, etc.); and (3) exotic organisms. He notes that the first category is widely publicized by the media and most prevalent in the minds of the public, that the second category can be remedied or prevented, but that the third category is prevalent and often permanent. McKnight (1991) also argues that biological pollution is the least well-known environmental problem.

The field of resource management has relied on information from the biological, ecological and geological sciences whereas in the related field of urban planning economic factors have played a greater role. Researchers argue that there is now a growing interest in integrating ecological information into disciplines outside the natural sciences. For instance, Forman (1995) believes that the chasm is narrowing between ecologists, who have traditionally bemoaned the spread of human habitat, and landscape planners, who have largely ignored natural systems and biodiversity. Collinge (1996) has cautioned, however, that the integration of ecological considerations into landscape planning is still in its infancy. As pressures grow to develop lands and to protect remaining natural ecosystems, the ability of parks to maintain wild plants and animals within urbanising landscapes becomes an increasingly crucial issue.

1.2.1 The Species of Human Habitat

Introduced species are the second greatest cause of species endangerment and decline worldwide, after habitat destruction (Schmitz and Simberloff 1997). The spread of human habitat is a major cause of habitat destruction, creating biologically impoverished derelict lands while opening niches for numerous human-selected, introduced plants and animals. Because of its rapid spread and capacity to mass distribute human-selected species, human habitat has potential to homogenise, on a local and global level, areas that were once ecologically distinct. Plants that are easy to care for, with characteristics such as heavy reproduction, fast growth and hardiness within human-disturbed environments, may have an advantage. The challenge to maintain indigenous organisms and habitats will increase for a number of reasons. The geographic

distribution of introduced and invasive species will continue to expand, numbers of introduced species will increase as more wild species are domesticated and existing species are altered, and people may be unable to distinguish native from introduced species. Introduced invasive plants have been likened to diseases that penetrate and spread across ecosystems, replacing their native species and transforming them (e.g. Schmitz and Simberloff 1997; Cronk and Fuller 1995). From conservation and landscape planning perspectives, the geography of invasive species in our remaining natural areas is, therefore, one of the most critical problems meriting study.

It might be intuitive to believe that deliberately introduced invasive species should be easy to control, yet the popularity of these species can make them, paradoxically, more difficult to control and manage. Ornamental plants are widely sold, highly appreciated by consumers and producers and very economically profitable. Estimates in the United States suggest that 10% of all ornamental plant species have escaped cultivation, many having devastating impacts on natural habitat (Schmitz and Simberloff 1997). The continued production, sale and distribution of invasive horticultural plants along with neglect and resistance to their control threatens to fill nearby natural habitats and parks with these species.

1.3 This Study

The growing body of research relating to exotic plant invasion has, to a large extent, focused on factors thought to affect their establishment and spread, on case studies

and on their control, management and prevention³. Researchers have come to understand the link between plant invasion and human activity through the study of disturbance, the study of landscapes and autecology or the study of invasive species' attributes and characteristics. Literature and research related to ivy can be grouped into several categories, including: horticultural (e.g. promotional information); biological (e.g. physiology, biochemistry); ecological (e.g. its distribution as described in floras, ecology within forest ecosystems in its native European range); and conservation (e.g. its ecology or invasiveness where it is not indigenous). The number of studies falling into the last category is small in relation to the others. The biogeography of ivy in western North American forests has received very little attention.

This research represents a case study of invasion that falls within the conservation category of research on ivy. It is broad and exploratory and represents a sketch to be filled in by further work related to habitat fragmentation and the effects of introduced and modified organisms on remaining wild habitat as represented in near-urban parks.

1.4 Thesis Outline

The remaining chapters of this thesis deal with specific themes, which build on and complement each other. Chapter 2 assembles information gathered about the ecology and invasiveness of ivy. Chapter 3 describes the problem of, influences on and consequences of plant invasion. The human factors that influence a park's invasion by

³ Some of the numerous case studies of plant invasion include Roze et al. (1984), Bossard and Rejmanek (1994) and Meyer and Florence (1996); examples of invasive plant management and/or prevention include Dearden (1983), Westman (1990) and Reichard and Hamilton (1997).

exotic plants focused on in this research are those of landscape type and land-use. The third chapter examines the concepts of habitat fragmentation and park boundary "permeability." As well as explaining these concepts more fully, the relationship between fragmentation and invasion and their application to the study's research objectives are developed. Methods of investigation and data collection are described in Chapter 4. Chapter 5 presents the findings from individual parks and Chapter 6 examines park fragmentation. I compare invaded and non-invaded areas in Chapter 7 and discuss the growth of ivy in Chapter 8. Chapter 9 is a discussion of the study's main findings. The final chapter broadens the discussion to consider the study's implications for conservation, management and future research. A small photo gallery is appended.

CHAPTER 2: *HEDERA HELIX* L.: BIOLOGY, DISTRIBUTION AND GENERAL ECOLOGY

This chapter provides an overview of the biology, geography and ecology of English ivy. The native range and general ecology of the genus *Hedera* and species *Hedera helix* are first discussed. This is followed by a brief account of the distribution of *Hedera helix* outside its native range, and its invasiveness and ecology in these areas.

2.1 Biology

Hedera helix is a woody, evergreen climber¹ with perennial stems, belonging to the family Araliaceae². English ivy's leaves are usually 5-lobed and often thinly elongated when on climbing stems. Around late August through fall in Greater Victoria, mature *H. helix* produces whorls of flowers that develop pea-sized fruit (see Philipson 1970), which ripen into dark burgundy-black berries by spring time. English ivy is pollinated by wasps, bees and flies in Britain and France (Clapham et al. 1962; Trémolières et al. 1988) and along North America's Pacific coast (Reichard, Center for Urban Horticulture, University of Washington in Seattle, pers. comm., 1997).

From physiological, anatomical and ecological perspectives, the interesting feature of *Hedera helix* is its two distinctive life phases: its juvenile and adult forms. Drastic developmental changes in plant parts between juvenile and adult life phases are

¹ Some of the oldest historic records indicate that vines were among the plants introduced by people in early times. King Tiglath-Pileser I (c. 1130 B.C.) of Assyria recorded that he had taken cedars and other trees and also rare vines from countries that he had conquered and planted them in the gardens of his own land (Reed 1942:8).

² Most of the approximately 58 genera of this family (ginseng) are moderately sized, tropical trees (Philipson 1970, Allaby 1992). The largest member of the family is *Peckeliopanax spectabilis*, a tree which grows up to 130 feet with a diameter at breast height of around 2 m, in New Guinean rainforests, the Bismarck archipelago and Solomon Islands (Philipson 1970).

"heteroblastic." Heteroblasty in *H. helix* is believed to be the result of reduced gibberellic acid caused by the absence of abundant roots, which triggers the change to its adult or "arborescent" form (Lee and Richards 1991). While in non-reproductive or juvenile, ground-crawling form, its leaves are darker green, velvety and often light veined with 3-5 lobes. In adult or reproductive form, *H. helix* has lighter green, thick, ovate to rhombic glossy sun leaves and, in season, bears clustered white to yellowish green flowers with dark fleshy fruit (Tutin 1968).>

↓
 ▽ Ivy's sun leaves are adapted to higher levels of light than its juvenile leaves but they are less plastic. Cuttings from adult or flowering shoots will continue to grow in that form into erect shrubs (Tutin 1968; Elliot 1995). The juvenile or ground-crawling ivy is adapted to darker conditions characteristic of the forest understory. However, laboratory tests indicate that the juvenile leaves of *H. helix* are also highly adjustable to drastic fluctuations in light, which enables the species to easily colonise understories of deciduous woodlands that experience high seasonal light variation (Bauer and Thöni 1988).

2.2 Major Taxa of the Genus *Hedera*: Native Range and Distribution

The genus *Hedera* is native to Europe, Northern Africa and Asia, and scientific opinion varies regarding the number of species recognised in the genus³. McAllister (see

³ Linnaeus recognised only one genus of Hederaceae (*Hedera*) (Seeman 1894). Tutin's (1968) *Flora Europaea* indicates that there are between 1-6 species recognised in Europe (*H. hibernica* from southwest Ireland, *H. colchica* and *H. helix*, including three subspecies of *H. helix*: ssp. *helix* from west, central and southern Europe eastward to Latvia and Ukraine, ssp. *poetarum* from Greece, Turkey, North Africa and Southwest Asia, naturalised in France and Italy and ssp. *canariensis* from N.W. Africa and the Canary and Madeira Islands). The Royal Horticultural Society listed 6 species of *Hedera* in 1989 and 11 species in 1992. Variation in the number of species recognised is linked to the plant's commercial circulation throughout Europe in the 18th Century, the introduction of new ivies from Asia in the 19th Century and a general lack of regard for botanical species distinctions among horticulturists (Wellingham-Jones 1985).

McAllister and Rutherford 1983 and Rutherford et al. 1993) distinguishes north European ivies (*H. helix* and its forms and *H. hibernica*) from southwest and eastern European ivies (*H. maroccana*, *H. maderensis*, *H. colchica*, *H. algeriensis* and *H. cypria*). In Britain and north-east Ireland, the only native ivies are English ivy (*H. helix*) and Irish ivy (*H. hibernica*, which has double chromosomes and larger, floppier leaves). Irish ivy dominates the ground flora in UK woodlands more than English ivy (McAllister, Assistant Director of Liverpool University Botanical Gardens at Ness, U.K., pers. comm., 1997), although both share similar habitats (Hackney 1992). Several other ivies native to south Europe, Africa and Asia have been introduced to north and west Europe.⁴ Tutin (1968) defines the native range of *H. helix* as north to 60° 30' in Norway and east to southern Latvia and western Ukraine.

As a result of the scientific debate over the number of species in the genus and since Headley et al. (1992) note that there are over 400 variants or cultivars of *H. helix*, each numbered by the American Ivy Society and with slightly different ecological tolerances, an in-depth discussion of the taxonomic classification (e.g. variations and subspecies) of *H. helix* is not attempted here. For the purposes of this study, all escaped English ivy is referred to as and assumed to be *Hedera helix* (see Appendix 7: Figure 1).

⁴ *H. colchica*, native to Colchis and Iran and adapted to high levels of light and acidic soils was introduced to Britain during the 19th Century (Wellingham-Jones 1985) where it rarely seeds (McAllister, pers. comm., 1997; Hackney 1992). *H. algeriensis* (Algerian ivy), also introduced to Britain, behaves similarly to *H. colchica* but is less hardy. In contrast, *H. maderensis*, native to the Madeira Islands (Portugal), is considered the most vigorous and dominant introduced ivy in Britain, the Orkney Islands and in other parts of Europe (McAllister, pers. comm., 1997). One subspecies of ivy, *H. helix* subsp. *rhizomatifera*, is recognized as having been introduced to Britain from south and eastern Spain. It has well developed rhizomatous underground stems that are thought to be fire, drought and cold resistant and they bear tiny leaves that mature into small plants (Rutherford et al. 1993; McAllister, pers. comm., 1997). *H. maroccana*, drought tolerant and native to the Atlas Mountains of northeastern Africa, is believed to have been introduced by the Moors to Spain where it now invades oak (*Quercus suber*) and pine (*Pinus* sp.) woodlands (McAllister, pers. comm., 1997).

The review of the genus indicates that many of the species are widely distributed and adaptable. It is likely that this ecological and morphological plasticity is responsible for not only the invasiveness of *H. helix* but its popularity among horticulturists: "no other ornamental is so adept at filling so many roles . . . ivy is versatile enough to find a niche in almost any space [or] climate" (Wellingham-Jones 1985:28).

2.3 Ecology and Habitats of *Hedera helix*

Hedera helix is a "liana", which Gentry (1991) believes should be distinguished from "vines" on the basis of the former's greater stem thickness and woodiness. Lianas are distributed primarily in tropical forests where they evolved their climbing strategies (Putz and Mooney 1991; Gentry 1991). Only two families of lianas are found in North American temperate forests besides Araliaceae: Vitaceae and Anacardiaceae (*Toxicodendron radicans* or poison ivy), both of which behave more like vines. In contrast, numerous families of lianas are represented in South American temperate forests (Gentry 1991).⁵ English ivy has been considered to be a relic of the Tertiary, said to be partially unadapted to cold temperate areas because its phenological cycles do not correspond to those of its host trees in Europe (Trémolières et al. 1988⁶). Lianas found in drier forests are more often wind-dispersed, while those in wetter forests are more often bird and mammal dispersed (Gentry 1991). English ivy is a moist forest dweller whose

⁵ Perhaps because of its smaller equatorial and tropical land mass, tropical lianas had greater difficulty colonising or re-colonising North (and South) America than Eurasia during the interglacials. A review and interpretation of paleobotanical and evolutionary research would be required to explain meager representation of lianas in North American forests.

⁶ The author argues that the spring fruit and leaf litter shed in temperate forests by the lianescent ivy boosts nutrients available for tree growth - a "space-time complementarity" more typical of the long-evolved, species-rich forest ecosystems.

seed is dispersed primarily by birds such as starlings (*Sturnus vulgaris*) and blackbirds (spp.) in its native range (Clergeau 1992).

Hedera helix is abundant in the alluvial temperate forests of Europe, and especially in Brittany (Schnitzler 1995; Clergeau 1992). In eastern France, *H. helix* favours moist, calcareous, eutrophic soils and in western France it grows to larger diameters and heights in a wider range of pH and soils (Schnitzler 1995). In the Rhine forest, *H. helix* is most adapted to highly fragmented and mid-late successional stands and especially plentiful where there is disturbance such as flooding or increased light (Schnitzler 1995; Trémolières et al. 1988). Schnitzler notes that while English ivy is often found along forest edges and in gaps, its seed dispersal does not limit it entirely to edge habitats. It may carpet the forest floor until a canopy gap stimulates its growth toward potential host trees (Schnitzler 1995). Old, "giant" lianas (growing 15-30 m tall with stems greater than 6 cm DBH) are most prevalent in the Rhine forest's *Quercus-Ulmetum*⁷ and *Salici-Populetum*⁸ phytosociological associations, with denser forest stands having higher liana density and typically richer soils (Schnitzler 1995).

Foresters in Europe often consider English ivy a nuisance and remove it because it overshadows seedlings, breaks branches and accelerates the death of trees (Schnitzler 1995; Trémolières et al. 1988). Also in Europe, considerable controversy exists over the

⁷ An old/end-successional Rhine forest association with *Quercus robur* (European oak), *Ulmus minor* (smooth-leaved elm) and *Fraxinus excelsior* (European ash).

⁸ *Salix alba* (white willow) and *Populus nigra* (black poplar).

degree to which English ivy smothers and kills trees and deciduous woodlands, destroys mortar and buildings and provides habitat for wildlife (Elliot 1995).⁹

2.4 *Hedera helix*: Distribution and Invasiveness in the New World

There is limited published information related to the invasiveness of *H. helix*¹⁰. As a result, the following sections draw from communications and correspondence with members of the International Union for the Conservation of Nature Invasive Species Specialist Group (IUCN - ISSG) as well as other European and American researchers with knowledge about English ivy.

Hedera helix is possibly the most pervasive and invasive species of the genus *Hedera* outside Europe. It was introduced to Australia, New Zealand, Hawaii and North America where it is now a common, naturalised plant. In New Zealand, English ivy is common on both the North and South Islands, invading abandoned homes, cemeteries, cliffs, riverbeds, streambanks, hedgerows, and forests, where it climbs up to 10 m on trees and forms large mats on the ground. Wardle's (1991) New Zealand Flora provides the following account of its distribution:

On (the eastern part of the South Island) coastal cliffs of late Tertiary volcanic rocks below urban settlements, garden escapes and weeds [including *Hedera helix*] form communities. (p. 395-96)

Respondents with information about the invasiveness of English ivy in New Zealand indicated that it is dispersed primarily by blackbird, starling, silvereye (*Zosterops*

⁹ Swain (1982) describes a controversy at Harvard over Boston ivy (*Parthenocissus tricuspidata*), introduced to North America from Asia in 1862 and planted on the campus in 1886. Engineers wished to strip it off all the buildings, claiming it destroys them. Boston ivy is deciduous, more cold tolerant than English ivy and climbs with adhesive discs.

¹⁰ It could be that ivy's horticultural nature and link to human activities makes its ecology less appealing to the biological sciences.

sp.), and kereru (*Hemiphaga* sp.) and is a serious invader of Paengaroa Reserve on the Central North Island near Taihape. This nature reserve contains locally and nationally threatened plants such as the shrub *Teucrium parvifolium*, which is known to be displaced by English ivy (Veitch, Ecological Restorationist with the Department of Conservation, Auckland Conservancy, Auckland, New Zealand, pers. comm., 1997). In parts of Paengaroa, ivy smothers trunks of every canopy tree. *Hedera helix* impedes the growth and vitality of most tree and shrub species in the reserve, increases tree mortality, has unknown effects on epiphytes, corticolous bryophytes and lichens and alters the reserve's light regime because of its abundance in the canopy (Veitch, pers. comm., 1997). In some parts of New Zealand, English ivy is thought to be one of the worst forest invaders in the long term.

In Australia, English ivy is considered a major problem in higher rainfall areas in the state of Victoria, where it invades moist sclerophyll forests (Blood, Weeds Specialist, Centre for Weed Management Systems, Government of Western Australia, pers. comm., 1997). *Hedera helix* is invasive also in New South Wales, Tasmania, Australian Capital Territory and South Australia (Swarbrick 1994). English ivy is also invasive in Hawaii, although it is not considered to be among the worst introduced plants that threaten the islands' native ecosystems and wildlife. Diefenbach and Becker's (1992) research indicates also that *Hedera helix* is a common plant in urban parks of Porto Allegre, a humid subtropical region of Brazil.

In North America, English ivy is abundant on the eastern seaboard of the United States where it has naturalised from Virginia southward (Gleason and Cronquist 1991). In Ontario, English ivy is found at Point Pelee National Park (just south of 42°N), where

it is considered a high priority for removal (White, Haber and Keddy 1993). In Boston (42°20'N), there is widespread planting of English ivy in gardens, suburbs and along building foundations, but it rarely escapes or fruits and its spread is primarily vegetative (Williamson, Professor, Department of Biology, University of York, U.K., pers. comm., 1997). On North America's West Coast, English ivy is very well established in Washington and Oregon (Hitchcock and Cronquist 1973:314) where it often invades along roadsides (Coblentz, Professor, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, pers. comm., 1997). English ivy is also grown in California (Appendix 7: Figure 2), where it is locally invasive in urban parks (e.g. as far south as San Diego) but where dry climate and habitat limits its spread somewhat. In British Columbia, English ivy invades mature forest ecosystems adjacent to populated areas on the south coast.

Thomas' (1980) study of a Potomac Island in Washington D.C. is one of few investigations examining the invasiveness of *Hedera helix* in North America. Thomas found that English ivy was initially confined to areas near an estate located on the island but it aggressively invaded and displaced other local flora and killed trees in upland and floodplain areas dominated by mixed deciduous woodland¹¹. The conclusion of this 1980s research was that English ivy would continue to spread and become a dominant species on the island:

With *Lonicera japonica* [Japanese honeysuckle] suppressing woody plants, particularly trees, and growing over shrubs and small trees and killing them, and *Hedera helix* killing the larger trees and suppressing

¹¹ Dominant trees included American elm (*Ulmus americana*), Manitoba maple (*Acer negundo*), white mulberry (*Morus alba*), black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), tulip tree (*Liriodendron tulipifera*), northern red oak (*Quercus rubra*), silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*) and black willow (*Salix nigra*).

herbs, the upland and floodplain forests are slowly disappearing and will be replaced by a vine-dominated community. *Hedera* has taken over *L. japonica* areas . . . and is able to accumulate biomass faster than *Lonicera*. The final community will be dominated by *Hedera helix*.

(Thomas 1980:72-73)

Since the 1980s and despite several abortive attempts by the National Park Service to control it, English ivy has continued to spread and take over new areas of the island including many of the areas dominated by Japanese honeysuckle¹² (Thomas, research biologist with the U.S. National Park Service in Greenbelt, Maryland, pers. comm., 1997). This finding indicates that English ivy has potentially significant impacts at local scales (e.g. on ground flora, tree sprouts, shrubs and other vegetation), altering the physical structural appearance of parks and natural areas. As physical space and access to light, nutrients, water and soils are finite, niches and resources otherwise available to native plants, or even to other invasive exotic plants, may be filled by English ivy.

2.5 Local Distribution

◀ English ivy was introduced to coastal British Columbia at least one hundred years ago. It can be seen climbing and flowering in the crowns of Garry oak (*Quercus garryana*) in old (c.1910-1920) photographs of Beacon Hill Park¹³. In his 1915 flora, J.K. Henry had considered English ivy a naturalised plant that would likely “become a permanent part of” the local vegetation (Henry 1915). English ivy thrives in deciduous forest (e.g. the Rhine forest in Europe, in eastern U.S. forests and in developed Garry oak

¹² Japanese honeysuckle (*Lonicera japonica*) and kudzu (*Pueraria lobata*) are highly prolific and considered extremely invasive in the southern United States. Carter and Terramura (1988) indicate that *H. helix* grows more slowly and is less widespread than these other climbers. However, ivy's displacement of *Lonicera* suggests it may be more successful in the longer term.

¹³ Walter Baer photographs, collections of the British Columbia Provincial Archives.

and mixed deciduous woodlands of Vancouver Island). However, English ivy is also found in coniferous, mixed Douglas-fir forest ecosystems on Vancouver Island, where it has naturalised from Greater Victoria to Port Renfrew and at least as far north as the Comox region. My informal telephone queries to local nurseries indicate that ivy is propagated locally to meet high consumer demand.

A concern and question regarding English ivy's local invasiveness is the degree to which the introduction of new plant forms, in this case, woody climbers, will have an impact on native forests. The presence and abundance of lianas and climbing plants are thought to be the most important physiognomic difference between tropical and temperate forests, literally tying the forest together and greatly changing its structure (Gentry 1991).¹⁴ In North America, lianas and vines are predominantly found in the southeastern, mid-late successional forests, although their distributions and densities have changed tremendously over the last century due to human activity and introduction of exotic vines¹⁵ (Teramura et al. 1991).

Vines of southeast Vancouver Island include the native honeysuckles (e.g. *Lonicera hispidula* and *Lonicera ciliosa*), the introduced, invasive bindweed (*Convolvulus sepium*) and the twining, parasitic dodders (*Cuscuta* spp.) that cling and feed by suckers (Pojar and MacKinnon 1994). The lack of large-stemmed or arborescent lianas makes English ivy atypical among the plants of western Canadian forests. Ivy-

¹⁴ Daubenmire (1947) noted that tropical forests are sometimes wrapped together so tightly by climbers that trees are often felled in large groups. There is a small but interesting literature on climbing plants, including Darwin's (1865) four-category classification based on climbing mechanism: spiral twiners, leaf climbers, tendril bearers and hook and root climbers.

¹⁵ Well-known climbing plants introduced to the southeastern United States include kudzu (*Pueraria lobata*) and Japanese honeysuckle (*Lonicera japonica*) (Thomas 1980, Carter and Teramura 1988a and Carter and Teramura 1988b).

filled forests appear remarkably altered and distinct from ivy-free forests, signifying a major physical change to the forest's original structure.

Many invasive plants such as ivy are encouraged by human activities and have great potential to transform natural ecosystems. It is therefore important to examine areas where ivy has naturalised or is currently spreading. Natural habitat and horticultural plants are of high value to people and a balance must be achieved between both. The potential for humans to transform all remaining "wild" or natural areas of the earth with their introduced and modified invasive plants, is a critical and underestimated long term environmental problem.

CHAPTER 3: INVASION OF EXOTIC PLANTS IN PARKS AND NATURAL AREAS

Invasive exotic plants have numerous ecological impacts on native species and ecosystems, which make them a serious cause for concern. The purpose of this chapter is to review plant invasion in the context of protected area preservation and to lay a theoretical foundation for the research. The general threats and scale of plant invasion as well as the factors that influence plant invasion are first discussed. The chapter then describes the attributes and characteristics of parks that are associated with their invasion by exotic plants, as justification for this study.

3.1 Context of Human-Introduced Biota

Plant invasion is a natural part of plant migration and success, usually associated with exceptional growth, abundance, spread or aggressive behaviour / sociability within the recipient ecological community. To be considered invasive, a plant must not only have naturalised and become abundant, it must have spread rapidly or thoroughly over large areas (Hengeveld 1989) or become problematic or destructive (Groves and Burdon 1986). White, Haber and Keddy (1993:3) note that many biologists do not define native species that spread invasively over large areas as problematic because this is viewed as a natural part of the dynamic nature of ecosystems. Although natural plant redistribution and invasion has been an essential ecological process since life evolved, human-introduced biota and human-induced invasion are newer and different phenomena. This biota is considered "exotic" and distinct from native or indigenous species.

We can trace human influence on plants back many millennia (Norton 1992) but since the Pleistocene, intentional species introductions increased through more deliberate plant cultivation and agriculture (Westman 1990). Early plant introductions, such as those occurring in Europe¹ during the past few thousand years, are more difficult to identify (Usher 1988). In the New World, well-known plant introductions occurred within the past 500 years. These relatively recent plant introductions comprise most case studies that examine the deleterious effects of invasive exotic plants on ecosystems (see Elton 1958; Groves and Burdon 1986; Mooney and Drake 1986; Crosby 1986; Hengeveld 1989; di Castri 1990; Cronk and Fuller 1995; Williamson 1996).

The most intense period of world exploration brought numerous newly discovered plants and animals into global circulation via commercial trade. Since then, there has been an impressive and unprecedented rate of geographic rearrangement of natural biota. Large numbers of newly discovered plants and foods were introduced and distributed throughout the Old World at the same time that Eurasian plants were introduced by colonists adapting to the New World (Crosby 1986; di Castri 1990). The history of evolution, discovery and commercial circulation of most of today's foods, medicinal and garden plants is often taken for granted. However, in addition to having evolved in a particular region, each of these species has a unique history of alteration through domestication, hybridisation or genetic manipulation, as part of its cultural or human-influenced history.

¹ See Kornas (1990:19) for a discussion of some of the Mediterranean and Near East plants introduced to Central Europe by Neolithic (c. 7000 years ago) and Mediaeval farmers. See Sykora (1990:37) for a discussion of the history of human impact on the distribution of plant species in Europe.

For instance, the worldwide spread of English ivy that followed European population and socio-cultural expansion is rooted in the species' historical significance within north European culture. In pre-historic times, ivy is claimed to have been used by humans as fodder for livestock, for drunkenness, rheumatism, arthritis, fever, bruises, rashes, burns and other ailments (Frutig Bales 1995). Ivy was selected as an ornamental species centuries ago, from many other possible species. Historic records illustrate that in medieval times, ivy and holly, evergreen and fruiting in the winter, were revered as symbols of fertility and life (Drury 1987). Throughout the Middle Ages, superstitions and rituals developed for the use of ivy and holly during the Christmas season. Preserving and maintaining this cultural attachment, English Victorians were extremely enthusiastic about planting ivy inside homes and outside in gardens and parks. By the 18th Century, ivy became a commercial plant, listed and advertised in nursery catalogues (Wellingham Jones 1985; Royal Horticultural Society 1993) and traded and sold internationally. Since then, ivy has become ubiquitous, in décor, as a houseplant and in synthetic form in homes, department stores and supermarkets. Ivy's history of human selection, besides its propensity to be naturally invasive, has contributed to its pervasiveness.

3.2 Threats to Natural Ecosystems from Introduced Plants

Researchers have identified numerous threats to wild ecosystems that result from invasive plants introduced by humans. However, it should first be noted that there is disagreement over the degree to which invasive species threaten ecosystems. Some authors have argued that there is nothing special about native species indigenous to a given ecosystem, since plant migration and biological invasion have been natural ongoing processes throughout the earth's history (e.g. Johnson and Mayeux 1992; Evans 1996).

However, in contrast to natural plant migrations that were less frequent and more gradual over time, recent human species introductions have been far more abrupt and numerous (Coblentz 1990). Lacking natural pathogens, parasites or herbivores for their control, many populations of introduced plant species have had catastrophic impacts on native species, particularly on island ecosystems such as in the Pacific Islands, Australia and New Zealand². After habitat destruction, the spread of invasive exotic species is considered by some authors to be the greatest threat to ecosystems worldwide (Schmitz and Simberloff 1997).

Every introduced plant alters ecosystem composition by changing the relative proportions of plant species in a region. One of the major threats of invasive plants is that these species, like urbanisation, fracture or disrupt the spatial continuity of native ecosystems. Exotic species invasion increases the spatial homogeneity of areas as a whole, for instance on a global level, through the repeated duplication of cosmopolitan communities comprising similar species (Norton 1992; and what Lövel, 1997, calls the McDonaldisation of the biosphere). On a local scale, dramatic changes to composition and diversity result as homogenous stands of exotic plants overtake large areas and crowd or displace native plants. The spread of human habitat and its accompanying plants thus homogenise areas that were once ecologically and floristically distinct. By altering the composition, structure and function of ecosystems, invasive plants disrupt the natural

² As one illustration, when the Europeans first arrived in New Zealand in the late 1700s, the only land mammals present on the islands were the native bats, humans (the Maori) and their introduced Polynesian rats and domestic dogs. The livestock, grazing mammals, crop plants and unintentionally introduced biota that inundated the islands shortly thereafter displaced and devastated rare indigenous species, caused enormous ecological changes and had detrimental effects on the Maori (Crosby 1986:222-268).

balance of long-evolved ecosystems (Elton 1958; Hengeveld 1989:126), not ever really coming into natural equilibrium with their environment (Wagner 1991).

Another concern is that invasive exotic plants alter the structural diversity of ecosystems or take over the functional roles of native species (Norton 1992). For instance, in addition to displacing and occupying the native plant and animal habitat, exotics can change or remove their food sources (e.g. knapweed - *Centaurea* spp. has been proved to be a poor food source for deer and elk) or introduce diseases into ecosystems (Schmitz and Simberloff 1997). On the other hand, Johnson and Mayeux (1992) argue, the "dire ecological consequences" of exotic plant invasion may not always occur since the function of native plants can be taken over by introduced plants. For instance, if an introduced grass replaces a native grass and is available to the same extent for grazing animals, it may fulfil the same general role as the native grass. In this case, Johnson and Mayeux argue that there is nothing exceptional about the native grass and no inherently fragile, mutualistic relationship between the grazers and their food plants. This example illustrates the need to assess all potential changes that result from each invasive species. It also illustrates that there is ongoing debate over the inherent value of native or indigenous species within ecosystems, even beyond their functional and structural roles.

✕The greatest threat of invasive plants to natural ecosystems is displacement or extinction of native species on local or larger scales (Usher 1988; Hobbs and Huenneke 1992). For instance, Scotch broom (*Cytisus scoparius*) invasion in Australia is believed to have led to the disappearance of diverse reptiles and changed the composition of bird populations (Schmitz and Simberloff 1997). These authors also note that invasive plants may completely transform an ecosystem into another type (e.g. turn a grassland or marsh

into a forest) or cause genetic extinction by hybridisation if closely related to native species. The biological diversity of native, wild species may be lost as increasing numbers of cultivated or human modified species are released, naturalise and reproduce.

3.3 Scale and Status of the Problem of Invasive Plants

*Schmitz and Simberloff (1997) estimate that in the U.S., one fourth of all plants and animals are introduced and exotic plants have invaded nearly all of the country's ecosystems. They point out that besides spreading over 4600 acres [approx. 1860 ha] per day on public western lands alone, exotic plants cause damage in the billions of dollars annually. White, Haber and Keddy (1993), citing Kaiser (1983) suggest that around 27% of the province of Ontario's total flora is exotic and the total cost incurred in dealing with exotic species in this province is estimated at over \$100 million (Snobelen 1998). On the Olympic Peninsula, although native vegetation still accounts for major patterns in the landscape, exotics are now a significant component of the flora (DeFerrari and Naiman 1994). Haber (vascular plant specialist with the Committee on the Status of Endangered Wildlife in Canada, pers. comm., 1999) indicates that there are approximately 3300 native species of vascular plants and about 900-1000 species of exotic plants in Canada. Szczawinski and Harrison (1972) found that 33% of the flora of the Greater Victoria region is exotic.

Many researchers believe that the number of deliberately introduced, invasive plants will continue to increase in coming decades (e.g. Reichard and Hamilton 1997) as will accidental introductions that accompany people and development (Cowie and Werner 1991; DeFerrari and Naiman 1994). *Reasons for this predicted increase include growing mobility of the human population, globalisation, free trade (e.g. impacts of the

North American Free Trade Agreement, the World Trade Organisation and the General Agreement on Tarrifs and Trade) and resistance to regulation (Schmitz and Simberloff 1997; Reichard and Hamilton 1997; Ruesink et al. 1995; Soulé 1990).

Since botanical gardens, nurseries and the public are able to exchange seeds at will, it is very easy for potentially invasive plants to be introduced (Reichard and Hamilton 1997). In the U.S., attempts to regulate introduction of, and trade in, exotic plants are unpopular or criticised as protectionist because these plants play a key role in agriculture, nursery/horticultural, pet and biological control industries (Schmitz and Simberloff 1997). Growing industry demand for deregulated trade and new plants, when coupled with a growing and increasingly urbanising world population, adds a degree of urgency to the need to conserve and protect natural ecosystems. However, the control and reduction of the spread of exotic plants rests on political will, informed by public concern³. Given the great potential and facility for plant introduction, increased public awareness for environmental protection is integral to any abatement strategy for the introduction of species that threaten or transform natural ecosystems.

3.4 Factors that Influence Invasion of Ecosystems and Parks

The primary factors that influence plant invasion (based on the work and conclusions of Elton 1958; Groves and Burdon 1986; Mooney and Drake 1986; Usher 1988; Hengeveld 1989; di Castri et al. 1990; Hobbs and Huenneke 1992; Cronk and

³ Currently, the regulation of a single invasive plant requires a lengthy campaign with dozens of signatures from concerned scientists. A recent U.S. example (described by members of the Invasive Species Specialist Group of the IUCN) involves concerned scientists urging the Department of the Interior to review its policy on non-indigenous aquatic organisms traded in the aquarium/pet industry and for a highly invasive green seaweed (*Caulerpa taxifolia*) to be listed under the Federal Noxious Weed Act. The onus is on scientists to prove harm rather than on industry to prove safety.

Fuller 1995; Reichard and Hamilton 1997 and others) include climate, isolation, disturbance, community and plant characteristics. Additional factors, described by several authors that affect plant invasion of nature reserves and parks, include landscape-scale influences such as landscape/habitat fragmentation by urbanisation and the associated influence of park size and shape. These influences are described in the following sections in relation to the general problem of park invasion and this case study of English ivy.

3.4.1 Climate

Climate is the greatest macro control on ecosystem invasion. Regions with the harshest climates such as Antarctica are generally less invaded by plants⁴ (Usher 1988), whereas warmer regions experience greater invasion. Regions with warmer climates not only contain larger human populations and more human traffic but more plant species, which are widely traded internationally (Schmitz and Simberloff 1997). Mediterranean-type climates, characterised by moderate temperature fluctuations, winter rainfall and summer drought, are found along parts of the West Coast of North America, including southern Vancouver Island (the study area), Chile, South Africa and southwest and southeast Australia. These regions contain rich and distinct biotas, high proportions of regionally rare and endangered taxa, threatened by exotic plants because of human settlement and urbanisation, agriculture and fire suppression (Macdonald et al. 1988).

⁴ During the first half of this century, numerous species were deliberately introduced to Antarctica and most were not successful. Some species (such as grasses - *Poa pratensis* and *Poa annua*) survived the climate and established colonies in the circum-sub-Antarctic islands and near research stations (Smith 1996). As new species continue to be unintentionally introduced to the continent, Smith adds that the area now contains a large and growing seed bank of species ready to establish if the climate changes.

Climate determines the potential for and extent of invasion by each species in each region or locale. Climate has played a role in English ivy's invasiveness, influencing its distribution from its native range in western Europe north to Norway and its successful invasion in New Zealand; New South Wales and Victoria, Australia; in parts of North America; Hawaii and in urban parks of humid, subtropical Brazil. The potential distribution of English ivy, therefore, extends to the world's moist, temperate to warm regions and coastal zones.

3.4.2 Isolation

Isolation is a fundamental control on the distribution or spatial heterogeneity of all species and a critical concept in biogeography and studies of invasion. The length of geological time that plant species and entire ecological communities have been isolated from each other, as a consequence of topographic, geologic or climatic barriers, provides a scale for understanding the impact of recent species introduction and invasion. For instance, isolation played an important role in the impact of micro-organisms (e.g. the ravage of smallpox introduced by Europeans) on indigenous peoples. Many tragic consequences have also resulted from the introduction of biota to remote islands where some of the world's rarest species have evolved in isolation⁵. Brockie et al. (1988) note that many of the native species of tropical and southern oceanic islands have become extinct⁶ as a direct or indirect result of human introduced biota. For examples, rats have

⁵ Many of these species are unique, resulting from the founder effect, which includes the outcome of natural selection operating over time on a very limited number of isolated individuals (Brockie et al. 1988; Quammen 1996).

⁶ Of the at least 217 bird species that went extinct in the past 4 centuries, over 200 were island birds (Brockie et al. 1988).

been introduced to over 80% of the world's islands (Brockie et al. 1988) and there are around 4600 exotic plant species in the Hawaiian Islands; three times more than are indigenous (Soulé 1990). The loss of isolation through the opening of an area to human activity and disturbance often leads to species invasion and loss of local species.

3.4.3 Disturbance

Although a few examples exist where major disturbance has not been necessary for particular exotic plants to establish and invade (Usher 1988; Anabel et al. 1992), there is general agreement that human disturbance⁷ promotes invasion by exotic plants (Hobbs and Huenneke 1992). For example, Smallwood (1994) found that most exotic plants in California occur in chaparral around human settlement; plant communities in urbanised coastal regions are approximately 40% exotic, compared to only around 5% exotic in less disturbed interior mountain regions. Norton (1992) also indicates that naturally created gaps in habitat, disturbed habitats and human-created habitats can help invasive plants enter ecosystems. In the case of parks, Norton (1992) adds that exotic plant species invasion has been shown to increase as the number of park visitors increases.

Other research supports the link between human disturbance and plant invasion in parks. For example, Cowie and Werner (1993) found fewer exotics in natural habitats of Kakadu National Park in Australia than they did in disturbed areas of the park including campsites and campgrounds and areas near roads and human settlement. Smallwood (1994) also found that reserves surrounded by agriculture and human settlement had the

⁷ Although natural disturbance (e.g. fire, lightning, climate change, mass wasting, animal activities) may lead to alterations in species composition, human disturbance is a principal process by which human-introduced biota colonize new areas.

highest exotic plant species richness (and lower native mammal species richness), whereas remote reserves had far fewer invasive plants. It might be hypothesised that human disturbance and invasion by exotic plants could, by nature of a synergistic relationship, induce further and greater impacts to ecosystem structure, type and biodiversity than either process could acting alone.

3.4.4 Plant Characteristics

Invasive plants originate in one geographic realm and spread to another (di Castri 1990). For instance, DeFerrari and Naiman (1994) found that 42 of the 52 exotic plants in their study on the Olympic Peninsula originated from Europe and 10 originated from Eurasia. In another study, Cowie and Werner (1993) found that exotics, which comprised approximately 5.8% of the flora in Kakadu National Park's flora versus 10% for the entire Australian flora, were of New World rather than Old World tropical origin. In addition to region of origin, taxonomic groups or particular plant families may be more invasive in certain ecosystems. For example, perennials were the most common type of invasive exotic plants in DeFerrari and Naiman's (1994) study, and families most often invasive were Asteraceae, Poaceae and Fabaceae. Further research is needed to analyse patterns in the origins and families of invasive plants in Canada's regional ecosystems.

Invasive plants tend to have wide ecological amplitudes (Reichard and Hamilton 1997; see Groves and Burdon 1986 for discussions of generalists versus specialists). Authors have found also that a major indication of whether a woody plant has potential to become invasive when introduced to a new environment is whether it is invasive in other ecosystems. For example, Reichard and Hamilton (1997) examined 235 plant species introduced to North America prior to 1930, of which 114 were not considered invasive

and 76 were identified as being of concern to resource managers. They found that over half of the introduced invasive species they examined had invaded elsewhere, compared with only 15% of the non-invasive introduced plant species.

3.4.5 Community, Habitat and Landscape Types

Smallwood (1994) has argued that most studies have focused on the attributes of invasive plants while neglecting study of their community, ecological and habitat roles. Habitats that are most susceptible to invasion include those that lack controls on the plant population, such as the parasites or herbivores that are present in the exotic species' home range (Burke and Grime 1996). A number of studies have sought to determine which ecosystems are more vulnerable to invasion. For example, Usher (1988) notes that south temperate regions have been more severely invaded than north temperate regions, and that islands have been the most drastically invaded. Also, Cowie and Werner (1993) found that dry, remote areas in Kakadu National Park had fewer exotic plants species, whereas structurally simple and more nutrient-rich areas such as wetlands appeared to be more vulnerable to invasion.

DeFerrari and Naiman (1994) found that clearcuts and disturbed riparian zones on the Olympic Peninsula had highest number and cover of exotics, whereas few exotic plants established under closed conifer canopies. Forests and natural woodlands usually have fewer invasive plants than other, typically more disturbed, ecosystems (DeFerrari and Naiman 1994; Norton 1992). Human disturbance and deforestation, in part by decreasing ecosystem complexity (structural and physical), create ecosystems and landscape types that are more easily invaded by exotic plants. Smallwood (1994) for

example, found that agricultural landscapes are a source of exotic agricultural plants in nearby California nature reserves.

The concept of habitat fragmentation, discussed in the following sections, is used as an umbrella theory for integrating several of the above-discussed influences on plant invasion. Habitat fragmentation provides a landscape-level perspective for human-designed terrestrial parks and park systems as well as a conceptual framework for studying their resistance to exotic plant invasion.

3.4.6 Landscape/Habitat Fragmentation

The effects of habitat and landscape fragmentation caused by human activity have become a major focus of conservation research in applied biogeography. Evolving from works such as MacArthur and Wilson's (1967) theory of island biogeography⁸, terrestrial islands of natural habitat surrounded by seas of human development have been viewed as somewhat analogous to true islands, experiencing similar processes and vulnerabilities to species invasion and extinction (see Diamond's 1975 application of island biogeography theory to the design of nature reserves). Since many nature reserves are either current or potential habitat islands, the effects of fragmentation on the preservation of species and habitat are interrelated phenomena and their relationship much pursued in the literature.

⁸ MacArthur and Wilson's (1967) theory, drawing on population data collected on island ecosystems, holds that the maximum number of species an island can support is a function of its size and distance to nearby land or sources of immigrating species. Their quantitative model assumes an equilibrium number of species is maintained as extinction and/or emigration balances immigration. Criticisms of the theory and its application to nature reserve design by authors such as Higgs (1981), Margules et al. (1982), Bloecken and Gotelli (1984) and Zimmerman and Bierregaard (1986) focus largely on the theory's oversight of habitat and species-dependent factors. The theory may not represent perfect reductionism or universal accuracy for all islands, species guilds, populations or habitats. However, island biogeography does present a conceptual simplification of a variety of variables that may result in the loss of species within insular habitat with finite resources.

Like oceanic islands, continental or terrestrial habitat islands have been identified as more susceptible to invasion than unfragmented habitats, suffering more negative effects (Coblentz 1990). By reducing the size and space of habitat, landscape fragmentation may diminish a terrestrial island's carrying capacity (e.g. number of species it can support) and facilitate the establishment of disturbance-adapted, invasive plants. Fragmentation creates "remnants" of habitat composed of native vegetation surrounded by a matrix of other land use. By cutting and carving out natural habitat, fragmentation produces edge habitats with characteristic changes to vegetation and microclimate such as increased or altered solar radiation, wind and water regimes (Saunders et al. 1991). As more edges are carved into and around remnant patches of native habitat, their vulnerability to exposure and invasion by exotic species increases (Norton 1992; Hobbs and Huenneke 1992).

Forman (1995) and Collinge (1996) indicate that the primary negative ecological consequences of fragmentation are the loss of native species and the invasion of exotic species. Supporting this, Aizen and Feinsinger (1994) found more exotic and fewer native pollinators in small forest fragments than in larger tracts of continuous vegetation⁹. Janzen (1983) has argued also that small forest patches are most likely to be easily invaded by exotics and would be best protected from invasion if surrounded by non-invasive plants. Small fragments of vegetation are more susceptible to invasion by

⁹ High proportions of exotic honey bees in their samples of small fragments raises questions about long term vegetation change caused by exotic pollinators, since not all plants can be pollinated by general pollinators such as exotic honey bees. A delay in the fruiting of one plant species as a result of not being pollinated can result in delayed visits by specialist pollinators (e.g. hummingbirds) resulting in delays and lower seed sets for other nearby native plants (Rathcke and Jules 1993). This illustrates another potential process by which native plants and animals may become displaced by exotic species in fragmented habitat.

exotics than larger less fragmented areas, according to the above literature. A similar relationship might exist between the extent of invasion by exotic species and the size or even shape of local parks.

3.4.7 Park Size and Shape

A number of studies have explored exotic plant invasion as it relates specifically to park size. Smallwood (1994) found no relationship between exotic species richness and areas or size of nature reserves in California. Similarly, Usher (1988) indicates that no relationship was found between invasion and the size of nature reserves in a study of Mediterranean-type and arid ecosystems. However, Macdonald et al. (1988) studied reserves of Mediterranean-type climates (three in California, two in Australia, one in Chile and one in South Africa) and found that smaller reserves, particularly urban reserves, had higher proportions of invasive, introduced plants. These findings suggest that the relationship between exotic plant invasion and park size remains problematic (see also earlier debates over the species-area relationship and its application to nature reserve design - Margules et al. 1982).

Small nature reserves have higher edge to interior ratios and increased exposure to outside influences. However, in addition to size, the shape of parks has also been cited as an influence on invasion. Since smaller remnants of natural ecosystems receive greater impacts resulting from edge effects, Saunders et al. (1991) note that their shape and particularly their edge to interior ratio is important to their conservation. Schonewald-Cox and Bayless (1986) note that exposure to the outside is lowest for circular parks and that boundary effects, which they consider to be the combined outcomes of administrative/legal borders and the boundaries they generate, may be more pronounced

in smaller reserves compared to large ones. Since most reserves are "angular edged polygons" with low area-perimeter ratios, Schonewald-Cox and Bayless (1986) suggest that their "boundary model" be used as a conservation tool and method for evaluating park exposure to outside influences. This research will discuss the variables of park size and park shape after observing patterns of invasion in the sample. Several aspects of the boundary model and related research on park boundaries are worth describing as they are applied and adapted to this research.

3.5 The Influence of Park Boundaries on Invasion

Ambrose (1986) traced the development of ecological concepts of "boundaries" in landscape ecology and conservation biology and applied these concepts to a field study of the vegetation and fauna within boundary zones of Smoky Mountain National Park. In a pure sense, boundaries represent perceived distinctions or planes of contact between phenomena that regulate the influx and loss of matter. Boundaries can be either abrupt or gradual separations between objects, defining them by what is inside and outside or on either side (Ambrose 1986). In ecological terms, boundaries include ecotones, delineations of plant formations, geophysical features or legally-delineated geographic areas. The natural ecological and human-defined boundaries of a park influence the flows of matter in and outside of it, and this has important effects on its natural communities.

Schonewald-Cox and Bayless (1986) describe these "boundary effects" as the multifarious changes that occur along administrative boundaries of nature reserves. These authors believe that the legal protection offered by a park's administrative boundary is the first filter between the park and the environment outside. The park's second filter is the

generated edge" or manifestation of the biological, anthropological and physical changes caused as a result of the first filter (Schonewald-Cox 1988). A park boundary absorbs the impacts of adjacent human activities. These human impacts may then be transmitted from the boundary deeper inside the park.

Furthering the ideas of Schonewald-Cox and Bayless, Forman (1995:96) writes that the landscape boundary may function as habitat, filter, conduit, source or sink. If invading plants establish inside park boundaries, park boundary habitat may be viewed as a sink for exotic plants as well as a potential conduit for their invasion deeper inside the park. There may be characteristics of resistant park boundaries that explain why they, and by extension entire parks, become either vulnerable or resistant to invasive plants.

One useful method for examining boundaries may be approached by returning to Schonewald-Cox's and Bayless' (1986) definition of "boundary segments" as units of varying length around a park or reserve border that are homogenous for a particular variable such as land ownership or vegetation. They suggest that boundary segments may be constructed from a multi-disciplinary perspective (e.g. with information on soils, cultural features, pollution, land use and zoning or species distributions) to solve particular conservation problems or to document specific changes occurring in parks. The definition of boundary segments offers one approach by which invasion of particular exotic plants in parks may be examined. A major component of this research thus examines park boundary segments specifically as they relate to potential influences on the invasion of *Hedera helix*. In near-urban areas, residential boundary segments are particularly important to the spread of horticultural plants.

The interface between people and nature has become a focal point for assessing the impacts of human disturbance (Matlack 1993; Rose 1997). As a result, the park border and boundary are good geographic foci for investigating the spread of exotic plants. Near-urban park borders are particularly critical to study, because they are under greater and more direct stress from human disturbance than larger, remote parks, and because urban areas will likely continue to expand both in population and areal extent.

Residents living near parks, natural areas and forest fragments may affect them in a direct way by collecting their wood and plants or by dumping "rubble" or clippings in them (Collinge 1996). Other specific human activities on properties near parks that may affect plant composition include trampling, pollution (e.g. disposal of chemicals or other materials), disruption of wild animals, pollinator or seed dispersers such as birds, the introduction and behaviour of domestic animals and incursion of edge effects from cleared vegetation. Collinge writes in Landscape and Urban Planning:

The influence of a suburban development on adjacent, native habitat may be visually subtle but may extend far beyond property line boundaries, and such significant influences must be an important consideration in the design and planning of suburban developments in continuous, native habitat.

(Collinge 1996:63)

Although the 'visually-subtle' nature of residential areas is disputable, the consideration of the effects of human habitat on nearby natural ecosystems is an indication that concepts from conservation biology and landscape ecology are being integrated into the planning discourse. The tendency for parks to resemble neighbouring, discordant landscapes (Schonewald-Cox 1988) is becoming all too apparent in the near-urban landscape.

Since administrative park boundaries do not often coincide with natural habitat boundaries (see Newmark 1985), particularly when there are abrupt habitat gradients, Smallwood (1994) argues that park boundaries themselves fail by inadequately protecting their internal ecosystems and native species and by allowing exotic species to infiltrate them. Processes internal and external to parks are not static. As a result of fragmentation and inadequate administrative boundaries, Smallwood (1994) argues that biotic resistance in a park today may be gone tomorrow. The long-term effects of park ecosystem transformation resulting from dramatic changes in the external landscape are often more tangible over a period of decades. However, dramatic changes that lower the resistance of parks to invasion occur immediately, following deforestation or fragmentation of natural habitat for the purposes of urban development.

3.6 Convergence and Application of Literature: Definition of Study

Shafer's (1990) review of island biogeography's application to nature reserve design explores the concepts of habitat fragmentation and insularisation. Expanding upon Shafer's descriptions, for the purposes of this research, fragmentation is defined as a process by which a once larger, contiguous tract of habitat becomes severed into smaller, isolated and disconnected remnants of habitat. The larger, contiguous habitat consists of vegetated landscapes that have become fragmented by human activities such as agriculture and residential development, and parks are viewed as remnants. Insularisation is defined as the outcome or consequence of fragmentation. It is a process by which a remnant piece of habitat, cut off from its previous connection to a larger sphere of influence, becomes affected by local, nearby areas. Insularisation of near-urban park

ecosystems originates from the human activity nearby, which includes increased human use and access with associated disturbance of vegetation, wildlife and abiotic features, the creation of edge ecosystems and the entry of exotic plants. The primary effect of insularisation examined in this research is the establishment and invasion of ivy in parks near human habitat.

Despite the direct role people play in distributing invasive plants, there is a lack of emphasis within the biological literature on exotic plant invasion on land-use and human activities. The fragmentation of the sciences into human / social studies and biological / physical sciences has created a shortage of available models and methodologies for successfully combining the two fields (see Whitney 1994:3). By integrating physical and biological field data with land-use history and human activities, this research attempts to understand each in general terms and to discuss the influence of landscape fragmentation on exotic plant invasion.

3.7 Research Objectives

This research aims to illustrate how the characteristics of parks and their boundaries make parks resilient or vulnerable to the invasion of *Hedera helix*. By looking at land use and, in particular, residential areas directly outside park borders, the research permits the qualitative and quantitative characterisation of parks based on their fragmentation by urbanisation from surrounding natural habitat. In addition to describing the general distribution of *H. helix* in parks, the research will examine the general ecology and habitats of this species, including its relationship with host trees, towards a better understanding of its naturalisation in Greater Victoria. This information will be used to address the management of ivy in parks and, more broadly, to discuss the management of

invasive plants as they relate to protecting natural ecosystems. The study's specific objectives are, therefore, to:

- 1) Determine the extent of invasion by ivy in selected parks.

This initial work will provide an overall assessment of the invasiveness of ivy within the sample of parks as a whole, within each park and near the park boundary.

- 2) Identify landscape and habitat factors that may be associated with the invasion of ivy.

This involves a comparison of general habitat variables that characterise and distinguish invaded and non-invaded areas within parks.

- 3) Characterise the type and extent of fragmentation within the sample of parks.

This requires the development of a working definition and methodology for determining the insularity of the selected parks. The results will be analysed in relation to the overall assessment of invasion, as outlined in the first objective.

- 4) Examine the growth of *H. helix*.

This will provide insight into how quickly, in vegetative form, this species grows and spreads within parks. This work should also describe aspects of the arborescent growth of ivy in terms of its overall success strategy.

- 5) Make recommendations about the management of ivy in parks.

From what is known about the ecology of English ivy, several hypotheses may also be formulated. A main hypothesis is that ivy escapes into parks by penetrating park boundaries that have adjacent, long settled residential areas. Most of the species distribution should, therefore, be spatially related to human, residential land uses, specifically homes/properties. However, not all homes/properties will be sources of ivy, and of those that are, invasion of nearby parks is not a given. It is hypothesised that favourable habitat must exist within its range of dispersal and that by studying its spatial distribution, more will be learned about this mechanism.

When exotic plants invade a park following its establishment, plants or plant propagules may penetrate park borders, establish in the park boundary and spread further

into the park. Alternatively, they may "parachute" in from areas far beyond the park boundary, possibly by way of birds or wind. This research examines the extent to which the park boundary is the initial point of entry for ivy in parks. The implication is that a park's ecosystems will become more heavily invaded as its fragmentation and insularity increase, as its overall area decreases and as the edge adjacent to nearby human landscapes such as residential development increases.

3.8 The Study Area

Greater Victoria is interesting from the perspective of horticultural plant invasion because of its colonial and cultural history, its climate, its isolation on an island and its highly valued, remaining natural habitat. The mild, Mediterranean-type climate and long frost-free period distinguishes Victoria as Canada's garden city, while at the same time, the highly-valued nature parks and landscapes of south Vancouver Island illustrate the importance of protecting the region's natural environment.

Many of south Vancouver Island's original, natural landscapes were replaced by agricultural and residential areas only after the mid 1800s when wild lands used by aboriginal people were sold, traded, logged, farmed and developed (Francis et al. 1992). At that time, ornamental horticulture was a pursuit subordinate to agriculture, particularly for the ordinary settler. No evidence exists that an ornamental gardening industry was then widely popular¹⁰. However, Henry (1915) lists numerous exotic plants in his flora,

¹⁰ To illustrate, the Daily British Colonist newspaper (February 1894) advertises staple foods, farms, liquor, loans, mouth organs, tooth extraction, cocoa, tickets to San Francisco, cure-all 'pills' and ads for "Ferry's Seeds". By the 1920s, less essential items are advertised including fashion clothing, cigars, diet treatments, cosmetics, market stocks, chewing gum, dental parlours, movie pictures and car/lawn equipment. Advertisements for gardening equipment include garden hose, food seeds (swiss chard, beans and potatoes), fertilizers and gardeners wanting employment "gardens dug . . . fruit trees, roses and climbers properly pruned" (May 1920). Interestingly, there are no ads for horticultural plants, even in the spring.

many of which may have originated from estate or urban garden parks. Widespread dispersion of exotic plants followed as population expanded, prospered and, one can assume, the post-war period's domestic focus provided new marketing opportunities directed towards the suburban garden.

By 1972, Szczawinski and Harrison identified 1,024 plant taxa in Flora of the Saanich Peninsula, of which 691 were indigenous and 333, or approximately one third, were introduced. Importantly, some of the more common escapees like ivy, Himalayan blackberry (*Rubus discolor*) and holly (*Ilex aquifolium*) were not included in this estimate, although the authors stressed that there was widespread introduction of cultivated plants in gardens, agricultural fields and parks.

Greater Victoria is situated primarily within the coastal Douglas-fir Biogeoclimatic Zone, and the region's flora comprises many species unique within Canada.¹¹ A number of regional and municipal parks are more or less representative of the natural environment and the areas nearby them are representative also of the kinds of land-use changes that have occurred throughout Greater Victoria's settlement history. Just as Henry (1915) had earlier hypothesised, ivy has become a naturalised and common species throughout this region.

¹¹ Garry oak (*Quercus garryana*) is restricted to east Vancouver Island and small pockets in the south Fraser valley and grand fir is also restricted to southern B.C. Bigleaf maple (*Acer macrophyllum*) and arbutus (*Arbutus menziesii*) are found in B.C. only along the south coast mainland and Vancouver Island.

CHAPTER 4: METHODS

4.1 General Methodology

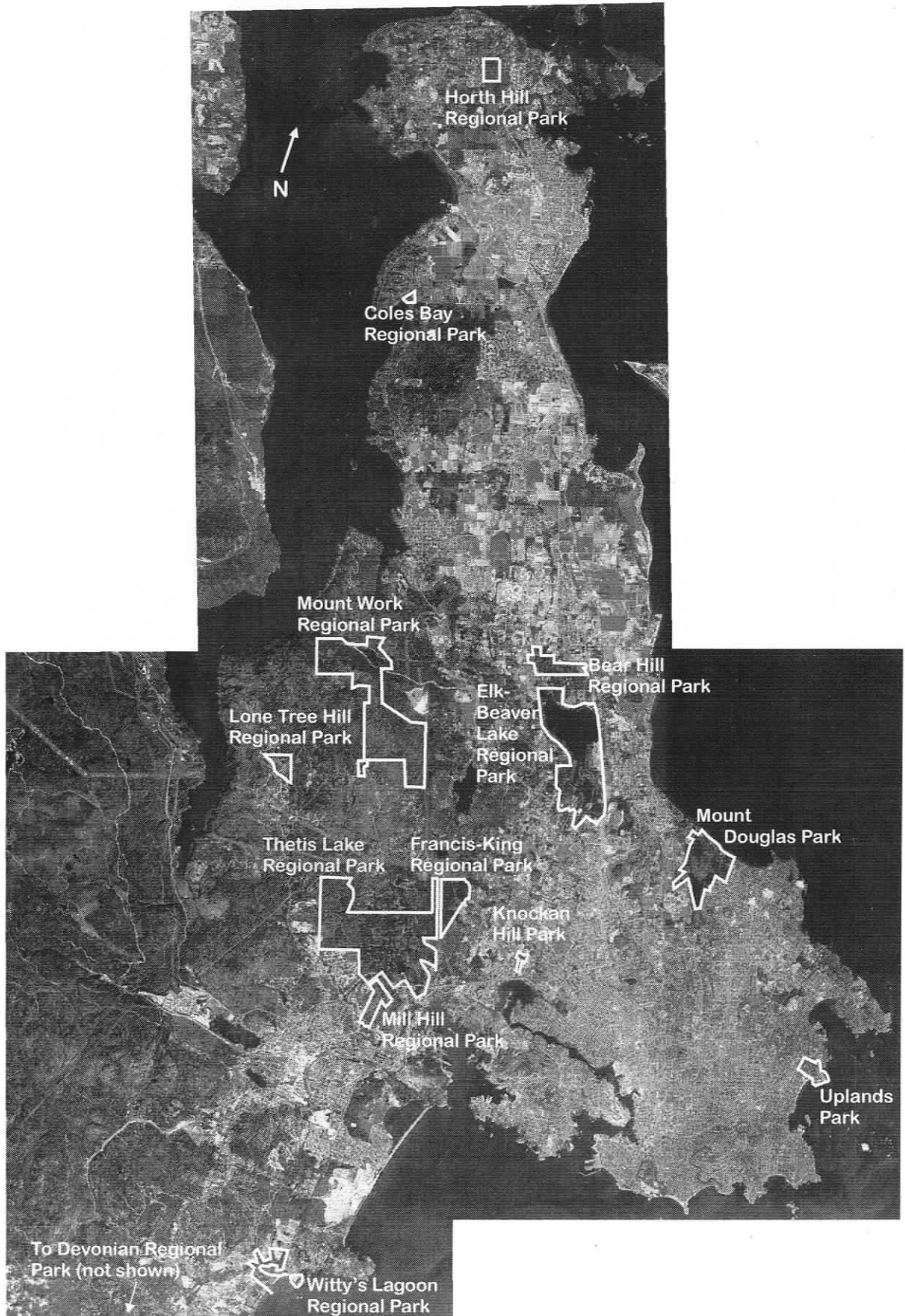
The overall design of this research is non-experimental, relying on descriptive, qualitative and quantitative data to meet the research objectives. The collection of primary data is essential to the research design due to the paucity of data sources on the invasiveness and ecology of ivy (*Hedera helix*) and on its status in Greater Victoria's parks. To study park fragmentation and invasion, sampling of near-urban parks requires areas invaded by ivy to be examined more closely and compared to areas that are not invaded. The methods used to select parks and examine their boundaries and overall fragmentation are explained in this chapter. The process by which the general habitat and vegetation were examined inside the parks' boundaries and how invaded and non-invaded sites were sampled and analysed is also explained.

4.2 Park Selection

Parks selected were limited to the municipalities of North Saanich, Saanich, Oak Bay, View Royal, Langford and the Metchosin and Highland Districts of Greater Victoria because of their overall urbanisation and range of land-use types. To characterise fragmentation and nearby land use, a variety of parks were needed that would differ by the degree to which each represented a "remnant" fragment of natural landscape. Parks also needed to differ by their degree of overall invasion by ivy and would also ideally contain a variety of major habitat and vegetation types.

To satisfy general sampling requirements, 11 regional Capital Regional District (CRD) Parks and three Municipal parks in the more urbanised municipalities were chosen for study (Figure 4.1). As well as representing several of the region's prominent protected areas, these parks have known histories, range in size and degree of invasion by ivy and have varying types of external adjacent land use and internal natural habitat. Francis-King, Thetis Lake and Mill Hill Regional Parks were selected because they form a prominent, larger park cluster in the region's centre. These parks contain a variety of habitats including riparian areas to hilltops, mixed western redcedar (*Thuja plicata*), grand fir (*Abies grandis*) and Douglas-fir (*Pseudotsuga menziesii*), arbutus (*Arbutus menziesii*) and Garry oak (*Quercus garryana*) communities. In the outlying and more agricultural District of Metchosin, Devonian and Witty's Lagoon Regional Parks were chosen for study. In North Saanich, Coles Bay and Horth Hill Regional Parks were examined. Uplands Park was chosen as a study area because it is the only large, major park within the more urbanised municipality of Oak Bay and contains significant Garry oak habitat. Mount Douglas and Knockan Hill Parks were selected because they are both Saanich Municipal Parks that contrast in size and are also invaded by ivy. Elk-Beaver Lake and Bear Hill Parks were included since they are both prominent CRD Parks within the Municipality of Saanich, are close to each other and yet have slightly different vegetation. Lastly, and to contrast the municipal and more "suburban" parks, Lone Tree Hill and Mount Work Regional Parks were briefly examined within the less-urbanised Highlands District. Overall, the number and type of parks were considered to be a fairly comprehensive representation of prominent parks in the study area.

Figure 4.1: Parks Selected in the Study Area



4.3 Analysis of Park Edge Types

To understand the characteristics of park boundaries, landscapes and land uses directly outside the terrestrial and non-terrestrial borders of each park were examined on air photographs, maps and through field reconnaissance. The types of external landscapes against the edges of a park represent boundary segments as viewed from inside the park (see Schonewald-Cox and Bayless 1986) and are referred to in this study as *park edge types*. Although gradients exist between the types of land use adjacent to parks, major categories are distinguished to assist in the characterisation of park edge types and understanding of park insularity (Table 4.1). Three major categories are distinguished: (1) residential areas; (2) roadways/accessways; and (3) semi-natural areas. Within each major category, sub-categories are defined in the following way (Table 4.1):

Table 4.1: Land-Use and Landscape Types for the Analysis of Park Edge Types

Major Categories	Sub-Categories			
1. Residential / Human	Higher-Density	Medium-Density	Lower-Density	Agricultural
2. Roadways / Accessways	Major Highways or Roadways	Roadways of / in Residential Areas	Footpaths	Roadways of / in Agricultural or Semi-Natural Areas
3. Semi-Natural / Natural	Very Low Density Residential / Vegetated	Vegetated / Forested, Vegetation is not cleared	Shoreline	

Three sub-categories of residential areas are distinguished based on the approximate sizes of lots found in the sample. Lot sizes of the higher residential density category (HDR) are identified as less than 1500 m², those of medium density (MDR) are defined as greater than or equal to 1500 m² and less than 2 ha, and those of low density (LDR) are defined as greater than or equal to 2 ha. Agricultural lands (e.g. cleared fields

or croplands) were identified as a special landscape type within the residential/human category, often coalescing into the lower density residential sub-category. Roadways are sub-categorised into major roadways or highways, residential roads (adjacent to either higher, medium, lower density residential areas or agricultural / semi natural areas as defined previously) and unpaved footpaths. Semi-natural areas are defined as those with limited human settlement and development and include sub-categories of non-cleared vegetated or forested areas, non-cleared vegetated areas with very low occurrence of housing, and shoreline/coastline (a non-terrestrial park edge type).

4.4 Overall Park Fragmentation / Insularity

As discussed in the previous chapter, Shafer (1990) and Forman (1995) define fragmentation as the isolation of a fragment of nature from other natural habitat. A small fragment of natural habitat is also viewed as being more insular than a larger fragment having similar isolation from other natural habitat and similar outside land use.

This study uses a park's size and edge types to characterise and define its fragmentation and overall insularity. The analysis of park edge types, measured from large-scale maps, consisted of determining the proportion of park perimeter comprising each land use and landscape category (i.e. the number and total length of distinct boundary segments). For reliability checking, comparisons between measurements made on large-scale maps at slightly different scales (e.g. 1:2500 versus 1:4500) were made and the results yielded little variability in overall proportions of park perimeter by land use. Parks were then ranked by size, by their perimeter (m) to area (m²) ratios, and in order of the proportion of their edges comprising more intense forms of human land use.

It was hypothesised that as a whole, insularisation by residential land use would render a park more exposed or vulnerable to invasion by ivy. Parks having relatively higher proportions of their perimeters / administrative boundaries next to dense residential land use were considered most insular and more likely to have their interior habitats transformed by invasive horticultural plants. A park's size, perimeter to area ratio and shape were also hypothesised to be influential factors explaining overall vulnerability to invasion.

4.5 Other Variables Outside Parks

Further insight into how the nature of residential land-use adjacent to parks may influence invasion of ivy was gained by, first, estimating the age of housing adjacent to parks and next, by an initial assessment of the presence of ivy in these areas. The age of residential areas was approximated by searching records in registries of Oak Bay, Metchosin and Saanich Municipalities and by searching other land records for North Saanich, as housing age data from this municipality was not readily available. Two limitations with these data should be noted: the possibility of incomplete records (especially for very old homes such as those built c.1900 or earlier) and records or dates that do not indicate if housing has been rebuilt on older, previously-established or demolished housing. Any given parcel of land may have had multiple layers of settlement and land use through time and it was not feasible in this research to undertake an in-depth historical study of settlement in each study region. However, the data gathered from municipal records were considered sufficiently accurate for newer subdivisions and for

discussion purposes. Older air photographs provided a brief historical glimpse into landscape-level land-use changes and human activities occurring since the 1950s.

The final outside-park variable consisted of an estimate of the number of properties adjacent to parks that may act as direct sources of introduction for ivy. Properties adjacent to park boundaries were surveyed from public lands on access routes (on foot and by vehicle). Information was recorded on the number and location of properties adjacent to parks where ivy was visible. Although the limitation with this type of data is that vegetation may be outside the observer's field of vision, general trends related to the popularity and distribution of the species were uncovered through this survey, particularly in easily accessed neighbourhoods with small or shallow lots. Most important, this information permits an exploration of the relationship between private unprotected and public protected lands. Since the park boundary is viewed in this research as a critical interface between human activities and protected areas, vegetation on both sides of the park border must be examined.

4.6 General Habitat and Vegetation Inside Park Boundary Zones

General habitat and dominant vegetation directly inside parks was described for the purposes of locating and characterising habitats where ivy had invaded and to assess the overall degree of invasion near different park edge types. A brief survey of general habitats and vegetation inside and parallel to park boundary zones (within 10 - 20 m of the park border) was conducted for each park.

4.7 Characterisation and Comparison of Areas Invaded and Not Invaded by Ivy

4.7.1 Invaded Areas and General Methodology

In addition to the reconnaissance-type evidence obtained from the qualitative habitat and vegetation descriptions, more information was collected on the specific characteristics of invaded and non-invaded areas that were identified during the vegetation reconnaissance and other park searches. Quadrats or plots were used as sampling units, based on the relevé method as developed by Braun-Blanquet and others following the European school of plant phytosociology (Daubenmire 1947, Braun-Blanquet 1965, Knapp 1984, Barbour et al. 1987, Kent and Coker 1992). A main object of vegetation sampling and description is to identify plant taxa and composition and to visualise and characterise associations of plants within larger communities:

Plant communities (syntaxa) are to be compared neither with crystals or chemical compounds, nor with organisms. They are, rather, more like organisations whose components are subject to changes in space and time, both in the number of their 'members' and the species that comprise them, and in their qualitative relationship. [. . .] The species (taxa), with their qualitatively fixed genetic equipment, form the actual building blocks of the plant communities. Through their quantitative and qualitative involvement, controlled by the reciprocal relationship between external (site) factors and the internal (sociological) influences, the existence and the character of individual plant communities are determined.

(Tüxen 1985:3)

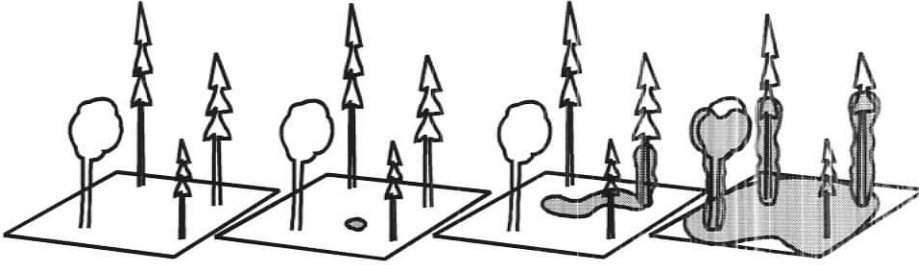
Whereas plant phytosociology is concerned with characterising vegetation over large areas, encompassing a wide spectrum of habitats and species, the focus of this research was more limited. The objective was to gain insight into ivy's favoured habitats and the plants that act as hosts for ivy commonly found in parks. To meet this objective, several invaded sites were selected and 10X10 m quadrats were used to record

information on general habitat and nearby vegetation. The data collection period was between September and November, 1997. While late in the year, this was a particularly warm and sunny fall in which local, dominant late summer vegetation remained quite vigorous into the winter months, associated with a strong El Niño influence.

Areas that were heavily invaded were the focus for sampling, although lesser-invaded areas were also examined. Heavily invaded areas are defined for this research as consisting of large carpets of ground-crawling ivy and/or areas where ivy is well established in reproductive form on trees, often into the canopy. Lightly invaded areas are characterised by small ivy shoots in juvenile form occupying less than 10% of a 10X10 m quadrat. Moderately invaded areas include larger distributions of ivy just beginning to climb trees.

Quadrats were centred upon heavily invaded areas or mature ivy "stands" (i.e. tree-climbing ivy) so as to include the larger ivy stems (>2 cm diameter but often much larger). Moderately and lightly invaded areas were also sampled with quadrats centred over them. In all, 41 quadrats were placed within invaded areas in eight parks (Table 4.2).

Table 4.2: Numbers of Plots Sampled in Each Park



Park	Non-Invaded	Lightly Invaded	Moderately Invaded	Heavily Invaded
Bear Hill Park	4 ✓			
Coles Bay Regional Park		2 (1 seedling)	2	2
Devonian Regional Park	2 ✓			
Elk-Beaver Lake Park	2		1	3
Francis-King Park	1	2 seedling		7
Horth Hill Regional Park	2 ✓			
Knockan Hill Park	2		3	3
Lone Tree Hill	2 ✓			
Mill Hill Regional Park	2 ✓			
Mount Douglas Park	3	1 seedling		5
Mount Work Regional Park	2 ✓			
Thetis Lake Regional Park	2	1 seedling		4
Uplands Park	2			6
Witty's Lagoon Regional Park	3		3	1
Sum	29	6	9	31

There were no other formal criteria for selecting invaded sites (e.g. attempting to represent particular community or vegetation types). Random or mixed “chance” samples were not attempted because they would have required a large number of already well-characterised invaded areas from which to choose. As well, invaded areas would have had to be sufficiently large to allow sampling from them. However, invaded sites often consisted only of small shoots or only filled a 10X10 m quadrat. The sampling strategy was therefore strategic and more qualitative, while measuring and data gathering within the plots was more quantitative.¹ The use of fixed-sized, 10X10 m quadrats permitted

¹ Grieg-Smith (1964) argued that a rigid focus on experimental sampling and quantitative design in plant ecology is usually only properly applied to problems after they have first been broadly grasped through a qualitative investigation.

standardised information to be collected and for plant communities to be identified and distinguished.

Within each quadrat, the following information was recorded:

1. Percentage cover of woody shrubs and other dominant vascular plants and ferns (following Pojar and McKinnon, 1994);
2. Percentage cover of ivy (as a ground cover but with vertical abundance noted);
3. Slope and aspect (directional orientation of slope);
4. Circumference of trees greater than 35 cm (approximately 11 cm diameter at breast height (DBH)) by species; the maximum height (in metres) attained by ivy (e.g. climbing shoots or crowns) noted either as juvenile or reproductive (if ready to flower, flowering or fruiting) and the diameter (cm) of the largest ivy vine on each tree;
5. Canopy closure in the centre of the quadrat with notes on exposure to light and wind;
6. Soil properties (qualitative assessment of the organic layer, thickness, colour and granularity of the surface, A and B layers, substrate, etc.);
7. Qualitative assessment of abiotic features such as rock outcrops, streams or other distinguishing features;
8. Other notes such as the amount of coarse woody debris, general location in relation to nearby human activity and land-use, visible human disturbance and surrounding vegetation.

Plant community structure can be expressed as trees (A layer), shrubs (B layer), herbs (C layer) and mosses (D layer). Plant cover may be estimated for each layer. Lianas such as ivy may not fit as neatly into the above four categories. Since ivy occurs both as a ground cover and in shrubs and trees, its percentage cover was based on "ground" cover only. Ivy's stem diameter and vertical abundance were noted separately. In this research, the vegetation layers examined were the shrub and herb layers, including ferns. Mosses, lichens, etc., although noted, were not included in the final analyses. All percentage covers were visually estimated.

Percentage cover estimates are often converted to cover classes or cover classes are used directly during data collection for expediency. This changes quantitative data into ordinal or ranked, qualitative data and reduces both the number and reliability of

statistical tests that may be performed on the data set. Another rationale for using ordinal cover classes is that estimates of plant cover are subjective and may vary between researchers, although there is consistency on the part of individual researchers estimating plant cover (Grieg-Smith 1964; Barbour et al. 1987). To equate plant-cover estimates with interval scale or cardinal level data is therefore not justified. In this study, percentage covers were converted to cover classes following Domin-Krajina's scale (Table 4.3) because this scale maintained a greater number of classes than others (e.g. scales of Braun-Blanquet and Daubenmire), particularly for plants with lower covers between 5 - 50%.

Table 4.3: Plant Cover Classes from Domin-Krajina (Barbour et al. 1987:186).

Cover Class	% Cover	Mean/Mid Point
10	100	100
9	75 - 99	87.0
8	50 - 75	62.5
7	33 - 50	41.5
6	25 - 33	29.0
5	10 - 25	17.5
4	5 - 10	7.5
3	1 - 5	2.5
2	<1	0.5
1	<<1	-
+	<<<1	-

In this study, only eight of the above 11 cover classes were used. There were no cases of highest cover class (100% cover) and the two lowest cover classes (+ and 1) were not used due to the difficulty in discerning between them in the field. Dominant plants were the focus of this study due to my unfamiliarity with rare or uncommon species and my desire to leave them untouched in the field. However, when an unfamiliar plant was

encountered, a best attempt was made to identify it in the field at least to the level of family. Notes and descriptions of the plant were made for later identification or, if robust enough, samples were collected and identified in the Herbarium at the University of Victoria. All primary references to plants made in this thesis are by common names, following Pojar and MacKinnon (1994), although Latin species names are provided at least once.

Canopy closure, in percent cover, was also visually estimated in the centre of plots. Aspect was noted for sloped areas. Tree circumference was measured and in analyses, the diameter of the summed circumferences of all trees in each plot (i.e. $\text{diameter} = \text{circumference} / \pi$) provides a secondary measure to simple tree density per 100 m^2 plot.

Descriptions of soils are qualitative. The darkest colour description 'very dark brown' denotes a soil that is almost black in visual appearance, while other descriptions note relative lightness and colour hue. The texture descriptions are also qualitative and relative to those found in areas examined with "clayish" soils being powdery, 'silty' soils slightly coarser and sandy soils coarsest. For the purposes of this research, 'loamy' soils refer to soil with slightly larger or mixed larger grains than silty soil.

4.7.2 Non-Invaded Areas

Non-invaded areas were sampled directly following the sampling of invaded areas between late November and February. A preliminary examination of invaded areas revealed that ivy was frequently found in Douglas-fir forests. It was rarely found in pure stands of western redcedar or in wet, red alder (*Alnus rubra*) groves. As a result, for better

comparison with the invaded habitats and to distinguish differences between them, Douglas-fir communities and areas containing Douglas-fir became the major focus for sampling non-invaded areas. As Uplands and Mount Work Parks did not contain significant Douglas-fir forest habitat, non-invaded quadrats located in these parks focused on Garry oak and grand fir habitat respectively. In all cases, locations were sampled with the intent of approximating and representing the nearby habitat without any preconceived personal "bias" (Barbour et al. 1987) and efforts were made to vary the position of quadrats within larger selected non-invaded stands so as to characterise them fairly. A total of 29 non-invaded quadrats were sampled in which information was recorded in the same way as it was in invaded plots.

During my searches for non-invaded areas of Douglas-fir, numerous sites initially considered non-invaded, upon close inspection, contained small newly germinating ivy sprouts or seedlings. Five of these areas were sampled to depict the types of habitats where ivy is beginning to spread. Within these seedling plots, the location and distance to nearest invaded areas, including flowering and seeding ivy, were also noted and information was recorded on the immediate and surrounding habitat of the sprouts. The locations of quadrats are described more fully in the next chapter alongside the general results from each park.

4.8 Discussion of Methodology

4.8.1 General Habitat and Dominant Vegetation inside Park Boundaries

At the outset of this research, the method thought best suited for mapping dominant vegetation and general habitat within park boundaries was that of a systematic

recording of dominant vegetation at fixed intervals along a line transect parallel to the park boundary. However, after increasing the number of parks examined, and reflecting upon the results of the line transect method, my approach to describing habitat and vegetation shifted to a more qualitative approach. Since each park is unique in terms of size, flora, habitats, proximity to human settlement and overall invasion, I also wished to compare alternative ways of gathering reconnaissance-level information along the park boundaries during the course of the research.

The quantitative approach involved recording dominant species at approximately 10 m intervals paced along boundaries. The strengths of this method are that bias is more easily avoided, considerable data are generated, species frequencies may be recorded and if percentage covers are also collected, the abundance of each dominant species may also be determined. However, the limits of this method relate to time requirements, scale of observation and the ability to capture the nuances in vegetation between sampling intervals. For small parks, decreasing the sampling interval seemed necessary, so as not to miss subtleties in landscape change. For larger parks, the systematic approach proved cumbersome and time consuming. I consequently modified the method by increasing the sampling interval and by recording more descriptive observations. This led me to the qualitative interpretation of landscape features and dominant plant associations.

The qualitative method involved recording vegetation where it seemed significant, altered or appropriate while moving along the park boundary transect. The information gathered therefore included both qualitative (field notes) and quantitative data (frequencies / abundance) of vegetation along transects. In the end, the descriptive, field notes were used as they enabled a more flexible and broad characterisation of each

section of park boundary and the quantitative data was written up into these descriptive notes (Appendix 1).

4.8.2 Influence of Human Activity

Ongoing human activity occurs in the park boundaries and parks. As a result, it is possible that park staff and/or local residents may have recently removed small amounts of ivy (e.g. small shoots), leaving no visible trace, in areas identified as not invaded. This research assumes human activity influences the results and observed patterns of park vegetation (e.g. the introduction of garden waste or species and removal of species), reinforcing the relationship between human activity and vegetation inside parks.

4.8.3 Quadrat Sampling and Comparisons between Invaded and Non-Invaded Areas

This research is based on the assumption that there is considerable variability between types of parks and land uses outside them, and between internal park habitat and the invaded and non-invaded areas within them. The overall diversity of the parks and the spatial and geographical variability within them makes absolute, scientifically “controlled” comparison challenging if not preclusive. The range of parks and observations are therefore intended to enrich a discussion of the potential and general influences and characteristics of parks and areas within them that are invaded by ivy.

CHAPTER 5: THE PARKS

Parks examined in this study differ in size, shape, habitat and proximity to nearby human activities. The current vegetation in each park, including the type, degree and location of exotic plant invasion, has been influenced by the park's natural history, history of establishment and ongoing changes in nearby land use. This chapter describes each park, providing a brief history of establishment and descriptions of general habitat, vegetation and invasion of English ivy in park boundary zones. The locations of areas selected for study that were invaded and not invaded by ivy are described in relation to outside land use. Observations and data within the quadrats specific to each park are incorporated into the discussion. Park descriptions end with an overall assessment of the amount, degree and location of invasion by ivy in each park.

A few points clarify information in this chapter. First, all brief park histories have been summarised with the help of information sources from the Capital Regional District Parks Department¹, Saanich Municipality, Metchosin Municipal Hall, Langford Fire Department, and documentation from the Friends of Mount Douglas Park Society and the Friends of Knockan Hill Park Society. All references to "large" trees indicate those equal to or greater than 35 cm in circumference (approximately 11 cm diameter at breast height). Finally, in table lists and descriptions, an * following a plant name denotes an introduced plant and a (*) denotes a possibly introduced plant.

¹ For example, information on land acquisitions and park sizes are from information/data sheets entitled "CRD Parks Facts:1994" and "CRD Parks Land Acquisition 1992 to 1997 (July)", received from the CRD Parks Planning Department.

5.1 Bear Hill and Elk-Beaver Lake Regional Parks²

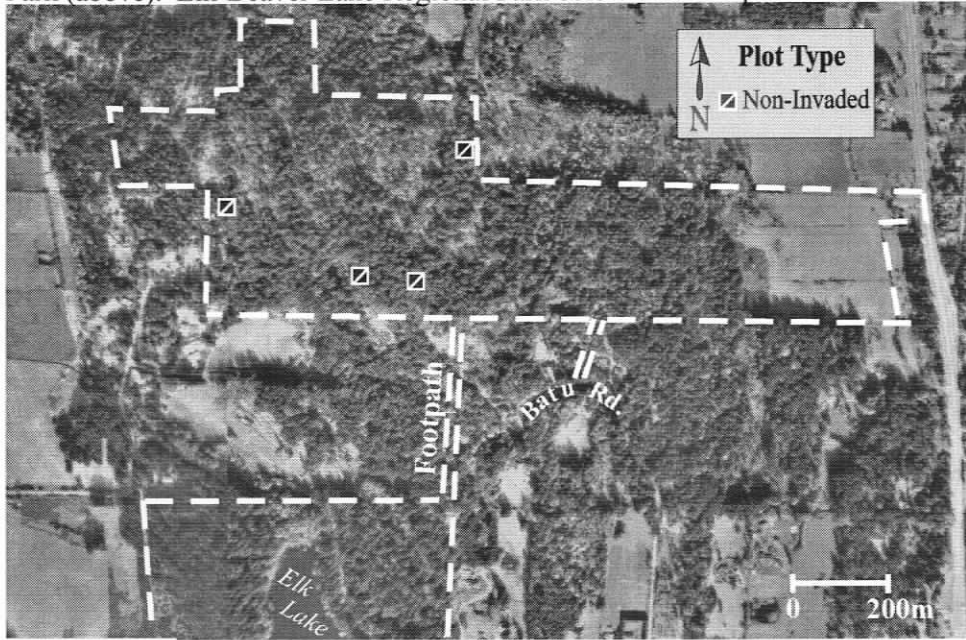
Bear Hill Regional Park is directly north of and connected by a thin corridor to Elk-Beaver Lake Regional Park (hereafter referred to as Bear Hill and Elk-Beaver Lake Parks). By 1955, both parks were clearly delineated by nearby agricultural and residential landscape (Figure 5.1). Today, Bear Hill Park is a rectangular, 48-hectare park, with two square parcels extending from both its west-north and northwest sides onto roads of medium density residential areas (Figure 5.1). The terrestrial component of Elk-Beaver Lake Park that encircles the now single body of water consists of small strips and pockets of vegetation, managed landscape and trails. The park is bound by highway and medium density residential areas to the east, roadway and residential areas to the north, and medium density and higher density, multi-complex residences to the south.

5.1.1 Dominant Vegetation and General Habitat of Park Boundaries

Habitat in all boundary zones of Bear Hill Park was fairly uniform. Douglas-fir dominated much of the lower elevations with arbutus (*Arbutus menziesii*) increasing in abundance at higher elevations and on steeper slopes and Garry oak frequent on hilltops and rock outcrops. From Batu Rd. clockwise around the park to Wakashan Place, four of the approximately 10 homes around the park have ivy in their yards. The homes directly

² The Saanich and Songhees used these lands historically. Following the signing of the treaty with James Douglas (on behalf of the Hudson's Bay Co.) in 1852, colonial farming and settlement became the dominant form of land use. Bear Hill Park has had numerous additions to its original size, including a near doubling of the park in 1993 (CRD Parks). Previous to recent additions and the eastward extension of the park to the Patricia Bay Highway, Bear Hill Park was square in shape and bounded to the east below Central Saanich Road. The earlier, square parcel of park on the west side has been the focus of my field observations. Elk Lake, Victoria's original water source in the early 1870s, was originally separate from Beaver Lake until Colquitz creek, south of Beaver Lake, was dammed. Elk-Lake Park was controlled by the City of Victoria and in 1966, both Elk-Beaver Lake and Bear Hill Park became CRD Parks. The 411-hectare Elk-Beaver Lake Park contains one of the larger freshwater recreation areas in the region.

Figure 5.1: Approximate Sampling Locations and Park Boundaries at Bear Hill Regional Park (above). Elk-Beaver Lake Regional Park below with footpath corridor between.



1955 View of Bear Hill and Elk-Beaver Lake Regional Parks



adjacent to Bear Hill Rd. and the south of Bear Hill Park date to the 1960s and 1980s and those north of the park date to the late 1980s with ongoing current construction of new homes.

Habitat in boundary zones of Elk-Beaver Lake Park varies greatly on both the east and west sides of the lakes and between the northern and southern limits of the park (Appendix 1). At least eight homes along the north boundary of Elk-Beaver Lake Park between the western boundary and the Bear Hill corridor have ivy in their yards and woods in this part of the park are heavily invaded. Woods on the eastern side of this boundary are moderately invaded throughout the thin strip toward the larger parcel on the northern tip of Elk Lake and lightly invaded toward the western end near the boat launch. Western redcedar increases in frequency toward the western end of the park and ivy here creeps along the ground in juvenile form sparsely among the other flora (Appendix 1).

5.1.2 Invaded Park Boundaries

No ivy was found in any of the boundary areas or interior parts of Bear Hill Park (Table 5.1). At lower elevation in the centre of the linear corridor that links Bear Hill Park to Brookleigh Rd. and Elk-Beaver Lake Park, small patches of juvenile ivy were found sparsely over the ground and climbing up fence posts and trees. Evidence from subsequent visits to this area suggests also that ivy is being cut and cleared here. In contrast, ivy is common to abundant in most boundary zones of Elk-Beaver Lake Park (Table 5.2).

Along the north boundary of Elk-Beaver Lake Park, Douglas-fir forest is the most heavily invaded, although ivy is found also on other host plants and in other habitats. For

instance, an arbutus tree growing with western redcedar close to the lake's shore along the north boundary, is climbed by abundant reproductive-form ivy with mature (5.8 cm diameter) stems.

The primarily cedar forest of the southeast boundary of Elk-Beaver Lake has sporadic invasion with ivy growing in open wet areas with large patches of vanilla leaf (*Achlys triphylla*) in clay soil under stands of Douglas-fir. The narrow, eastern, terrestrial part of Elk-Beaver Lake Park contains greater numbers of deciduous trees and sporadic ivy invasion; large, mature stems with flowering ivy grow on individual trees near and outside this part of the park border.

Table 5.1: Summary of Park Boundary Characteristics and Invasion: Bear Hill Regional Park

Park edge	Adjacent land use (category)	Dominant vegetation and general habitat	Invasion in boundary (heavy, medium, light, none) and location
North	Unbuffered residential (density = medium).	Douglas-fir with arbutus increasing on rocky slopes; oceanspray (<i>Holodiscus discolor</i>), Oregon grape (<i>Mahonia nervosa</i>) dominant understory plants.	None.
East	Buffered residential (density = medium).		None.
South	Unbuffered residential (density = light) Unbuffered residential on both sides of thin corridor/footpath to Brookleigh Rd and Elk-Beaver Lake Park.		None in main park parcel. Medium to light in centre and south portion of corridor with evidence of cutting/removal.
West	Unbuffered residential (light to medium density) and unbuffered roads of residential areas.		None.

Table 5.2: Summary of Park Boundary Characteristics and Invasion: Elk-Beaver Lake Regional Park

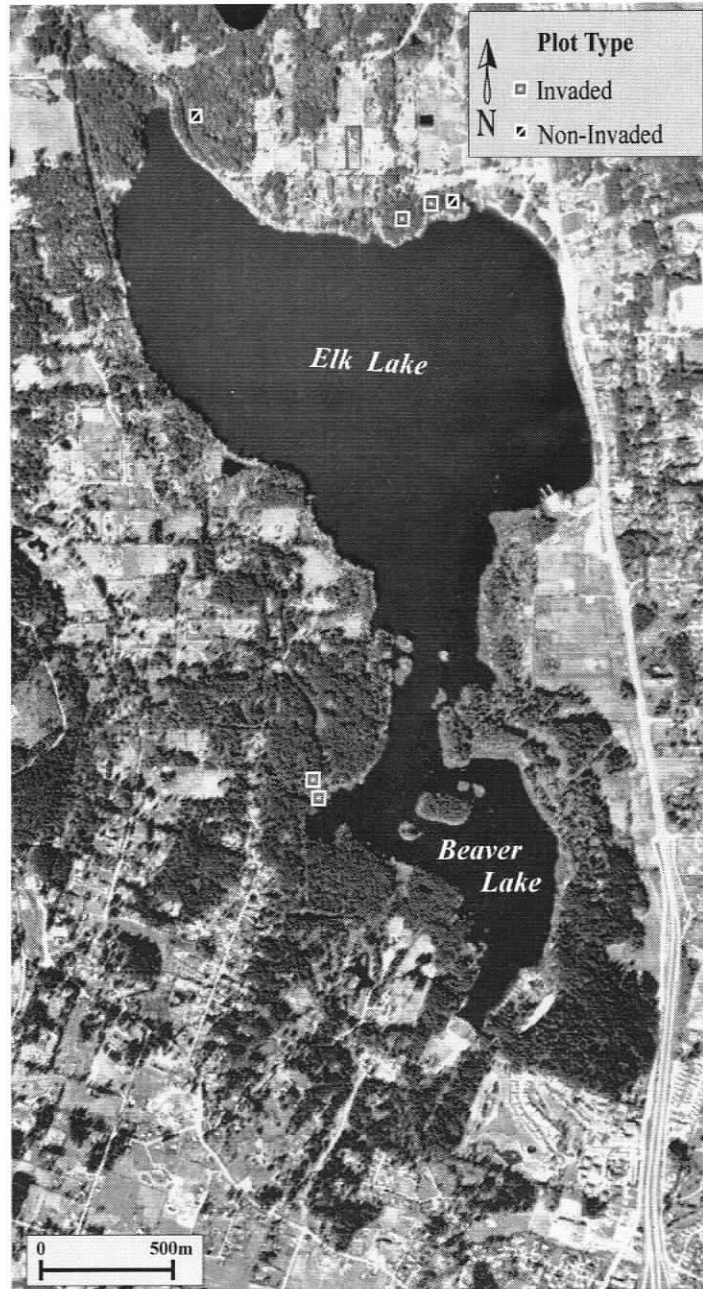
Park edge	Adjacent land use (category) and housing age range	Dominant vegetation and general habitat	Invasion in boundary (heavy, medium, light, none) and location
North	Unbuffered residential (density = medium) and residential roads. 1930s – present; most 1950s and 1970s.	East: managed lawn, Douglas-fir, grand fir (<i>Abies grandis</i>) and arbutus forest with pockets of redcedar. Central part heavily invaded. West: western redcedar with red huckleberry, salal (<i>Gaultheria shallon</i>), occasional Douglas-fir and Oregon grape.	Heavy in eastern forest and central part of the boundary. Heavy in woods directly west of both parking areas. Sparse in cedar woods near the northwest parking lot/boat launch. Stems greater than 5 cm in diameter.
East	Highway and Elk Lake Dr.; 1910s and 1990s near Forest Hill, 1950s, '60s where ivy is abundant also '70s, '80s: ages are very mixed.	Fir and mixed shrubs within mowed lawn. South = Mixed Douglas-fir and western redcedar.	North: Medium/heavy in fir with unmanaged / uncleared understory Central: Heavy/medium South: Medium. Light to none under cedar.
South	Unbuffered residential (density = medium – heavy) and roadways Most 1960s some 1950s.	Mixed fir and western redcedar, oceanspray, salal, twinflower and Oregon grape dominant in understories.	None on east side. Heavy to medium on west side.
West	Unbuffered (low density) residential.	South = Douglas-fir woodland. Central (from Beaver Lake narrows to Elk Lake paths) = deciduous tree species.	Heavy at Pond/Beaver Lake Rd. Light and None northward to Linnet Ln. Sporadic along Elk Lake shoreline, heavy at break in park and along park border. Ivy stems at least 2 cm in diameter.

5.1.3 Characteristics of Invaded Areas

The 43 live and dead trees greater than 35 cm in circumference within invaded plots sampled at Elk-Beaver Lake Park included 31 Douglas-fir, six bigleaf maples (*Acer macrophyllum*) and six grand fir (Figure 5.2). Twenty-five of these trees were climbed by juvenile ivy, of which five were bigleaf maples and four were grand fir. All eight trees that hosted reproductive ivy and stems greater than 2 cm in diameter were Douglas-fir.

Canopy cover ranged between 65- 85% and soils were dark brown to brown and clayish in texture. Besides ivy and Douglas-fir, all invaded plots contained Oregon grape and trailing blackberry (*Rubus ursinus*) and most (3/4) contained salal,

Figure 5.2: Sampling Locations, Elk-Beaver Lake Regional Park



snowberry (*Symphoricarpos albus*) and holly* (*Ilex aquifolium*). In the most lightly invaded plot, ivy comprised approximately 8% of the ground cover and within it, plants not found in other invaded plots included twinflower (*Linnaea borealis*), red huckleberry, hairy honeysuckle (*Lonicera hispidula*) and broad-leaved starflower (*Trientalis latifolia*). In all other invaded plots from Elk-Beaver Lake, ivy cover ranged between 25 – 70%.

5.1.4 Characteristics of Non-Invaded Areas

Habitat characteristics of the four non-invaded plots sampled at Bear Hill Park include canopy closures of 55-85% and soils with one or two cm of organic material and very thin dark brown crumbly A horizons on rocky substrates. All areas were moderately sloped and composed nearly exclusively of Douglas-fir, with western redcedar saplings found in several plots. The most steeply sloped plot contained large stemmed arbutus, red huckleberry and daphne-laurel* (*Daphne laureola*) (Table 5.3).

Non-invaded Douglas-fir habitat in the woodland along the north boundary of Elk Lake was difficult to find. Two non-invaded locations that were sampled had canopy closures of 70% and 90% and soils (A horizon) that were brown to dark brown and silty in texture. Plants found in invaded and non-invaded plots are summarised in Table 5.3 below.

Table 5.3: Plants in Non-Invaded Plots: Bear Hill Regional Park

Found in 4/4 non-invaded plots	Found in 2-3/4 of the non-invaded plots	Found in 1/4 of the non-invaded plots
<ul style="list-style-type: none"> ◆ Douglas-fir ◆ oceanspray ◆ trailing blackberry ◆ Oregon grape ◆ hairy honeysuckle ◆ licorice fern (<i>Polypodium glycyrrhiza</i>) ◆ grasses/Poaceae^(*) 	<ul style="list-style-type: none"> ◆ western redcedar ◆ sweet-scented bedstraw (<i>Galium triflorum</i>) ◆ rattlesnake plantain (<i>Goodyera oblongifolia</i>) ◆ salal ◆ snowberry ◆ broad-leaved starflower ◆ bracken fern (<i>Pteridium aquilinum</i>) ◆ sword fern (<i>Polystichum munitum</i>) 	<ul style="list-style-type: none"> ◆ bigleaf maple ◆ red huckleberry ◆ wild strawberry (<i>Fragaria virginiana</i>) ◆ daphne-laurel* (<i>Daphne laureola</i>) ◆ Himalayan blackberry* (<i>Rubus discolor</i>) ◆ twinflower ◆ mock-orange (<i>Philadelphus lewisii</i>)

Table 5.4: Plants in Invaded and Non-Invaded Plots: Elk-Beaver Lake Regional Park

Found in $\geq 2/4$ of the invaded plots	Found in 1/4 of the invaded plots	Found in 2/2 non-invaded plots	Found in 1/2 of the non-invaded plots
<ul style="list-style-type: none"> ◆ bigleaf maple ◆ Indian plum (<i>Oemleria cerasiformis</i>) ◆ snowberry ◆ grand fir ◆ salal ◆ oceanspray ◆ sword fern 	<ul style="list-style-type: none"> ◆ red huckleberry ◆ helleborine* (<i>Epipactis helleborine</i>) ◆ broad-leaved starflower ◆ Nootka rose (<i>Rosa nutkana</i>) ◆ rose (<i>Rosa</i> sp.) ◆ licorice fern ◆ twinflower ◆ hairy honeysuckle 	<ul style="list-style-type: none"> ◆ Douglas-fir ◆ grand fir ◆ oceanspray ◆ salal ◆ Oregon grape ◆ trailing blackberry ◆ grasses^(*) 	<ul style="list-style-type: none"> ◆ bigleaf maple ◆ holly* ◆ Himalayan blackberry* ◆ red huckleberry ◆ snowberry ◆ western trumpet honeysuckle (<i>Lonicera ciliosa</i>) ◆ broad-leaved starflower ◆ wall lettuce* (<i>Lactuca muralis</i>) ◆ licorice fern ◆ bracken fern ◆ sword fern

5.1.5 Overall Invasion

Many of Elk-Beaver Lake Park's Douglas-fir ecosystems are heavily invaded by ivy, while those of Bear Hill Park remain non-invaded. Abiotic features such as slope, aspect, elevation and soil are the principal differences between Douglas-fir ecosystems in each park. Woodlands of Elk-Beaver Lake Park that are less invaded occur, in general, north of housing along the southwest boundary near Beaver Lake and in areas predominated by western redcedar. The non-invaded Douglas-fir habitat at Bear Hill Park occurs with arbutus on slopes and at higher elevation. Some of the narrowest

terrestrial strips of park at Elk-Beaver Lake Park that are forested and sandwiched between water and nearby residential activity are very open, receiving considerable light, and are also heavily invaded by ivy (e.g. the central west boundary and north central boundary). Land use and human activities adjacent to each park also vary. Records indicate homes adjacent Bear Hill Park are younger than those at Elk-Beaver Lake Park, although homes around both parks have ivy growing in their yards. Comparisons between these parks suggest that while there are direct sources of ivy near Bear Hill, its thin soil and exposed upland Douglas-fir habitats may preclude invasion altogether.

5.2 Coles Bay Regional Park³

Coles Bay Park is a small, four-hectare, triangular-shaped park, centred on the banks and surrounding woodlands of a small creek that flows into Coles Bay on the Saanich Inlet. The park has four principal types of adjacent land use, defined as park edge types in the previous chapter. These park edge types include shoreline to the west; unbuffered, medium density residences on the northwest; an unbuffered lower density residential area to the south; and a paved roadway adjacent to a residential area along the east side of the park. The three terrestrial edges are linear, human-generated and human maintained.

The point sources of introduced ivy, and possibly other ornamental plants, are hypothesised to correspond to the residential areas adjacent to the park, particularly those

³ The area surrounding Coles Bay Park was previously agricultural, belonging to a larger farm in the early part of the century. In April of 1914 the original farm was subdivided into numerous lots, one of which became established in 1966 by the Capital Regional District as Coles Bay Regional Park. The appearance of most houses around the park would suggest that they might have become established around the same time as the park. Air photographs from the 1950s reveal that agriculture was the predominant adjacent land use and that the southeast corner of the park was cleared of vegetation (Figure 5.3).

unbuffered by roads or other physical features. Reproductive (flowering or fruiting) ivy was found at four of the total of nine residences along the unbuffered north and south park borders, while no ivy was visible on any of the seven residences on the eastern boundary that is buffered from the park by a paved residential road.

5.2.1 Dominant Vegetation and General Habitat of Park Boundaries

Currently, the general habitat and dominant vegetation within the park's boundaries is primarily mixed woodland and managed lawn. Along the north, the boundary consists of open Douglas-fir and shrubs closer to the shoreline and a thickening forest of trembling aspen (*Populus tremuloides*) and redcedar (*Thuja plicata*) nearer the east corner. Along the east park boundary, cedar and mixed unidentified fir occur on the northern tip of the park and trembling aspen increases in abundance further south to the parking area. The parking area is predominantly lawn with rows of Douglas-fir, Himalayan blackberry*, Scotch broom* (*Cytisus scoparius*) and planted cedars parallel to and along the outside border of the park. At the southeast corner of the park where vegetation was cleared during the 1950s, wide mats of Himalayan blackberry* now grow on lawn. Much of the southern boundary consists of a gravel roadway lined on each side with a row of fir and deciduous trees. Further inside the park past this strip of trees, much of the eastern and middle part of the park boundary consists of a large mowed lawn, a great amount of which is covered with large mats of Himalayan blackberry* and young, neatly planted ornamental cedars(*). Nearer the shoreline, east of a turn in the gravel road and the picnic area, there is an area of woodland with larger Douglas-fir, cedar and an occasional arbutus tree. Bracken fern (*Pteridium aquilinum*), daphne-laurel* and assorted

grasses^(*) are common understory plants in this woodland. The shoreline boundary is small, consisting of a small shrub zone, which turns into woodland further back from the beach.

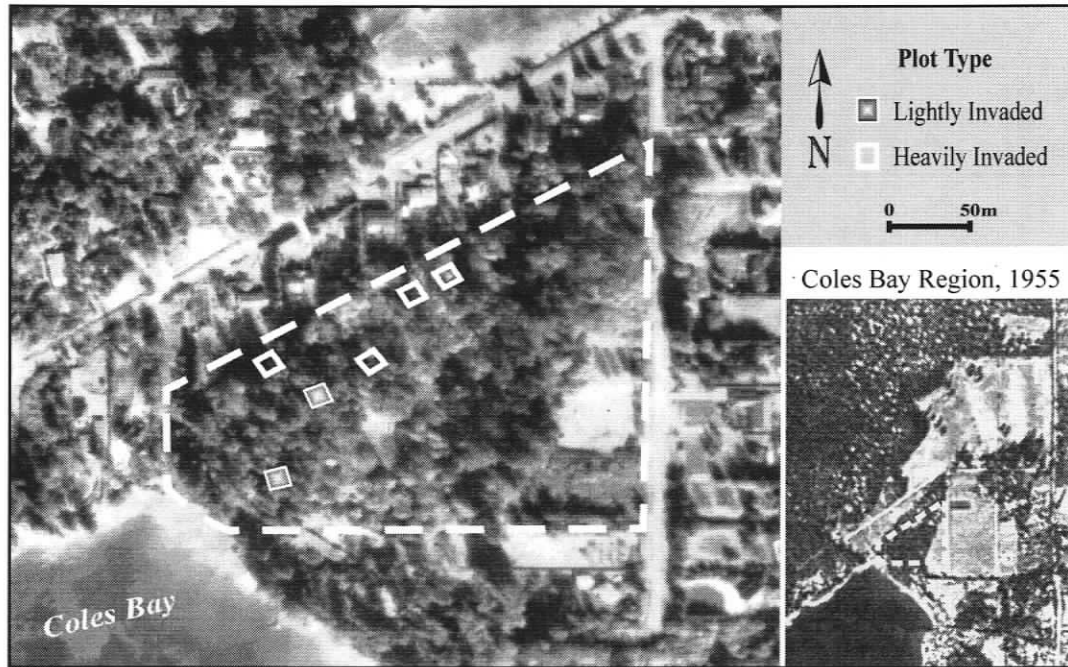
5.2.2 Invaded Park Boundaries

Heavy distributions of ivy are currently found along the north boundary and the western end of the south boundary, in the woodland nearer the shoreline. Ivy is not established along other boundaries, which include the east roadway boundary and the eastern portion of the south boundary. Ivy decreases in abundance as one moves toward the small length of shoreline, which is close to the two most heavily invaded parts of the park and the most heavily invaded boundaries. The habitat and abiotic environment directly in front of the shoreline (e.g. coastal plants and shrubs, ocean mist and the mouth of the creek) likely also account for the limited invasion along this boundary. The relationship between land use, points of introduction, habitat and invasion are summarised below in Table 5.5.

5.2.3 Characteristics of Invaded Areas

In addition to the above general description of invaded park boundaries, four plots were set in heavily invaded areas (Figure 5.3). Canopies ranged from 5-65% closed and soil in all plots was dark brown and clayish in texture. Ivy cover in plots ranged from 10-40%. Ivy climbed 15 trees of the 23 over 40 cm in diameter present in the plots. Ivy stems grew to a maximum diameter of 4 cm on Douglas-fir and attained diameters greater than 1 cm also on grand fir and black cottonwood. Trees found in plots by percentage

Figure 5.3: Coles Bay Regional Park: Approximate Boundaries and Sampling Locations



frequency included bigleaf maple (30%), grand fir and Douglas-fir (22% each), western redcedar (17%), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*; 4%) and red alder (*Alnus rubra*; 4%). Bigleaf maple, Douglas-fir and grand fir were climbed by both juvenile and reproductive ivy, while western redcedar and black cottonwood were climbed only by juvenile ivy.

Table 5.5: Summary of Park Boundary Characteristics and Invasion: Coles Bay Park

Park edge	Adjacent land use (category)	Dominant vegetation and general habitat	Invasion in boundary (heavy, medium, light, none) and location
North	Unbuffered residential (density = medium)	Open shrub, Douglas-fir, windthrow and cedar.	Heavy east of shoreline and center of boundary. None in east corner.
East	Buffered residential (density = medium)	Mixed cedar and fir (Douglas-fir and grand fir), trembling aspen, mowed lawn, Himalayan blackberry*.	None.
South	Unbuffered residential (density = light)	Fir (unidentified), mowed lawn, Himalayan blackberry* on east side. Mixed fir, cedar, arbutus woodland on west side.	None on east side. Heavy to medium on west side.
West	Shoreline	Shrubs such as snowberry behind beach.	Light to none.

5.2.4 Characteristics of Less Invaded Areas

No non-invaded, predominantly Douglas-fir habitat with developed understory vegetation was found in the park. Two slightly invaded areas were examined that contained mixed fir and were close to invaded areas (Figure 5.3). One of these areas was characteristic of the park's streambank habitat. The other was characteristic of the mixed deciduous Douglas-fir woodland in the park's southwest corner. Ivy comprised 2% or less of the ground cover in these two plots, consisting primarily of small shoots or recently germinated sprouts. Canopy closure was slight (15% in the stream-bank plot and 5% in the corner woodland plot which contained numerous deciduous trees beginning to drop leaves). Soil was similar but slightly finer in texture than more heavily invaded

plots, with almost no organic or “H” layer and a yellowish B horizon 5-10 cm below the surface. The streambank area contained two species of mustard not found in plots of heavily invaded areas and the woodland area also contained daphne-laurel* and cyclamen* (*Cyclamen persicum*). A greater variety of plants was found in the two less invaded plots than in the four heavily invaded plots (Table 5.6).

Table 5.6: Plants (not including trees) in Plots: Coles Bay Park

Found in 4/4 heavily invaded plots	Found in 2/2 lightly invaded plots	Found in both plot types
<ul style="list-style-type: none"> ◆ common dandelion* (<i>Taraxacum officinale</i>) ◆ Indian plum ◆ salmonberry (<i>Rubus spectabilis</i>) ◆ false lily of the valley (<i>Maianthemum dilatatum</i>) ◆ Siberian miner's lettuce (<i>Claytonia sibirica</i>) ◆ Cooley's hedge nettle (<i>Stachys cooleyae</i>) ◆ stinging nettle (<i>Urtica dioica</i>) ◆ false Solomon's-seal (<i>Smilacina racemosa</i>) 	<ul style="list-style-type: none"> ◆ oceanspray ◆ red huckleberry (<i>Vaccinium parvifolium</i>) ◆ daphne-laurel* ◆ hairy honeysuckle ◆ sweet-scented bedstraw ◆ Himalayan blackberry* ◆ salal ◆ broad-leaved starflower ◆ cyclamen* ◆ rattlesnake plantain (<i>Goodyera oblongifolia</i>) ◆ falsebox (<i>Pachistima myrsinites</i>) ◆ unidentified small rose (likely <i>R. gymnocarpa</i>) ◆ saskatoon (<i>Amelanchier alnifolia</i>) ◆ red elderberry (<i>Sambucus racemosa</i>) ◆ unidentified carrot^(*) (Apiaceae) ◆ western bittercress (<i>Cardamine occidentalis</i>) ◆ two species of unidentified mustard^(*) (Brassicaceae) 	<ul style="list-style-type: none"> ◆ ivy* ◆ snowberry ◆ trailing blackberry ◆ sword fern ◆ Oregon grape ◆ bracken fern ◆ holly* ◆ cascara (<i>Rhamnus purshiana</i>) ◆ wall lettuce* (<i>Lactuca muralis</i>) ◆ western dock (<i>Rumex occidentalis</i>) ◆ grasses/Poaceae^(*) ◆ Pacific water parsley (<i>Oenanthe sarmentosa</i>)

5.2.5 Overall Invasion

The interior of Coles Bay Park was not heavily invaded by ivy. In areas where woodland is not the predominant vegetation, one finds large areas of lawn near picnic and parking areas, steep, mucky streambanks and nearby muddy flats and trembling aspen groves where ivy is absent or very sparse. Mixed cedar and fir woodland is most heavily invaded by ivy and these habitats are also found against the unbuffered residential areas

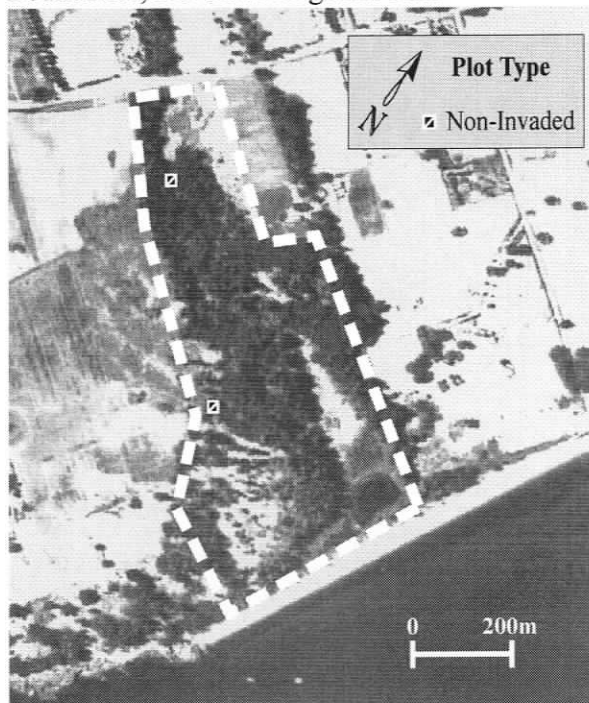
north and south of the park. The overall distribution of ivy in this park would support the hypothesis that invaded park boundaries are spatially related to adjacent residential development and to favourable habitat. However, the habitat most suitable for invasion is also adjacent to the housing.

5.3 Devonian Regional Park⁴

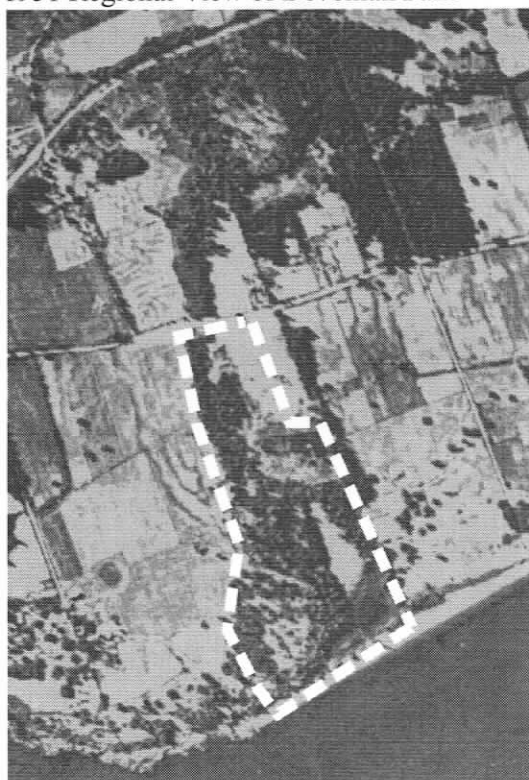
This rectangular park with its entranceway and frontage on Metchosin Rd. is surrounded by medium to low density residential and agricultural land that has not changed considerably over the last half century (Figure 5.4). The park's entranceway and parking areas are mowed regularly into a field of mixed grasses^(*) and the nearest point of introduction for ivy is directly against the park across Metchosin Rd., where ivy grows high and flowers. Despite this, ivy is not found within any of the park boundary areas. Only one shoot of juvenile ivy was found approximately 100 m in from Metchosin Rd. and in the centre to southwest portion of the park, located near the entrance of the park near an intersection of paths in an area of heavier foot traffic. Except for this one shoot in this particular location, no other ivy was found at Devonian Park. Subsequent searches of the park (i.e. approximately three months later) revealed that this ivy had been removed. Habitat factors for low invasion are developed below.

⁴ The Ka-Kyaaken (of the Coast Salish) people used the lands now designated as Devonian Park until 1850, when the Hudson Bay Company appropriated lands that form much of today's Municipality of Metchosin. A Scottish settler named John McGregor purchased the land around Devonian Park and sold it in 1865 to a Nordic traveler named Hans Hegelson. The Hegelson family owned the property, known as Sherwood farm, for 115 years. In 1980, the Devonian Foundation and the Provincial government purchased 11.3 ha and designated the lands as a CRD Park. Since then, an additional 2.2 ha were purchased and added to the park in 1983.

Figure 5.4: Approximate Sampling Locations and Boundaries, Devonian Regional Park



1951 Regional View of Devonian Park



Two non-invaded areas located on the northwest (roadway) boundary and southwest boundary were examined. The northwest plot, approximately 70 m from the road in forest behind the cleared mowed parking area, contained two very large Douglas-fir and five grand fir forming a 95% closed canopy, a sparse mid stratum consisting of two small oceanspray shrubs and an assortment of understory plants (Table 5.7). The southwest area, approximately 300 m from the road, was characteristic of the vegetation within this boundary having a 90% closed canopy with a large Douglas-fir and five large stemmed grand fir, no mid stratum and only sparse ground cover. Both areas had light brown compacted clay soil and each was on a different slope of the ravine.

Apart from their slopes and pale coloured clay soils, there appeared to be nothing exceptionally different between the areas not invaded by ivy and the small area where ivy was found, besides location and overall disturbance (e.g. foot traffic). Situated in the front of the park, the small area where ivy occurred was closest to the only nearby residential area where ivy was visible. Agricultural and shoreline park boundaries were not invaded, supporting the hypothesis that invaded areas correspond at a landscape scale to nearby areas of introduction. The evidence from this park illustrates the human influence, associated with disturbance, on observed patterns of invasion. People are attempting to prevent the spread of ivy deeper into the park.

Table 5.7: Plants in Non-Invaded Plots: Devonian Regional Park

Found in 2/2 non-invaded plots	Other plants found in north plot	Other plants found in west plot
<ul style="list-style-type: none"> ◆ large stemmed grand fir and seedlings ◆ Douglas-fir ◆ trailing blackberry ◆ grasses^(*) ◆ wall lettuce* 	<ul style="list-style-type: none"> ◆ Garry oak seedlings ◆ mountain-ash^(*) seedling (likely <i>Sorbus aucuparia</i>) ◆ oceanspray ◆ vetch ◆ snowberry ◆ Himalayan blackberry* ◆ unidentified <i>Rubus</i> sp. ◆ broad-leaved starflower ◆ bracken fern ◆ Nootka rose 	<ul style="list-style-type: none"> ◆ pathfinder (<i>Adenocaulon bicolor</i>) ◆ baldhip rose (<i>Rosa gymnocarpa</i>) ◆ sword fern

5.4 Francis-King Regional Park⁵

The park is triangular in shape with residential and agricultural areas on its southeast-facing side (its hypotenuse) and its shorter north facing border. The park is situated in a light farming and residential region that has been long established. Although some of the original and very early homes are probably not recorded in the municipal records searched, current records suggest that residences along Prospect Lake Rd. date from the turn of the century and 1910s to the 1940s and 1950s. As records and the history of the Francis lands illustrate, many newer homes have replaced or been rebuilt

⁵ Francis-King Regional Park is one of the larger parks in Greater Victoria and is directly northeast of Thetis Lake Regional Park. The Saanich people used the lands of today's Francis-King Park, until the arrival of permanent colonists and the Hudson's Bay Company. In the 1840s, James Nathan Thomas purchased the lands and his family's original home was built across the road from where the nature house is currently situated. In the late 1900s, a newer home was built near the nature house and James' son, Thomas, continued to live there. Thomas Francis donated his family's farm to the government of British Columbia in 1960 for its protection and preservation. Mr. Francis' house was destroyed by fire and rebuilt, although he lived there only briefly, dying in 1961. Thereafter, the province's Parks Branch administered the property as a nature sanctuary (Class C Provincial Park), controlled by a local board and chaired by Freeman King, a Victoria naturalist. In 1967 it was transferred to the Victoria Natural History Society for management and a year later, an additional, contiguous 50 acres were secured and called Freeman King Park. Both parks became established as CRD Parks in 1981. An additional 21.8 hectares of land were transferred from B.C. Hydro in 1993, forming approximately 113 ha of protected parkland.

upon older homes. All housing against the park occurs along its northeast border and ivy was visible on about 10% of these properties.

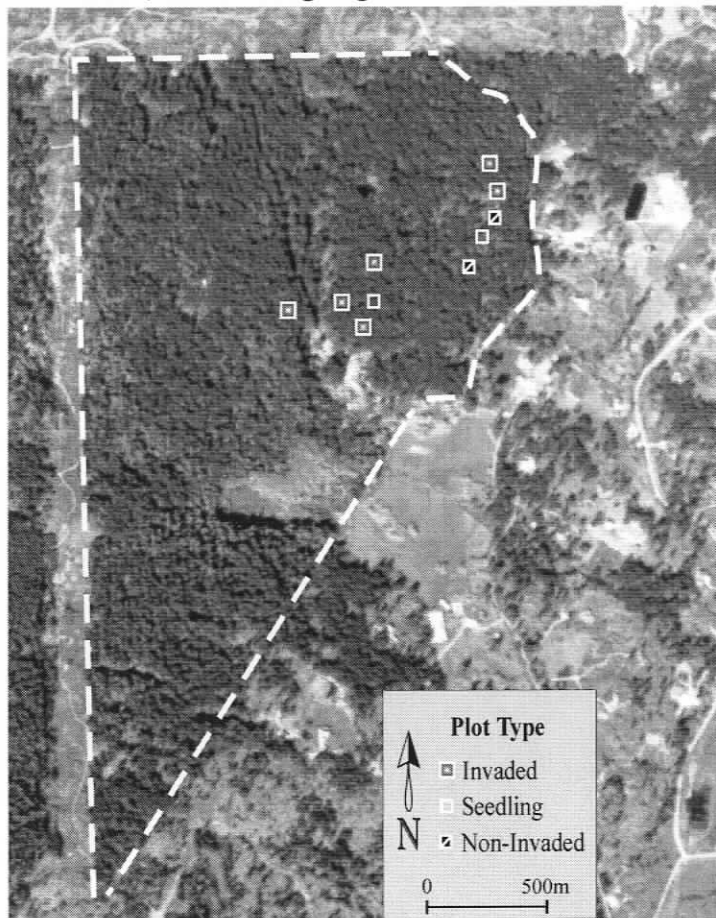
5.4.1 Dominant Vegetation, General Habitat and Invasion of Park Boundaries

The long, linear western boundary is managed for hydro lines, meaning that trees have been cleared and Scotch broom* and mixed shrubs are the dominant plants. A single lane roadway (Prospect Lake Rd.) adjacent to a low-density residential area bounds the northeast edge of the park along which are found Douglas-fir and grand fir with Garry oak and arbutus on rockier slopes and exposed areas. Deciduous trees and mixed meadow plants grow opposite the nature house, and western redcedar predominates further northwest and deeper into the park. The northeast boundary along Prospect Lake and Munn Rd. is patchily invaded by ivy that flowers primarily on Douglas-fir trees and is very scant as a ground cover. The western hydro line boundary is non-invaded and neither is the nearby forest habitat along this boundary.

5.4.2 Characteristics of Invaded Areas

Seven plots in invaded areas were sampled (Figure 5.5). Canopies in the invaded plots ranged between 40 – 90% closed and soils varied. Invaded plots near the nature house and Munn Rd. had brown to very dark brown loamy soil (A horizon), with considerable organic (Ho) layer. The Elsie King trail plot had similar but more scant soil with prevalent large rock outcrops. Plots along Prospect Rd. had finer textured, lighter coloured and thinner layers of soil (A horizon) or organic layers on thin soil on rock. The majority of the 45 trees present in invaded plots were Douglas-fir (n=29) or Garry oak (n=6). Six species of tree were climbed by ivy, which grew in juvenile form on bigleaf

Figure 5.5: Approximate Sampling Locations and Park Boundaries, Francis-King Regional Park



maple and in reproductive form on Douglas-fir, Garry oak, grand fir, arbutus and Pacific crab apple (*Malus fusca*). Ivy grew in juvenile form on fewer than one third of the 25 trees that hosted ivy in this sample. Nine trees had ivy stems 2 cm in diameter or less, while six trees hosted stems greater than 5 cm. Ivy grew to a maximum height of 21.5 m on Douglas-fir in sample plots along Munn Rd. Ground cover of ivy was low in all plots, ranging between approximately 3-50% with four of the seven invaded plots having ivy cover of 5% or less. More exotic plants were found in plots where ivy cover was greater, and several less frequently encountered plants were found only in plots with less ivy cover (Table 5.8). Plots with 15% or greater ivy cover had more developed soils, while plots with 5% or less ivy cover had thin undeveloped soils.

Table 5.8: Plants in Invaded Plots: Francis-King Park

Found in 3/7 plots where ivy* cover was >15%	Found in 4/7 plots where ivy* cover was 5% or less	Found in both invaded plot types (previous two columns)
<ul style="list-style-type: none"> ◆ red alder ◆ unidentified poplar (<i>Populus</i> sp.) ◆ holly* ◆ Himalayan blackberry* ◆ Scotch broom* ◆ saskatoon ◆ mixed garden* and wildflowers ◆ western trumpet honeysuckle ◆ unidentified saxifrage (<i>Saxifragaceae</i>) ◆ bracken fern ◆ grasses^(*) 	<ul style="list-style-type: none"> ◆ Indian plum ◆ Pacific ninebark (<i>Physocarpus capitatus</i>) ◆ oceanspray ◆ twinflower ◆ salal ◆ broad-leaved starflower ◆ sweet-scented bedstraw ◆ licorice fern ◆ bracken fern ◆ spiny wood fern (<i>Dryopteris expansa</i>) 	<ul style="list-style-type: none"> ◆ ivy* ◆ Douglas-fir ◆ grand fir ◆ bigleaf maple ◆ Garry oak ◆ Pacific crab apple ◆ arbutus ◆ snowberry ◆ baldhip rose ◆ trailing blackberry ◆ daphne-laurel* ◆ Oregon grape ◆ wall lettuce* ◆ false Solomon's-seal ◆ sword fern ◆ grasses^(*)

5.4.3 Characteristics of Less Invaded and Non-Invaded Areas

As in other parks, recently sprouted ivy was found in areas that initially appeared non-invaded. Canopy closures in the two seedling plots and the non-invaded plot ranged

between 80 and 85%. Soils in seedling plots were thin, undeveloped and consisted mostly of detritus and organic matter (H₀) on solid rock, while soil in the non-invaded plot was thicker (8-12 cm A horizon), rusty coloured with a loamy, pebbly and brownish yellow B horizon and was also near large rock outcrops. The non-invaded plot was approximately 8 m from a zone of seedlings, which was 20 m to a Douglas-fir hosting a large pillar of flowering ivy. Plants are listed below (Table 5.9).

Table 5.9: Plants in Seedling and Non-Invaded Plots: Francis-King Park

Found in 2/2 seedling plots	Found in non-invaded plot
<ul style="list-style-type: none"> ◆ ivy* (less than 2% of ground cover) ◆ Oregon grape ◆ trailing blackberry ◆ Douglas-fir ◆ Garry oak ◆ bigleaf maple ◆ oceanspray ◆ snowberry ◆ daphne-laurel* ◆ hairy honeysuckle ◆ twinflower ◆ wild strawberry (<i>Fragaria virginiana</i>) ◆ western buttercup (<i>Ranunculus occidentalis</i>) ◆ wall lettuce* ◆ broad-leaved starflower ◆ sweet-scented bedstraw ◆ sword fern ◆ licorice fern 	<ul style="list-style-type: none"> ◆ Douglas-fir ◆ twinflower ◆ holly* ◆ bigleaf maple ◆ bitter cherry (<i>Prunus emarginata</i>) ◆ saskatoon ◆ Oregon grape ◆ trailing blackberry ◆ Himalayan blackberry* ◆ rattlesnake plantain ◆ sweet-scented bedstraw ◆ broad-leaved starflower ◆ bracken fern

5.4.4 Overall Invasion

Francis-King Park's Douglas-fir ecosystems are patchily invaded by ivy. Areas along Munn Rd. and the Elsie King and Centennial trails contain several pillars of flowering ivy but with limited horizontal spread or ground cover. Where ivy is found in the park, it is primarily in reproductive form. Ivy stems are largest near the site of the old house and nature house (multiple 9 cm diameter braided stems on arbutus), inside the west side of the Elsie King loop trail (9 cm on Douglas-fir) and along the lower portion of

the Centennial trail north of Munn Rd. (8 cm in diameter on Douglas-fir).

In 1961, samples of flowering ivy were collected at Francis Park (Herbarium of the Royal British Columbia Museum) and a very large ivy plant was already well established near the nature house. However, ivy may have been planted in other parts of the park as well, where it is now well established and flowering. Another possibility is that ivy may have naturally dispersed southeast and northeast from the nature house area and been left untouched on trees over the years. The newly-sprouting ivy found near mature plants suggests it continues to disperse naturally.

5.5 Horth Hill Regional Park

Horth Hill became established as a CRD Park in 1966 and following an addition of 2.3 ha in 1991, it now comprises approximately 31 hectares of protected parkland. The park includes one main rectangular shaped parcel bounded to the south by a dirt road (a road allowance) and a second parcel of park in the form of a small triangle south of the dirt road. Regrettably, records for the age of housing were unavailable; however, many homes visible from roads appear relatively young. Numerous forested or undeveloped lots can still be found around the park, some of which appear to have been recently cleared for new housing. The highest density housing around the park is found on its west side, whereas the southeast part of the park is adjacent to forested areas. Less developed areas south of the park around Tatlow and Clayton Rds. include low density housing and small scale agricultural operations. The housing along the north and north east of the park along Eagle Way and Hedgerow Rd. is medium-low density, three of which are within woodland and not readily visible from the road. Of the approximately

12 homes that are directly against the park, ivy was only visible on one against the west boundary. However, four of the total 12 were not well viewed. Not far outside the park's southwest corner, along Tatlow Rd., extremely tall pillars of ivy flower.

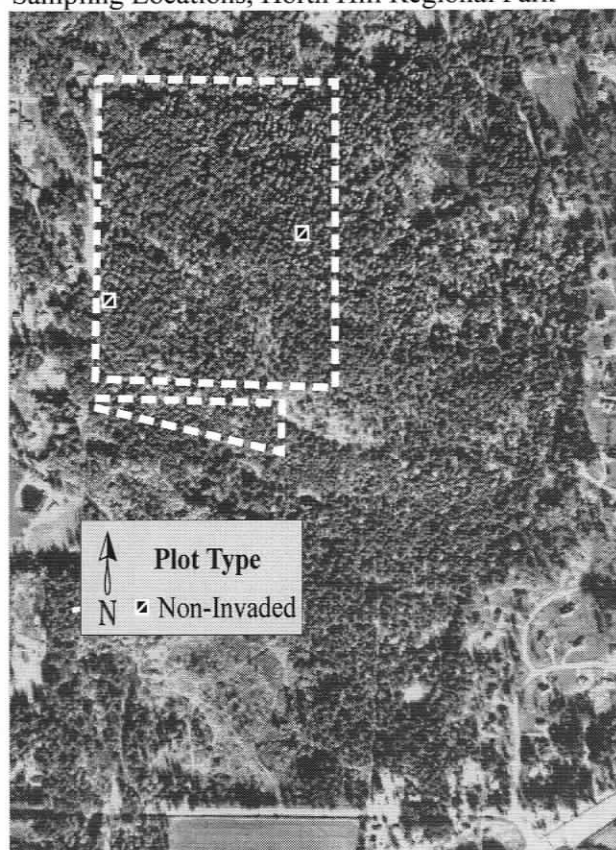
5.5.1 Dominant Vegetation and General Habitat of Park Boundaries

Dominant vegetation of the park boundaries is primarily western redcedar and grand fir forest with scattered Douglas-fir and bigleaf maple. The south boundary is predominantly western redcedar with scattered grand fir and small stands of Douglas-fir with bigleaf maple and red alder. Douglas-fir and bigleaf maple are predominant along the south part of the west boundary with western redcedar increasing in frequency toward the north and along the north boundary. The east boundary includes western redcedar and Douglas-fir.

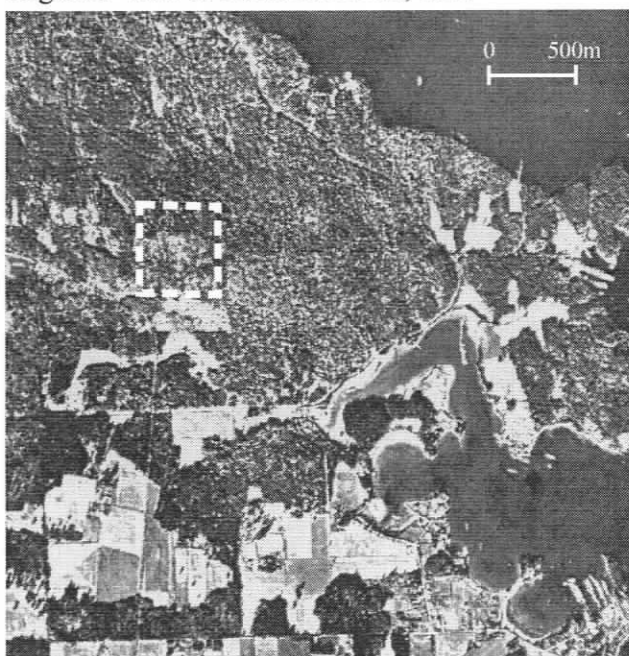
5.5.2 Invaded and Non-Invaded Areas

Ivy was found in this park only in the southwest corner near the main parking and entrance area. The ivy here was very sparse, growing in juvenile form under western redcedar directly east of the park sign board. No ivy was found in any of the other boundaries. The two non-invaded stands of Douglas-fir that were selected to represent habitat in the boundary zones for closer examination did not reveal any significant insight into ivy's distribution (Figure 5.6). The first area contained quite diverse flora under a 95% canopy of 11 large stemmed trees (7 Douglas-fir, 2 live and one dead bigleaf maple and an arbutus tree) on a thick (several centimetres) layer of brown clay (Table 5.10). The second, higher up the hill, contained more homogenous flora, including five Douglas-fir trees, many fir seedlings, a 90% closed canopy and abundant

Figure 5.6: Approximate Boundaries and Sampling Locations, Horth Hill Regional Park



Regional View of Horth Hill Area, 1955



organic matter on a thick layer of brown silty clay (Table 5.10). In this plot, only pathfinder (*Adenocaulon bicolor*) was found in addition to dominant plants listed in Table 5.10.

Table 5.10: Plants in Non-Invaded Plots: Horth Hill Regional Park

Found in 2/2 non-invaded plots	Other plants found in first non-invaded plot (inside west boundary)
<ul style="list-style-type: none"> ◆ Douglas-fir ◆ oceanspray ◆ Oregon grape ◆ baldhip rose ◆ broad-leaved starflower ◆ sword fern ◆ grasses^(*) 	<ul style="list-style-type: none"> ◆ bigleaf maple (young, live and dead) ◆ large stemmed arbutus tree ◆ cedar saplings ◆ trailing blackberry ◆ vetch (<i>Vicia</i> sp.) ◆ baldhip rose ◆ salal ◆ rattlesnake plantain ◆ stinging nettle ◆ western buttercup ◆ wall lettuce* ◆ western trillium (<i>Trillium ovatum</i>) ◆ abundant Oregon beaked moss

Both non-invaded areas were less disturbed than the entrance area invaded by ivy. Additionally, the heavy canopy closure of the first area and the rockier, higher and more distant (to housing) habitat of the second area likely contribute to abundant native plants found in these areas.

5.6 Knockan Hill Park⁶

Knockan Hill Park is shaped like the letter "T", with an old established home to its north, dating to the 1920s and another old home outside its northeast border. Nearby

⁶ The Songhees people used the areas of Knockan Hill Park, among other things for harvesting camas in the meadows, probably up until the 1850s when Scottish settlers settled the area of Craigflower farm. Friends of the park indicate that one possible origin of the hill's name could be from the Gaelic word "gnocan" for 'hill' or 'knoll'. (This suggests the park's name is "Hill Hill".) In the first decade of the 1900s, the municipality of Saanich kept four acres of the hill as public lands. Much later, in 1973, Mrs. Maude Hall sold her adjacent three-hectare property to the municipality, adding to the public lands. Knockan Hill became an official Saanich Community Park in 1989, administered under the municipality's Parks and Recreation Department. An additional acre of land in the southeast corner was added to the park in 1993. The Hall cottage and garden were designated as a local heritage site and a pilot project devoted to their restoration is ongoing.

and against the park's north top border are newly-built (1990s) homes and ongoing construction. Helmcken Rd. bounds a small portion of the northwest corner of the park and its east linear edge is adjacent to unbuffered medium-high density recently-built (late 1980s) residential areas. Its south and west sides are next to established, medium density housing (c. 1930s-50s). A single-lane road lies against the south boundary and inside this area is the Hall cottage and garden, built around 1935. As well as being cultivated on the cottage grounds inside the park, ivy is found on many properties around the park, particularly along its northeast border where it grows on all nearby properties. Otherwise, approximately three of the 22 newer homes on the east side of the park, none of the other new homes along the east part of the north border and at least three of the homes adjacent to the west side of the park have ivy in their yards.

5.6.1 Dominant Vegetation, General Habitat and Invasion of Park Boundaries

Vegetation along the south entrance of the park and near the cottage includes Douglas-fir, cascara (*Rhamnus purshiana*) and Garry oak with many ornamental and garden plants such as ivy thriving in the area. The park's eastern boundary is a mixed woodland dominated by deciduous tree species and Douglas-fir on the south end, mixed grand fir and holly* further north and Garry oak increasing toward the hilltop with abundant Indian plum and sword fern. Ivy is fairly abundant within most areas of this boundary wherever there is soil and at least a slight canopy. The north boundary is primarily rocky habitat with Garry oak, grasses(*), Scotch broom* and meadow species. The northeast corner contains tall oaks and English hawthorn* (*Crataegus monogyna*) on more developed soils and is heavily invaded by flowering ivy. The park's west boundary

contains mixed fir and oaks on rockier soils and, similar to the east boundary, is also heavily invaded by ivy particularly towards the cottage and Burnside Rd.

5.6.2 Characteristics of Invaded Areas

Six areas invaded by ivy were sampled. One plot was located near the Hall cottage garden, two were placed on each of the two lower sides of the park and one was located in the back or north corner of the park (Figure 5.7). Both the cottage and the north corner plot contained plants distinct from other plots (Table 5.11). Canopy cover in all invaded plots at Knockan Hill Park ranged between 5 – 90% closed with the lowest characteristic of a canopy gap under which ivy was abundant (approx. 65%) as a ground cover. Soils in invaded plots were dark brown and loamy in texture. In invaded sample plots, there was a total of 44 trees of which 39 were climbed by ivy and 14 hosted reproductive-form ivy. Trees climbed by ivy included Garry oak, Douglas-fir, grand fir and bitter cherry. Bitter cherry was climbed only by juvenile ivy. All stems greater than 5 cm in diameter were found on Garry oak, which also hosted the tallest ivy (13.5 m).

Figure 5.7: Approximate Sampling Locations and Boundaries, Knockan Hill Park



Table 5.11: Plants in Invaded Plots: Knockan Hill Park

Found in cottage plot	Found in north plot	Found in the 4 other plots
<ul style="list-style-type: none"> ♣ Garry oak ♣ ornamental yew* (<i>Taxus</i> sp) ♣ Douglas-fir ♣ grand fir (dead) ♣ maple cultivar* (<i>Acer</i> sp.) ♣ Pacific crab apple ♣ Indian plum ♣ ivy* ♣ daphne-laurel* ♣ Scotch broom* ♣ Himalayan blackberry* ♣ ornamental shrub* (<i>Cotoneaster</i> sp.) ♣ rose cultivars* (<i>Rosa</i> sp.) ♣ Nootka rose ♣ hairy honeysuckle ♣ Helleborine* ♣ snowberry ♣ other unidentified garden plants and flowers* ♣ unidentified carrot(*) (<i>Apiaceae</i>) ♣ wall lettuce* ♣ assorted grasses(*) ♣ unidentified violet(*) (<i>Viola</i> sp.) 	<ul style="list-style-type: none"> ♣ Garry oak ♣ Douglas-fir ♣ native black hawthorn (<i>Crataegus douglasii</i>) ♣ English hawthorn* (<i>Crataegus monogyna</i>) ♣ ivy* ♣ daphne-laurel* ♣ holly* ♣ Himalayan blackberry* ♣ snowberry ♣ Helleborine* ♣ Indian plum ♣ licorice fern 	<ul style="list-style-type: none"> ♣ Garry oak ♣ grand fir ♣ Douglas-fir ♣ bigleaf maple ♣ bitter cherry ♣ cherry* (<i>Prunus avium</i>) ♣ cascara ♣ holly* ♣ Indian plum ♣ trailing blackberry ♣ Himalayan blackberry* ♣ snowberry ♣ ivy* ♣ Scotch broom* ♣ Nootka rose ♣ wall lettuce* ♣ Oregon grape ♣ licorice fern ♣ rattlesnake plantain ♣ sword fern ♣ assorted grasses(*) ♣ unidentified thistle(*) (<i>Cirsium</i> sp.) ♣ unidentified saxifrage (<i>Saxifragaceae</i>)

5.6.3 Characteristics of Less Invaded Areas

Few Douglas-fir habitats in the southern part of the park do not contain ivy. However, two areas that were not invaded are described. One was characteristic of a Douglas-fir meadow in a rocky area just south of the hilltop. It contained very abundant grasses(*) (>80% ground cover), tall Oregon grape (*Mahonia aquifolium*), massive clumps of daphne-laurel* and Scotch broom* and other small herbacious plants (Table 5.12). It had a thin layer of pale-brown, loamy-textured soil, a light (approximately 50% closed) canopy and low tree density.

The second non-invaded Douglas-fir area was lower down the south slope of the hill inside a thicker forest. It had a similar canopy closure (55%) a slightly darker brown loamy textured soil with three species of tree and understory vegetation predominated by

grasses^(*) and abundant western trumpet honeysuckle (Table 5.12). Possible influences on the lack of ivy in this site could include a large rocky outcrop and a footpath on either side of the plot.

Table 5.12: Plants in Non-Invaded Plots: Knockan Hill Park

Non-invaded Douglas-fir meadow plot	Second Douglas-fir plot
<ul style="list-style-type: none"> ◆ One massive and one small large stemmed Douglas-fir ◆ daphne-laurel* ◆ mature Scotch broom, Scotch broom and/or gorse (<i>Ulex europaeus</i>) seedlings* ◆ common camas ◆ Indian plum sprouts/seedlings ◆ snowberry ◆ tall Oregon grape ◆ sword fern ◆ western buttercup ◆ grasses^(*) (predominantly orchard grass*) 	<ul style="list-style-type: none"> ◆ 8 large stemmed Douglas-fir ◆ Garry oak sprouts ◆ arbutus (juvenile) ◆ western trumpet honeysuckle ◆ Himalayan blackberry* ◆ snowberry ◆ Oregon grape ◆ rattlesnake plantain ◆ licorice fern ◆ false bugbane (<i>Trautvetteria caroliniensis</i>) ◆ Pea^(*) (<i>Lathyrus</i> sp. probably <i>L. latifolius</i>, maybe <i>L. nevadensis</i>)

5.6.4 Overall Invasion

Knockan Hill Park's fir ecosystems are very heavily invaded by ivy, the majority distributed along the south part of the park radiating northward from the cottage and adjacent established housing. The two non-invaded areas did not differ significantly in terms of canopy closure, but were situated closer to rocky regions and their soils were significantly lighter in colour. Interestingly, members of the Friends of Knockan Hill Park, concerned about the rapid growth and northward spread of ivy in the park, indicate that they had ivy cut from all trees in the park in January 1992. Numerous trees, particularly in the south part of the park, have evidence of this cutting (Appendix 7: Figure 3) and remaining stems on these trees are small (e.g. approximately one cm in diameter). If all stems were in fact cut from all trees, as the Friends of the park indicate, the amount of ivy on trees in the park today suggests a rapid regrowth of ivy over a 5-6

year period⁷. Indeed, ivy is a dominant ground flora in the park and areas where it is particularly well established are in somewhat shaded forest in proximity to older housing in the south interior and exterior of the park and in its northeast corner.

5.7 Lone Tree Hill and Mount Work Regional Parks

Two parks in the Highlands District and Gowland Range area were briefly investigated to examine how development and population affects exotic vegetation in parks. Population density in the Highlands District and on the west of the Saanich Inlet and Finlayson Arm is low compared to that of the regions surrounding the other parks studied. Less development may also explain the undetermined zoning in parts of this region. Lone Tree Hill was established as a CRD Park in 1982, while Mount Work Park was established in 1970. Recently, the establishment of the Gowland Tod Provincial Park increased the amount of protected area in the region.

5.7.1 Dominant Vegetation and General Habitat of Park Boundaries

Areas thought to be more disturbed from nearby residential activity at both parks were examined, including the southeast boundary of Lone Tree Hill Park, a section along Durrance Rd. between the roadway intersection and Durrance Lake and a forested area south of Fork Lake. In both parks, western redcedar and grand fir were dominant

⁷ In an attempt to estimate growth over this period, I measured the maximum height of ivy on 35 trees that were covered in dead / cut stems in the south part of the park near the cottage in July 1997. Ivy ranged between 0.8-4.7 m tall on these trees, had a mean height of 2.6 m (median height of 2.5 m) and S.D. of 1.14 m. There is no certainty that each of these stems was not already alive or climbing on these trees following the cutting on January, 1992. However, given their small size, it is quite likely that some stems measured were new growth.

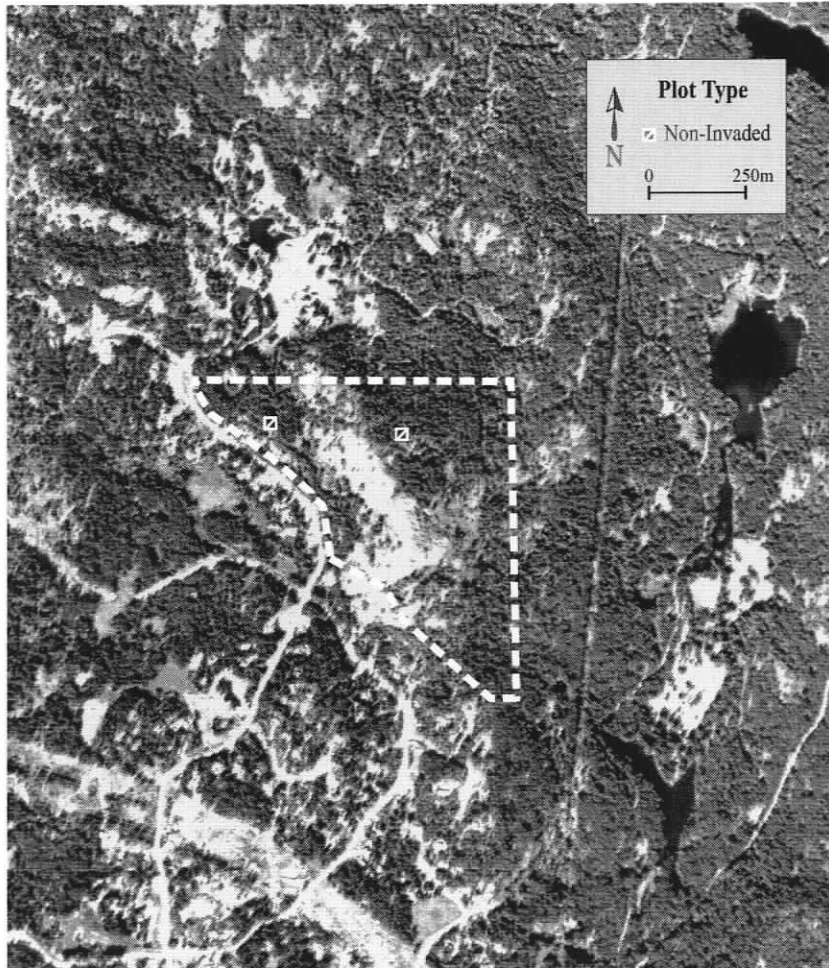
vegetation in the boundaries examined, with arbutus and Garry oak occurring at higher elevation on exposed areas. No ivy was found growing on properties adjacent to Mount Work Park, either along Fork Lake Rd. or Durrance Close. No ivy was found growing near Lone Tree Hill Park, either along Caleb Pike or Millstream Rds., although several lots along this road were deep and more difficult to view. The vegetation in these areas is described below.

5.7.2 Characteristics of Non-Invaded Areas

Two non-invaded areas of Douglas-fir habitat were sampled along the southeast park boundary of Lone Tree Hill (Figure 5.8). The higher elevation plot was characteristic of open Douglas-fir over meadow with occasional arbutus, slight canopy and thin soil. Hairy honeysuckle and Scotch broom* were dominant, and although lichens and mosses were not regularly included among the dominant plants, freckle pelt lichen (*Peltigera britannica*) was particularly abundant in the second plot (Table 5.13). Canopy closures in the centres of both plots were approximately 50%. In the first and second plots, dark brown silty and brown silty soils were found respectively, although unevenly distributed in depressions within the hill's large rock outcrops.

Two areas of Mount Work Park were briefly examined at Fork and Durrance Lakes. In both these locations, Douglas-fir is occasional or absent and is not characteristic of the overall vegetation. On a southwest bank of Fork Lake in a large stand of grand fir, the area examined had canopy closure of 85% and nine large stemmed grand fir and other plants (Table 5.14). A thin layer of pale, yellow-brown clay coated the rocky outcrop, which was quite typical of the surrounding slopes. The plot located

Figure 5.8: Approximate Sampling Locations and Park Boundaries:
Lone Tree Hill Regional Park



north of Durrance Lake inside the Durrance Rd. boundary was in a moist habitat, had a brown silty soil with abundant stones, a 90% closed canopy, large stemmed western redcedar and grand fir, a juvenile bigleaf maple and moist habitat plants like vanilla leaf (Table 5.14).

Table 5.13: Plants in Non-Invaded Plots: Lone Tree Hill Park

Found in 2/2 plots	Other plants found in higher elevation plot	Other plants found in lower elevation plot
<ul style="list-style-type: none"> ◆ Douglas-fir ◆ wild strawberry (<i>Fragaria virginiana</i>) ◆ oceanspray ◆ wall lettuce* ◆ sword fern 	<ul style="list-style-type: none"> ◆ arbutus ◆ snowberry ◆ hairy honeysuckle ◆ vetch ◆ unidentified aster (Asteraceae) ◆ hairy honeysuckle ◆ Scotch broom* 	<ul style="list-style-type: none"> ◆ four live and one snag Douglas-fir ◆ bitter cherry ◆ trailing blackberry ◆ salal ◆ rattlesnake plantain ◆ baldhip rose ◆ grasses(*) ◆ bedstraw (<i>Galium</i> sp. likely <i>triflorum</i>) ◆ kinnickinick (<i>Arctostaphylos uva-ursi</i>) ◆ licorice fern ◆ broad leaved starflower ◆ Oregon grape ◆ numerous varieties of mosses ◆ western trumpet honeysuckle

Table 5.14: Plants in Non-Invaded Plots: Mount Work Park

Plants found in both plots	Other dominant plants found (Durrance Lake plot)
<ul style="list-style-type: none"> ◆ 4 grand fir ◆ large western redcedar ◆ oceanspray ◆ red huckleberry ◆ salal ◆ bracken fern ◆ grasses(*) 	<ul style="list-style-type: none"> ◆ wall lettuce* ◆ sword fern ◆ vanilla leaf ◆ pathfinder

5.7.3 Overall Invasion

In addition to residential areas consisting of sparse, low density housing near these two parks, no ivy was visible near any of the homes directly near the areas examined. The grand fir and western redcedar habitat in the low elevation areas examined near the lakes at Mount Work Park and near the boundary at Lone Tree Hill Park contained few areas of

primarily Douglas-fir forest. Both parks are considerably less disturbed by foot traffic and general human use than the others examined and both contained far fewer common exotic plants, including ivy, in their forested areas.

5.8 Mill Hill Regional Park⁸

The majority of housing against the south of the park near Atkins Rd. and along Langvista Dr. on the underside of the northwest park border, according to records from the Langford Fire Department, was established approximately during the early to mid 1980s. In addition, there is an older home in the centre part of the south boundary. Housing on the south part of the east boundary was likely established around the late 1970s and mid 1980s. There is no other housing along the east boundary, although a subdivision of a large farm further east could eventually increase housing density near the park. Along the south, east and southwest park borders, ivy was visible on only one property. A trailer park is another form of nearby housing along the west park border and it is established and landscaped. However, ivy was not visible here or further north along the housing at Langvista Dr. that is tucked under the northwest corner of the park.

5.8.1 Dominant Vegetation and General Habitat of Park Boundaries

Both east and west boundaries of Mill Hill Park occur along rocky sloped parts of Mill Hill. The vegetation on these slopes is characterised by arbutus and Garry oak

⁸ Mill Hill Park was established as a CRD Park in 1981, having a subsequent addition of 0.8 ha in 1991. The park, in the shape of an eastward-bent letter "T", has in the far south, a roadway (Atkins Rd.) that bisects the main parcel from a smaller parcel of land, approximately one hectare in size. This parcel of land south of Atkins Rd. is not the focus of this discussion. Mill Hill Park is currently the Headquarters of the CRD Parks Department and has several buildings within it devoted to their operations as well as ongoing internal building construction.

meadow habitat with increasing occurrence of Douglas-fir and bigleaf maple at lower elevations. Inside the park near Langvista Dr. housing and the trailer park, rocky, arbutus-Garry oak and Scotch broom* habitats predominate. The north boundary zone of the park to the south parcel of Thetis Lake Regional Park consists of more large stemmed mixed grand fir and Douglas-fir forest. The south part of the park contains a lower-elevation western redcedar, bigleaf maple and fir forest and is the focus of the discussion below.

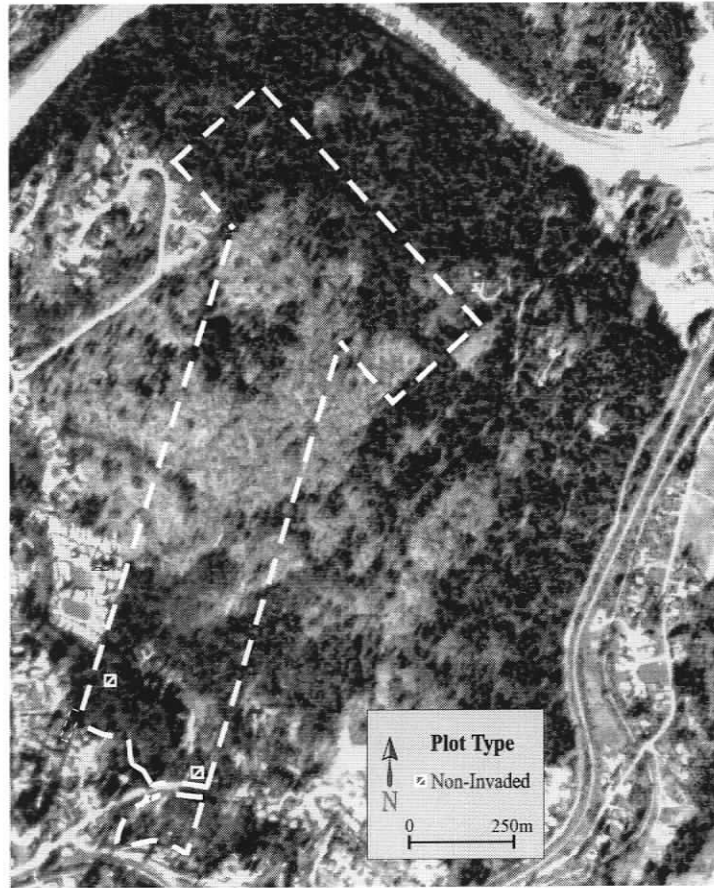
5.8.2 Characteristics of Invaded Areas

One invaded area was found in the south part of the park. Located near the stream in the central to west part of the south boundary (approximately 25 m inside the park's south border), ivy consisted of several short juvenile form shoots and very young sprouts. Here, it grew near Cooley's hedge-nettle (*Stachys cooleyae*), Pacific bleeding heart (*Dicentra formosa*), herb-robert* (*Geranium robertianum*) and mountain sweet-cicely (*Osmorhiza chilensis*) under a western redcedar and Indian plum canopy in a deep, dark brown clayish-textured soil. Holly* and daphne-laurel* were also very abundant in this area and it appeared more disturbed than other areas including the non-invaded areas that are discussed below.

5.8.3 Characteristics of Non-Invaded Areas

Two non-invaded areas were examined, thought to be fairly typical of nearby lower elevation fir forest in the south part of the park (Figure 5.9). The first non-invaded plot, located in the east boundary south of a rocky outcrop, had a 90% closed canopy and a light brown clayish soil that was several centimetres thick. It contained four large

Figure 5.9: Approximate Sampling Locations and Park Boundaries, Mill Hill Regional Park



stemmed Douglas-fir and Garry oak trees, a middle stratum of arbutus, oceanspray and tall Oregon grape and assorted understory plants (Table 5.15). The western plot, on a steep, south-facing slope, had a thick, 98% closed canopy with thick layers of organic material under numerous decomposing tree trunks, a very thin layer of brown loamy textured soil on rock outcrops and several boulder-sized rocks in and nearby the plot. A very large stemmed grand fir and one Douglas-fir formed the upper canopy, under which a thick middle stratum of young grand fir and bigleaf maple grew with other understory plants (Table 5.15).

Table 5.15: Plants in Non-Invaded Plots: Mill Hill Park

Found in 2/2 non-invaded plots	Other plants found in east plot	Other plants found in west plot
<ul style="list-style-type: none"> ◆ Douglas-fir ◆ arbutus ◆ Oregon grape ◆ sword fern ◆ trailing blackberry ◆ wall lettuce* ◆ daphne-laurel* ◆ oceanspray ◆ licorice fern ◆ mountain sweet-cicely (<i>Osmorhiza chilensis</i>) ◆ sweet-scented bedstraw ◆ grasses(*) 	<ul style="list-style-type: none"> ◆ young arbutus ◆ Garry oak ◆ snowberry ◆ western buttercup 	<ul style="list-style-type: none"> ◆ grand fir ◆ bigleaf maple ◆ western trillium ◆ salal ◆ broad-leaved starflower ◆ baldhip rose ◆ foamflower (<i>Tiarella trifoliata</i> var. <i>trifoliata</i>) ◆ grasses(*) ◆ bedstraw (<i>Galium</i> sp.) ◆ hairy honeysuckle ◆ baldhip rose

5.8.4 Overall Invasion

On the whole, Mill Hill Park has a limited number of areas containing ivy as well as limited suitable habitat for it on the east and west sides of the south part of the park. Ivy was found in the far south of the park near a property landscaped with it, inside a predominantly western redcedar and grand fir stand and with abundant other mixed invasive exotic plants. In addition to being in a moister, low-elevation location close to a known point source, the soil in the invaded area was considerably darker and deeper than

the non-invaded areas examined. Other residential areas against forested park habitat did not appear to have ivy in their yards and none was found inside adjacent park boundaries.

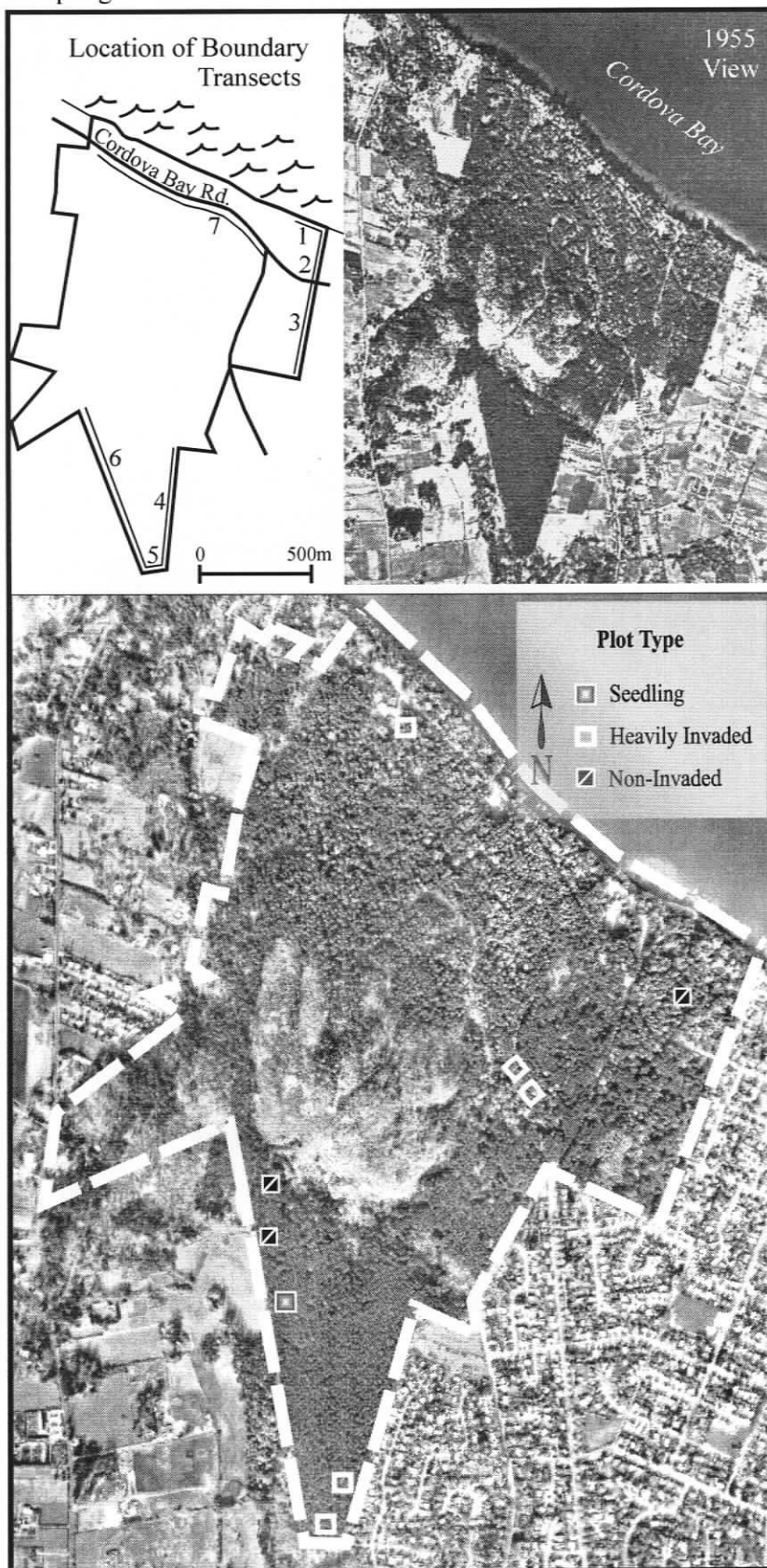
5.9 Mount Douglas Park⁹

Mount Douglas Park was already an isolated remnant natural area, delineated by agricultural land in air photographs of 1951. The density of residential housing, particularly on the east side of the park, increased steadily from the 1950s to that of today with the majority of homes on the park's northeast border established in the early 1970s. Most homes directly against the park's southeast border were established in the early 1960s, with some dating to the 1940s; and the farm in the top corner near Cedar Hill Rd. dates back to at least the very early part of this century.

Today, subsequent to several additions to the original reserve lands, Mount Douglas Park is a relatively large, 176-hectare Saanich municipal park. Overall, it has an irregularly triangular shape, wider to the north, narrowing into a thin, elongated 'peninsula' to the south and a shorter one to the southwest. Mount Douglas Park is bounded by shoreline to the north, agricultural to low-density residential areas to the west and higher density residential areas to the east. The park now has at least 19 linear, human generated edges around its perimeter (Figure 5.10: left inset). The main point sources for introduced ivy and other escaped domestic plants are hypothesised to coincide with the higher density residences along the east side of the park, particularly the older residential

⁹ The Songhees were reported to have cut trees from the Mount Douglas ("Cedar Hill") area to help build Fort Victoria in the early 1840s. In 1858 James Douglas reserved lands that became known as Mount Douglas Crown Reserve in 1889 (Saanich Municipality, Parks Department). The lands were reserved to "maintain and preserve as a public park or pleasure ground for the use, recreation and enjoyment of the public." Lands around the park have been farmed since at least the 1850s and the reserve's establishment. See also Jupp's (1975) local history.

Figure 5.10: Mount Douglas Park: Approximate Park Boundaries and Sampling Locations



areas unbuffered by roads. Ivy was visible on at least 12 of the approximately 77 properties along the east border, from the shoreline to the southern tip of the park, and most abundant along the southeast edge of the southern 'peninsula', where nearly 30% of the homes had used ivy in landscaping.

5.9.1 Dominant Vegetation and General Habitat of Park Boundaries

As a result of the large number of park edges, this description and analysis of vegetation focuses on seven linear boundaries of the park (Figure 5.10: Inset). Douglas-fir and bigleaf maple are dominant along transects one through six. In addition to these trees, western redcedar and holly* are common along the northeast boundary above the shoreline (transect 1), while holly*, trembling aspen (*Populus tremuloides*) and red-osier dogwood (*Cornus stolonifera*) are dominant along the northeast boundary (transect 2). Douglas-fir, bigleaf maple and holly* trees are dominant along the southeast, south tip and south west park boundaries (transect 3, 4, 5 and 6). The vegetation of the north boundary (transect 7) differs significantly from other boundaries and is composed primarily of western redcedar and Douglas-fir, with arbutus growing further inside the park on rock outcrops.

5.9.2 Invaded Park Boundaries

Ivy was found in all seven boundary zones and was most abundant along the southeastern side of the park, where thick mats blanket many parts of the forest understory. Along the north boundary (transect 7), ivy was sparse to absent, occurring in three locations. First, near the picnic / parking areas, second, in juvenile form in one small patch inside the forest approximately 150 metres from the picnic / parking area and

last, on the far west side of the park next to a multi-unit residential-type complex (Table 5.16). The southwest boundary (transect 6) contained several areas where no ivy occurred and others where ivy seedlings were beginning to sprout (Table 5.16).

5.9.3 Characteristics of Heavily Invaded Areas

Canopy cover within the five invaded plots ranged between 10-75% closed. Soils were dark brown to very dark brown, silty in texture with prominent H or organic layers. Twenty-nine trees greater than 35 cm in circumference were present in total in the five areas sampled. Arbutus and western redcedar only occurred as small, young trees and seedlings. The mean circumference for large stemmed trees (greater than 35 cm circumference) was 155 cm, and in order of frequency included Douglas-fir, grand fir, bigleaf maple, western yew and Scouler's willow (*Salix scouleriana*). Ivy climbed a majority (25/29) of the large stemmed trees. Grand fir and Douglas-fir were most often climbed by reproductive-form ivy, and western yew and bigleaf maple were most often climbed by juvenile ivy. Stem diameters greater than 3.5 cm grew exclusively on Douglas-fir (live and snags) with the largest stems (7-11 cm in diameter) in the southeast plot. Ground cover of ivy ranged from approximately 40-90%, with significant vertical abundance on trees. Plants that were particularly abundant in heavily invaded plots included cascara, Indian plum, oceanspray, holly*, snowberry, Himalayan blackberry* and sword fern (Table 5.17).

Table 5.16: Summary of Park Boundary Characteristics and Invasion (# = transect number): Mount Douglas Park

Park edge (#)	Adjacent land use (category)	Dominant vegetation and general habitat	Invasion in boundary (heavy, medium, light, none)
North (1)	Shoreline to north and unbuffered residential to east	Mixed Douglas-fir, bigleaf maple with mixed shrubs.	Heavy throughout.
East - north (2)	Residential roads of residential areas and unbuffered residential (density = heavy)	Mixed Douglas-fir, bigleaf maple forest with patches or groves of alder and red-osier dogwood along park border.	Medium to heavy throughout.
East - north (3)	Unbuffered residential (density = heavy)	Mixed Douglas-fir, bigleaf maple forest.	Heavy throughout.
East - south (4)	Unbuffered residential (density = heavy)	Mixed Douglas-fir, bigleaf maple with holly* trees.	Heaviest. Most established of all boundaries with largest ivy stems found in the park (up to 11 cm in diameter).
South tip (5)	Residence buffered by pathway (density = low - medium)	Mixed Douglas-fir, bigleaf maple forest with holly* trees. Disturbed by windthrow, trampling and camping.	Heavy. Stems over 3 cm in diameter.
West (6)	Agricultural, low density residential	Mixed Douglas-fir, bigleaf maple forest with holly* trees.	Medium to heavy. Some non-invaded areas and areas becoming established.
North (7)	Shoreline. Residential areas on far east and far west sides.	Cedar with Douglas-fir in centre of boundary. Mixed fir forest with occasional western yew (<i>Taxus brevifolia</i>) on extreme west.	None in centre of boundary. Heavy to medium near main parking /picnic area and on far east and far west sides.

Table 5.17: Plants in Plots: Mount Douglas Park

Found in 9/9 plots (invaded, seedling and non-invaded)	Other plants found in the 5 heavily invaded plots	Other plants found in the seedling plot	Other plants found in the 3 non-invaded plots
<ul style="list-style-type: none"> ♣ Douglas-fir ♣ bigleaf maple ♣ cascara ♣ oceanspray ♣ snowberry ♣ holly* ♣ trailing blackberry ♣ Oregon grape ♣ unidentified rose ♣ sword fern ♣ bracken fern ♣ grasses(*) 	<ul style="list-style-type: none"> ♣ grand fir ♣ western redcedar ♣ arbutus ♣ western yew ♣ bitter cherry ♣ Scouler's willow ♣ Indian plum ♣ Himalayan blackberry* ♣ ivy* ♣ Helleborine* ♣ salal ♣ false Solomon's-seal ♣ Nootka rose 	<ul style="list-style-type: none"> ♣ bitter cherry ♣ ivy* ♣ Nootka rose ♣ baldhip rose ♣ licorice fern ♣ broad-leaved starflower ♣ sweet-scented bedstraw ♣ buttercup (<i>Ranunculus</i> sp.) 	<ul style="list-style-type: none"> ♣ arbutus ♣ western redcedar ♣ western yew ♣ hairy honeysuckle (<i>Lonicera hispidula</i>) ♣ red huckleberry ♣ wall lettuce* ♣ Himalayan blackberry* ♣ licorice fern ♣ salal ♣ Helleborine* ♣ sweet-scented bedstraw ♣ unidentified violet(*) (<i>Viola</i> sp.)

5.9.4 Characteristics of Non-Invaded and Becoming-Invaded Areas

Three non-invaded areas that contained Douglas-fir were investigated. The first plot was located in a dry, Douglas-fir meadow on a slight slope along the western boundary. The canopy in this plot was full and uniform, around 95% closed. The soil had an organic litter of fir needles, was dark brown, crumbly, coarser than other non-invaded plots with no discernible B horizon and a shallow, rocky parent material. This meadow plot contained 11 large stemmed Douglas-fir and one Douglas-fir snag. Live trees were generally large with an average circumference of 150 cm. Hairy honeysuckle dominated the understory at approximately 45% cover and climbed large shrubs, while licorice fern and snowberry were the other abundant understory plants.

A second non-invaded area, 20 m from the southwestern boundary and south of the first non-invaded plot, contained several large stemmed and young western yew, Douglas-fir, bigleaf maple and young arbutus and a canopy closure of at least 90%. Large cascara climbed by hairy honeysuckle, oceanspray and young western yew formed a thick, bushy middle stratum. Oregon grape dominated over 80% of the lower stratum and snowberry, rose, sword fern and bracken fern were also found. This plot was the most structurally full and floristically diverse of the plots sampled in this park. Bigleaf maples and abundant ivy surrounded the area. The A horizon of soil in this plot was similar in composition but thicker in depth than the previously described non-invaded plot.

A third non-invaded area was found near the streambank in the northeast corner of the park. It had a canopy cover of approximately 65%, a thick A horizon (over 16 cm) composed of gray-brownish clay and was steeply sloped. Douglas-fir, grand fir and western redcedar grew with oceanspray, red huckleberry, Oregon grape, Himalayan

blackberry*, holly*, salal and sword fern. Ivy was abundant on flat areas higher up the slope but did not creep further down towards the creek, possibly impeded by the cedars (and their litter) that grew on the streambank.

The last area that was sampled contained approximately nine, tiny, recently germinated ivy sprouts, none of which had more than five small, "true" leaves. Canopy closure in the seedling plot was 80% and soil was similar to but slightly finer and deeper than that of the fir meadow area higher up the hill. Douglas-fir, bigleaf maple, cascara, holly*, bitter cherry, oceanspray, snowberry, Oregon grape, broad-leaved starflower, sweet-scented bedstraw, buttercup (*Ranunculus* sp.), licorice fern, sword fern, bracken fern, Nootka and baldhip rose were found in this plot. Ivy seedlings sprouted on spongy, mossy ground and on mossy logs and stumps.

The most distinguishing characteristics of the non-invaded areas and the area just becoming invaded by seedlings described in the above sections is that their canopies (65-95%) were more closed than those of the heavily invaded areas (10-75% closed). Soils of non-invaded plots were either less developed (e.g. thin, on slopes) or deep-packed clay, while the soil of the area just becoming invaded by seedlings was intermediate to these both in thickness and texture. Slopes were also greater in non-invaded plots and some contained thick, stratified layers of shrubs with more diverse vegetation. Plants found only in the non-invaded plots included hairy honeysuckle, red huckleberry, wall lettuce* and violet^(*) (*Viola* sp.) (Table 5.17). Plants found only in the non-invaded and seedling plots included ivy, licorice fern and sweet-scented bedstraw, while plants found only in the seedling and heavily invaded plots included bitter cherry and Nootka rose.

5.9.5 Overall Invasion

All seven of the park boundaries investigated contained distributions of ivy, although the north shoreline boundary, which is predominantly western redcedar with fir, had little to none along its interior. Douglas-fir and bigleaf maple ecosystems were most heavily invaded by ivy and the park's southern 'peninsula' appears to be the most densely invaded area of the entire park. Other heavily invaded areas of the park are found in forests adjacent the roadway to the hilltop near this park entrance. Overall, Mount Douglas Park is one of the more heavily invaded natural areas discussed in this section, containing large mature ivy stems (up to 11 cm in diameter) and having a significant proportion of its Douglas-fir forest understory occupied by ivy.

5.10 Thetis Lake Regional Park¹⁰

The northern boundary of Thetis Lake Park is still primarily in a semi-natural or undeveloped state (uncleared with fairly well-established vegetation and forest) with

¹⁰ Thetis Lake Park is one of the largest parks in Greater Victoria, with approximately 635 hectares of terrestrial lands and freshwater. The Saanich, who lived, harvested and hunted in this area, knew it as the home of the Raven (MacCallum 1939). In 1885, Thetis Lake was added to expand the region's water supply at Elk and Beaver Lakes, but by 1915, the Sooke Lake system replaced these reservoirs and the City of Victoria retained the undeveloped lands. During the Depression, trees were cut in the north and east part of the park and a few years later a pistol range was built inside the park on the southeast border. In 1932, still controlled by the City of Victoria, the park was opened to the public for swimming and recreation (Thetis Park Nature Sanctuary Association or TPNSA 1974, Baskerville 1986:109). Many park trails were cut in the late 1930s as part of a provincial government, job creation project. Later, the Trans Canada Highway was re-routed along the south part of the park, effectively clipping off two small fragments, near Mill Hill Park, from the main park parcel. Photographs from 1951 illustrate the extent of low-density residential development directly north of the highway on the south and east sides of the park. In 1957, TPNSA was formed to protect the park's native flora and fauna with the setting aside of 160 ha east of Thetis Lake. Their first major fight was against the routing of a hydro line through the eastern part of the park. The city nonetheless sold over 100 acres for a right of way in 1960, although the Association "aroused public interest to further encroachment" (TPNSA 1974). In 1993, 635 ha, comprising the original nature sanctuary and nearby lands were transferred from the City of Victoria to the CRD, creating a large regional park. Since then, the Trans Canada Highway has widened, and housing, development and population have increased east and south of the park. Thetis Lake, Francis-King and Mill Hill Regional Parks still appear as one larger park, bisected only by the Trans Canada and Hydro line corridors.

limited housing occurring, for instance, at McKenzie Lake. The north portion of the west boundary could also be characterised as semi-natural, as may the north portion of the east boundary, which is a hydro right of way contiguous to Francis-King Regional Park. The south portion of the east boundary includes a residential development with older homes on the far south near the highway (at Watkiss Way) and newer homes currently being constructed further north along Highland Rd. (near the pistol range and Craigflower Creek Trail). None of these newly built homes and none of the older homes on this boundary had ivy in their yards. The south portion of the western boundary is also adjacent to residences with current housing (along Phelps Rd.) dating to the early 1970s and late 1980s. None of these homes appeared to have used ivy in landscaping.

5.10.1 Dominant Vegetation, General Habitat and Invaded Park Boundaries

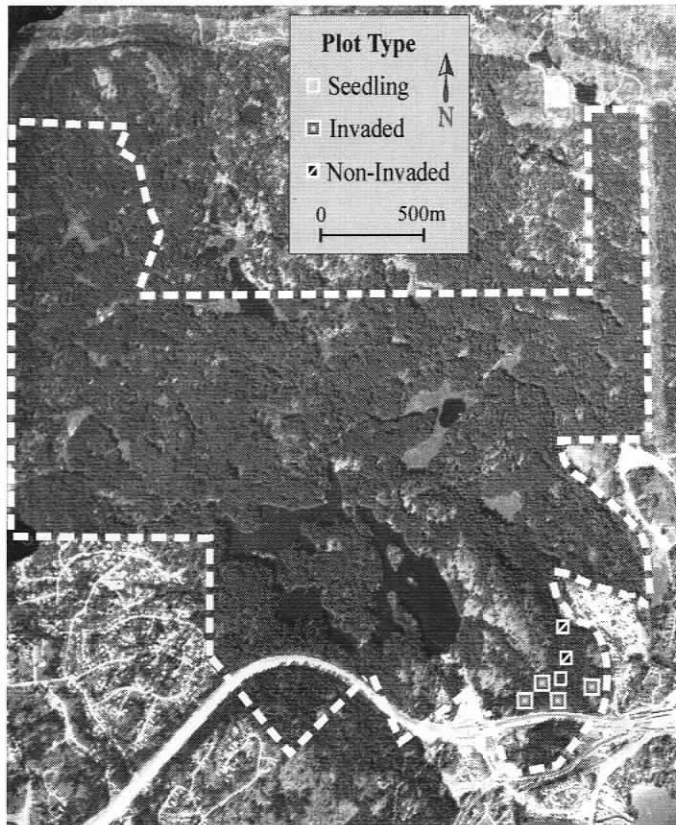
No ivy was found in searches along the park's north boundary, a very moist area with primarily mixed fir and western redcedar forest where salal and moss are abundant in the understory. Vegetation along the south portion of the western boundary adjacent to housing (Phelps Rd.) included mixed fir, redcedar and bigleaf maple, oceanspray, roses, Oregon grape with Himalayan blackberry* and Scotch broom* growing in open areas, and no evidence of ivy. In the south of the park, ivy is scattered along the old highway path and is very heavy inside the south part of the east boundary. Major vegetation along the old highway path included Douglas-fir and Douglas-fir meadow, bigleaf maple, arbutus and Garry oak on rock outcrops directly north. Holly*, daphne-laurel*, Himalayan blackberry* and Scotch broom* are also common in this area. The east boundary adjacent to housing contained many of the same plants as the low-lying areas

along the old highway, with salal replacing ivy as the primary understory cover further north, next to new housing. Invaded areas near the old highway in the southeast part of the park are discussed below.

5.10.2 Invaded Areas

Four invaded plots were sampled along the old highway and deeper north inside the park (Figure 5.11). Canopy cover in these invaded plots ranged between 50-95% closed. Their soils were dark brown and loamy in the first, light brown and loamy in the second, brown mucky and clay in texture near a creek in the third and the fourth had a thick organic layer and very dark brown thick A layer. In all, there were only 20 trees (greater than 35 cm circumference) in the invaded plots, probably representative of the fairly open nearby forest. Ivy climbed all nine of the Douglas-fir in the invaded plots, as well as four grand fir, two Garry oak trees and a bigleaf maple tree. Almost all of the ivy climbing trees in the invaded plots was in reproductive form with Garry oak hosting the only juvenile ivy. Stem diameters were very evenly spread in size from >1- 8 cm, the largest of which grew on Garry oak. Most other large stems were found on fir and the largest stem on bigleaf maple was 2 cm in diameter. Ivy climbed very high on Douglas-fir in these plots, reaching a maximum height of just over 26 m. The plants found in these areas are summarised in Table 5.18.

Figure 5.11: Approximate Sampling Locations and Park Boundaries, Thetis Lake Regional Park



1955 Regional View of Francis-King, Mill Hill and Thetis Lake Regional Parks

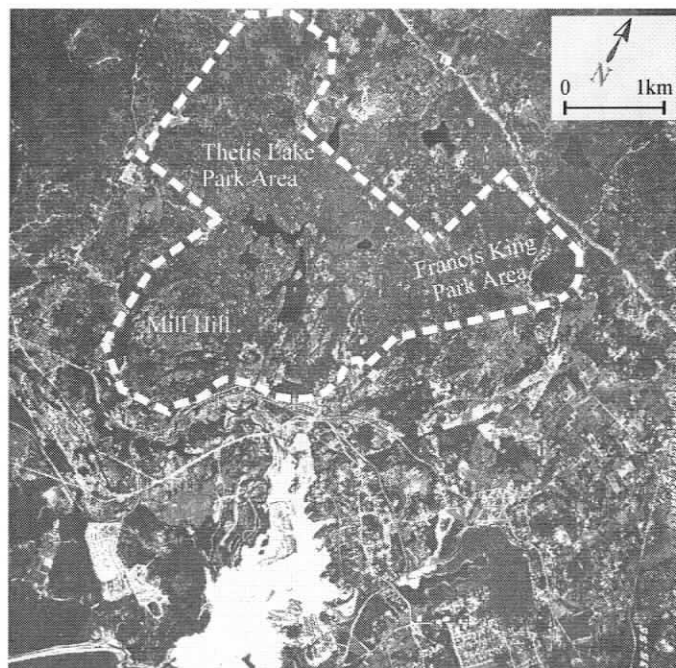


Table 5.18: Plants in Invaded Plots: Thetis Lake Park

Found in all four heavily invaded plots	Other plants found in plots where ivy cover was 2-11%	Other plants found in plot where ivy cover was 40%	Other plants found in plot where ivy cover was >90%
<ul style="list-style-type: none"> ◆ ivy* ◆ daphne-laurel* ◆ snowberry ◆ Indian plum ◆ Douglas-fir 	<ul style="list-style-type: none"> ◆ Garry oak ◆ Oregon grape ◆ trailing blackberry ◆ hemp nettle* (<i>Galeopsis tetrahit</i>) ◆ stinging nettle ◆ false Solomon's-seal ◆ five stamened mitrewort (<i>Mitella pentandra</i>) ◆ rattlesnake plantain ◆ wall lettuce* ◆ yerba buena (<i>Satureja douglasii</i>) ◆ sweet-scented bedstraw ◆ hairy honeysuckle ◆ licorice fern ◆ sword fern 	<ul style="list-style-type: none"> ◆ grand fir ◆ red alder ◆ arbutus ◆ bigleaf maple ◆ oceanspray ◆ salal ◆ broad-leaved starflower ◆ unidentified lily (Liliaceae) ◆ unidentified saxifrage (Saxifragaceae) ◆ wall lettuce* ◆ sword fern 	<ul style="list-style-type: none"> ◆ grand fir ◆ red alder ◆ bigleaf maple ◆ bitter cherry ◆ holly* ◆ Himalayan blackberry* ◆ Oregon grape ◆ sword fern ◆ grasses^(*)

5.10.3 Characteristics of Less Invaded and Non-Invaded Areas

Two non-invaded plots and one “seedling” plot that contained a small sprout of ivy with three true leaves (less than 1% of the ground cover) were sampled near invaded areas. The seedling plot had a very dark brown clay-textured soil. One of the non-invaded areas was in a slightly disturbed and drier, open Douglas-fir habitat, behind the pistol range and closer to Highland Rd. It had a very thin layer of organic material on rock and several escaped exotic species (Table 5.19).

Another non-invaded site was set deeper inside the reserve also in the southeast part of the park, in a wetter and less disturbed area containing a dark brown clay soil and several plants less commonly found in other plots (Table 5.19). Canopy closures ranged between 75-95% closed in these three non-invaded plots. Compared to invaded areas, soils in these non-invaded sites did not, therefore, differ as significantly as did their general location and canopy, which was on average, only slightly more closed.

Table 5.19: Plants in Seedling and Non-Invaded Plots: Thetis Lake Park

Found in all seedling and non-invaded plots	Other plants found in seedling plot	Other plants found in more disturbed non-invaded plot	Other plants found in moist, less disturbed non-invaded plot
<ul style="list-style-type: none"> ◆ Douglas-fir ◆ grand fir ◆ snowberry ◆ trailing blackberry ◆ Oregon grape ◆ rattlesnake plantain ◆ hairy honeysuckle ◆ licorice fern 	<ul style="list-style-type: none"> ◆ bracken fern ◆ bigleaf maple ◆ daphne-laurel* ◆ bracken fern ◆ Helleborine* ◆ ivy* (one small shoot) ◆ holly* ◆ Pacific crabapple (<i>Malus fusca</i>) ◆ Himalayan blackberry* ◆ broad-leaved starflower ◆ creeping buttercup* ◆ wall lettuce* ◆ unidentified lily (Liliaceae) ◆ grasses^(*) 	<ul style="list-style-type: none"> ◆ Indian plum ◆ salal ◆ oceanspray ◆ broad-leaved starflower ◆ bracken fern ◆ hairy honeysuckle ◆ falsebox ◆ stonecrop ◆ cyclamen* ◆ Siberian miner's lettuce 	<ul style="list-style-type: none"> ◆ red alder ◆ bitter cherry ◆ sword fern ◆ Siberian miner's lettuce ◆ sweet-scented bedstraw ◆ salmonberry ◆ vanilla leaf ◆ unidentified pea/legume (Fabaceae) ◆ stinging nettle ◆ unidentified water iris in water filled depression (Iridaceae) ◆ unidentified carrot (Apiaceae)

5.10.4 Overall Invasion

The strategic sections of boundary in the north, west and southeast sections of Thetis Lake Regional Park indicate clearly that patterns of invasion correspond to human settlement. Further north inside the park, as well as off the extensive circuit of trails, there is no evidence of invasion. Ivy is clustered in Douglas-fir stands near older residences. Similar to what was found at Francis-King Park, ivy at Thetis Lake Park is concentrated in a limited number of areas where it is found climbing trees rather than rambling through the forest's understory. Large stems are found along the old highway and heavy carpeting of the forest understory occurs inside the Highland Rd. border. Both of these areas are in the southeast part of the park where human activity has been more intense and ongoing.

5.11 Uplands Park¹¹

Although early homes probably existed near Uplands Park in earlier subdivisions, records from the municipality indicate that homes surrounding the park were built in the 1940s, 1950s and 1970s. Homes along the south park boundary (Beach Dr., Heron Rd., Lincoln St., etc.), the north boundary (Lansdowne Rd.) and east boundary (Valdez Pl., Surrey Rd., etc.) were built in the late 1940s to early 1950s. The west boundary near Midland Rd. has newer homes that were mostly built in the middle to late 1970s. Today, almost 30% of properties next to the park have ivy in their yards.

5.11.1 Dominant Vegetation and General Habitat of Park Boundaries

The park is rectangular in overall shape, constricted in the southeast where it expands again into a paddle-shaped parcel bound by shoreline and fragmented by two roads and parking lots. Habitat of this parcel becomes increasingly more vegetated and less exposed from the rocky shoreline inland, with Garry oak increasing in size and growing with Scotch broom, gorse, grasses^(*), willow, snowberry, Nootka rose and other shrubs. The dominant habitat west of this shoreline parcel along the southern boundary includes mixed deciduous trees, shrubs, and meadow and wet sedge meadow. Some of the major plants include introduced apple* (*Malus* sp.), English hawthorn*, Himalayan

¹¹ Uplands Park is in a well established region of Greater Victoria on lands that were subdivided for farms by the 1850s. Since the turn of the century, the park has been well delineated against housing and has experienced considerable vegetation and community change. Between 1906, when Oak Bay was incorporated, and 1913 when much of Oak Bay's roads and housing were planned (including the Uplands subdivision), the undeveloped lands which later became the park were preserved in part to retain shoreline access. Uplands Park was formally established in 1946 when the municipality of Oak Bay purchased the land to keep as a public park in perpetuity. It has been described as containing "[t]he largest and best preserved Garry oak community" on the Saanich Peninsula as well as a number of rare and interesting plants (Szcawinski and Harrison 1972:17). In this respect, Uplands Park is unique among the parks in this study, containing no Douglas-fir habitat and also having been long enclosed within a residential community.

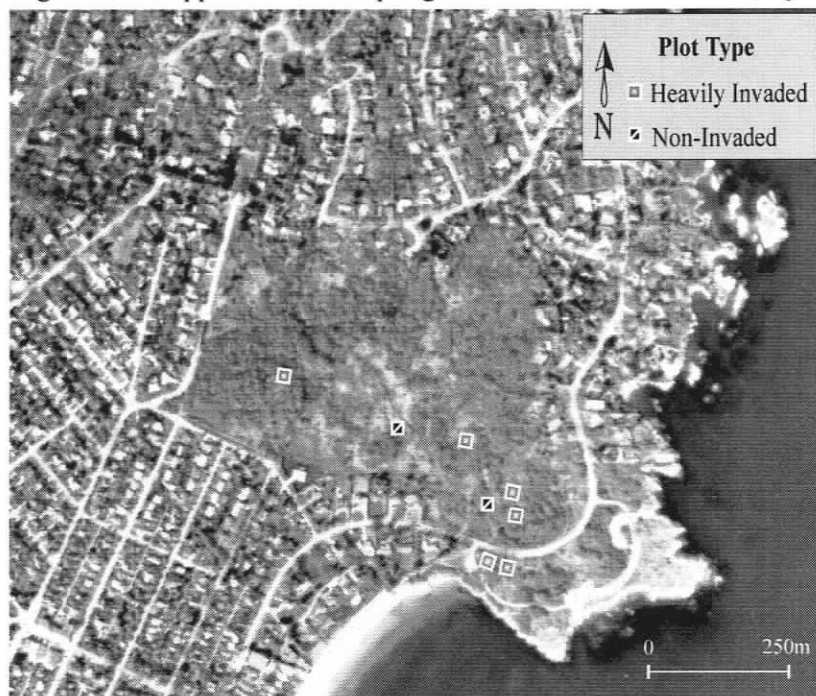
blackberry*, Scotch broom*, gorse*, snowberry, Nootka rose and assorted grasses^(*). A thick stand of trembling aspen grows in the far west corner of the park. The western boundary includes aspen, English hawthorn*, snowberry, Nootka rose, grasses^(*), Himalayan blackberry* and the occasional introduced pine (*Pinus* sp.). The northern boundary includes Garry oak, Scouler's willow, English hawthorn*, trembling aspen and black cottonwood, and the eastern boundary primarily includes Garry oak meadow and grasses^(*) on rocky outcrops. Further inside the park, dominant plants are patchily distributed (e.g. wet meadow species with willow groves and hawthorn-daphne-laurel* meadows in the east part of the park, and Garry oak meadows, Scotch broom* and grassy rock outcrops elsewhere).

5.11.2 Invaded Park Boundaries and Invaded Areas

Unlike other parks where distinct lines may be drawn between where invasion begins and ends, ivy is established in all park boundaries and interior habitats of Uplands Park. The limiting habitats for ivy in the park include rock outcrops, scrub Scotch broom* communities, Himalayan blackberry* mats, expanses of mowed and managed grasses^(*), dry and wet meadows and hawthorn and daphne-laurel* communities. Further, Uplands Park is a relatively simple ecosystem in which to discern and delimit the habitats of ivy, partly because it is so accessible and its woodland is almost entirely, except for a few pines and arbutus, composed of deciduous trees. All invaded areas share the characteristic that they are in deciduous woodland, primarily of Garry oak but also including trembling aspen and Sitka willow (*Salix sitchensis*).

Six invaded plots were sampled (Figure 5.12). Two plots, in which ivy comprised less than 20% of the ground cover, characterised the moisture and abiotic limits of ivy's habitat. The first of these areas was a bright open meadow where ivy was climbing only one very large stemmed Garry oak (first column of Table 5.20 – only dominant grasses^(*) were identified). The second area was a Sitka willow grove next to a wet, marshy area with clayish soil, abundant horsetails (*Equisetum* sp. probably giant horsetail: *E. telmateia*) and other hydrophillic plants (second column of Table 5.20). Four plots were sampled where ivy comprised 80% or more of the lower vegetation stratum. In them, canopy cover ranged between 5–70% closed. Trees in invaded plots were, on average, smaller in circumference than those from other parks (i.e. mostly Garry oak growing densely and in slightly krummholtz-type form from exposure to coastal winds). In all, 90 trees were measured, eight of which fell in the 20–35 cm circumference range. The majority (n=75) of the 90 trees were Garry oak and of these 90 trees, 83 were climbed by ivy, illustrating the degree to which these areas were invaded. Twenty-two of the 25 samples of reproductive / flowering ivy climbed Garry oak. Large stems (from 5–10 cm in diameter) grew on Garry oak, trembling aspen and Sitka willow. Forty trees hosted small stems (equal to or less than 1 cm in diameter), including red alder, cascara, Sitka willow and Garry oak. Cascara and red alder hosted juvenile-form ivy only. Within the sample, ivy grew to heights over 10 m on Garry oak, both species of willow and

Figure 5.12: Approximate Sampling Locations and Boundaries, Uplands Park



trembling aspen, and to a maximum height of 15 m on Garry oak. Invaded areas contained numerous species of trees and shrubs not present in the non-invaded areas including cascara, Pacific crab apple, trembling aspen, red osier dogwood, saskatoon, possibly introduced cherry* (possibly *Prunus avium*) and introduced plants including holly*, American elm* (*Ulmus americana*), rowanberry* (*Sorbus aucuparia*) and privet* (*Ligustrum vulgare*).

5.11.3 Characteristics of Less Invaded and Non-Invaded Areas

Uplands Park's open, rocky outcrops with Scotch broom* or English hawthorn* and daphne-laurel*, and heavily managed human landscapes such as cleared lawns and meadows are unsuitable habitat for ivy. Garry oak woodland at Uplands Park is abundant and variously invaded. Oak groves that are characteristically very exposed and xeric, having few large understory shrubs and plants besides daphne-laurel*, grasses^(*) and/or mixed wildflowers are often barely invaded or non-invaded. The bright open invaded meadow plot discussed in the previous section represents the limit of ivy invasion in this type of oakland. A second type of Garry oak woodland that appeared to be characteristically non-invaded has very dense understory shrubs. Both of these types of oak ecosystems, in contrast to the invaded oak ecosystems, contained numerous small, short oaks with very small trunk circumferences. Two plots in non-invaded woodland with thick shrub layers were examined. One contained a very large arbutus tree and four large stemmed oaks, the other contained four oaks that ranged between 50-90 cm in circumference. Other large dominant plants in both these plots were Indian plum, daphne-laurel*, Scotch broom* and Nootka rose (Table 5.20). Both have heavy canopy closures

(90-95% closed) in summer and very light canopy closures (5-10%) after oak leaves have fallen and both had several centimetres of loamy textured (A horizon) soils.

Table 5.20: Plants in Invaded and Non-Invaded Plots: Uplands Park

Found in the four heavily invaded plots	Found in the invaded meadow plot (more xeric)	Found in the invaded hydric plot	Found in non-invaded plots
<ul style="list-style-type: none"> ◆ ivy* ◆ Garry oak ◆ Sitka willow ◆ introduced cherry* ◆ elm* (<i>Ulmus americana</i>) ◆ snowberry ◆ cascara ◆ holly* ◆ daphne-laurel* ◆ Nootka rose ◆ false lily of the valley ◆ creeping buttercup* 	<ul style="list-style-type: none"> ◆ ivy* ◆ snowberry ◆ daphne-laurel* ◆ Scotch broom* ◆ common camas ◆ mixed garden flower bulbs* ◆ dovefoot geranium* (<i>Geranium molle</i>) ◆ orchard grass* (<i>Dactylis glomerata</i>) ◆ blue wildrye (<i>Elymus glaucus</i>) ◆ other assorted grasses(*) 	<ul style="list-style-type: none"> ◆ ivy* ◆ rowanberry* (<i>Sorbus aucuparia</i>.) ◆ snowberry ◆ daphne-laurel* ◆ giant horsetails and possibly other horsetails ◆ salmonberry ◆ Cooley's hedge nettle ◆ unidentified bulbs(*) (possibly onions, lilies and/or garden flowers) ◆ Pacific water parsley ◆ unidentified fine-leaved carrot(*) (Apiaceae) 	<ul style="list-style-type: none"> ◆ Garry oak ◆ arbutus ◆ daphne-laurel* ◆ Indian plum ◆ Himalayan blackberry* ◆ Scotch broom* ◆ Nootka rose ◆ western trumpet honeysuckle ◆ common camas ◆ assorted native and introduced grasses* ◆ other mixed wildflowers (e.g. fawn lily -<i>Erythronium oreganum</i>, shootingstar <i>Dodecatheon pulchellum</i> probably also <i>D. hendersonii</i>) ◆ other mixed garden flowers and bulbs*

5.11.4 Overall Invasion

The driest of the study areas in terms of rainfall (Environment Canada 1993), Uplands Park's mature Garry oak and woodland ecosystems have been heavily invaded by ivy. The presence of large, thick mature ivy stems up to 10 cm in diameter suggests the long establishment of ivy in the park. Residential and human activity around the park has been ongoing since the last century and more intensely over the past half century. Human activities such as planting, mowing and clearing of vegetation have greatly altered Upland Park's former ecosystems. Of all the parks examined, Uplands Park has the greatest proportion of its entire area invaded by spreading, dominant common exotic plants, most notably Scotch broom, Himalayan blackberry*, daphne-laurel*, ivy*, introduced

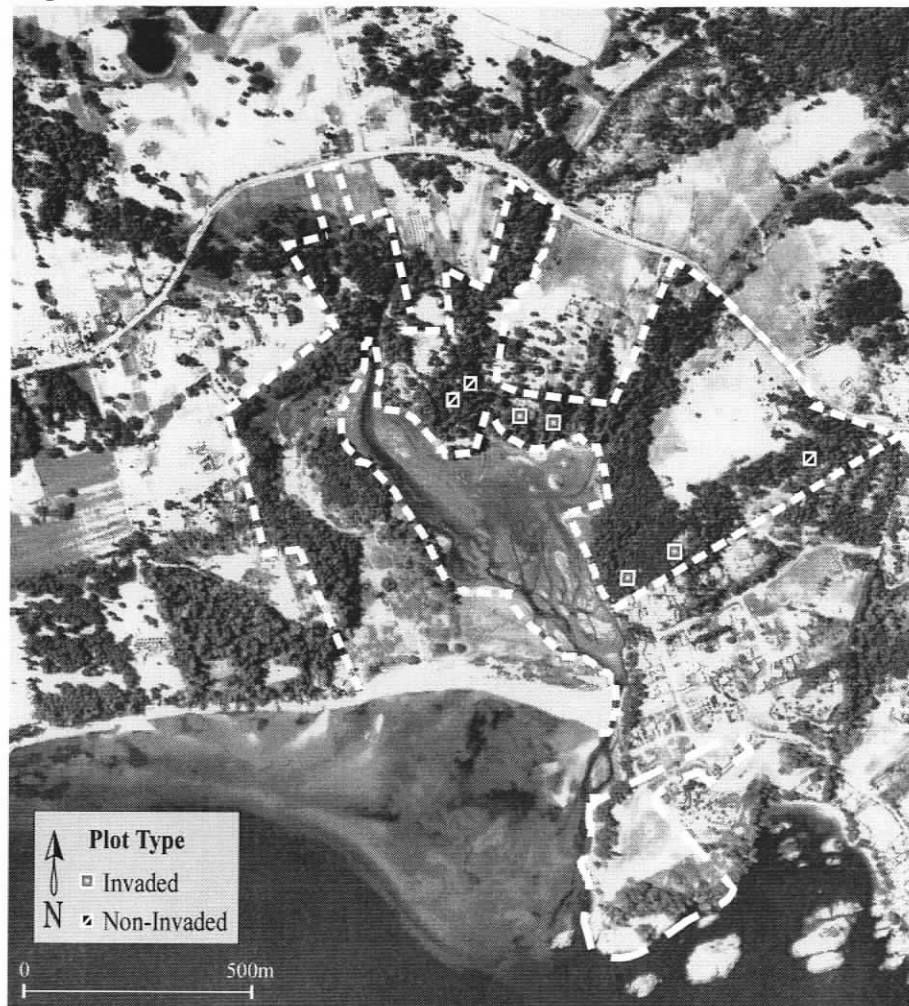
ornamental trees like English hawthorn*, maple*, rowanberry* and cherry, garden flowers* and bulbs* (e.g. daffodils), houseplants (e.g. cyclamen*) and grasses(*). Introduced garden and ornamental plants are extensive in Uplands Park.

5.12 Witty's Lagoon Regional Park¹²

Today, Witty's Lagoon Park is approximately 66 hectares in size and irregularly shaped, corrugated between farms and highway and having a high edge to interior ratio (Figure 5.13). Several areas surrounding the main parcel of park, at least as viewed from the highway, are for the most part still semi-agricultural and low density residential, lending a rural character to the park. More suburban-type housing occurs on either sides of the lagoon near the shoreline and at Tower Point. Records indicate that this suburban type housing, on the south-most part of the park south of the lagoon was built in the early 1920s, 1950s and mid 1960s. Homes of the slightly greater density subdivision on the southeast edge of the park were built in the early 1960s and new ones are currently being built further north towards Duke Rd. and the highway. In lower density agricultural

¹² Native settlements on the spit of the lagoon were thought to have helped create the lagoon ecosystem itself, as shellmidden sites and burial cairns contributed to the spit's expansion over time (Keddy 1991). More recent human activities resulting in physical changes to the current park followed the 1850s when James Douglas obtained the region of Metchosin from the Ka-Ky-aaken in exchange for blankets and sold 385 acres [approximately 155.8 ha] including the lagoon to an individual named Captain Cooper. In 1867, John Witty purchased the property and built a new home for his family there in 1898. The region surrounding the Witty's farm remained largely agricultural through the first part of the next century, although regional growth in Metchosin was ongoing. By the 1960s, increasing pressures to protect the lagoon from development resulted in the Capital Regional District Board purchasing and expropriating lands from the Witty's family farm. These were subsequently named Witty's Lagoon and established as a CRD park in 1966. By the early 1970s, additional lands were purchased, including Tower Point. Witty's Lagoon is now primarily a wetland reserve consisting of a forest buffer of varying length extending from the lagoon's shoreline.

Figure 5.13: Approximate Boundaries and Sampling Locations, Witty's Lagoon Regional Park



View of Witty's Lagoon Area, 1951



areas, homes on the park's western edges south of Metchosin Rd. date from the 1940s to the 1990s, and on the north side of the park, from the 1960s and early 1920s. On the east park edge, near the lagoon trail, a few homes were landscaped with ivy, including at least one on the west near the nature house trail and on the south edge of the park along Witty Beach Dr. At Tower Point, there is very old housing against the north border of the park and a slightly younger, higher density subdivision along the northwest linear entranceway. None of these homes appeared to be landscaped with ivy at the time of observation. In total, of the approximately 28 homes directly against the park, at least one fifth had been landscaped with ivy, although five of the 28 properties were not easily surveyed. The subsequent discussions on Witty's Lagoon Park focus mainly on Tower Point and the western parcel of the main park.

5.12.1 Dominant Vegetation, General Habitat and Invasion of Park Boundaries

The most heavily disturbed park boundaries are found at Tower Point, where regular mowing of vegetation occurs at the entranceway, parking areas and a large portion of the northern and interior parts of this parcel. Dominant shrubs along the corridor entrance between the parking area and the main parcel of Tower Point are primarily Himalayan blackberry*, mixed roses and snowberry and underneath them there is sparse, juvenile ivy. The east edge of the main parcel of Witty's Lagoon Park is predominantly Douglas-fir, in which ivy is abundant along the south and centre-south parts closer to the lagoon. The north boundary along the highway west of Duke Rd. is also predominantly Douglas-fir but is not invaded by ivy. Just west of this, a northwest facing boundary along the lagoon trail, where the park is constricted between nearby residential housing and the

lagoon, Douglas-fir and western redcedar predominate and the area contains abundant ivy. This area north of the lagoon trail and the invaded areas along the east park boundary are the focus for sampling and discussion below.

5.12.2 Characteristics of Invaded Areas

Four invaded areas were examined and in these four plots, ivy cover ranged between 7-70%, canopy cover ranged from 45-85% and soils included thick layers of dark brown clayish to silty soils in very wet areas (Figure 5.13). There was a total of 46 trees present in the invaded sample plots, the majority being Douglas-fir (n=22), grand fir (n=10) and western redcedar (n=7). Bitter cherry, arbutus and red alder were also found. Ivy climbed 28 of these trees, most of which were Douglas-fir (n=15) and western redcedar (n=6) but also grand fir, red alder and unidentified snags. Ivy climbed 27 of the 28 trees in juvenile form, having stems under 1.5 cm in diameter. The one Douglas-fir tree that hosted reproductive-form ivy in the invaded plots had the largest stem, which measured only 3 cm across. Plants found in plots are summarised in Table 5.21.

5.12.3 Characteristics of Non-Invaded Areas

Three non-invaded areas were examined for contrast. The first was located on the west-north west slope of a ravine west of the lagoon trail invaded plots and contained six Douglas-fir with a 90% canopy closure and its soil was composed of approximately 15 cm of brown clay on solid rock. In addition to the plants found in all non-invaded plots (Table 5.21), this plot contained Himalayan blackberry* and abundant palm tree moss (*Climacium dendroides*). A second non-invaded area, located at slightly higher elevation approximately 65 m southeast of the first, had a 95% closed canopy and 5 cm each of

organic material and greyish-brown clayish soil on a layer of pale gray clay (B horizon). Very thick and tangled masses of roots covered most of the ground in the plot and it contained no tall shrubs, although salal was very abundant. Blackberry, sweet-scented bedstraw and hairy honeysuckle were present in addition to the plants listed in Table 5.21.

The third non-invaded plot, located nearer Metchosin Rd. in the west boundary of the main northeast park parcel, contained nine Douglas-fir, a grand fir and a dead western redcedar tree, had an 87% canopy closure and 5-8 cm of brown silty-clay soil on a compact, yellow-gray lower stratum. Trailing blackberry, oceanspray, bedstraw, creeping buttercup*, Nootka rose, daphne-laurel*, holly* and licorice fern were found in addition to the plants listed in Table 5.21 and the area appeared slightly more disturbed than other non-invaded areas discussed above. On the whole, these three non-invaded areas appeared to have slightly drier microhabitats, paler soils and greater canopy closures than the invaded plots.

Table 5.21: Plants in Invaded and Non-Invaded Plots: Witty's Lagoon Park

Found in all invaded plots	Found in 2 or 3 of the 4 invaded plots	Found in one invaded plot	Found in all non-invaded plots
<ul style="list-style-type: none"> ◆ ivy* ◆ Douglas-fir ◆ trailing blackberry ◆ snowberry ◆ wall lettuce* ◆ bracken fern ◆ daphne-laurel* 	<ul style="list-style-type: none"> ◆ arbutus ◆ grand fir ◆ western redcedar ◆ Oregon grape ◆ salal ◆ holly* ◆ creeping buttercup* ◆ sword fern 	<ul style="list-style-type: none"> ◆ bigleaf maple ◆ red alder ◆ bitter cherry ◆ mountain-ash* (<i>Sorbus aucuparia</i>) ◆ oceanspray ◆ red elderberry ◆ hairy honeysuckle ◆ baldhip rose ◆ Himalayan blackberry* ◆ false Solomon's-seal ◆ sweet-scented bedstraw ◆ licorice fern 	<ul style="list-style-type: none"> ◆ Douglas-fir ◆ salal ◆ Oregon grape ◆ sword fern ◆ bracken fern ◆ baldhip rose ◆ grasses^(*)

5.12.4 Overall Invasion

Douglas-fir habitat at Witty's Lagoon Park is not heavily invaded by ivy. The areas of the main park that are invaded are mostly scattered along the eastern boundary and the thin section of park along the Lagoon trail next to housing that is 30 and more years old. Ivy stems, having diameters of around 3 cm, are not particularly large in relation to those found in other parks, indicating that ivy may not be as long established, at least in climbing form, at Witty's Lagoon Park. The general nature of nearby housing and the location of homes with ivy is diffuse over the landscape surrounding the park, a possible contributing factor to the moderate to slight invasion of this plant. At Tower Point, ivy is locally distributed adjacent to housing and in vegetative form only, creeping sparsely under shrubs that line the entrance corridor from the parking area to the main part of the park. Management and on-going removal of ivy may be another contributing factor to the observed distribution of ivy at both Tower Point and the main parcel of Witty's Lagoon Park.

CHAPTER 6: PARK FRAGMENTATION AND PARK EDGE TYPES

This chapter describes the landscape types outside the administrative boundaries of the parks sampled. The analysis of park edges provides a characterisation of the parks in terms of their overall fragmentation from nearby natural habitat and the quality and quantity of their direct contact with various external land-use. The overall invasion of parks by ivy is then related to these findings, in order to draw conclusions about the effect that a park's insularity by residential and other land use has on its invasion by exotic species.

6.1 Park Edges in the Sample of Parks as a Whole

Major landscapes and land-use types were measured for each park by marking land-use or landscape categories on maps each time they changed around the perimeters of each park (summarised in Appendix 2; and see Chapter 3). Several segments of a particular land use category, each varying in length, were often marked around a single park. In total, 134 boundary segments were drawn around all 14 parks (Appendix 4), indicating the irregular and varied nature of land use around administrative park boundaries. The majority of boundary segments (60/134) were residential categories (lower-density/agricultural, medium-density and higher-density in that order). There were 39 boundary segments of park boundary adjacent to roadway/accessway categories and 32 segments of semi-natural type categories (shoreline).

More important than the number of park boundary segments is the length and proportion of park border touching each category of landscape. If all park edges or perimeters in this sample of parks are combined, semi-natural/vegetated area is the landscape category most often found along park borders (comprising 36% of the sum of

all park perimeters). Lower-density residential/agricultural areas are found against 24% of all park perimeters. Higher-density residential areas, generalised shorelines (non-terrestrial borders) and medium-density residential areas are the third most abundant park edge types in this sample at 8%, 8% and 7% of all park edges respectively. Major highways (Trans Canada and Patricia Bay) and roads adjacent to lower-density residential/agricultural, medium and higher-density residential areas each comprised between 2-5% of the park edges in the sample.

The inclusion of two large, regional parks (Mount Work and Thetis Lake Parks) in this sample accounts for 79% of the most frequently encountered park edge type: semi-natural/vegetated areas. In contrast, lower-density residential and agricultural areas were regularly found around a majority of the parks and contributed to the majority of fragmentation in this sample. The characterisation of overall enclosure by human activities and the proportion of edge occupied by various land-uses can, therefore, shift widely with the sample of parks. For instance, when the two large parks (Mount Work and Thetis Lake Parks) are excluded, the proportion of high and medium density residential edge increases from 15 to 19% and semi-natural/vegetated edge decreases from 46 to 26%.

As the characterisation of insularity for this sample of parks is based on their size and edge characteristics, a breakdown of size and edge to area ratios provides the first indication of overall park insularity (Table 6.1). In general, the smaller parks (e.g. Knockan Hill, Coles Bay and Devonian Parks) tend to have less interior habitat per length of border or edge when compared to larger parks (e.g. Mount Work, Elk-Beaver Lake and Thetis Lake Parks).

Table 6.1: Parks Ranked by Edge (Perimeter in m) to Interior (Area in ha)

Park	Perimeter (m)	Area (ha)	Perimeter:Area (m:ha)	Approx. Distance to CBD ♦ (km)
Knockan Hill	2015	8	252:1	5.6
Coles Bay	826	4	207:1	23.2
Devonian	2344	13	180:1	15
Witty's Lagoon	9080	56	162:1	12.5
Uplands	3585	33	108:1	4.5
Lone Tree Hill	2725	31	88:1	14.5
Mill Hill	3848	50	77:1	8.5
Horth Hill	2143	31	69:1	28.9
Bear Hill	4415	49	45:1	13
Mount Douglas	7730	176	44:1	6
Francis-King	4440	113	39:1	8
Mount Work	17600	536	33:1	13.2
Elk/Beaver Lake	12405	411	30:1	9
Thetis Lake	15810	635	25:1	7.5

♦Central Business District (i.e. City Hall)

6.2 Park Size, Edge to Interior Ratios and Overall Invasion

Based on the areas searched and the overall distribution of ivy, four categories of park invasion were distinguished. Eight of the parks contained significant amounts or large distributions of ivy, while six had limited or no invasion (Table 6.2).

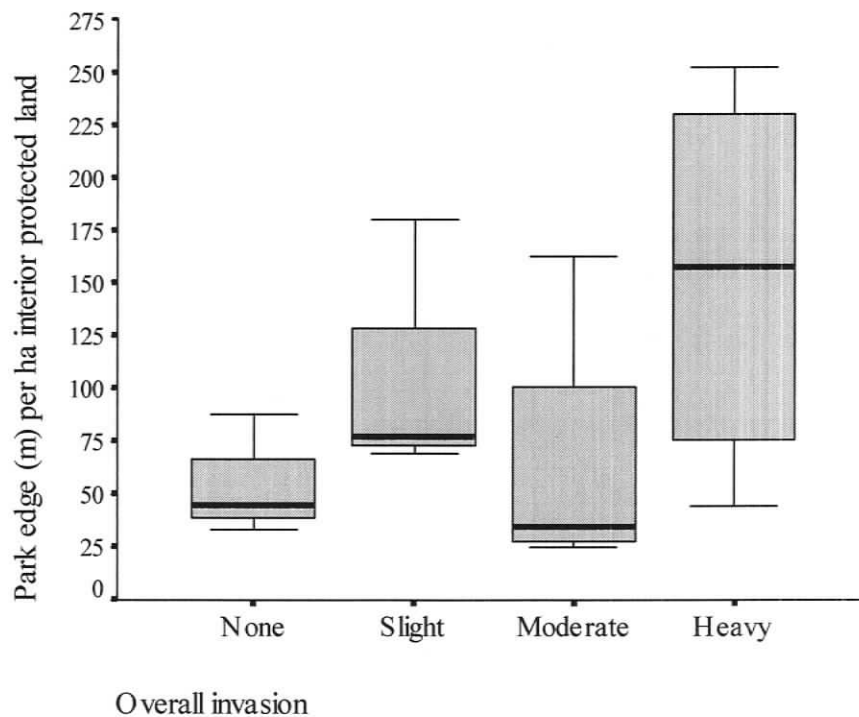
Table 6.2: Parks by Overall Invasion of ivy

None: Not found in any areas examined	Slight: Spotty distribution; single sprouts or small shoots	Moderate: Several or large distributions and in reproductive-form	Heavy: Abundant in a significant proportion of suitable/available habitat
<ul style="list-style-type: none"> • Bear Hill • Lone Tree Hill • Mount Work 	<ul style="list-style-type: none"> • Horth Hill • Mill Hill • Devonian 	<ul style="list-style-type: none"> • Elk-Beaver Lake • Francis-King • Thetis Lake • Witty's Lagoon 	<ul style="list-style-type: none"> • Knockan Hill • Uplands • Mount Douglas • Coles Bay

Knockan Hill Park has the highest proportion of park border to area and was the most heavily invaded park in the sample. However, for other parks, the relationship between edge / interior ratio and overall invasion is weak. For instance, Devonian and Lone Tree Hill are both small parks with little or no invasion, while some of the larger parks with several times less perimeter/edge per unit of area have large distributions of

ivy (e.g. Elk-Beaver Lake, Francis-King). Although the most heavily invaded parks had the highest median edge to interior ratio (Figure 6.1), no general relationship is evident for other categories of overall invasion in this sample of parks. The ratio of edge:interior is thus not as powerful a variable for explaining overall invasion as hypothesised at the outset of the research.

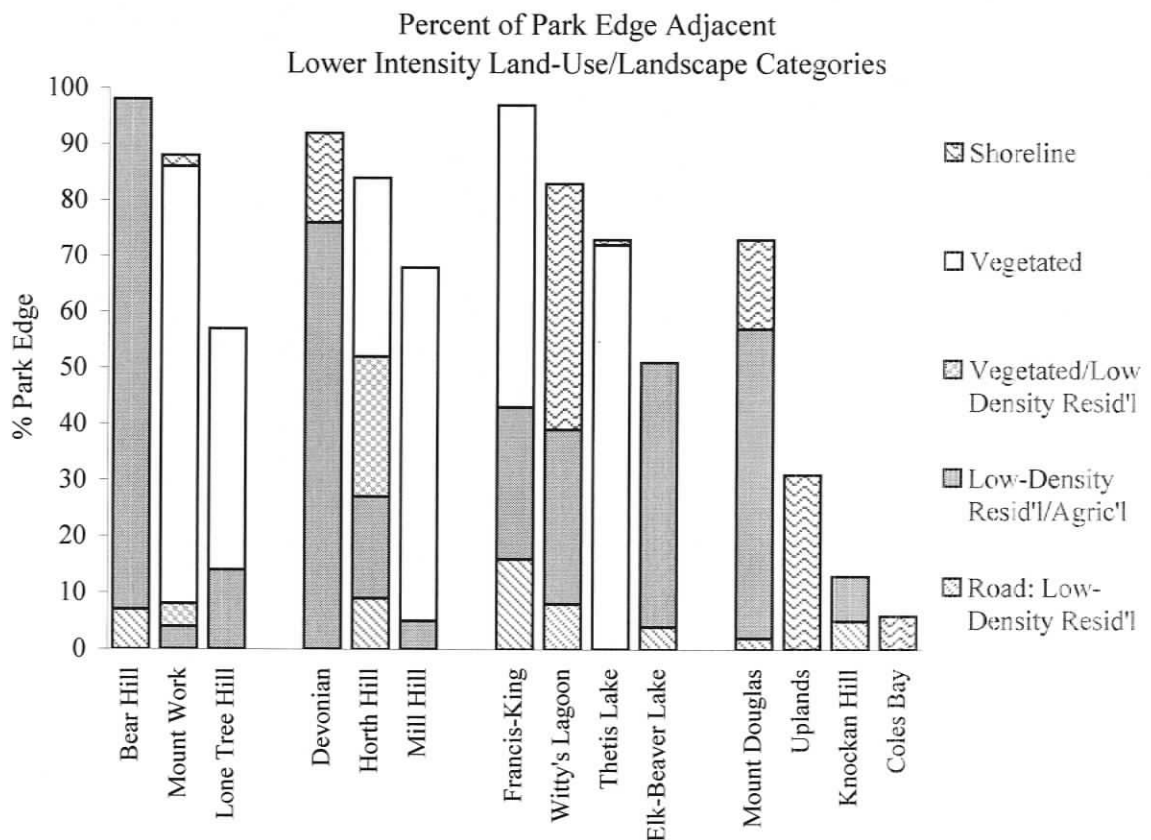
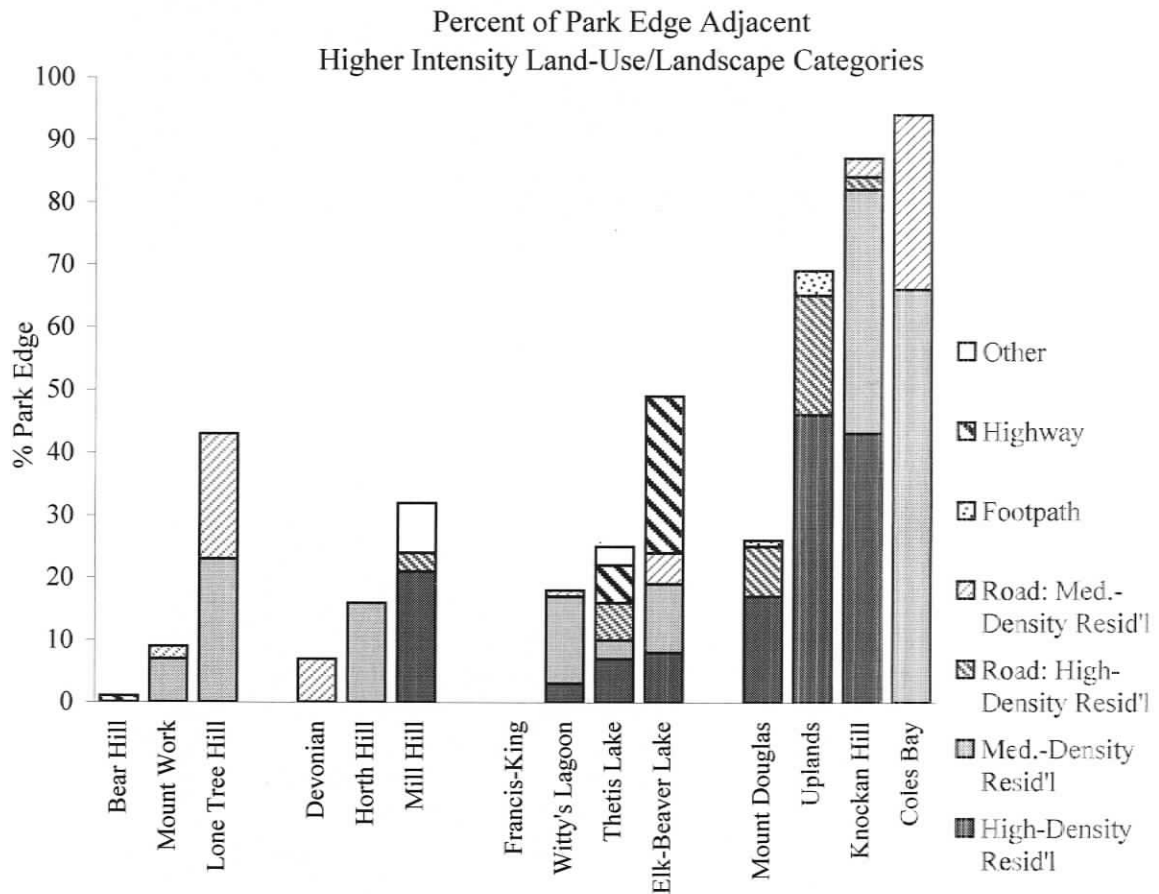
Figure 6.1: Park Edge: Interior by Overall Invasion. Median indicated by dark horizontal line; 50% of cases fall within shaded area.



6.3 Park Edge Types and Invasion of Ivy

The proportion of park perimeter in contact with major types of land uses provides a different picture for overall park invasion than park perimeter:area ratio, particularly when categories of adjacent land-use are divided into higher and lower intensity human activities (Figure 6.2). Coles Bay, Uplands, Knockan Hill and Elk-Beaver Lake Parks have the highest proportions of edge against higher intensity human

Figure 6.2: Park Edge Types



land-use categories, whereas Bear Hill, Devonian, Francis-King and Mount Work Parks have the lowest. The overall extent of invasion in the parks examined generally follows outside land use (see Table 6.2), with highly invaded parks (e.g. Coles Bay, Elk-Beaver Lake, Knockan Hill and Uplands Park) having the greatest proportion of border against high-intensity land-use (Figure 6.2). Greater invasion by ivy observed in the more urbanised parks in this study supports Smallwood's (1994) observations of high exotic plant abundance in reserves near human settlement.

Mount Douglas Park, since it is identified as having heavy overall invasion yet has a low proportion of its perimeter adjacent to higher-density category residential areas, presents an exception to this general finding. The reasons for this may include the irregular shape of Mount Douglas Park's west border along lower-density/agricultural areas, the park's extensive shoreline and the absolute length of its perimeter adjacent to residential areas. Mill Hill Park also has only slight invasion yet has a considerable amount of contact with residential areas. Reasons for these exceptions are developed in Section 6.4.

The non-invaded parks provide the best illustration of the effect of park boundaries on invasion. All three non-invaded parks have medium and lower-density residential edges, with the non-invaded Gowland-area parks having greater proportions of semi-natural edge compared to human-generated edge. Two of the three slightly invaded parks have more edge adjacent to natural areas than human-use areas with much of the residential human use category comprising lower density housing. When the moderately invaded parks are examined, half have more semi-natural than human-use oriented edge. Whereas, in contrast, the four heavily invaded parks have high proportions of human-generated edge in comparison to semi-natural (shoreline) edge. For example, the edges of

the highly invaded Knockan Hill Park are entirely human-generated. Residential categories of heavily invaded parks are also comprised of considerable high and medium density residential housing. The characterisation of park edge types from the sample as a whole indicates that moderately and heavily invaded parks have greater numbers of human-generated edges than lesser and non-invaded parks.

6.4 Overall Occurrence of Ivy Outside Parks and Invasion

The survey of ivy in yards adjacent to parks may not be directly indicative of its popularity as a horticultural plant in the regions sampled but it does represent a conservative estimate of its frequency there (Table 6.3).

Table 6.3: Minimum Frequency of ivy on Properties Adjacent to Parks

Park	Min. <i>n</i> homes	Min. <i>n</i> homes with ivy	Min. proportion with ivy
Bear Hill	10	4	40%
Uplands	55	15	27%
Coles Bay	16	4	25%
Knockan Hill	49	11	22%
Elk/Beaver Lake♦	59	11	19%
Devonian	6	1	17%
Mount Douglas	77	12	16%
Witty's Lagoon [†]	28 [7] (34)	5 [0] (5)	18% [0%] (15%)
Francis-King	20	2	10%
Horth Hill	10	1	10%
Thetis Lake	22	2	9%
Mill Hill♦♦	12	1	8%
Mount Work ^{††}	8	0	0%
Lone Tree Hill	18	0	0%
Total	396	69	17%

♦ Not including homes on Pat Bay Highway or strata homes on south park border

† Homes south of Metchosin Rd. only [Tower Point] (both parcels of park)

♦♦ Homes in trailer park not included

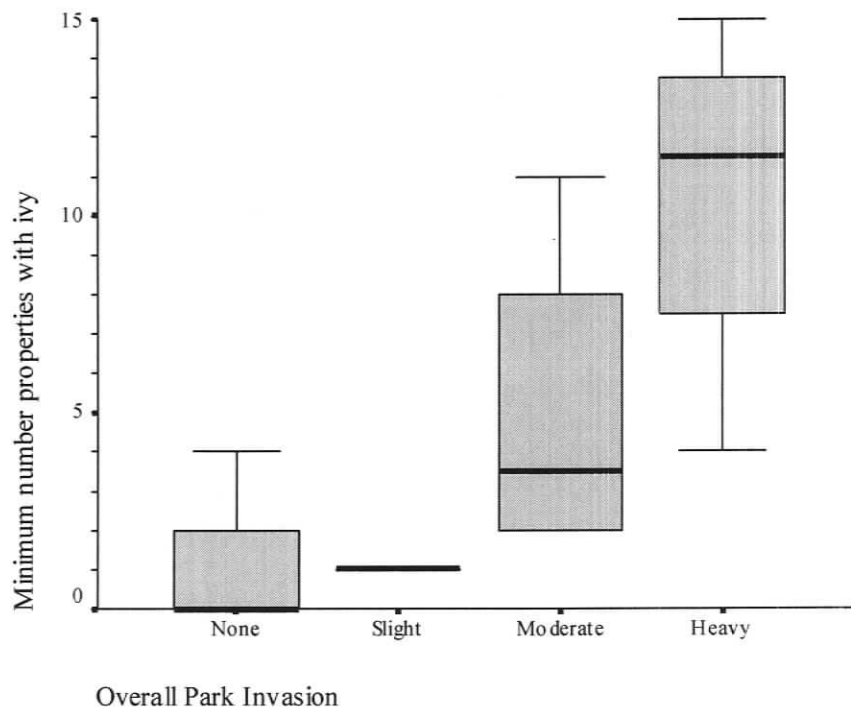
†† Includes only homes at Durrance Cl. and several at Fork Lake

In all, ivy is growing on a significant proportion (a minimum of 17%) of properties that were surveyed. Ivy was less frequently found near the more rural, remote parks (Francis-

King, Mount Work, Lone Tree Hill and Thetis Lake Parks) and most frequent near parks of older established neighbourhoods (Uplands, Bear Hill and Mount Douglas Parks).

The data from this sample indicate that overall park invasion increases as the median number of properties adjacent to parks acting as point sources of ivy increases (Figure 6.3). This supports the hypothesis that near-urban parks surrounded by higher-density residential areas, that are sources of horticultural plants (e.g. ivy), are more likely to have their internal habitats transformed by these species.

Figure 6.3: Minimum Frequency of ivy on Properties Adjacent to Parks and Overall Park Invasion. Median Indicated by Dark Horizontal Line; 50% of cases fall within shaded area.



CHAPTER 7: CHARACTERISTICS AND COMPARISON OF INVADED AND NON-INVADED AREAS

This chapter describes and compares observed characteristics from the 41 ivy-invaded, 5 seedling and 29 non-invaded plots. As in previous chapters, a * denotes an introduced species and a (*) denotes a possibly introduced species.

7.1 Characteristics of Invaded Areas

A total of 329 trees or large shrubs with circumferences greater than or equal to 35 cm were measured in the 41 invaded plots¹. Indicative of the intensity of invasion within the plots, 78% of the trees were climbed by, mostly juvenile-form ivy (Table 7.1). All species of trees found in invaded plots were hosts to ivy. However, Garry oak, grand fir and Douglas-fir were the most frequent host species.

When looking at the condition of trees in invaded plots as a whole, healthy trees hosted ivy in higher proportion to trees in poor condition (e.g. dying, lying, snags) (Table 7.2). All snags climbed by reproductive-form ivy were in very heavily invaded areas (such as Uplands Park plots) and hosted large ivy stems (4.5-9.5 cm in diameter). All other snags were found in less heavily invaded sites and were either not climbed or climbed only by young juvenile ivy shoots, indicating they were dead before the ivy arrived. In more invaded areas, knowing the age of snags would be necessary to determine whether ivy had established on these trees while they were alive and whether ivy played a role in their death.

¹ 14 trees/shrubs had circumferences between 20-35 cm such as those from Uplands Park plots and are left out of analyses in this chapter.

Table 7.1: Summary of Trees (≥ 35 cm) from Invaded Plots

Trees / Large Shrubs			<i>n</i> Trees Climbed by Ivy		% Trees Climbed by Ivy		% not climbed
	<i>n</i>	%	Juvenile -form	Reproduc -tive form	Juvenile -form	Reproduc -tive form	
Douglas-fir	119	36.2	50	44	42	37	21
Garry oak	98	29.8	53	34	54	35	9
grand fir	44	13.4	17	14	39	32	30
bigleaf maple	21	6.4	10	4	48	19	33
western redcedar	11	3.3	8	0	73	0	27
Sitka willow	6	1.8	3	1	50	17	33
trembling aspen	4	1.2	2	2	50	50	0
yew♦	4	1.2	2	0	50	0	50
arbutus	3	0.9	0	1	0	33	66
red alder	3	0.9	1	0	33	0	66
unidentified conifer	3	0.9	2	0	66	0	33
American elm*	2	0.6	2	0	100	0	0
bitter cherry	2	0.6	0	1	0	50	50
casara	2	0.6	1	0	50	0	50
unidentified deciduous	2	0.6	2	0	100	0	0
black cottonwood	1	0.3	1	0	100	0	0
Pacific crab-apple	1	0.3	0	1	0	100	0
cherry* (<i>Prunus avium</i>)	1	0.3	1	0	100	0	0
Scouler's willow	1	0.3	0	1	0	100	0
unidentified	1	0.3	0	0	0	0	100
total	329	100	155	103	47	31	22

♦ Three western yew (*Taxus brevifolia*) and one ornamental yew* (*Taxus* sp.)

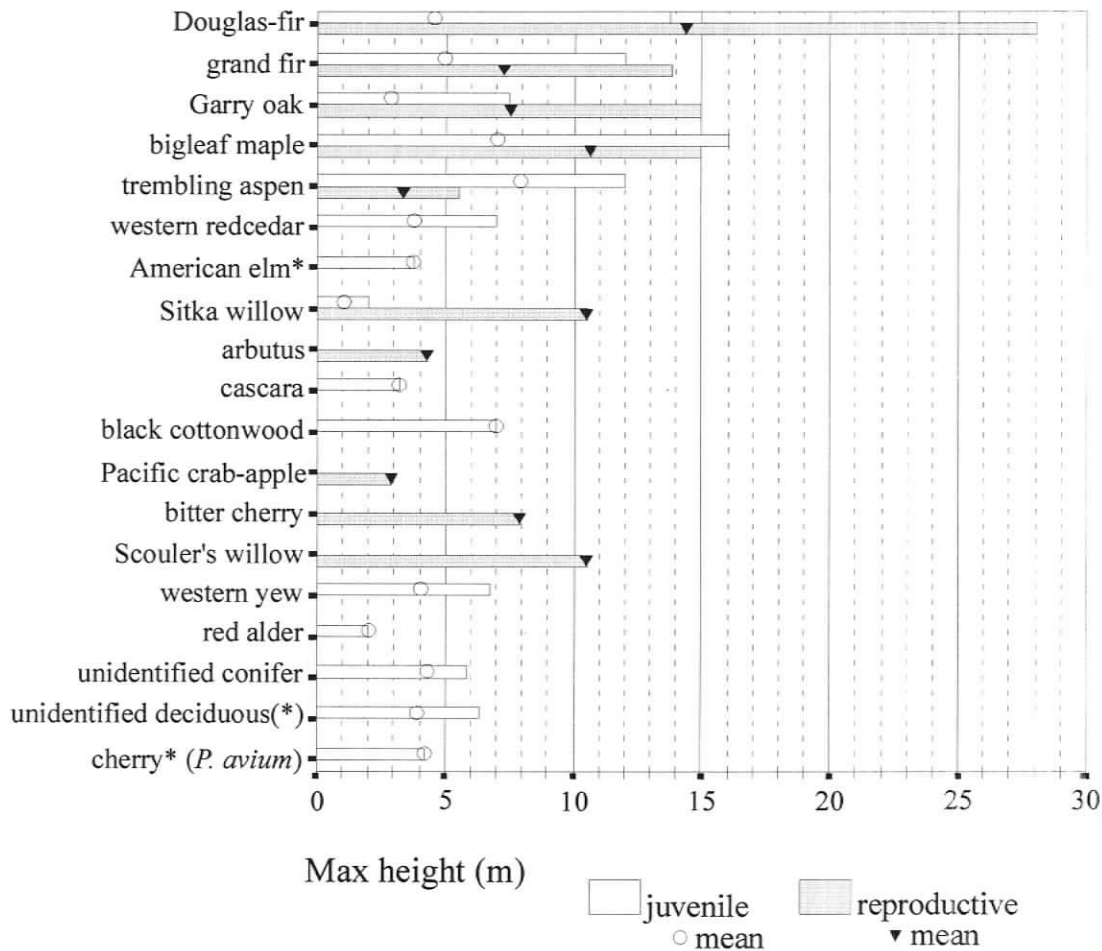
Table 7.2: Trees in Invaded Plots by Condition and % Hosting Ivy

Tree Condition	Number	<i>n</i> Climbed (%)		% Climbed
		Juvenile	Reproductive	
Lying♦	3	1 (33)	1 (33)	66
Dying	3	0	1 (33)	33
Dead	27	13 (48)	4 (15)	63
Snag	7	1 (14)	4 (57)	71
Sum (unhealthy) above	40	16 (39)	10 (24)	65
Other (healthy) trees	289	155 (54)	103 (36)	89

♦Lying trees were alive but on the ground

Trees hosting the highest mean heights of juvenile-form ivy were trembling aspen, bigleaf maple and black cottonwood. Douglas-fir, bigleaf maple and willow had the highest mean height of reproductive-form ivy (Figure 7.1).

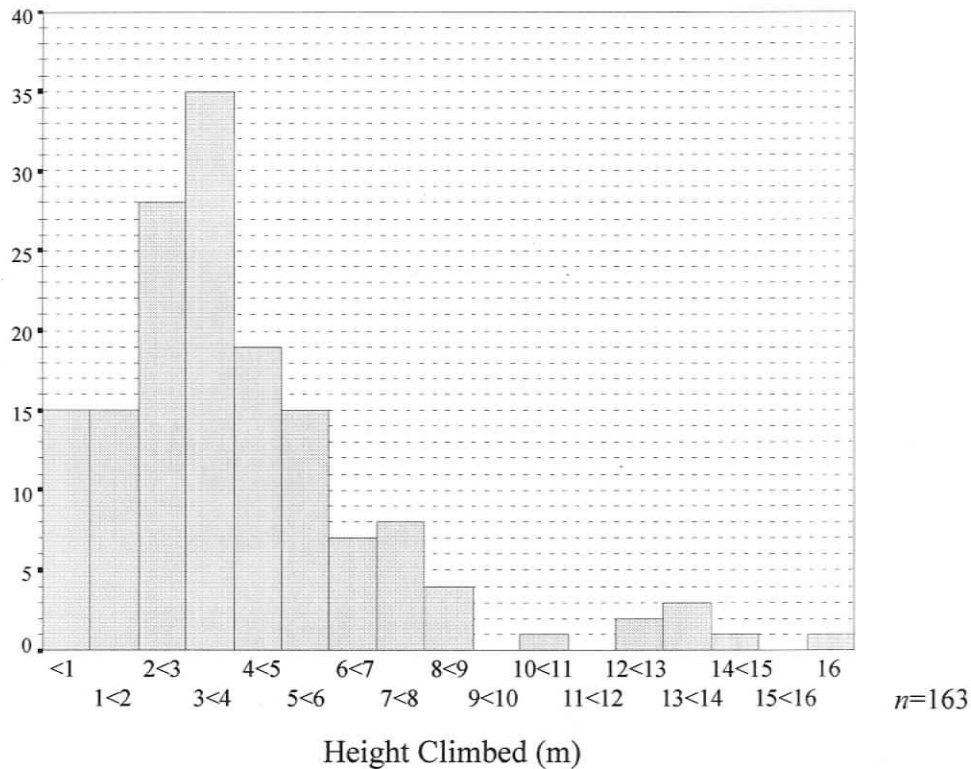
Figure 7.1: Maximum Height of Climbing Ivy (Bars) on Host Trees (Symbols Indicate Mean Height) in Invaded Plots



The maximum height that juvenile ivy shoots climbed host trees in invaded plots peaked in frequency between 3-4 m and then decreased to a maximum height of 16 m. The distribution was skewed with a majority of juvenile vines (83%) growing less than 6 m tall on host trees (Figure 7.2). Although ivy was found flowering on the ground where very heavily established in open and bright woodlands (e.g. in Garry oak woodlands at Uplands Park), it typically flowered and seeded on host trees. Flowering or reproductive-form ivy reached far greater heights on host trees than juvenile-form ivy, averaging 11 m

in this sample and often filling in the lower canopy. Most of the reproductive-form ivy on host trees reached maximum heights of 3-16 m (Figure 7.3).

Figure 7.2: Frequency Distribution for Maximum Height of Juvenile Ivy on Host Trees



Arborescent or reproductive-form ivy has large stems that allow it to reach greater heights and complete its life cycle by flowering and developing seeds in the canopy (see Carlquist 1991). Stem diameters of ivy in this sample were positively correlated with the maximum height ivy climbed trees ($r = 0.55$; significant at $p < .01$) and with tree circumference ($r = 0.31$; significant at $p < .01$) (Figure 7.4). The majority of ivy stems supported by trees in this sample were small, measuring less than 2 cm in diameter, and grew also on relatively small trees, under 200 cm in circumference (approximately 64 cm DBH).

Figure 7.3: Frequency Distribution for Maximum Height of Reproductive-form Ivy on Host Trees

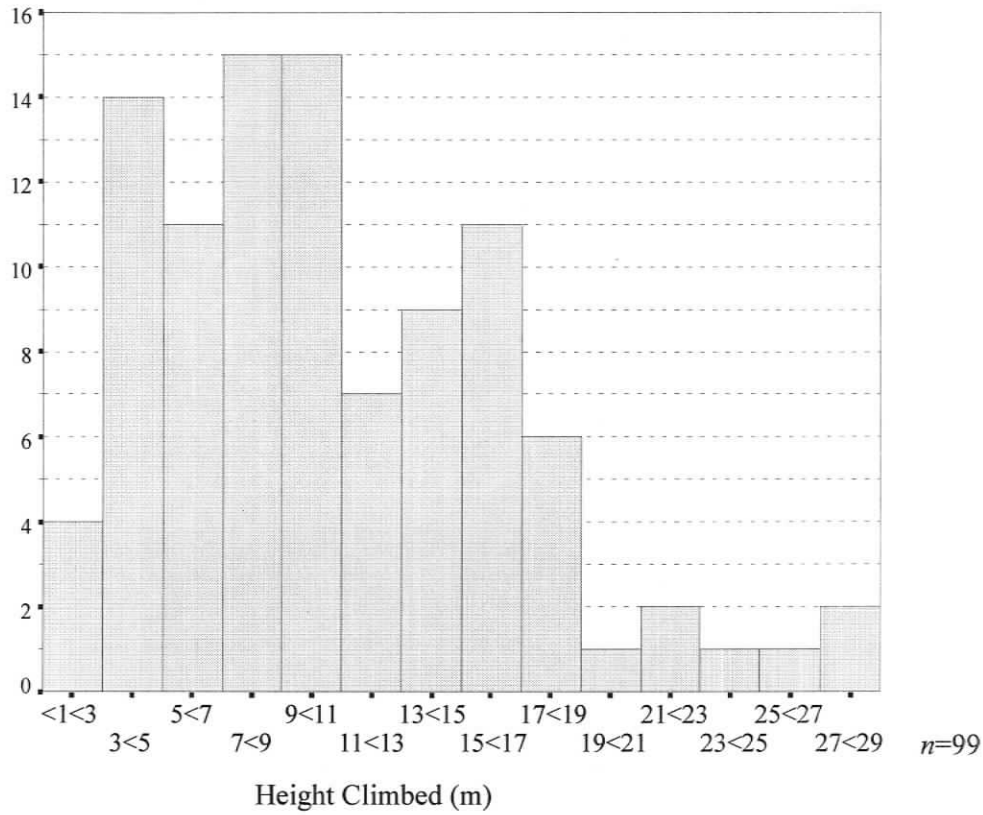
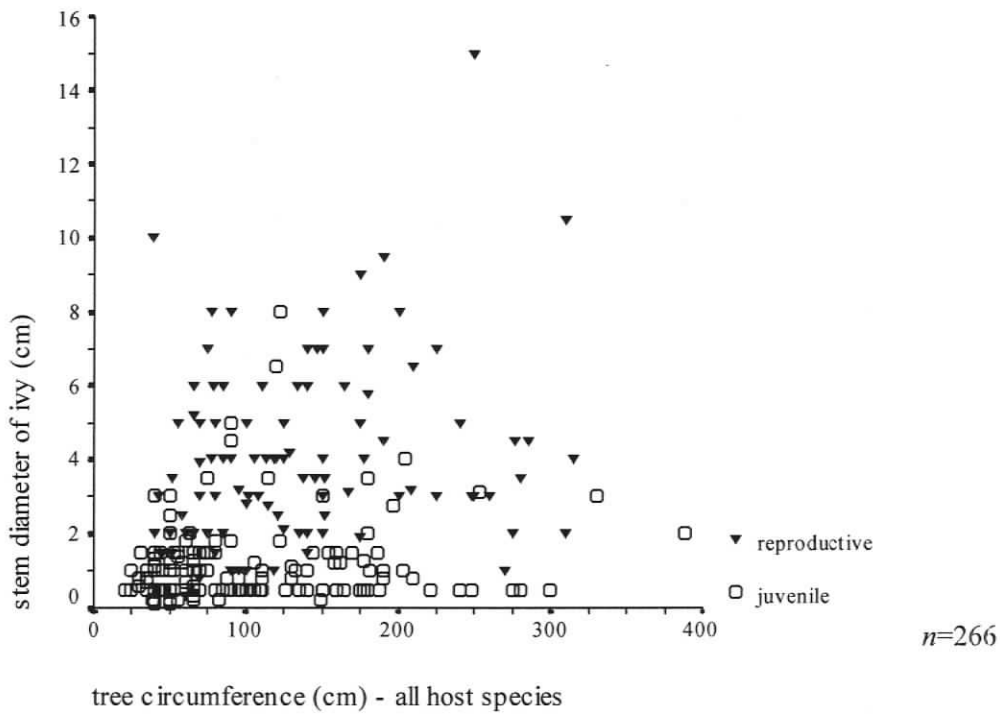


Figure 7.4: Size of Ivy on Host Trees



Height of ivy is also positively correlated with host tree circumference ($r=0.35$; significant at $p < .01$). Given the larger stem diameters of arborescent ivy, the relationship between host circumference and ivy's maximum height is slightly stronger for reproductive ivy than for juvenile ivy (Figure 7.5). Douglas-fir trees provided the largest and tallest supports for ivy (Figure 7.6) followed by grand fir (Figure 7.7). For Garry oak, there is a steep increase between maximum height of ivy and host tree circumference compared to grand fir and Douglas-fir (Figure 7.8).

Figure 7.5: Height of Ivy on Host Trees

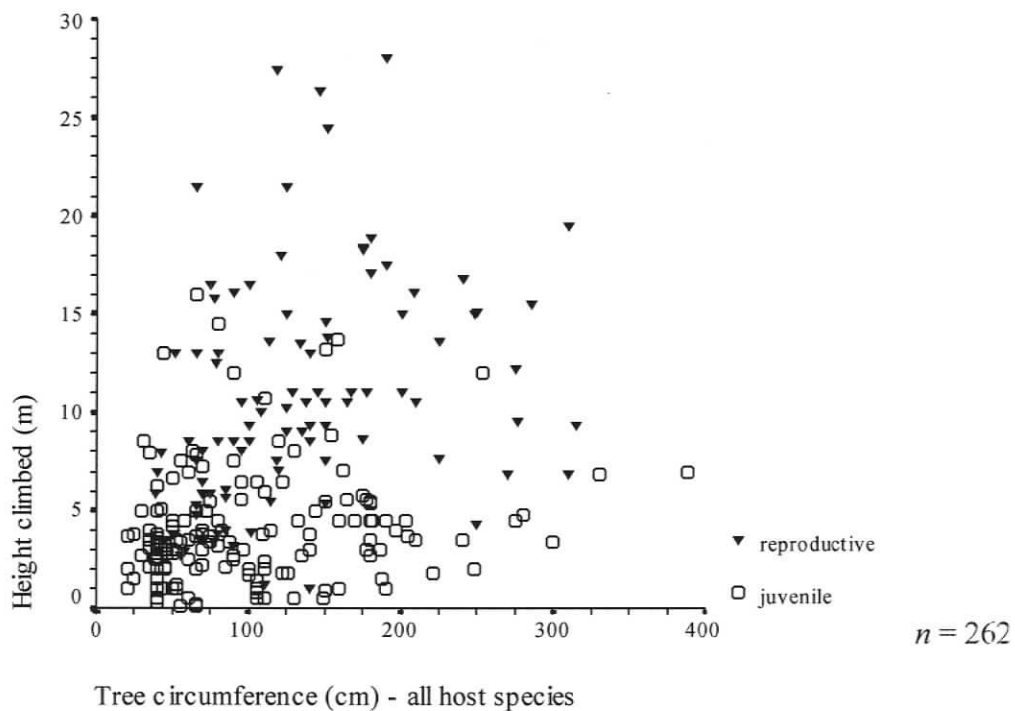


Figure 7.8: Height of Ivy on Garry Oak

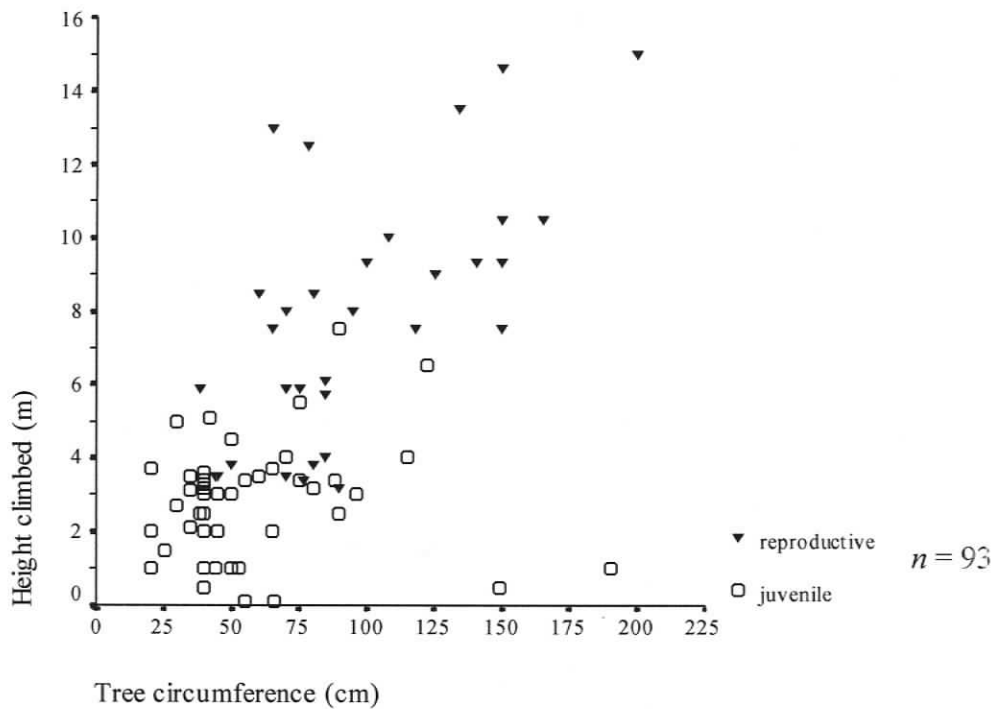


Table 7.3: Common Plants Found in Plots Invaded by Ivy

Plants found in 20 or more (approx. >50%) of the 41 invaded plots	Plants found in 10-19 (approx. 25-50%) of the 41 invaded plots	Plants found in 6-9 (approx. 15-25%) of the 41 invaded plots
<ul style="list-style-type: none"> ◆ Douglas-fir ◆ grand fir ◆ snowberry ◆ sword fern ◆ trailing blackberry ◆ holly* ◆ daphne-laurel* ◆ Oregon grape ◆ grasses^(*) 	<ul style="list-style-type: none"> ◆ bigleaf maple ◆ Garry oak ◆ Indian plum ◆ wall lettuce* ◆ Himalayan blackberry* ◆ bracken fern 	<ul style="list-style-type: none"> ◆ western redcedar ◆ red alder ◆ cascara ◆ licorice fern ◆ salal ◆ helleborine* ◆ oceanspray ◆ Nootka rose ◆ unidentified saxifrage^(*)

Plots invaded by ivy have been consolidated and typified into general community types, differentiated primarily by major tree species and general habitat. However, groups grade into each other, as there is considerable spatial heterogeneity in forest stands, understory species and degree of disturbance. For instance, there may be sharp or gradual transitions between stands of western redcedar and nearby open Garry oak stands, fewer species on steeper slopes or greater abundance of exotic plants in disturbed areas. In the groups described below, trailing blackberry, snowberry, wall lettuce*, holly* and daphne-laurel* are common species throughout. The overall degree of invasion found in each group is also indicated.

1. **Western redcedar, grand fir with occasional Douglas-fir, red alder and bigleaf maple.** Associated plants include sword fern, bracken fern, creeping buttercup* and ash*. Open areas near stream banks contain cascara, Indian plum, Siberian miner's lettuce, false Solomon's-seal and saxifrage (possibly *Tellima grandiflora* - tall fringe-cup). Areas having moist, developed, dark clay soils. Light to moderate invasion.
2. **Grand fir and Douglas-fir with bigleaf maple and occasional red alder.** Western redcedar seedlings or on western redcedar transitions. Salal, Oregon grape, creeping buttercup*, bracken fern and sword fern with occasional oceanspray, lily and saxifrage. Dark moist soils in lowland areas or brown loamy soils on steeper slopes. Light invasion.
3. **Grand fir and black cottonwood.** Abundant cottonwood with roots putting out abundant sucker saplings in poorly drained areas, occasional Douglas-fir. Common plants include Pacific water parsley, creeping buttercup* and stinging nettle. Wet, mucky, dark brown clay soils, moderately steep slopes on stream banks. Light to moderate invasion.

4. **Douglas-fir and grand fir.** Indian plum, salal, oceanspray, Nootka rose, Oregon grape, twinflower, bracken fern, broad-leaved starflower, hairy honeysuckle, yerba buena, red huckleberry, rattlesnake plantain, sweet-scented bedstraw and sword fern. Low to moderate slopes with brown or light brown silty soils. Moderate invasion.
5. **Grand fir and Douglas-fir and bigleaf maple saplings.** Helleborine*, Indian plum, oceanspray, salal, buttercup^(*), Himalayan blackberry*, Cooley's hedge nettle, broad-leaved starflower, bracken fern and sword fern. Occasional arbutus seedlings. Negligible slope with dark brown mucky clay. Drier areas with brown clay having fewer dominant species but include cherry*, broom* and thistle^(*). Moderate to heavy invasion.
6. **Douglas-fir, Garry oak with mixed tree species** including occasional western yew, Pacific crab-apple, Sitka willow, arbutus or western redcedar. Broom*, Indian plum, Saskatoonberry, cascara, falsebox, salal, Oregon grape, oceanspray, Nootka and baldhip rose, hairy honeysuckle, Himalayan blackberry*, false Solomon's-seal, sword fern, bracken fern and disturbed areas with introduced rose*, cotoneaster* and helleborine*. Slight slope with dark brown loamy or coarse soils. Moderate to heavy invasion.
7. **Grand fir, Douglas-fir with dying Garry oak.** Cascara, mustards^(*), red elderberry, sword fern, hairy honeysuckle, bracken fern, western bittercress and arbutus seedling in dry area. Deep dark brown clay on stream bank with moderate slope. Light invasion.
8. **Douglas-fir, grand fir, bitter cherry, bigleaf maple (often young).** Cascara, Indian plum, oceanspray, salal, sword fern, bracken fern and occasional licorice fern, rattlesnake plantain, helleborine*, sweet-scented bedstraw, red elderberry and hairy honeysuckle. Not sloped with dark brown loamy or clay soils. Arbutus, Garry oak, licorice fern and Himalayan blackberry* on grassy upland transitional areas, and Pacific crab-apple, Pacific ninebark, Saskatoonberry, false Solomon's-seal, baldhip rose and tall Oregon grape in moist transitions on slight slopes. Heavy invasion; light on slopes.
9. **Douglas-fir, occasional bigleaf maple and Garry oak.** Licorice fern, spiny wood fern, grasses, sword fern, Oregon grape, twinflower, salal, occasional oceanspray, sweet-scented bedstraw and broad-leaved starflower. Slight slopes or outcrops with thin brown silty soil. Light ground invasion; heavy on trees.
10. **Garry oak, black hawthorn, English hawthorn.** Plants include Indian plum, broom*, grasses (e.g. blue wildrye and introduced orchard grass*), mixed introduced flowers*, wildflowers, common camas, hairy honeysuckle, dove foot geranium*, licorice fern and sweet-scented bedstraw, sword fern, false Solomon's-seal, hemp nettle* and stinging nettle. Negligible to low slope with thin brown loamy soils. Occasionally on transitional areas to Douglas-fir or with fir seedlings and Himalayan blackberry* and helleborine* in dark brown soils. Very light ground invasion in open meadow; heavy invasion in oak-hawthorn stands.
11. **Garry oak and trembling aspen with mixed deciduous tree species** including red osier dogwood, Sitka willow, occasional Pacific crab-apple, arbutus, black hawthorn, American elm, cherry (*Prunus* sp). Cascara, Indian plum, Nootka rose, Oregon grape, Himalayan blackberry*, grasses^(*), mixed introduced flowers*, wildflowers and broom* in open areas. Moist areas contain giant horsetails, introduced mountain-ash* (*Sorbus aucuparia*), creeping buttercup*, salmonberry, Pacific water parsley, Cooley's hedge nettle and false lily of the valley, Slight to no slope with dark brown loamy clay soils. Moderate to heavy invasion.

7.1.2 Community Characteristics of Seedling Plots

Seedling plots contained not only abundant ivy seedlings but also abundant bigleaf maple, holly*, grand fir and Douglas-fir seedlings (see Table 7.4). Ivy seedling plots are grouped below by dominant tree species, into three broad types, with trailing blackberry, hairy honeysuckle, broad-leaved starflower and sweet-scented bedstraw occurring in all groups:

1. **Douglas-fir, Garry oak with bigleaf maple seedlings.** On steep slopes or irregular bedrock outcrops with thin soils. Associated plants include Oregon grape, daphne-laurel*, western buttercup, grasses and licorice fern on rock ledges. Ivy seeds sprout in pockets of soil in rock crevices.
2. **Douglas-fir with bigleaf maple and bigleaf maple saplings.** Associated plants include bitter cherry, cascara, oceanspray, snowberry, sword fern, Nootka rose, baldhip rose, bracken fern, licorice fern, sword fern and western buttercup. Ivy seeds sprout in profusion with holly* seedlings in thick mats of step moss (*Hylocomium splendens*) in south exposed, open areas under tall trees with high canopies. On slopes with thinner, coarser, brown soils with glacially rounded stones, ivy seeds sprout in mossy ground near wild strawberry, hairy honeysuckle and daphne-laurel*.
3. **Grand and Douglas-fir with bigleaf maple.** Associated plants include trailing blackberry, daphne-laurel*, bracken fern, creeping buttercup*, rattlesnake plantain, holly*, helleborine*, bitter cherry, Indian plum, bracken fern, sword fern, licorice fern and abundant mushrooms (spp.) in fall. Salal, cyclamen*, cascara, mountain boxwood, twinflower, Saskatoonberry, red huckleberry also found, and ivy sprouts with abundant fir seedlings on mossy ground. Very dark brown, deep clay soils with well developed, stratified layers.

Table 7.4: Common Plants Found in Plots with Ivy Seedlings or Young Sprouts

Plants found in all or 4 of the 5 seedling plots	Plants found in 3 (60%) of the 5 seedling plots	Plants found in 2 (40%) of the 5 seedling plots
<ul style="list-style-type: none"> ◆ bigleaf maple ◆ snowberry ◆ sword fern ◆ trailing blackberry ◆ Oregon grape ◆ broad-leaved starflower ◆ sweet-scented bedstraw ◆ grasses(*) 	<ul style="list-style-type: none"> ◆ holly* ◆ daphne-laurel* ◆ bracken fern ◆ wall lettuce* ◆ licorice fern ◆ hairy honeysuckle ◆ oceanspray 	<ul style="list-style-type: none"> ◆ Douglas-fir ◆ grand fir ◆ Himalayan blackberry* ◆ cascara ◆ salal ◆ rattlesnake plantain ◆ big-leaved sandwort ◆ baldhip rose

7.2 Community Characteristics of Non-Invaded Areas

Table 7.5 lists the most commonly occurring plants in non-invaded plots. General vegetation and community characteristics are summarized below, grouped by dominant tree species. The plant species listed provide a characterization of the non-invaded areas.

Table 7.5: Common Plants Found in Plots (Fir and Garry Oak Forest) Containing No Ivy

Plants found in 14 or more (approx. 50%) of the 29 non-invaded plots	Plants found in 7-13 (approx. 25-50%) of the 29 non-invaded plots	Plants found in 3-6 (approx. 10-25%) of the 29 non-invaded plots
<ul style="list-style-type: none"> ♦ Douglas-fir ♦ salal ♦ sword fern ♦ oceanspray ♦ snowberry ♦ trailing blackberry ♦ Oregon grape ♦ hairy honeysuckle ♦ licorice fern ♦ grasses^(*) 	<ul style="list-style-type: none"> ♦ grand fir ♦ bracken fern ♦ broad-leaved starflower ♦ sweet-scented bedstraw ♦ daphne-laurel* ♦ Himalayan blackberry* ♦ baldhip rose ♦ rattlesnake plantain ♦ wall lettuce* 	<ul style="list-style-type: none"> ♦ bigleaf maple ♦ arbutus ♦ Garry oak ♦ common camas ♦ broom* ♦ Indian plum ♦ western redcedar ♦ bitter cherry ♦ holly* ♦ Nootka rose ♦ twinflower ♦ wild strawberry (<i>Fragaria virginiana</i>) ♦ pathfinder ♦ vetch ♦ big-leaved sandwort ♦ red huckleberry

1. **Grand fir, Douglas-fir, western redcedar, bigleaf maple.** Common understory plants include salal, Oregon grape, oceanspray, red huckleberry, snowberry, sword fern, bracken fern, hairy honeysuckle, sweet-scented bedstraw, trailing blackberry, baldhip rose, rattlesnake plantain, broad-leaved starflower; holly*, Himalayan blackberry* and daphne-laurel* in disturbed areas. Occasional stinging nettle, western trillium (in spring), twinflower, Nootka rose, vetch, licorice fern, western trumpet honeysuckle and mock orange. Pathfinder and wall lettuce* near clearings and vanilla leaf, Pacific water parsley or creeping buttercup* in moist areas. From slight to steep slopes with brown to light brown clays or silty-pebbly soils.
2. **Douglas fir with bitter cherry.** Occasional bigleaf maple. Oregon grape, twinflower, rattlesnake plantain, sword fern, bracken fern, sweet-scented bedstraw, big-leaved sandwort, trailing blackberry, broad-leaved starflower, occasional Saskatoonberry; holly* and Himalayan blackberry* in disturbed areas. Slight slopes with yellow brown silt. Areas with negligible slope and dark brown clay soils also include grand fir with Siberian miner's lettuce, vetch, vanilla leaf in moist areas, stinging nettle and occasional salmonberry. Arbutus in exposed areas on rockier slopes with baldhip rose, wild strawberry or occasional kinnickinnick.

3. **Douglas-fir, grand fir and arbutus.** Oregon grape, hairy honeysuckle, broad-leaved starflower, oceanspray, salal, sword fern, trailing blackberry, daphne-laurel*, baldhip rose, occasional mountain sweet-cicely, western trillium in spring, cascara and bigleaf maple filling in lower canopy. Moderate slopes with brown loamy soils. Also occasional western yew, bracken fern and western trumpet honeysuckle.
4. **Douglas-fir, occasional arbutus and Garry oak.** Indian plum, oceanspray, hairy honeysuckle, falsebox, broad-leaved starflower, bracken fern and licorice fern, cyclamen*, big-leaved sandwort, trailing blackberry, snowberry, rattlesnake plantain, Siberian miner's lettuce, Oregon grape and Himalayan blackberry*. Soils brown and loamy. Open areas with red huckleberry sprouting on woody debris and occasionally helleborine* and daphne-laurel*. Sloped areas with bedrock outcrops and licorice fern, transitional to open Douglas-fir with meadow, containing more grasses (e.g. orchard grass*), broom*, tall Oregon grape, vetch, common camas and occasional western buttercup, occasional western trumpet honeysuckle and false bugbane.
5. **Garry oak.** With Douglas-fir often includes tall Oregon grape, snowberry, daphne-laurel*, trailing blackberry, sweet-scented bedstraw, big-leaved sandwort, sword fern, grasses, western buttercup, mountain sweet-cicely, daphne-laurel*, oceanspray and occasional arbutus seedlings. Little or no slopes with brown loamy clay. With arbutus often includes Indian plum, Himalayan blackberry*, daphne-laurel*, broom*, beach pea, Nootka rose, camas, mixed wildflowers and western trumpet honeysuckle.

7.3 Comparison of Invaded, Seedling and Non-Invaded Plots

The majority of invaded plots in this sample contained Douglas-fir trees, located primarily within Douglas-fir habitat. Although spatial and habitat complexity makes absolute comparisons difficult, general differences can be described.

The mean number of trees per 100 m² (plot area) with circumferences greater than 35 cm was not significantly higher in non-invaded plots than in invaded plots (Table 7.6). Mean canopy closures were lowest in invaded plots, slightly higher in seedling plots and highest in non-invaded plots. The most common tree species of seedling plots was bigleaf maple, a species that often begins growing in gaps and fills the lower canopy. Many of the heavily invaded areas occurred inside forest edges and none of the invaded areas could be characterized as having completely closed tree canopies. This lends some

support to Schnitzler's (1995) observations in Europe that ivy prefers gaps within forest and forest edges.

Low tree densities (1-2 trees/plot) as well as higher densities were represented in all three plot types. However, non-invaded plots with low tree density tended to be in open Douglas-fir communities; exposed transitional areas with open meadow-type understories, few shrubs, abundant grasses, low canopy closure and high light penetration from surrounding habitat. A more important distinction between invaded and non-invaded plots was soil accumulation and colour. Most invaded plots had several centimetres of dark brown fine to medium textured soil, and had a slight to negligible slope (Table 7.7). In contrast, non-invaded plots contained thinner layers of lighter coloured soil. When sloped, invaded plots most often had south or east facing aspects or exposures, whereas non-invaded plots had a variety of orientations (Figure 7.6). Although the proportion of seedling plots with particular orientations is less informative as only five samples were made, all had access to light from nearby open habitat. This suggests that bright or south-exposed forest habitat with rich soil is most vulnerable to colonization by ivy.

Table 7.6: Summary of Tree, Canopy and Slope Characteristics by Type of Plot

	Invaded n=41	Seedling n=5	Non-Invaded n=29	All Plots n=75
Mean tree density (number mature)	8	5	7	7
Mean summed diameters of trees	282	209	230	257
Mean canopy closure (% closed)	57	67	77	65
Range in canopy closure (% closed)	5-95	5-95	10-98	5-98
% of plots with negligible slope	34	20	24	30
% of plots with slight slope	42	20	24	33
% of plots with moderate slope	12	40	17	16
% of plots with steep slope	12	20	35	21

Figure 7.9: Proportion of Plots by Aspect






Invaded			Seedling			Non-Invaded			All Plots			
	2		20			10	3	10	3.7	2.5	5	
	15			20			14		6.2		11.1	
	5	34	10		40		10	14	3	6.1	25	6.1
	34 nil		20 nil		24 nil			35 nil				

Table 7.7: Percentage of Plots (by Type) with Various Soil ("A" horizon) Qualities

	Invaded n=41	Seedling n=5	Non-Invaded n=29	All Plots n=75
Clay/fine texture	45	40	35	41
Silt texture	23	60	48	34
Loam (med. texture or mixed grains)	28	0	14	21
Coarse texture	5	0	3	4
Light brown	5	20	14	8
Brown	23	60	55	37
Dark brown	65	20	31	49
Very dark brown	8	20	0	5
Depth thin or negligible (e.g. <2 cms)	10	40	31	20
Depth of several cms (e.g. >2 cms)	90	60	69	80

Invaded Douglas-fir stands with undeveloped or absent middle strata (small trees and tall shrubs) differed from non-invaded Douglas-fir stands also lacking developed middle strata in that they were often within thick forest. In contrast, non-invaded Douglas-fir habitat with undeveloped middle strata represented distinct habitat types typical of open meadow-type ecosystems (e.g. recently invaded Garry oak woodland with thin layers of soil). The relatively low abundance of shrubs and middle strata in invaded closed Douglas-fir and mixed forests supports evidence that ivy may suppress the growth of small trees and shrubs (Thomas 1981; Putz and Mooney 1991; and see Chapter 2). In contrast, in closed canopy Garry oak woodland where ivy was also long-established, tall

shrubs and small trees (e.g. hawthorn, Indian plum, cascara) were often abundant. Ivy's impact on vegetation strata is, therefore, different in coniferous forests where its juvenile form is prevalent compared to in deciduous woodland where its reproductive form dominates and species are more tightly packed nearer ground level.

7.2.1 Dominant Vegetation Characteristics

Seedling plots were most diverse in vegetation and contained a greater mean number of dominant native species than other plot types (Table 7.8). However, seedling and invaded plots contained more introduced plant species than non-invaded plots. The total mean number of dominant species was similar for invaded and non-invaded plots, although invaded plots had the lowest mean number and proportion of native plant species (Table 7.8). In this sample, areas invaded by ivy were as diverse in terms of dominant plant species as non-invaded areas but exotic plants constituted a greater proportion of this diversity. It could be suggested that exotic plants may replace native plants and form cosmopolitan communities over whole areas of the landscape, while overall species numbers or the diversity of dominant plant species remains relatively constant.

Table 7.8: Mean Number and Proportion of Dominant Plant Species by Type of Plot

Mean number (Minimum and Maximum)	Invaded n=41	Seedling n=5	Non-Invaded n=29	All Plots n=75
Native	8.9 (3-15)	13.8 (9-18)	10.7 (4-18)	9.9
Introduced	3.4 (1-10)	3.4 (2-6)	1.4 (0-3)	2.7
Possibly introduced	1 (0-3)	1.6 (0-2)	1.3 (0-4)	1.2
All dominant plants	13.3 (8-23)	18.8 (11-25)	13.4 (5-22)	13.7
Proportion				
Native	69	73	85	71
Introduced	23	16	8	21
Possibly introduced	8	11	8	7

When plots in the most heavily invaded Garry oak habitats in Knockan Hill and Uplands Parks were examined, lower mean numbers of dominant plant species and lower proportions of native species were found compared to the remaining sample (Table 7.9). This illustrates that habitats vary in the numbers of native and introduced species, both before and after invasion. It is difficult to determine how many dominant native species ivy alone may displace because of the synergistic nature of variables associated with disturbance in heavily invaded habitats.

Table 7.9: Mean Number of Dominant Plant Species in Heavily Invaded Garry Oak Woodland in Uplands and Knockan Hill Parks (proportion of all dominant plants) compared to all other invaded woodland examined in the sample

	Heavily Invaded Garry Oak Woodland	All Other Invaded Woodland
Native	6.1 (54%)	9.4 (69%)
Introduced	3.9 (35%)	3.4 (25%)
Possibly introduced	1.3	0.9
all dominant plants	11.3	13.7

CHAPTER 8: GROWTH OF IVY

Growth is fundamental to plant success and dispersal. The rapid growth of a newly introduced plant may forewarn of its potential adaptability, naturalisation or invasion of natural ecosystems. For plants already known to be invasive, determining rates of growth is useful for forecasting future dispersal and potential range. The types of growth important to plant invasion include the growth of individuals, population growth and areal range growth (Hengeveld 1989). As an epiphyte, individual leader shoots of ivy grow horizontally into larger areal patches and/or vertically up supports where the plant reaches maturity. Little published data are available on the growth rates of ivy and none were found that described its growth outside human control in forests. However, parks staff, researchers, residents and gardeners in Greater Victoria, descriptions of ivy's growth in European temperate forests (Schnitzler 1995) and this research suggests ivy's growth may be rapid and vigorous.

8.1 Growth of Shoots

A number of researchers have studied aspects of liana growth, employing different methods under field and controlled conditions. For example, Weschler (1977) measured shoot elongation of kudzu (*Pueraria lobata*) in the field near Athens, Georgia during the spring and summer. Although it was a different species and in a different climate, Weschler's growth rate results provide a baseline for comparing ivy's growth. Studies of the growth of ivy (*Hedera helix*) are limited but include Thomas' (1980) measurements of biomass in the field near Washington D.C. and Derr's (1993) measurements of the weight of shoots grown in pots at the Iowa State Horticultural

Research Station. However, measuring ivy's shoot elongation in the field is a direct way to determine how quickly it may grow in the forest and spread in parks. An objective of this research was, therefore, to collect preliminary data on how fast ivy grows in Greater Victoria's parks.

8.1.1 Method

Ivy's growth was monitored in the field during the growth season in the summer of 1997. Horizontal (ground-crawling) and vertical (tree-climbing) shoot elongation were treated separately and measurements were made only on juvenile-form shoots (Appendix 7: Figure 6). For horizontal measurements, leader shoots were selected on the edges of expanding ivy patches, marked, measured and re-marked¹ bimonthly. Invaded areas at four parks (Mount Douglas and Knockan Hill Parks and Thetis Lake and Francis-King Regional Parks) served as study areas. All areas were located within stands of Douglas-fir. The Mount Douglas Park site contained abundant bigleaf maple and was located on the edge of a large, dense and expanding ivy patch north of Churchill Drive (approximately two hundred metres from the park entrance). Most leader shoots from the west side of the patch near the roadway and down the slope into the forest were monitored.

Tree-climbing and ground crawling ivy were measured at Francis-King and Thetis Lake Parks. At Francis-King Park, the site was located inside the west part of the Elsie King Loop Trail where smaller-leaved ivy was established around a single Douglas-fir

¹ All marks, made approximately two centimetres from the growing tips of each shoot, were kept permanently visible during the period of observation with white correction fluid. It was later suggested to me that small ribbons or coloured bands could have been an effective way to mark and track shoot growth and this would have also avoided the need for the tenacious, though effective, correction material.

tree and climbing a nearby rock outcrop. This site was chosen to contrast with the other sites because it had less soil development, a rockier habitat and was also less heavily invaded. At Thetis Lake Park, two sites were monitored. The first was located just inside the park at Highland Road near Watkiss Way and the second was approximately two hundred metres west of this site along the south side of the old highway path.

At Knockan Hill Park, vertical growth of shoots was measured exclusively, on grand fir and Douglas-fir trees from the Hill cottage northward along the main park trail. Only tree-climbing shoots within reach (i.e. from ground level to approximately 2m high) were monitored.

8.1.2 Results and Discussion

Shoot elongation rates over the summer growth season from measurements taken at all sites were on average, greater for horizontal growth than for vertical growth (Appendix: 6). There was considerable variation in growth between shoots at each site, between sites and by period (Figure 8.1). Ground-crawling ivy grew slowly at the Francis-King Park site in the rocky mixed Douglas-fir, arbutus and Garry oak habitat, compared to the heavily invaded site at Mount Douglas Park in the Douglas-fir and bigleaf maple forest. The "A" layer of soil was thicker and dark brown at the Mount Douglas site. In late June, the mean growth for ground-crawling and tree-climbing shoots at all sites was low, likely the result of considerable rain and cloud cover during that period (Figure 8.2). Mean shoot growth was greatest during periods with moderate precipitation (early June and early July). There does not appear to be a very clear relationship between growth and periods of increasing mean maximum temperatures and decreasing mean minimum temperatures (Figure 8.2).

Whereas ground-crawling ivy grew fastest during early June and slowed by late July, tree-climbing ivy grew faster later in the season (early July). The mean growth rate of all tree-climbing shoots measured at all sites was highest for the first half of July (just under 10 cm). The lowest rates of growth for both tree-climbing and ground-crawling ivy were measured at the Francis-King Park site. The rocky habitat, typical of other invaded areas in Francis-King Park, is likely the reason why ivy grows slowly and is sparsely distributed on the ground in this park, although abundant on certain trees (Appendix 7: Figure 7). In contrast, ivy grew quickest where it was most abundant at the Mount Douglas Park site in deep, dark soil. The Mount Douglas Park site can also be considered representative of other park habitats where there is heavy invasion. This illustrates that favourable habitat encourages faster growth and more rapid invasion of park forests.

Between mid May and early August, ground-crawling ivy shoots in this study grew, on average, over 50 cm and tree-climbing shoots grew over 40 cm. These growth rates are higher than those reported by Derr (1993), whose untreated ivy "controls" grew an average of 13 cm in length between April and June 10 (approximately a 2 month period) in the Iowa State Horticultural Research Station. Shoots grew a maximum of 48 cm in 16 days, at the Mount Douglas site, which indicates that ivy is not likely as fast-spreading a liana as kudzu, whose shoots Weschler (1977) measured growing as much as 19 cm in 24 hours. Nonetheless, average monthly growth for ground shoots was around 22 cm and around 17 cm for tree-climbing shoots. A conservative extrapolation, based on only four months of growth per year at these mean monthly growth rates, suggests juvenile-form ivy spreads 3 - 4 m higher into the canopy and 4 - 5 m on the ground every

5 years. This illustrates how, given increasing numbers of newly established patches (e.g. beginning with seedlings and individual shoots), ivy expands into larger areal patches, finds hosts and climbs and matures into the canopy, particularly in favourable sites and in park habitat where it is already abundant.

A secondary observation related to ivy's growth was that not all shoots on the edges of expanding areal patches elongate quickly. Some shoots are aligned upwards towards the light, similar to shoots in the patch centre. Growth of these shoots may be very slow but rapid elongation may begin after weeks or months of relative "dormancy" or if stems are damaged (Appendix 7, Figure 8).

Figure 8.1: Rate of Ivy Shoot Elongation by Site and Period

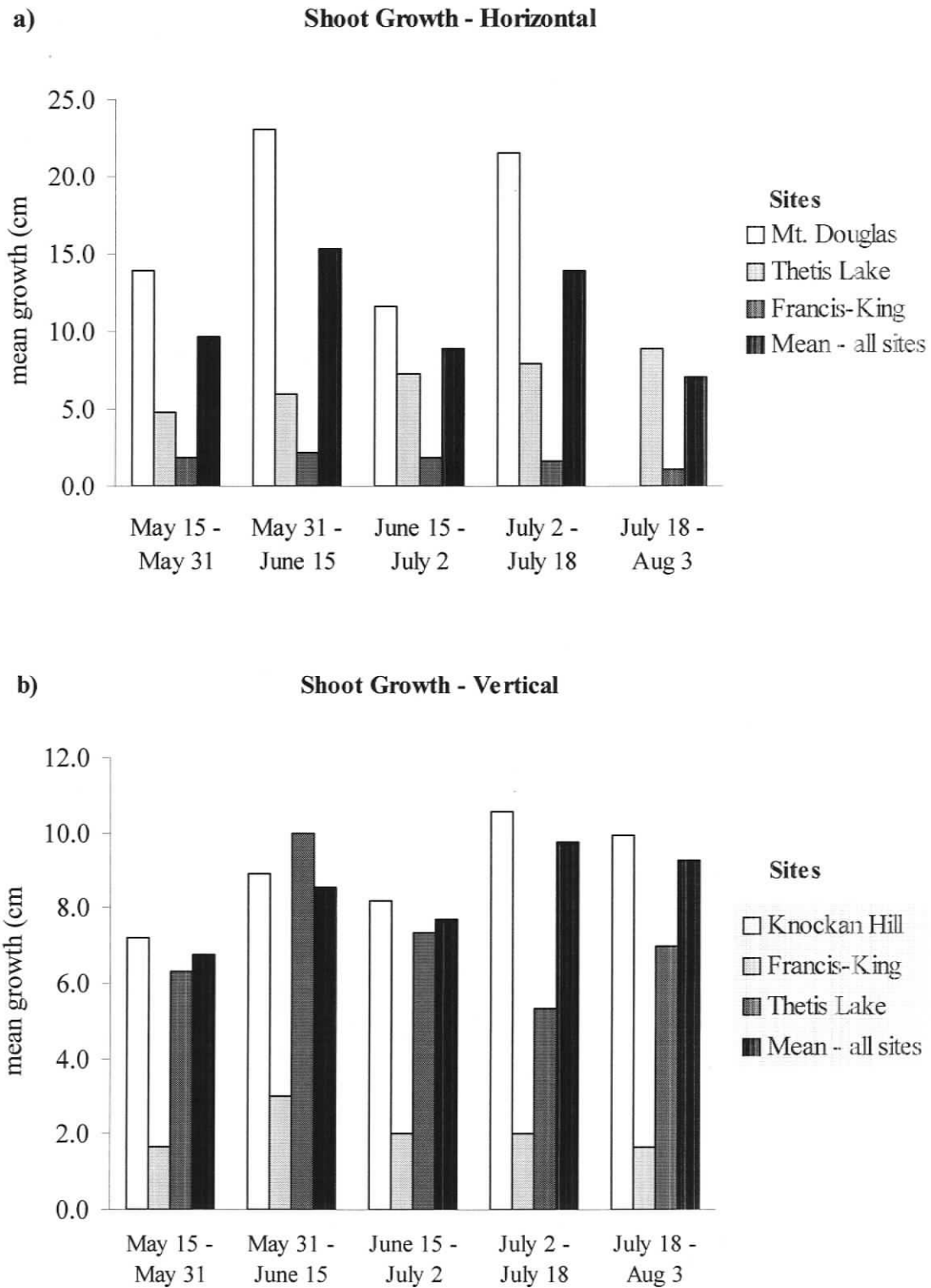
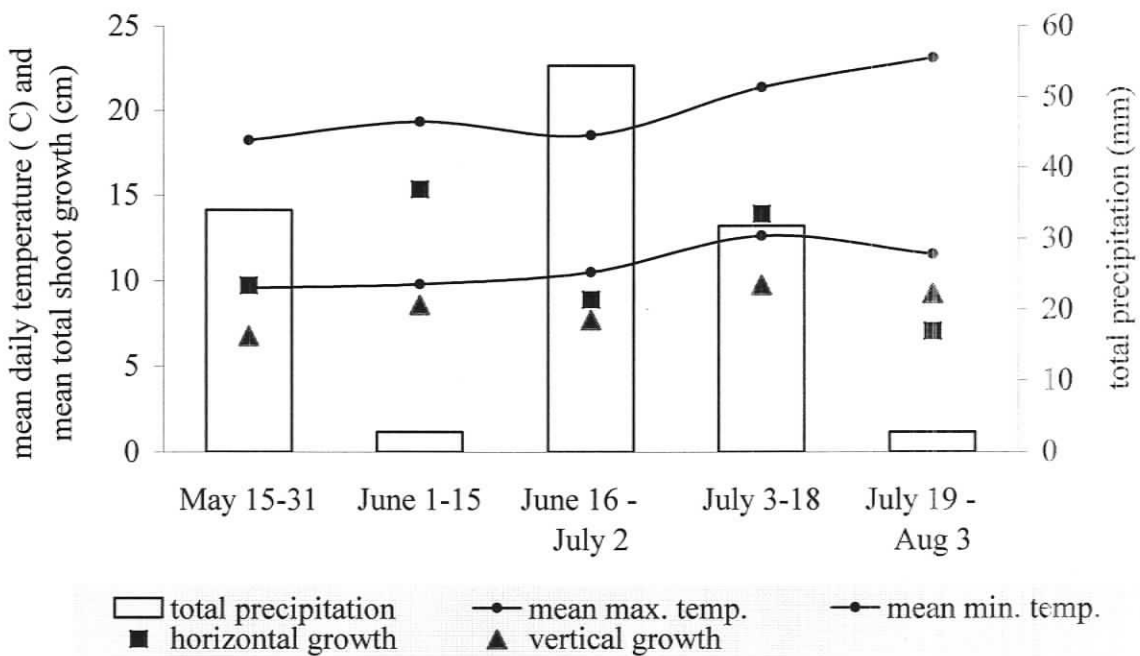
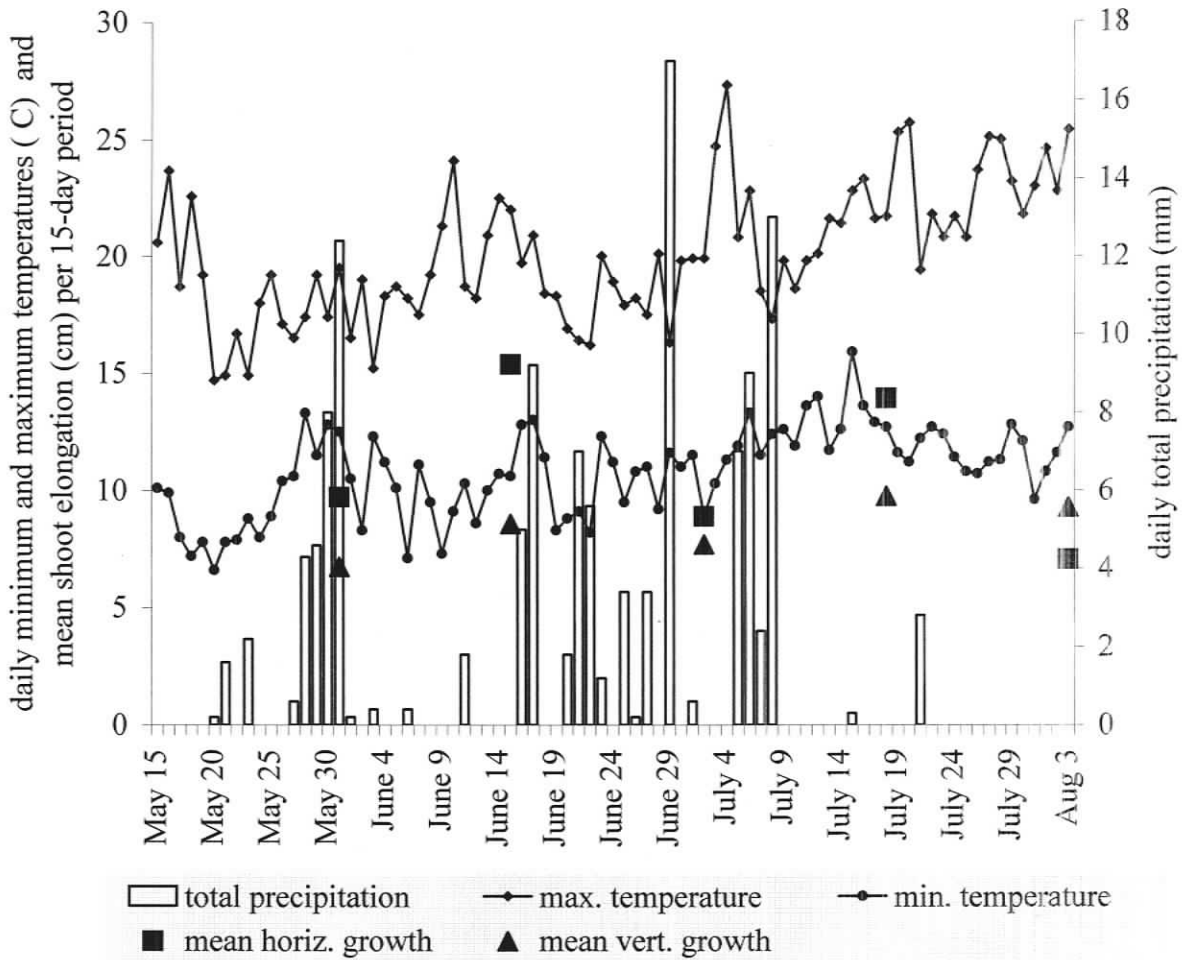


Figure 8.2: Weather Data and Mean Total Shoot Growth (All Sites), 1997 Growth Season



8.2 Growth of Woody Stems

Ivy's mature stems are structurally very different than its juvenile-form leader or searcher shoots (see Putz and Holbrook 1991). Like other lianas, ivy is a long-lived plant that can reach hundreds of years of age (Gentry 1991). Since all lianas lack supportive tissues they must cling to other supports to reach the light (Schnitzler 1995). However, lianas grow tall² more quickly than self-supporting plants like shrubs and trees (Givnish 1995). Gentry (1991) and Carlquist (1991) state that little more is known about the woody structures of lianas (e.g. the structure and function of their sclerenchyma³) than in the 19th century. As part of the study of ivy's growth, it became an objective of this research to briefly examine the stems of ivy (Appendix 7: Figures 9 and 10).

While trees and shrubs have "normal" cambium that allows them to grow dense wood and be self-supporting, lianas have more parenchyma⁴ interspersed in their wood, allowing them to retain more water and heal more quickly (Carlquist 1991). Rays (i.e. regular columns of parenchyma between the growing wood and the pith that appear like spokes in a wheel), are thus an important and prevalent feature of lianas. Rays do not subdivide much during growth but are strengthening features that aid in lateral conduction (Stokes and Smiley 1996) and help lianas bend, twist and achieve large diameters⁵ (Carlquist 1991). In addition to rays, stems of ivy in Greater Victoria feature

² For instance, ivy easily attains heights of 30m in European forests (Tutin 1968, Trémolières 1983).

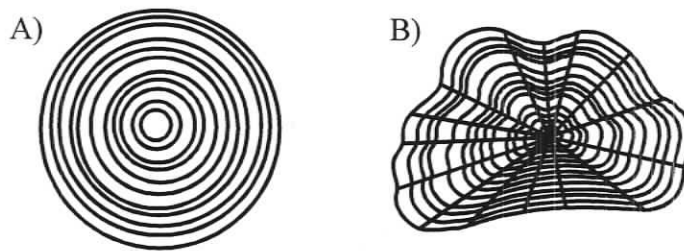
³ Sclerenchyma are the woody, fibrous tissues that give a plant its mechanical support. The cells grow alone or in groups and are formed when cell walls thicken with cellulose and lignin (Allaby 1992). Esau (1960) indicates that sclerenchyma are the strengthening parts of plants and include fibre cells.

⁴ Parenchyma are cells with networks of air spaces that run between them and are the least differentiated of plant cells, thought to be an original type of cell from which others evolved (Allaby 1992). Parenchyma cells include vertical strands like rays and usually originate in the pith of the wood (Esau 1960) and can act as "padding" for the tissues of lianas (see Gartner 1995:141).

⁵ In its native habitat, ivy stems grow to be "wrist-thick" in Britain (Elliot 1995) and attain circumferences greater than 30 cm (around 9.5 cm in diameter) in the Rhine Forest (Trémolières et al. 1988).

concentric rings that are visible in cross section. Some stems of ivy may become irregularly rounded, due to their soft tissues twisting and adhering to trees (Figure 8.3). However, examples of symmetrically circular stems are also found.

Figure 8.3: Simplified difference in form between a cross section of a round, annual, ring-bearing tree (A) and a comparably-sized large, irregularly-rounded ivy stem with tree-ward side on bottom (B).

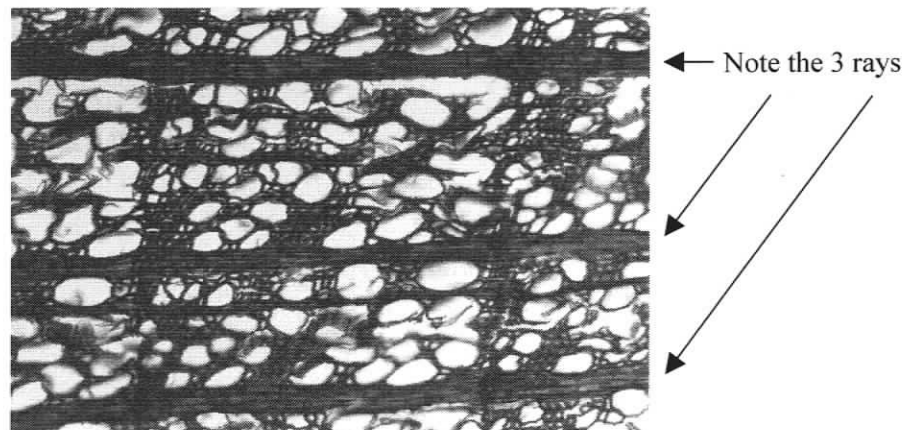


A second objective of the study of ivy's growth was to examine growth rings. The presence of annual rings would provide more insight into the results of vine diameters from studies of its invasion in local parks, indicating perhaps how long it may have been established on host trees in the study area. Several samples of arborescent stems were collected within well-established sites of ivy during data collection in 1997. Since ivy is viewed as invasive in Greater Victoria and it is often cut from trees in parks as well as on public and private lands, large specimens are not abundant and this limited the number of samples collected⁶. Ivy's wood is spongy-soft and crumbly when collected and its grain is best exposed by cutting stems into disks, drying them slowly away from direct sources of heat and subsequently sanding and polishing them with increasingly fine-grained sand paper.

⁶ Local landscapers and gardeners were also contacted and asked if they could provide samples of any large vines they were cutting or removing. However, the largest available at the time of study were only 4 cm in diameter and were left out of the analysis.

To better view its rings and structures, cross and tangential sections of stem were prepared by rehydrating pieces of wood and slicing thin sections at 90° angle to the grain with a sliding microtome (sledge). Sections were then stained with safranin, mounted onto slides and photographed under magnification. These photographs reveal that ivy's rays (horizontal) are more pronounced than its concentric rings (vertical) under magnification (Figure 8.4). Vessels are large and numerous throughout each ring, narrowing in latewood where tracheids (close-ended linear cells) are most pronounced. This suggests that ivy is a ring-porous species (see Carlquist's 1988 "Type 5" growth ring classification), having a high proportion of the ring occupied by wide vessels (Gartner 1995:142).

Figure 8.4: Cross section of one ivy ring (6 X 6.3 X 0.4 magnification).



Growth rings form when there is reduced cambial activity. Cambial activity can be halted in response to reduced water, cold temperature or even low levels of light (Carlquist 1988). Growth rings may thus result from seasonal environmental or climate change. However, not all growth limiting factors and growth rings are annual. For instance, non-annual growth rings have been found in mangrove species (Carlquist 1988). Winter climate conditions in Greater Victoria are characterised by lower overall sunshine,

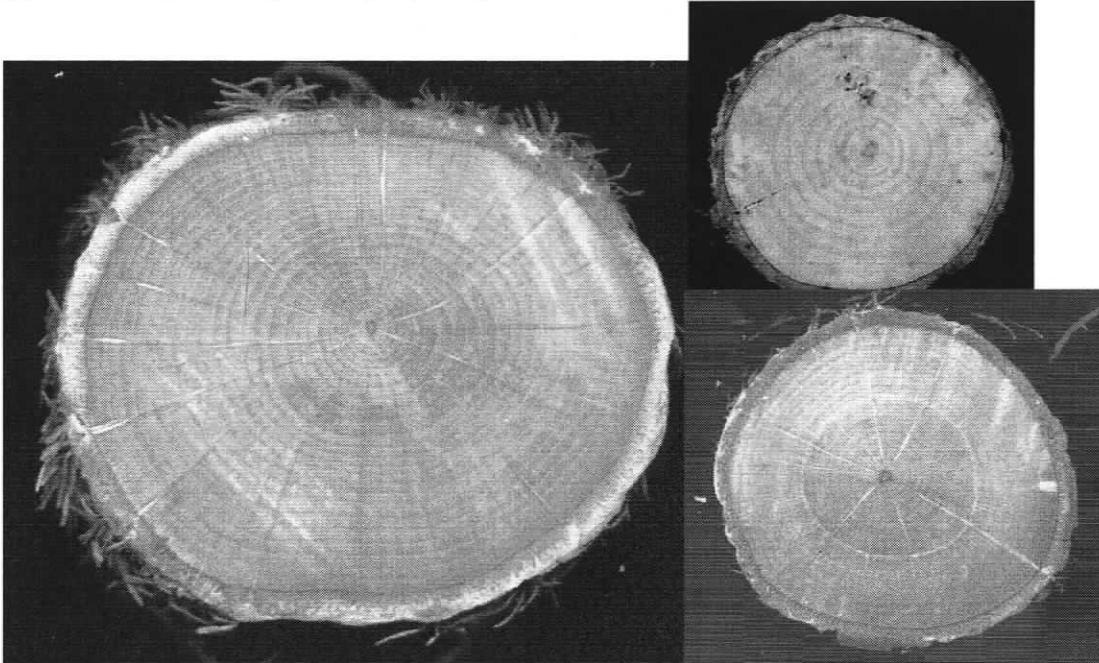
high rainfall and cool temperatures. Ivy is known to preserve assimilatory enzymes throughout the winter that enable it to rapidly restart growth again in the spring as soon as temperatures rise (Fischer and Feller 1994). A marked increase in shoot growth and visible patch expansion was observed in my study over the summer growth season. Temperature, coupled with reduced sunshine, is, therefore, the most likely winter growth-limiting factor that would explain the formation of annual growth rings in ivy.

While the rings of numerous tree species have been examined and numerous growth chronologies have been developed, my research uncovered no literature on whether the growth rings of ivy or other lianas might be suitable for dendrochronological analyses⁷. Stokes and Smiley (1996) note that a specimen must fulfil four principles to be used in tree ring dating: (1) it must add only one ring per year or growing season (2) it must have a limiting factor; (3) its growth limiting factor must vary from year to year and the width of the plant's annual rings must vary accordingly; and (4) its limiting factor must be uniformly effective over a large geographical area. While irregularly-rounded stems such as the type depicted in Figure 8.3 would not likely be suitable for ring-width analysis due to their compression, samples collected having rounded stems might offer

⁷ For instance, in the University of Arizona's electronic bibliography of dendrochronology, only one reference to grape vine (*Vitis* sp.) was found. There are a few possible reasons for a lack of information on growth rings of vines. It could be that the commercial utility of wood and forestry operations has stimulated research related to tree growth. Since lianas are shorter-lived than trees and climate records often exist over the short term, there is limited climatic information to be gained by analysing their growth response. Also, most lianas and vines are tropical and may lack a single seasonal limiting factor for "climate sensitive" ring growth. In addition, dendrochronology is also more uncertain in mild and maritime climates (Wilson and White 1986) where ivy is distributed. However, in south, coastal British Columbia, mean winter temperatures may be slightly colder than in parts of Europe where ivy is native and this may be a potential limiting factor.

this possibility (Figure 8.5). Interestingly, the number of rings in these samples varied among stems of similar diameter, indicating that as in trees, large ivy stems may not necessarily imply aged plants.

Figure 8.5: Visible rings in samples of ivy (scale = 1:1). Left: approximately 23 rings, compression on top (tree-ward side). Top right: approximately 8 rings. Bottom right: approximately 18 rings in slightly larger stem than above.



In a very preliminary examination, ring widths were measured on six of the larger and more evenly growing samples of ivy in the Tree Ring Laboratory, Department of Geography. Graphs of the width of each sample's rings, going back approximately 10 years appeared to reveal a slight pattern, with periods marked by wide and narrow rings coinciding on several samples. However, too few aged, large samples were available at the time of this research to statistically validate variance of measurements necessary for cross-dating ring widths. Ring widths of certain specimens of ivy may, therefore, not only be annual but may vary in width according to annual climatic conditions.

CHAPTER 9: DISCUSSION

9.1 Influence of Park Boundaries, Park Size, Park Shape and Park Fragmentation / Insularity on Invasion

The park boundaries examined comprised a wide assortment of forest, shrub, meadow and lawn habitats varying in degree of human disturbance. The hypothesis that fragmentation of natural habitat from residential land-use increases the likelihood of invasion by ivy in nearby park habitat was generally supported by observations. The observed relationship between intense human land-use and invasion of nearby parks supports Forman's (1995) idea of the park boundary acting as a sink, in this case for horticultural plants. The frequency of ivy in park boundaries versus park interiors, owed in part to its vegetative spread into parks from outside properties, indicates that ivy often begins its incursion into parks by establishing inside the boundary zone, that is, within several metres inside the park border. On a conceptual as well as physical level, the park boundary is important to park conservation. Defined and delineated by adjacent landscape heterogeneity, park boundaries can be viewed as open or closed, regulating the stability of the internal, park system (Ambrose 1986). In this case, open boundaries could be conceptualised as those adjacent to areas intensely modified by human activity.

Park size is another important variable of park insularity that influences park boundaries. As the size of the reserve decreases, the amount of edge per unit of interior land increases and internal habitat theoretically becomes more difficult to protect from external influences (Shafer 1990; Saunders 1991). In this study, the two smallest parks examined, Coles Bay Regional Park and Knockan Hill Park, had a considerable proportion of their total area invaded by ivy compared with many of the larger parks such

as Witty's Lagoon, Thetis Lake, Francis-King and Mount Work Parks. However, for other parks examined, there was no apparent relationship between invasion of ivy and park size. Although this study focuses on one invasive species, the findings align with those of Usher (1988) and Smallwood (1993) who found no relationship between reserve size and invasion of plant species. As an example, the third smallest park examined (Devonian Regional Park) is in the early stages of invasion whereas the fourth largest (Mount Douglas Park) is heavily invaded. It follows that the edge, boundary and habitat characteristics of parks must be controlled for to test size-dependent influences on their invasion. The park boundary characteristics of Devonian Park, which has far less human activity along its borders, differ significantly from Mount Douglas Park, precluding comparisons based on size. However, what can be concluded is that, given similar external conditions, colonisation rates, rates of plant spread and proportions of suitable habitat, large parks should take longer to become heavily invaded by ivy than small parks.

Another characteristic of park boundaries is their shape. Varying sizes of triangles, rectangles, T-shaped parks and multi-faceted geometric designs characterised the landscape forms of near-urban parks. Parks with borders that are irregular and corrugated against residential settlement have high edge to interior ratios, just like small parks, and as a result they also have more contact area with potential sources of exotic plants. In the most heavily invaded parks, edge to interior ratios were high. However, edge to interior ratio did not decrease as would be predicted from the theory for the moderately, lesser and non-invaded parks. The ratio of park border (length) per unit of interior habitat (area), an ostensibly useful measure or rule of thumb for overall park resiliency (see Smallwood 1994), like park size, treats all park edges as equal. In failing

to account for the variability of landscape types around a park, edge to interior ratios could not accurately explain the invasion inside the parks in this study.

Similar in shape but different in size or scale, Mount Douglas and Knockan Hill Parks are islands in residential areas with ivy and other woodland exotic plants distributed heaviest in their southern, elongated parts. Mill Hill is similarly shaped to Mount Douglas and Knockan Hill Parks and ivy and other invasive woodland species are distributed, on a lesser scale of invasion, also primarily in its southern parcel where protected area is elongated. This supports Schonewald-Cox's and Bayless' (1986) and Forman's (1995:125) conclusions that elongated patches of protected area are less effective than round patches in preserving internal resources. In addition to direct human disturbance, elongated park parcels receive increased light, which may further promote invasion of exotic species¹. Since park shapes reflect patterns of land development, entranceways and heavy-use areas coincide with road frontage, which in less urbanised areas is limited often to one park edge (e.g. in this sample, major roadways were often along south edges: Mill Hill, Knockan Hill, Thetis Lake and Lone Tree Hill Parks). Larger, non-elongated, non-corrugated blocks of landscape are more easily preserved where there is already less development pressure (e.g. Horth Hill Regional Park is an example of a square parcel with a low perimeter-area ratio, diffuse nearby residential development and only slight invasion by ivy). The geometric pattern or shape of a park is therefore less meaningful to its invasion by horticultural plants than the types of landscapes that give it its shape.

¹ Forman (1995:125) notes that a landscape patch that has its long axis oriented in such a way as to be aligned with natural processes that follow flows in the landscape may be affected by them. In this study, the angle of orientation in park habitat that coincided with prevailing winds (e.g. the northwest edge of Coles Bay Park, the west facing lower "peninsula-shaped" parcel of Mount Douglas Park) suffered windthrow and high invasion.

The parks examined here suggest that temporal processes of land development and settlement history are as important or more to their overall invasion by ivy than their size or shape. Ambrose (1986:4) indicates that boundaries represent interfaces between spatial patterns and temporal processes. Based on the characteristics of its boundaries, each near-urban park examined here could be placed along a time continuum of transformation. As it ages within residential areas, a park may tend toward becoming an extension of private garden with lower proportions of native species and less indigenous landscape. The future appearance of oak meadows of Thetis Lake Park may be found today at least to some degree of similarity at Uplands Park.

9.2 Land-Use Change and Landscape Transformation

Broadly and apart from indigenous peoples' activities, two major phases of landscape fragmentation transformed landscapes around the sample of parks and encouraged invasion of exotic vegetation. The first involved the initial fragmentation of native vegetation by logging and agriculture, from the mid-1800s into the early part of this century. The second was marked by intensified residential development and increasing housing density, from the second half of this century and ongoing (e.g. now at Thetis Lake, Knockan and Bear Hill Parks).² Both phases encouraged invasive plant species: the conversion of forest to farmland encouraged agricultural ruderals and invasive plants of cropland, whereas conversion of farmland and forests to residential areas and natural refugia or parks encouraged the spread of horticultural species.

² Forman (1995) describes five spatial processes driven by human activities that transform land. They include (1) perforation (making "holes" in habitat by clearing or logging it); (2) dissection (separation of habitat usually following road construction); (3) fragmentation (further separation and increased isolation of habitat parcels); (4) shrinkage (subsequent carving into these small fragments); and (5) attrition (the disappearance of patches and corridors altogether).

9.3 General Habitats and Vegetation Communities of Parks Invaded by Ivy

The most heavily invaded park habitat was Douglas-fir and medium-open established Garry oak communities and stands of trembling aspen in dry areas near human settlement. Ivy was less vigorous in western redcedar habitat, in open, rocky arbutus-Garry oak habitat, in Douglas-fir meadow-type habitat and in wet trembling aspen and red alder groves. Ivy was not frequently found in open native and English hawthorn meadow (except in mixed Garry oak-hawthorn woodland at Knockan Hill Park where very abundant) nor with black cottonwood (except in mixed Douglas-fir-cottonwood communities at Coles Bay Park).

Invaded areas vary in terms of horizontal and vertical (host-dependent) characteristics. Most often, heavy carpets of ivy in the forests' understory were associated with abundant vertical cover on nearby host trees. However, mature, aged ivy was also found confined to single host trees, nearly absent from the ground. For example, with many potential Douglas-fir host trees at Francis-King and Thetis Lake Parks, ivy is limited to a small number of trees on which it grows large vines (greater than 4 cm in diameter). Abiotic influences are suggested as explanations for this diffuse pattern of invasion by ivy. Thinner, lighter coloured soils, steeper, rockier habitats and slow shoot growth were characteristic of Francis-King and Thetis Lake Parks.

Juvenile form ivy is shade tolerant and is found in areas where canopy closure is moderate, under closed canopies where light penetrates from surrounding areas or where canopy closure is low but surrounding areas are more closed and forested. Most of the naturalised or escaped ivy that grows under moderately-closed canopy is robust in appearance, supporting the assertions of Roemer (pers. comm. 1996) and Wellingham

Jones (1985) that cultivars are unstable and revert back to their original stock³. Typical forest "gaps" or openings within otherwise closed forest often characterise invaded areas, as do park edges facing cleared adjacent land (e.g. at Knockan Hill, Mount Douglas and Coles Bay Parks). Ivy colonises dry steep slopes (e.g. north portions of Francis-King Park), whereas wet or mucky slopes were less heavily invaded (at Mount Douglas and Coles Bay Parks).

In terms of ground flora, uncommon or less ubiquitous species were found in non-invaded and less invaded plots compared to invaded plots. The research found that as the cover of ivy increased in sample plots, the overall cover and number of other dominant plant species decreased. Red huckleberry and salal were both rarely found in areas invaded by ivy in this study but would be present just beyond invaded areas. Field observations suggest that twinflower, salal and honeysuckle (both hairy and western) may be at risk of being suppressed by ivy. All four of these species share a similar niche, colonising decomposing logs and tree stumps, especially when young. When ivy replaces some of these taller species, the height of the lower, woody plant stratum of the forest decreases making invaded areas appear less stratigraphically full or complex (Appendix 7: Figure 11).

9.4 Relationships between Ivy and Host Trees

Lianas receive no nourishment from their hosts and are therefore not viewed as ectoparasitic plants. Ivy dies when the connection is cut to its true roots, which have a different anatomy than its anchoring rootlets (Goebel 1905:286). Daubenmire (1947:316) noted that although lianas use hosts only as supports and anchors, they may engulf

³ Darwin (1859:16) described the tendency of wild traits to return in species that escape from domestication in his chapter on 'Variation under Domestication' in the Origin of Species.

supporting tissues and canopies of their hosts. The degree to which ivy harms its hosts is, however, commonly disputed both among ecologists and, less surprisingly, between horticulturists and ecologists. For example, Elliott (1995) argues from a horticultural perspective that ivy is not an inherently aggressive and destructive plant “strangling, smothering, weakening, parasitising” trees and deciduous woodlands throughout Britain. Elliott's (1995) article suggests also that European foresters are perplexed; believing that ivy does not harm trees and provides valuable habitat for fauna, while simultaneously listing it in the “Forester's Companion” as a harmful plant to be cut down on sight. The potential ecological harm and benefits of lianas should be examined, first, leaving aside the issue that ivy is an exotic species.

Much of the ecological literature states that lianas such as ivy compete with and harm their host trees. For example, Putz (1991) argues that lianas deform and break tree stems and compete with them for water, light and nutrients and Hegarty (1991) states that trees are thought to be at a disadvantage when climbed by large lianas. Gentry (1991:5) argues that lianas exert a strong selective pressure on trees and are a major cause of their mortality and Thomas (1980) states that ivy is detrimental and deadly to trees in eastern, deciduous North American forests. It is also thought that girdling by lianas deforms trees and increases susceptibility to disease and pathogens (Putz 1991).

The beneficial role of lianas is that they play an active role in nutrient cycling because of their very rapid growth rates and voluminous leaf production (Schnitzler 1995). Trémolières et al. (1988) believe that because of the time and distinct way that lianas cycle nutrients, a mutualistic rather than competitive relationship exists between ivy and its hosts. These authors believe that European foresters' practice of cutting giant lianas from trees to save them from being killed by ivy is misguided:

Or pendant plusieurs décennies, ces lierres magnifiques furent coupés, au cours d'interventions forestières dans les forêts rhénanes d'Alsace, sous prétexte qu'ils inhiberaient la croissance de l'arbre porteur. Les observations de terrain montrent au contraire que les plus beaux lierres sont portés par les arbres les plus grands et les plus vigoureux.

[Yet, over several decades, these magnificent lianas were cut, by successive forestry interventions in the Rhine forests of Alsace, under the pretext that they would inhibit the growth of the supporting tree. The field observations indicate that, on the contrary, the most beautiful lianas are supported by the largest and most vigorous trees.]

(Trémolières et al. 1988:189)

Trémolières et al. (1988) argue that nutrients leached from ivy's spring (April through June) litter nourishes trees during their growth season, and that trees hosting the largest lianas produce larger annual growth rings. In my study, a positive correlation was found between trees with large circumferences and large ivy stems, indicating that larger hosts are better able to support larger vines and larger ivy crowns.

However, most authors believe that lianas accelerate the death of damaged hosts, while their heavy ground cover kills most seedlings and affects tree regeneration (e.g. Schnitzler 1995). In my study, young deciduous trees were particularly susceptible to becoming engulfed and pulled down by ivy (Appendix 7, Figures 12 and 13). It is likely that the death of the largest host trees could be delayed for decades, but still hastened, once its faster growing climber reaches the maximum size it can support.⁴ As future forests become more saturated with aged ivy, its relationship with host trees should become increasingly important.

9.5 Other Influences on Ivy's General Distribution

Distributional patterns of ivy, in seedling areas inside already-invaded parks and

⁴ Daubenmire (1947:316) noted that in tropical trees that become constricted and eventually engulfed by lianas, natural grafting may prevent the tree's short term starvation. However, even the largest ivy stems I removed never penetrated the bark of trees.

in parks in the early stages of invasion (e.g. Devonian Regional Park and Roche Cove Regional Park - a CRD park not discussed in this study but where ivy is beginning to spread), suggest that it is not effectively dispersing over long distances (e.g. between several hundred metres to several kilometres). Ivy seedlings were found within several dozen metres of seeding ivy, in part because its seeds are too heavy to be dispersed by wind over long distances. Other dispersal agents, such as small mammals or rodents may be able to scatter ivy's seed, although little research was uncovered related to the ingestion and dispersal of ivy seed by animals.

Lianas, in general, have high levels of bird dispersal (Gentry 1991). A study examining the ingestion of ivy seed by birds in the U.K. by Barnea et al. (1993) indicated that the toxicity of unripe fruit affects their consumption. Cyanogenic glycosides in the unripe fruits, bitter enough to discourage consumption and toxic enough to cause diarrhoea in frugivores, decreased in concentration as seeds matured, making them more palatable to birds in the spring. Mild toxicity decreased the number of seeds consumed by each bird per foraging bout, ensuring ingested seeds are retained long enough to help germination yet not long enough to be broken down chemically through digestion. The removal of the pulp of seeds by partial digestion is important for germination. In Brittany, Clergeau (1992) found that germination rates of ivy seeds doubled when their pulp was removed either by researchers or birds (starlings and blackbirds).

In Victoria, ivy berries are an important food source for robins and starlings (Edgell 1998, pers. comm.). Even if the species of birds that consume ivy spend considerable time in suburban, agricultural or settled areas, birds consume large quantities of seed and their mobility should encourage the diffusion of ivy beyond highly settled areas. The mechanism discussed by Barnea et al. (1993), described above, may

limit the retention of seeds by these birds. However, it must only be a partial explanation of the surprisingly limited spread of ivy over relatively long distances (e.g. further from housing and into the Highland parks) since it was introduced about a century ago. If viable seeds have been widely scattered throughout the region, other site, habitat and disturbance variables must also affect germination success. Since landscape and human influences on ivy's distribution were the focus of this study, biological or faunal influences on dispersal, recognised as potentially very important, are not well understood and beyond the scope of this study.

Over the study period, there was evidence of ivy clearing / management in the Elk-Beaver Lake to Bear Hill Park corridor, at Devonian Park and in general over the whole of the study area. My discussions with park managers and local residents suggest that the primary agents of removal are parks staff. However, based on evidence that no records of exotic plant clearing were offered to me by parks staff, periodic removal of ivy may not be systematically planned and recorded. This research did not focus on the degree to which parks staff removes ivy, nor whether other park visitors eradicate or encourage it. However, the active roles that people play in introducing and removing plants from specific locations inside parks, make ecological and biological explanations for ivy's diffusion and distribution incomplete.

9.6 Growth of Ivy

As soon as temperatures rise, even for very short periods of time, juvenile ivy can immediately start growing (Fischer and Feller 1994). Leaves in the interior of ivy patches seize light while shoots along patch margins elongate in search of hosts. It is

hypothesised that to conserve energy⁵ for the ascent and reproduction in the canopy, ivy produces smaller, thinly elongated leaves while climbing until its heteroblastic shift to its arborescent, adult phase. Vines can alter their form and growth more easily than trees and shrubs in order to respond to changing habitats and environmental conditions. Heterophylly allows the seedlings to begin life in the shade and reach more direct sunlight when mature (Lee and Richards 1991).

But why would ivy develop two phases of growth and climb to flower under higher light regimes instead of simply flowering on the forest floor or growing self supporting stems like other plants? The characteristics of heavily invaded areas in local parks suggest there may be ample room for flowering on the ground. It was suggested that ivy retained characteristics that were strategic where it evolved in tropical climates (Trémolières et al. 1988) where competition for space and access to light may have been fierce. Ivy's reproductive strategy has proven extremely successful in moist western temperate forests – it climbs, flowers, and develops fruit that fall or are distributed by birds or other species. In the parks examined, the highest potential supports for fruit are offered by tall Douglas-fir, on which ivy flowers 30 m off the ground. The plasticity of lianas that allows them to specialise in colonising forest overstories and understories without wiping out the hosts and forests on which they depend can be interpreted as an evolutionary advantage to both lianas and forests (Givnish 1995).

When mature and in arborescent form, ivy's stems increase in diameter and produce radial growth rings. Preliminary observations of the interior structures of stems suggest that ivy, and possibly other arborescent lianas with growth limiting factors

⁵ Darwin (1865) observed that all climbers have as an objective to reach higher levels of light while expending the least possible amount of "organic matter".

growing in temperate regions, could be suitable specimens for dendrochronological analysis, although such analyses would be of limited utility. Ivy's phloem and bark is sometimes deeply grooved on the outside, similar in appearance to stems of Douglas-fir trees, and it anchors this bark to trees by secreting gummy cement from its rootlets.

From an evolutionary perspective, having only recently encountered them, local trees have not developed defences against adhesive-root climbers. Tree defences against lianas include bark shedding, found where vines are prevalent in flood-plain forests of the eastern U.S., and mutualistic relationships with ant "bodyguards" that remove vines from trees (Givnish 1995:38). The deeply fissured outer bark of Douglas-fir, the bumpy and rough textures of Garry oak, the long, vertically-grooved trunks of black cottonwood and the shade these trees cast make these species excellent hosts and habitat for ivy.

CHAPTER 10: IMPLICATIONS FOR CONSERVATION, MANAGEMENT AND FUTURE RESEARCH

The fragmentation of natural habitat around near-urban parks will continue to increase the number of park boundaries in contact with intense forms of human land use, such as residential areas, which are known sources of invasive, horticultural plants. Invasive horticultural plants will increasingly saturate near-urban parks, particularly park boundary zones, which in fragmented landscapes also suffer from increased sunlight, decreased canopy closures, increased windthrow (e.g. fallen, dying and unhealthy trees) and increased numbers of shrubs and disturbance-adapted species. Also likely to contribute to increased invasion of exotic plants such as ivy in interiors and boundary zones of near-urban parks are trampling / foot traffic, litter (e.g. garden waste, compost, garbage), mowed fields, lawns and manicured landscapes.

In each near-urban park, the quality of habitat will determine the degree of invasion by each locally invasive plant species. For instance, Himalayan blackberry and Scotch broom, common edge and clearing species, benefit from deforestation and are most prevalent in highly fragmented and open parks, whereas holly, daphne-laurel and English ivy form communities in urban forest¹ near fragmented and deforested habitat. Where forest is limited in a park, there may be greater risk of quick saturation by shade tolerant, forest-invading species. Since rock outcrops constitute significant amounts of the total area of several of the parks examined (e.g. Mt. Douglas, Knockan Hill, Bear

¹ Holly is invasive even within less disturbed forest communities of Francis-King Park and daphne-laurel is diffused throughout humanised areas of parks. Holly, daphne and ivy are evergreen species, which may be advantaged in winter, particularly in deciduous woodland. The advantages for an evergreen plant include increased carbon gain and extended growth, while disadvantages include leaf damage, increased need for respiration and exposure to herbivory (Teramura et al. 1991). Herbivory on these forest-invading species is likely negligible.

Hill, Lone Tree Hill, Horth Hill, Uplands Parks), forest-invading horticultural plants such as ivy should be of critical concern.

Park boundaries that contain mixed Douglas-fir forest or woodland such as Garry oak and that are adjacent to residential areas may become heavily invaded by ivy without on-going invasive species management. The observations of stem diameters of ivy (i.e. diffusion from areas of initial establishment deeper inside parks) and of shoot growth suggest that on a landscape scale, this species' spread is moderate, steady and thorough in favourable habitat. Within a few centuries, if ivy is not removed, it could become a dominant species within most soil-rich Douglas-fir forest ecosystems on the West Coast. If short lived and fast growing lianas such as ivy hasten the death of their older growing host trees, aged trees and forests may face a new threat. The sprawl of urban areas on Vancouver Island will promote the spread of ivy and other invasive horticultural species into western forests.

10.1 Implications for Conservation

Parks are our principal insurance that there will be ecosystems that have been moulded by forces besides human beings. However, near-urban parks exist within a habitat increasingly designed by human beings, and their survival will likely be contingent upon human intervention. Unlike gardens, near-urban parks are more than ornamental features of landscapes. As refugia for indigenous species, near-urban parks protect biodiversity and natural complexity in an increasingly urbanising world. In the near-urban parks sampled in this research, Himalayan blackberry, Scotch broom, daphne-laurel, holly, wall lettuce, creeping buttercup, numerous grasses and less ubiquitous horticultural species including cotoneaster, ornamental trees and shrubs, helleborine,

cyclamen and other species are pervasive. Together, these species have dramatically altered the original floristic composition of Greater Victoria's natural areas. Yet, these species are commercial commodities sold in stores without warnings. As human settlement and introduced species consume the physical and ecological spaces of native flora, parks are transformed into relics of nature within suburbia and indigenous species are lost.

Regional parks typically have a higher conservation value and less disturbance, are often less accessible to large populations (often formed by lands transferred from municipalities: see R.S.C. Chapter 310: Parks (Regional) Act 1989). Municipal parks are typically smaller, accessible and designed for human activities (e.g. Greater Victoria's Beacon Hill Park is a prime example of a utilitarian nature park, which as Young (1995) notes emerged in the 1880s, featuring zoos, playgrounds, manicured lawns and mass plantings of exotic ornamental plants). Natural and indigenous species in the smaller human-use oriented near-urban parks are particularly difficult to protect. However, if a purpose of these parks is indeed to promote long-term protection of indigenous species and habitats, ongoing and immediate management of exotic vegetation is essential.

10.2 Implications and Recommendations for Management

Controlling invasive exotic plants requires a long-term commitment (Cowie and Werner 1991). Long-term park habitat restoration will be challenged by invasion of new exotic species following the removal of exotic plants, due partly to increasing proportions of exotic plant propagules or seeds in the ambient "seed bank" but also from disturbance and future environmental change. Brockie et al. (1988) stated that problems stemming from invasion of exotic species range from negligible to virtually impossible to manage.

However, it is important to remain optimistic that exotic species management and long-term ecosystem restoration are possible and worthwhile investments.

Saunders et al. (1991) argue that the management of fragmented habitats can focus on natural systems and the internal dynamics of nature "remnants" or on the external influences that affect them. For small remnants of natural habitat, Saunders et al. (1991) believe that management should focus on the external influences because conservation will be impossible if the external matrix continues to affect the internal species, natural dynamics and habitat. Smallwood (1994) has argued that managing and removing exotic species inside a park only serves to distract from the real threats outside the park in the surrounding landscape. However, a more complete approach to managing invasive horticultural species would ideally target both the inside and outside dynamics of parks.

The management and control of horticultural plants in particular presents a challenge to local park managers and conservation groups (Schmidtz and Simberloff 1997). In addition to ostensible social, fiscal, structural or institutional constraints, outside-park management is difficult since parks are public property with little authority over nearby private property. Parks are often treated as extensions of private property with nearby landowners or residents extending their activities freely into them. However, some residents are also highly protective of parks near their homes and are concerned about disturbance, the activities of park visitors and the general ecology of the park. While there are disadvantages for park protection associated with nearby residential areas and human activities, the advantages include nearby residents who could assist in a potentially effective method of park protection, given agreed-upon principles, objectives

and methods. Saunders et al. (1991) argue that the protection and maintenance of park ecosystems and species diversity strongly depends on land owners and neighbouring land uses meeting to develop integrated management strategies. The natural interests of residents could be carefully directed towards the creation and implementation of management and protection strategies as Saunders et al. describe.

Inside the park, managing invasive plants such as ivy should be a priority. The spread of invasive plants is of concern to many park managers and there is evidence of ongoing removal of ivy and other exotic plant species in many of the Capital Regional District Parks. As one of the invasive species that is relatively slow spreading on a year-to-year basis compared to other invasive vines such as kudzu or invasive shrubs like Scotch broom, ivy should be fairly easy to control in its early growth stages and be an encouraging species to manage.

10.2.1 Methods for Controlling Ivy and other Invasive Plants

Effective forms of biological, microherbicide (application of pathogenic fungi), chemical and mechanical control are often sought for invasive plants. However, criticisms of biological control measures centre on their ineffectiveness and their potential to further disturb ecosystems. Biological control necessitates the introduction of new species, some of which, particularly those used in early efforts (see Laycock 1966), have caused more problems than the species they were attempting to control. There is also considerable evidence that biological and pest control measures have extremely low success rates in managing invasive plants (Cronk and Fuller 1995). While methods of biological control are improving, the success of such programmes is contingent upon the target species and the outcomes are limited:

None of the 610 biological control projects conducted on Earth to date, involving 94 weed species in 53 countries . . . has eliminated any plant species completely. [T]he historical evidence suggests that neither insects nor diseases are likely to eliminate ecologically successful species, whether native or introduced.

(Johnson and Mailleux 1992:330)

The application of chemical herbicides for invasive plant control can pose potential and real risks to non-target species. However, there is active use of chemical control² in some parks (e.g. for controlling ivy in Vancouver's Stanley Park) and fervent interest on the part of some park managers and interest groups.

The control of exotics is a growth industry. . . The bad news is that there will once again be calls for the widespread application of herbicides, insecticides, and rodenticides. On ecological grounds it is to be hoped that such shotgun approaches can be avoided, but this will depend on the existence of integrated management programs, which in turn will depend on basic research

(Soulé 1990:236)

The pursuit of biological and chemical methods of control may represent abortive attempts that in some cases defy principles of environmental protection. For this reason, old fashioned, mechanical/physical removal of invasive plants, often overlooked because it is perceived as more labour intensive and ongoing than biological and chemical control, offers great potential. For ivy it involves cutting climbing stems and removing or pulling out ground cover. The berries of ivy are also large enough that care can be taken when removing them or it can be removed before it seeds. Resprouting and recolonisation is to be expected as seeds already present may germinate and vegetative regrowth may occur if all plant material is not removed. However, it is not suspected that ivy would re-invade as vigorously following removal and disturbance, which can be the case for some species

² The chemical control of ivy was studied by Derr (1993). The author describes the effects of various postemergent herbicides such as 'Roundup' (glyphosate) and 'Weedar 64' (2, 4-D) in Virginia. He found that single applications reduced shoot growth and caused abnormal, deformed leaf growth and two applications of Weedar halted regrowth after 11 weeks.

(e.g. such as purple loosestrife - *Lythrum salicaria* L. whose seeds are tiny and easily scattered by removal - see Wagner 1991). The success of removal will be measured in the long run (Appendix 7: Figure 14). Park rangers in Australia (Young 1996, pers. comm.) and restorationists in New Zealand (Veitch 1996, pers. comm.) report having had great success with the mechanical control of ivy in their parks. Other strategies for controlling the spread of invasive plants must focus attention outside the park, on broader policy and management instruments.

10.2.2 Legislative, Regulatory and Policy Instruments

At the international level, agreements exist to discourage and prevent the introduction of exotic species (e.g. the Council of Europe's Berne Convention on the Conservation of European Wildlife and Natural Habitats; the Protocol for Protected Areas and Wild Fauna and Flora in Eastern African Region) (Cronk and Fuller 1995). For example, the International Union for the Conservation of Nature has called for a permit system for the deliberate introduction of exotic species and the United Nations Convention on the Law of the Sea (UNCLOS) has called for measures to prevent the introduction of new species (Cronk and Fuller 1995). National-level legislation regulating the introduction of exotic invasive plants relates primarily to agricultural weed control (e.g. the Australian Federal Quarantine Act of 1908, the U.S. Plant Quarantine Act of 1912 and the Canada Seeds Act³, 1985, c. S-8 and Weed Seeds Order, 1986). Ivy and many other invasive horticultural plant species are not among the prohibited noxious weeds listed in the schedules of the Canadian Weed Seeds Order, 1986.

³ Originally the Seed Control Act, 1905, c. 41; 1911, c. 23; 1923, c. 27; 1937, c. 40; 1959, c. 35; RS 1906, c. 128; 1927, c. 185. This legislation relates mainly to quality, purity and grades of seed. These national laws were developed to support the pioneering industry of farming around the turn of the Century.

In the U.S., national level vegetation management policies for parks call for the removal of exotics to the extent feasible (Westman 1990). Yet, despite legislation having been introduced in the U.S. nearly a century ago to curtail destructive exotics, the number of introductions has dramatically risen (Ruesink et al. 1995). The Federal Noxious Weed Act of 1974 targets 94 weeds, but does not require new species to be evaluated for potential invasiveness and lists only a fraction of the more than 750 plants in the U.S. that would qualify under the Act's definition of weed (Reichard and Hamilton 1997). For example, although kudzu was added to the U.S. Department of Agriculture's noxious weed list by act of Congress (H.R.2160.30, Sec 728), purple loosestrife, a species destructive to wetlands, is not listed. Fortunately, states and counties may also regulate and list noxious weeds that are a problem in their region. Washington State, for example, lists purple loosestrife as a noxious weed, and in King County, Washington State, although English ivy and Himalayan blackberry are not listed as noxious weeds, they are considered damaging species and addressed by a public education campaign. In Canada, the Plant Protection Act⁴, 1990, is designed to protect the agriculture and forestry industries from the spread of injurious introduced species or pests, by providing for their control and eradication. Canadian policy, legislation and enforcement, like that of other nations, needs to be updated to focus on protecting natural habitat and indigenous species from biological pollution. Ruesink et al. (1995) argue for a policy shift to a protective position for natural ecosystems and a process for "learning from past mistakes".

⁴ This Act repeals the Plant Quarantine Act, 1985 (Revised Statutes of Canada c. (chapter) P-15 that prevents a person to "legally introduce or admit to Canada any pest or plant that is or may likely be infested with a pest or that constitutes a biological obstacle to the control of any pest"; R.S.C. 1970, P-13. It repealed the Destructive Insects and Pest Act, 1968-1969 c.35 pending R.S.C. 1952, c.81; and the Destructive Insect and Pest Act, 1910 c.47. The Destructive Insect Act, 1877 (U.K.) c.68 directed against the introduction of the Colorado Beetle into Great Britain.

At the provincial level in Canada, British Columbia also lists noxious weeds and requires land occupiers to control them under the British Columbia Weed Control Act and Weed Control Regulation, 1985. However, as with federal and international legislation, listed weeds consist primarily of agricultural ruderals that invade cropland. Since few horticultural species are listed as noxious in B.C. or other provinces, few controls exist to limit their sale or distribution. Even for legally designated weed species, enforcement of the British Columbia Weed Control Act is difficult because unlike in other provinces, B.C. has no provincial weed inspectors (Cranston, Provincial Weeds Specialist, pers. comm., 1997).

Provincial government ministries are not mandated to manage exotic species and have few policies⁵ and programs related to their control. There are no sections pertaining to the control, regulation or prohibition of introducing exotic or invasive species in the B.C. Parks Act, 1979 or Park Amendment Act, 1995, which apply to Provincial parks or in the Parks (Regional) Act, 1979, which applies to regional parks. The Capital Regional District Parks Department has a policy calling for the control of exotic invasive species in their parks and Saanich Municipality has a Parks Department policy to cut ivy growing on park and boulevard trees. However, a walk through a regional or municipal park reveals that policies alone are not effective or are not being effectively implemented.

The control and reduction of invasive urban plants requires legislation and regulation that would include ornamental plants of the horticultural industry⁶. However,

⁵ The government of B.C.'s Ministry of Environment, Lands and Parks began developing policy in 1997 that included a statement on management and control of exotic and invasive species in provincial parks.

⁶ The nursery industry does not regulate itself against developing or distributing invasive plants. If a plant will grow, it will be sold unless it is on a noxious species list. For instance, provincial authorities (e.g. weed specialists) advise nurseries not to grow purple loosestrife, but as yet there exists no legislation against its sale, nurseries may not always comply (Cranston, pers. comm., 1997).

in British Columbia, the horticultural plant industry was estimated to be worth \$824 million in 1992 (Mathers 1996, nursery specialist, pers. comm.). It would likely be difficult to pass legislation that would require testing a plant's invasion potential before general sale or that would require pulling invasive plants off store shelves. The legislation and regulation that is essential to environmental protection and invasive plant spread rests on the political and democratic participation and demands of citizens; participation that is often wanting in relation to the private interest lobbies.

Assuming there is a will to regulate invasive horticultural plants, regulatory bodies can develop protection strategies based on models already developed. For example, Smallwood and Salmon (1992) devised a pro-active rating system for setting research and control priorities for pest species based on their potential to be introduced, to establish, cause damage and be controlled. Reichard and Hamilton (1997) have also developed models for predicting the potential for woody plants to become invasive. They have also urged that the economic potential of a plant be considered of secondary priority to its potential invasiveness and threat to native ecosystems. Reichard and Hamilton (1997) emphasise that the aim is not to restrict the variety of species available to horticulturists, agronomists and consumers but to have a more thoughtful protocol for evaluating and reducing the potential for plants to be destructive to natural ecosystems. A protective approach to natural ecosystems would err on the side of caution by considering every new plant potentially invasive until proven harmless (Gillis 1992).

Legislative forms of control to prevent the spread of exotic species are only one component of management. For example, the strictest international rules controlling the introduction of exotic plants have existed since the 1960s for Antarctica. However, seed

propagules have increased with tourist and research traffic and with the routine use of "sterile" horticultural soils in experiments, which contain viable seeds and propagules (Smith 1996). Since developing legislation can be a long and contested process and existing laws may not be enforced, management of invasive species must also include measures beyond legislation, policy and regulation.

10.2.3 Other Strategies and Recommendations for Abating the Spread of Invasive Plants

Co-operation among interests and agents has been stated as being preferable to enforcement for protecting parks (Schonewald-Cox 1988). Co-operation may also be viewed as preferable to litigation⁷ and involves ongoing dialogue between interests. Public education is an important component of dialogue and may involve multiple fora and media. The power of television, radio and advertisements should not be overlooked in increasing public awareness, although, as Dearden (1983) explains, media (newspapers, television, radio, magazines, etc.) tend to be more interested in sensationalism than in promoting and diffusing helpful ecological information on exotic species. Discussion groups, documentaries, information brochures and formal education⁸ are important to increasing ecological dialogue and awareness. If co-operation among competing interests fails, the development of incentives (e.g. awards, tax credits, grants or publicity for nurseries and other industries) by governments and public interests might

⁷ However, in favour of litigation, Giesser (1993) advocates the use of public nuisance laws against an array of external threats for U.S. National Parks. The author argues that the National Park Service's hesitancy in addressing external threats, possibly attributed to their belief that the constitution prevents interference with private landowners, should be overcome and actions should be brought against developers, etc. who infringe on the rights of the public to an undamaged park.

⁸ In many countries, environmental education receives little if any attention (Cronk and Fuller 1995). Current practices of streaming students out of the natural sciences and into social sciences and humanities do not encourage understanding of ecosystems, ecology and natural history. Curricula and programmes of study should promote the intellectual examination of ecological concepts, at all levels, by all students.

be part of an effective strategy. It is eventually in the interest of the nursery industries that species do not become so invasive that demand for them all but disappears.

Specific recommendations for managing, controlling and preventing the spread of invasive plants may differ slightly depending on the agencies and actors involved. However, in general, natural habitat protection will benefit from accurate information and science. At the park level, the best designed and implemented management strategy would integrate a scientific research component with the choice of control treatments defined by type of invaded ecosystem, and incorporating longitudinal monitoring, evaluation and an adaptive approach to management. For resource managers, greater access and postings to local and global databases and networks (to build on the IUCN's Invasive Species Specialist Group, the Invasive Plants of Canadian Project and the Invaders Database System already on line) will increase regional information sharing and specialisation of internet sites. Comprehensive on-line resources on invasive plants, and species inventories, by region, are required to build Canada's environmental protection and research network. This would begin with a complete exotic species list compiled for British Columbia, networked with those of other provinces in a national database and Geographic Information System. National funding matched by contributions from provincial and regional government should be made available to develop these important components of a Canadian invasive species management programme. Other general recommendations for researchers, environmental scientists, restorationists, conservation biologists, and public and private agencies are to:

- Increase and co-ordinate municipal, regional, provincial, national and international government priorities to fund and promote natural areas protection through legislation and enforcement, co-operation, incentive-building and public relations;
- Increase levels of awareness among government and political officials and the

- public to the importance of park protection and the threats⁹ of invasive plants;
- Build and co-ordinate legislative and regulative instruments for invasive plants and for increasing the priority of protecting remaining indigenous wild habitat. This should include the development and promotion of incentives (e.g. municipal tax credits and for funding non profit groups) for joint management of invasive plants with private landowners and for native plant landscaping and land restoration;
 - Direct a proportion of regional and municipal government budgets for lawn and garden keeping towards the management of highly invasive plants in parks and natural areas;
 - Initiate an adaptive management strategy including ongoing monitoring of areas where invasive plants are being removed. Records should be kept of the status and spread of invasive species, removal schedules (e.g. dates, location, method of removal) and follow-up evaluations (e.g. efficacy and comparison of methods of removal). The systematic accounting of the removal strategy is valuable scientific information enabling park managers to reduce the overall proportions of exotic plant species, prevent species extinction and protect ecosystems in the long-term;
 - Publish a local rare/invasive plant list and protection/prevention strategy, and make it widely available to the public and in schools;
 - Work with non-governmental organisations, environmental organisations and local media to increase public environmental awareness (e.g. produce short documentaries, news items and maintain and increase information brochures for parks such as those currently produced by Saanich Municipality). This should also involve urging private citizens, nurseries and retailers to take an active role in ecosystem conservation by reconsidering the purchasing and distribution of plants invasive in their biogeographic region; and
 - Encourage the scientific testing of various, safe methods for removing invasive plants such as ivy.

Within particular parks and park systems, the establishment of permanent plots and transects as well as comprehensive species inventories will enable monitoring and longitudinal study of vegetation change (e.g. plant invasion, local extinction, adaptation to climate changes or other ecosystem conditions).

Another technique for monitoring environmental change that may offer great potential for protecting species in the long run is the use of photography, video and

⁹ As an example, Cronk and Fuller (1995) describe three types of threats including: the replacement of diverse systems with single-species stands of aliens, invasion that poses a direct threat to native fauna or that leads to species extinction and invasion that alters soil chemistry, fire regimes, hydrology and/or geomorphological processes.

description. Local residents' descriptions and photographs have been of immense utility towards reconstructing historical ecosystems and understanding land use change. For example, Fawcett's (1911) description of walks to school through the thick alder groves and 'swampy' woods along View Street deeply illustrate the changes to Victoria's ecosystems in the past 150 years, before widespread photography. From the late 1800s to early 1900s, photography has chronicled the demise of many of the large, old growth trees and forests (e.g. see Whitney's 1994 photographs of old growth eastern North American forests). The deforestation and expansion of residential areas that occurs over decades and throughout a single human life span, although drastic, is dwarfed in comparison to the change occurring over several generations. Thus, photographs of vegetation and landscapes, provided they are not digitally modified, will provide future generations with the most vivid and accurate representations of natural ecosystems as they exist today. Grievously, they may be the only representations of such ecosystems. Currently, low flight aerial photography provides regional representations of landscape features and change. However, systematic, large-scale photography of natural systems should be initiated on the ground at a human scale.¹⁰ The inclusion of exact locations and aspects will allow species-level changes that occur in protected areas over generations to be visually documented. Conventional and digital photography or video offers economical forms of habitat documentation and monitoring, particularly if shot during fixed seasons at decade intervals or if limited to locations of special interest and vulnerability.

¹⁰ Whereas aerial photography was initiated and is arguably still carried out primarily for the purposes of defence and natural resource identification, and regular flights and photographs are available, ground level photography of vegetation even for a few key areas is nil.

10.3 Implications for Further Research

This research raises numerous questions about the biology of invasive species such as ivy, the geography of invasive, exotic plants in protected areas and the social dimensions and implications of ecological knowledge. Despite having contributed to the field of conservation biology over the past century and significantly since the mid 1980s, invasive species research has yet to be fully integrated with other disciplines and made accessible to resource decision-makers and social scientists. From the biological sciences, questions critical to explaining and forecasting the spatial distribution and diffusion of ivy on the West Coast relate to fruit toxicity, seed consumption and dispersal by birds and seed germination success. The best methods of removing and managing ivy and other species of exotic plants should be further researched and monitored in the parks. The biodiversity and ecology of introduced plants requires study including the charting of ecological networks between exotic and native species. Census data and inventories should be compiled for species within the near-urban environment (e.g. the Capital Regional District), widely distributed or made accessible to households, residents and schools to increase public awareness.

Introduced plants may increase fuel loads for fires in ecosystems (e.g. Scotch broom in oak and grassland communities). As ivy envelops mature oak stands in parks, it will be informative to know whether fuel loads in the canopy increase the risk of destructive crown fires in oak-meadow communities. Many of the ideas in recent works on lianas and climbing plants repeat what Darwin wrote in 1865 because there has been so little research conducted on these species since that time. Questions should also be answered relating to vegetation community resistance and resilience, two components of

ecosystem stability (Barbour 1987:171) that may help park habitat endure and rebound from disturbance. Scenarios relating to future environmental change in parks should be developed (e.g. the opening or closing of niches for new or existing invasive species as a result of climate change or intensified transformations of remnant wild ecosystems from urbanisation).

Schonewald-Cox and Bayless (1986) and Smallwood (1994) suggest that parks require connectivity and buffers for their interiors to be better protected. Of the parks examined in this study, only Francis-King and Thetis Lake parks are remotely connected (i.e. unbroken by residential areas or highways), bisected by a hydro corridor¹¹. Although beyond the scope of this research, the best methods of sheltering parks and park boundary zones from intense forms of human land use and invasive species, and which may differ for each park, have yet to be determined. Depending on their design, buffers and connectors will have advantages and disadvantages for native and introduced species of near-urban parks. Landscape design features that run along the edges of near-urban parks may slow the process of exotic plant invasion, while drawing attention to the larger problems of natural ecosystem fragmentation, isolation and shrinkage in urbanising areas.

Plant control may necessitate a consideration of the ethical implications of removing exotic species for conservation purposes. How right is it to view certain species as unwanted, "inconvenient to current circumstances and requiring removal" (Quammen 1997:360)? One view argues that invasive plants should be celebrated as a tribute to our successful humanisation of landscapes and that removing them equates to

¹¹ The hydro right of way has created a linear edge habitat with increased light penetration in Thetis and Francis-King Parks. In addition to affecting and replacing vegetation, powerline corridors have been shown also to deter numerous species of birds, mammals and insects from crossing or entering them (see Forman 1995:174-176).

racism or genocide, driven by xenophobia and a desire to eradicate diversity (Evans 1996). However, not removing invasive plants may lead to the eradication of indigenous plants and reduced diversity, which will fail to conserve species and park ecosystems in the long run (Appendix 7: Figure 15). Therefore, there is a need for geographers and conservation biologists to define the specific threats, if any, that each invasive species will pose to indigenous species and communities. The degree to which native species and communities are preferable to introduced or modified species and entire communities is an issue in need of considerable thought and research.

Accurate understanding of the formation of perception, awareness and values toward nature conservation is essential to keeping pace with emerging findings in the natural and ecological sciences. For instance, thousands of visitors and residents enjoy the species and landscapes of Greater Victoria's parks. However, the problems and threats of lush, green monostands of invasive plants may not be apparent to the untrained eye (Schmitz and Simberloff 1997). Discussions with residents who believed that ivy was native to Vancouver Island suggest that many people are unable to distinguish introduced from native flora, and by extension, may not see a connection between ivy in supermarkets and its invasion of parks. Botanical and ecological literacy is essential for environmental decision-making, allowing more lucid appreciation of past and potential landscape transformation. Consequently, there is a need for social science and humanities research to examine park and nature perception, conservation awareness, landscape aesthetics and environmental behaviour¹². Field guides to introduced and

¹² For example, Dearden (1989) suggests that human preferences for landscape types may be influenced by innately-human or even evolutionarily-programmed tastes, cultural traditions and familiarity with an environment, and by socio-economic and demographic factors such as one's age, gender, social class and generation.

invasive plants of British Columbia or its regions could increase public awareness of them. A guide to introduced plant and animal species could include an updated version of Carl and Guiget's 1958 guide to introduced animals.

Management of exotic plants and prevention of biological pollution rests ultimately on widely held social values, informed by science, ethics and knowledge. Public support is desirable if not essential for successful restoration of natural areas, especially in the ecologically stressed and fiercely valued near-urban environment. Anthropocentric disciplines (e.g. law, economics, anthropology, etc.) should be applied in the design of nature reserves (Schonewald-Cox 1988) and should become concerned with vegetation management. However, natural scientists must make better efforts to transmit their knowledge in order to convince lawyers, economists, anthropocentric disciplines and the public that vegetation ecology and invasive plant management are important to protect ecosystems and parks in the long term and important to humanity. This research examining the spread of ivy in near-urban parks represents an attempt to integrate and mediate between the social and natural sciences, by discussing ecological and urban landscape development factors associated with the spread of invasive plant species and park habitat protection.

SUMMARY AND CONCLUSION

The objective of this research was to examine a number of factors thought to influence the spread of an invasive horticultural plant (*Hedera helix* - English ivy) in parks of Greater Victoria. Fourteen parks were selected as a representative sample of natural areas. Two scales considered important to the distribution and overall invasiveness of ivy were determined and examined. At the site scale, the general habitats and vegetation communities where ivy was successful were described and the horizontal, vertical and stem growth of ivy was studied. At the landscape scale, hypotheses were formulated relating the distribution of ivy to (1) the influence of park boundary / edge characteristics and (2) overall park insularity as defined by external land use.

Outside land use explained patterns and extent of horticultural plant invasion more than park shape and size. Small parks that lacked multiple, outside sources for the introduction of ivy (e.g. Lone Tree, Bear Hill Parks) were less invaded overall than larger parks with multiple, long-established sources (e.g. Mount Douglas and Elk-Beaver Lake Parks). Measures of park perimeter to area were less able to explain park invasion by ivy than the length or proportion of park perimeter adjacent to intensive human land use. Park boundary zones of parks that were most insularised by human activities suffered greater invasion by ivy than less insularised parks.

Evidence supports the hypothesis that the park boundary serves as an important entranceway for ivy to establish, reproduce and disperse deeper into the park. The presence of ivy outside a park was the strongest influence on park invasion and on invasion in the park boundary zone. Areas of parks vulnerable to invasion by ivy include:

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- Douglas-fir habitat and mature Garry oak woodland; forest gaps, brightly exposed areas;
- Boundary zones adjacent to cleared land where there is windthrow (e.g. Coles Bay, Mount Douglas Park);
- Parking areas, park entrances, particularly near roadways (e.g. at Devonian and Mill Hill Parks), other accessways, trails, trailheads or areas near signboards;
- Narrow entranceway corridors to parks (e.g. Tower Point, Elk-Beaver Lake to Bear Hill Parks), where homes have been established for many decades.

Areas of parks less vulnerable to invasion by ivy include:

- Boundary zones adjacent to cleared, agricultural lands (e.g. non-invaded at Devonian Park, Witty's Lagoon, Bear Hill, Francis-King Park, less invaded at western edge of Mount Douglas Park);
- Boundary zones against natural park edges such as forests (e.g. north Thetis Lake Park) or forests along coastlines;
- Interior portions of parks including forest gaps far from established populations of ivy (e.g. >500m);
- Rocky forest habitat with thin soils (such as slopes of Bear Hill, Lone Tree Hill and Francis-King Parks).

As one of the most invasive garden escapees in remnant natural areas in Greater Victoria, ivy covers many hectares of park habitat in forests adjacent to residential areas. Habitat type and isolation from human activities are the most important variables related to invasion. Douglas-fir and Garry oak forest habitat within insularised parks are most susceptible to heavy invasion by ivy. It is hoped that the research encourages discussion of how the characteristics and invasiveness of ivy and the characteristics of near-urban parks affect their ability to protect naturally evolved, wild species and ecosystems in the long-term.

BIBLIOGRAPHY

- Agassiz, D.J., Nash, D. R., Godfray, H.C. and Lawton, J.H. 1994. Estimating the spread of small invading organisms using information from the public. Global Ecology and Biogeography Letters, 4: 1-8.
- Aizen, M.A. and Feinsinger, P. 1994. Habitat fragmentation, native insect pollinators feral honey bees in Argentine "Chaco Serrano". Ecological Applications, 4(2):378-392.
- Allaby, M. 1992. The Concise Oxford Dictionary of Botany. Oxford, U.K: Oxford University Press.
- Ambrose, J.P. 1986. Dynamics of ecological boundary phenomena along the borders of Great Smoky Mountains National Park. Unpublished doctoral dissertation, University of Georgia, Athens.
- Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial plant ecology. Menlo Park, California: Benjamin/Cummings Publishing Co.
- Barett, S.C. and Richardson, B.J. 1986. Genetic attributes of invading species. In Groves, R.H. Burdon, J.J. (Eds.), Ecology of Biological Invasions, pp. 21-33. Cambridge, U.K: Cambridge University Press.
- Beadle, N.C.W. Evans, O.D. and Carolin, R.C. 1972. Flora of the Sydney region. (Rev. ed.). Sydney, Australia: HA and AW Reed.
- Barnea, A., Harborne, J.B. and Pannell, C. 1992. What parts of fleshy fruits contain secondary compounds toxic to birds and why? Biochemical Systematics and Ecology, 21(4):421-429.
- Bauer, H. and Thoni, W. 1988. Photosynthetic light acclimation in fully developed leaves of the juvenile and adult life phases of *Hedera helix*. Physiologia Plantarum, 73:31-37.
- Blocklen, W.J. Gotelli, N.J. 1984. Island biogeographic theory and conservation practice: Species-area or species-area relationships? Biological Conservation, 29:63-80.
- Blood, K. 1997. Personal Communication. Weeds Specialist, Cooperative Research Centre for Weed Management Systems, Department of Agriculture, Government of Western Australia.
- Blouin, M.S. 1985. Is there a best shape for nature reserves? Biological Conservation, 32:277-288.
- Borthwick, D. 1955. Settlement in British Columbia. Victoria, BC: British Columbia Lands Service, Government of British Columbia.

- Bossard, C.C. and Rejmanek, M. 1994. Herbivory, growth, seed production and resprouting of an exotic invasive shrub (*Cytisus scoparius*). Biological Conservation, 67:194-200.
- Braun-Blanquet, J. 1965. Plant sociology. New York: Hafner Publishing Company.
- Brockie, R.E., Loope, L.L., Usher, M.B. and Hamann, O. 1988. Biological invasions of island nature reserves. Biological Conservation, 44:9-36.
- Brown, J.H. 1984. On the relationship between abundance and distribution of species. The American Naturalist, 124(2):255-279.
- Buechner, M. 1987. Conservation in insular parks: Simulation models of factors affecting the movement of animals across park boundaries. Biological Conservation, 41:57-76.
- Burke, M.J. and Grime, J.P. 1996. An experimental study of plant community invasibility. Ecology, 77(3):776-790.
- Cain, M.L. 1994. Consequences of foraging in clonal plant species. Ecology, 75(4):933-944.
- Carl, G.C. and Guiguet, C.J. 1958. Alien animals in British Columbia. (Handbook No. 14). Victoria, BC: British Columbia Provincial Museum.
- Carlquist, S. 1991. Anatomy of Vine and Liana Stems. In Putz, F.E. and Mooney, H.A. (Eds.), The biology of vines, pp. 53-71. New York: Cambridge University Press.
- Carter, G.A. and Teramura, A.H. 1988a. Vine photosynthesis and relationship to climbing mechanics in a forest understory. American Journal of Botany, 75(7):1011-1018.
- Carter, G.A. and Teramura, A.H. 1988b. Nonsummer stomatal conductance for the invasive vines kudzu and Japanese honeysuckle. Canadian Journal of Botany, 66: 2392-2395.
- Carter, G.A., Teramura, A.H. and Forseth, I.N. 1989. Photosynthesis in an open field for exotic versus native vines of the southeastern United States. Canadian Journal of Botany, 67: 443-446.
- Chutter, M. 1996. Personal communication. Provincial Birds Specialist, Wildlife Branch, Ministry of Environment, Lands and Parks, Government of British Columbia, Victoria, BC.
- Clapham, A.R., Tutin, T.G. and Warburg, E.F. 1962. Flora of the British Isles. Cambridge, U.K: Cambridge University Press.

- Clergeau, P. 1992. The effect of birds on seed germination of fleshy-fruit plants in temperate farmland. Acta Oecologica, 13(6):679-686.
- Coblentz, B.E. 1990. Exotic organisms: A dilemma for conservation biology. Conservation Biology, 4(3):261-265.
- Coblentz, B.E. 1997. Personal Communication. Professor, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR.
- Colinvaux, P.A. 1986. Ecology. New York: John Wiley and Sons.
- Collinge, S.E. 1996. Ecological consequences of habitat fragmentation: Implications for landscape architecture and planning. Landscape and Urban Planning, 36:59-77.
- Cowie, I.D. and Werner, P.A. 1993. Alien plant species invasive in Kakadu National Park, tropical northern Australia. Biological Conservation, 63:127-135.
- Cranston, R. 1997. Personal communication, Provincial Weeds Specialist, Ministry of Agriculture, Government of British Columbia, Cloverdale, BC.
- Cronk, Q.C. and Fuller, J.L. 1995. Plant Invaders. New York: Chapman and Hall.
- Crosby, Alfred W. 1992. Ecological Imperialism: The biological expansion of Europe, 900-1900. Cambridge, U.K: Cambridge University Press.
- Darwin, C. 1865. On the movements and habits of climbing plants. Journal of the Linnaen Society (Botany), 9:1-118.
- Darwin, C. 1905. The movements and habits of climbing plants. (Popular Edition). London, U.K: John Murray, Albermarle Street.
- Darwin, C. 1880. The origin of species. (Vol. 1). New York: International Science Library.
- Daubenmire, R.F. 1947. Plants and environment. New York: John Wiley and Sons, Inc.
- Davy, H. 1939. Thetis: Home of the raven. The Daily Colonist, March 19: follows feature article on Thetis Lake.
- Dearden, P. 1983. Anatomy of a biological hazard: *Myriophyllum spicatum* L. in the Okanagan Basin, British Columbia. Journal of Environmental Management, 17:47-61.
- Dearden, P. 1989. Societal landscape preferences: A pyramid of influences. In Dearden, P. and Sadler, B. (Eds.), Landscape Evaluation, Western Geographical Series, 24:41-55.

- DeFerrari, C.M. and Naiman, R.J. 1994. A multi-scale assessment of the occurrence of exotic plants on the Olympic Peninsula, Washington. Journal of Vegetation Science, 5:247-258.
- Derr, J.F. 1993. English ivy (*Hedera helix*) response to postemergence herbicides. Journal of Environmental Horticulture, 11(2):45-48.
- di Castri, F., Hansen, A.J. and Debussche, M. 1990. Biological invasions in Europe and the Mediterranean basin. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Diamond, J.M. 1975. The island dilemma: Lessons of modern biogeographic studies and the design of nature reserves. Biological Conservation, 7:129-146.
- Diamond, J.M. and May, R.M. 1984. Island biogeography and the design of natural reserves. Theoretical ecology: Principles and applications, pp. 163-86.
- Diefenbach, M.G. and Becker, M. 1992. Carabid taxocenes of an urban park in subtropical Brazil: II. Specific diversity and similarity (*Insecta: Coleoptera: Carabidae*), Studies on Neotropical Fauna and Environment, 27(4):189-200.
- Doak, D.F., Marino, P.C. and Kareiva, P.M. 1992. Spatial scale mediates the influence of habitat fragmentation on dispersal success: Implications for conservation. Theoretical Population Biology, 41:315-336.
- Doran, R.F. 1989. Exotic or alien - either defines pest. Park Science, 9(3):5. National Park Service, U.S. Department of the Interior.
- Doyle, S.S. 1992. External threats to National Parks. M.A. Thesis, Department of Geography, University of Victoria, Victoria, British Columbia.
- Drury, S. 1987. Customs and beliefs associated with Christmas evergreens: A preliminary survey. Folklore, 98(2):194-199.
- Earthwork Communications, Inc. 1991. Victoria, British Columbia: A portrait from above. (Imagery by Landsat 5:7/30/91 and Spot 2:8/4/91). Squamish, BC: Earthwork Communications.
- Edgell, M.C.R. 1998. Chair, Department of Geography, University of Victoria.
- Egerton, F.N. 1973. Changing concepts of the balance of nature. The Quarterly Review of Biology, 48:322-350.
- Elliott, C. 1995. The ivy debate. Horticulture, pp.21-23, March 1995.

- Elton, C.S. 1958. The ecology of invasions by animals and plants. London, U.K: Chapman and Hall.
- Environment Canada. 1993. Canadian climate normals 1961-1990, British Columbia. Ottawa, ON: Atmospheric Environment Service, Canadian Climate Program.
- Esau, K. 1960. Anatomy of seed plants. New York: John Wiley and Sons Inc.
- Evans, P. 1996. Alien empire. The Geographical Magazine, April, pp.14-15.
- Fischer, A. and Feller, U. 1994. Seasonal changes in the pattern of assimilatory enzymes and of proteolytic activities in leaves of juvenile ivy. Annals of Botany, 74(4):389-396.
- Fitter, A.H. and Peat, H.J. 1994. The ecological floral database. Ecology, 82:415-425.
- Forman, R.T. 1995. Land mosaics. New York: Cambridge University Press.
- Fox, M.D. and Fox, B.J. 1986. The susceptibility of natural communities to invasion. In Groves, R.H. and Burdon, J.J. (Eds.) Ecology of Biological Invasions, pp.57-66. Cambridge, U.K: Cambridge University Press.
- Francis, R.D., Jones, R. and Smith, D.B. 1992. Origins: Canadian history to confederation. Toronto, ON: Holt, Rinehart and Winston of Canada Ltd.
- Frutiger, S. 1995. Burpee American gardening series: Vines. New York: Macmillan, Inc.
- Gartner, B.L. (Ed.) 1995. Plant stems. Toronto, ON: Academic Press.
- Gentry, A.H. 1991. The distribution and evolution of climbing plants. In Putz, F.E. and Mooney, H.A. (Eds.), The biology of vines, pp.3-49. New York: Cambridge University Press.
- Giesser, J.L. 1993. The National Park service and external development: Addressing park boundary-area threats through public nuisance. Environmental Affairs, 20:761-809.
- Gillis, A. 1992. Keeping aliens out of paradise. Bioscience, 42(7):482-485.
- Givnish, T.L. 1995. Plant stems: biomechanical adaptation for energy capture and influence on species distributions. In Gartner, B.L. (Ed.), Plant stems, pp.3-49. Toronto, ON: Academic Press.
- Gleason, H.A. and Cronquist, A. 1963. Manual of vascular plants of northeastern USA adjacent Canada. New York: Van Nostrand Reinhold Co.

- Goebel, K. 1905. Organography of plants, part II: Special organography. (1969 facsimile of the 1905 edition). New York: Hafner Publishing Company.
- Grieg-Smith, P. 1964. Quantitative plant ecology. London, U.K: Butterworths.
- Groves, R.H. and Burdon, J.J. (Eds.). 1986. Ecology of biological invasions. Cambridge, U.K: Cambridge University Press.
- Haber, E. 1996. Invasive Plants of Canada: 1996 National survey results. For the invasive plants of Canada project, biodiversity convention office, Environment Canada, Government of Canada. Ottawa, ON.
- Haber, E. 1999. Personal Communication. Biologist / vascular plant specialist. Chair of the sub-committee for vascular plants, mosses and lichens, Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Environment Canada and National Botanical Services.
- Hackney, P. (Ed.) 1992. Flora of the north-east of Ireland. (3rd ed.). Belfast, Ireland: Institute of Irish Studies, the Queen's University of Belfast.
- Hansen, A.J., Garman, P.L. and Horvath, E. 1993. Do edge effects influence tree growth rates in Douglas-fir plantations? Northwest Science, 62(2):112-116.
- Harcombe, A.P. and Oswald, E.T. 1990. Vegetation resources of Vancouver Island, Volume 1: Forest zonation. (Technical Report No. 27). Victoria, BC: B.C. Ministry of the Environment.
- Harre M. 1997. Personal Communication. Biosecurity plant pest officer, Waitakere City Council (on contract to Auckland Regional Council), New Zealand.
- Headley, D.B., Bassuk, N. and Mower, R.G. 1992. Sodium chloride resistance in selected cultivars of *Hedera helix*. HortScience, 27(3):249-252.
- Hengeveld, R. 1989. Dynamics of biological invasions. London, U.K: Chapman and Hall Ltd.
- Henry, J.K. 1915. Flora of southern British Columbia and Vancouver Island. Toronto, ON: W.J. Gage and Co. Ltd.
- ✱ Higgins, S.I., Richardson, D.M. and Cowling, R.M. 1996. Modelling invasive plant spread: the role of plant-environment interactions and model structure. Ecology, 77(7):2043-2054.
- Higgs, A.J. 1981. Island biogeography theory and nature reserve design. Journal of Biogeography, 8:117-124.

- Hitchcock, C.L. and Cronquist, A. 1973. Flora of the Pacific Northwest: An illustrated manual. Seattle, WA: University of Washington Press.
- Hobbs, R.J. and Huenneke, L.F. 1992. Disturbance, diversity invasion: Implications for conservation. Conservation Biology, 6(3):324-337.
- Janzen, D.H. 1983. No park is an island: Increase in interference from outside as park size decreases. Oikos, 41:402-410.
- Johnson, H.B. and Mayeux, H. 1992. Viewpoint: A view on species additions and deletions and the balance of nature. Journal of Range Management, 45(4):322-333.
- Jupp, U. 1975. From cordwood to campus in Gordon Head, 1852-1959: The story of a district from its days as primeval forest to the establishment of a University. Victoria, BC.
- Kaiser, J. 1983. Native and exotic plant species in Ontario: A numerical synopsis. The Plant Press, 1:25-26.
- Keddy, G. 1991. Archaeology in urban parks, paper presented at the 39th Annual Training Institute of the International Northwest Parks and Recreation Association, Victoria, BC, 8pp.
- Kent, M. and Coker, P. 1992. Vegetation description and analysis. Boca Raton, FL: CRC Press.
- Knapp, R. 1984. Sampling methods and taxon analysis in vegetation science: Handbook of vegetation science, part 4. The Hague: Dr. W. Junk Publishers.
- Knops, J.M., Griffin, J.R. and Royalty, A.C. 1995. Introduced and native plants of the hastings reservation, Central Coastal California: A Comparison. Biological Conservation, 71:115-123.
- Kornas, J. 1990. Plant invasions of central Europe: Historical and ecological aspects. In di Castri, Hansen, A.J. and Debussche, M. (Eds.), Biological Invasions in Europe and the Mediterranean Basin, pp. 19-36. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Laurance, W.F. 1991. Predicting the impacts of edge effects in fragmented habitats. Biological Conservation, 55:77-92.
- Laurance, W.F. 1991. Edge effects in tropical forest fragments: Application of a model for the design of nature reserves. Biological Conservation, 57:205-219.
- Laycock, G. 1966. The alien animals. Garden City, NY: The Natural History Press, the American Museum of Natural History.

- Lee, D.W. and Richards, J. 1991. Heteroblastic development in vines. In Putz, F.E. and Mooney, H.A. (Eds.), The biology of vines, pp.205-244. New York: Cambridge University Press.
- Lövel, G.L. 1997. Global change through invasion. Nature, August 14, 388:6?
- Ludyanskiy, M.L., McDonald, D. and MacNeill. 1993. Impact of the zebra mussel, a bivalve invader. Bioscience, 43(8):533-544.
- McAllister, H.M. and Rutherford, A. 1983. The species of ivy. The Ivy Journal, 9(4):45-54. West Carrollton, Ohio: The American Ivy Society.
- McAllister, H.M. 1997. Personal communication. Assistant Director of Liverpool (England) University Botanical Gardens at Ness, U.K.
- McCoy, E.D. 1983. The application of island-biogeographic theory to patches of habitat: How much land is enough? Biological Conservation, 25:53-61.
- McKnight, B.N. 1991. Biological pollution: The control and impact of invasive exotic species. (Proceedings of a Symposium held at the University Place Conference Center). Indianapolis, IN: Indiana Academy of Science, Indiana University-Purdue University.
- MacArthur, R.H. and Wilson, E.O. 1967. The theory of island biogeography. Princeton, N.J: Princeton University Press.
- MacCallum, H.C. 1939. Thetis Lake. The Daily Colonist, (Feature article). March 19.
- Macdonald, I.A.W., Graber, D.M., DeBenedetti, S., Groves, R.H. and Fuentes, E.R. 1988. Introduced species in nature reserves in Mediterranean-type climatic regions of the world. Biological Conservation, 44:37-66.
- Margules, C., Higgs, A.J. and Rafe, R.W. 1982. Modern biogeographic theory: Are there any lessons for nature reserve design? Biological Conservation, 24:115-128.
- Mathers, H. 1996. Personal communication. Nursery Specialist, Government of British Columbia, Abbotsford, BC.
- Matlack, G.R. 1993. Sociological edge effects: Spatial distribution of human impact in suburban forest fragments. Environmental Management, 17(6):829-835.
- Matthysen, E., Lens, L., Van-Dongen, S., Verheyen, G.R., Wauters, L.A., Adriaensen, F. and Dhondt, A.A. 1995. Diverse effects of forest fragmentation on a number of animal species. Belgian Journal of Zoology, 125(1):175-183.
- Menninger, E.A. 1970. Flowering vines of the world. New York: Hearthsides Press Inc.

- Meyer, J.Y. and Florence, J. 1996. Tahiti's native flora endangered by the invasion of *Miconia calavescens* D.C. (Melastomataceae). Journal of Biogeography, 23:775-781.
- Mooney, H.A. and Drake, J.A. (Eds.) 1986. Ecology of Biological Invasions of North America and Hawaii. New York: Springer-Verlag.
- Moore, P.D. and Chapman, S.B. (Eds.) 1986. Methods in plant ecology. (2nd ed.). Oxford, U.K.: Blackwell Scientific Publications.
- Newmark, W.D. 1985. Legal and biotic boundaries of western North American National Parks: A problem of congruence. Biological Conservation, 33:197-208.
- Newsome, A.E. and Noble, I.R. 1986. Ecological and physiological characters of invading species. In Groves, R.H. and Burdon, J.J. (Eds.), Ecology of Biological Invasions, 1-20. Cambridge, U.K: Cambridge University Press.
- Norton, D.A. 1992. Disruption of natural ecosystems by biological invasion. In Willison, J.H.M. (Ed.), Science and the Management of Parks and Protected Areas, pp.309-319. New York: Elsevier Press.
- Peters, R.H. 1991. A critique for ecology. Cambridge, U.K: Cambridge University Press.
- Pettinger, A. 1996. Native plants in the coastal garden. Vancouver, BC: Whitecap Books.
- Philipson, W.R. 1970. Constant and variable features of the *Araliaceae*. In Robson, N.K., Cutler, D.F. and Gregory, M. (Eds.), New Research in Plant Anatomy, pp.87-100. London, U.K: Academic Press, The Linnean Society of London.
- Pojar, J. and MacKinnon, A. (Eds.) 1994. Plants of Coastal British Columbia. Vancouver, BC: Ministry of Forests and Lone Pine Publishing.
- Putz, F.E. 1982. Natural history of lianas and their influences on tropical forest dynamics. Unpublished doctoral dissertation, Cornell University, Ithaca, NY.
- Putz, F.E. and Holbrook, N.M. 1991. Biomechanical studies of vines. In Putz, F.E. and Mooney, H.A. (Eds.), The Biology of Vines, pp.73-97. New York: Cambridge University Press.
- Putz, F.E. and Mooney, H.A. 1991. The biology of vines. New York: Cambridge University Press.
- Quammen, D. 1996. The song of the dodo. New York: Simon and Schuster Inc.
- Rathcke, B.J. and Jules, E.S. 1993. Habitat fragmentation and plant-pollinator interactions, Current Science, 65(3):273-277.

- Reed, H.S. 1942. A short history of the plant sciences. New York: Ronald Press Co.
- Reichard, S.H. and Hamilton, C.W. 1997. Predicting invasions of woody plants introduced to North America. Conservation Biology, 11(1):193-203.
- Reichard, S.H. 1997. Personal communication. Center for urban horticulture, University of Washington, Seattle.
- Robinson, J.V. and Dickerson, J. 1987. Does invasion sequence affect community structure? Ecology, 68(3):587-595.
- Roemer, H.L. 1990. Protecting rare and endangered plants in ecological reserves. Bioline, 9(3):7-11.
- Rosenzweig, R. 1984. The parks and the people: Social history and urban parks. Journal of Social History, 18:289-295.
- Rose, S. 1997. Influence of suburban edges on invasion of *Pittosporum undulatum* into the bushland of northern Sydney, Australia. Australian Journal of Ecology, 22:89-99.
- Royal Horticultural Society, 1992. The new Royal Horticultural Society dictionary of gardening, 2:510-515. Huxley, A., Griffiths, M. and Levy, M. (Eds.). London, U.K.: Macmillan Press.
- Royal Horticultural Society, 1989. Gardeners Encyclopaedia of Plants and Flowers. Brickwell (Ed.), pp.1437-1438.
- Roze, L.D., Frazer, B.D. and McLean, A. 1984. Establishment of diffuse and spotted knapweed from seed on disturbed ground in British Columbia, Canada. Journal of Range Management, 37(6):501-502.
- Ruesink, J.L., Parker, I.M., Groom, M.J and Kareiva, P.M. 1995. Reducing the risks of nonindigenous species introductions, Bioscience, 45(7):465-477.
- Rundel, P.W. and Franklin, T. 1991. Vines in arid and semi-arid ecosystems. In Putz, F.E. and Mooney, H.A. (Eds.), The biology of vines, pp.337-356. New York: Cambridge University Press.
- Rutherford, A, McAllister, H.A. and Mill, R.R. 1993. New ivies from the Mediterranean area and Macaronesia. The Plantsman, 15(2):115-128.
- Saunders, D.A., Hobbs, R.J. and Margules, C.R. 1991. Biological consequences of ecosystem fragmentation: A review. Conservation Biology, 5(1):18-32.

Schmitz, D.C. and Simberloff, D. 1997. Biological invasions: A growing threat. Issues in Science and Technology, 13(4):33-40 (Summer).

Schnitzler, A. 1995. Community ecology of arboreal lianas in gallery forests of the Rhine Valley, France. Acta Oecologica, 16(2): 219-236.

Schonewald-Cox, C.M. 1988. Boundaries in the protection of Nature Reserves. Bioscience, 38(7):480-486.

Schonewald-Cox, C.M. Bayless, J.W. 1986. The boundary model: A geographical analysis of design and conservation of nature reserves. Biological Conservation, 38:305-322.

Seeman, B. 1894. Revision of the natural *Hederaceae*. Journal of Botany, British and Foreign, pp.235-249.

Shafer, C.L. 1990. Nature reserves: Island theory and conservation practice. Washington, DC: Smithsonian Institution Press.

Simberloff, D. 1986. Introduced Insects: A biogeographic and systematic perspective. In Mooney, H.A. Drake, J.A. (Eds.), Ecology of Biological Invasions of North America and Hawaii, 3-26. New York: Springer-Verlag.

Smallwood, S.K. 1994. Site invasibility by exotic birds and mammals. Biological Conservation, 69:251-259.

Smallwood, S.K and Salmon, T.P. 1992. A rating system for potential exotic bird and mammal pests, Biological Conservation, 62:149-159.

Smith, L.R. 1996. Introduced plants in Antarctica: Potential impacts and conservation issues. Biological Conservation, 76(2):135-146.

Snobelen, J. (Ontario Minister for Natural Resources), 1998. Debates of the Ontario Legislature, 2nd Session, 36th Parliament. Oral questions on the round goby (spp.). Office of the Legislative Assembly of Ontario, Toronto, ON (Tuesday, December 15).

Soulé, M.E. 1990. The onslaught of alien species other challenges in the coming decades. Conservation Biology, 4(3):233-239.

Stamps, J.A. Buechner, M. and Krishnan, V. V. 1987. The effects of edge permeability and habitat geometry on emigration from patches of habitat. The American Naturalist, 129(4):533-548.

Stokes, M.A. and Smiley, T.L. 1996. An introduction to tree-ring dating. Tucson, AZ: Tucson University Press. (Original work published in 1968 by Chicago University Press, Chicago, IL).

Strauss, S. 1995. Sorry, Mr. Suzuki, but foreign plants have been good for our cities. The Globe and Mail, pp.D8. (Sept. 16).

Swain, R.B. 1982. Stripping the halls of ivy. Discover, pp.44-46. (August).

Swarbrick, J.T. and Skarratt, D.B. 1994. The bushweed 2 database on environmental weeds in Australia. Gatton, Queensland: the University of Queensland, Gatton College.

Szczawinski, A.F. and Harrison, A.S. 1972. Flora of the Saanich Peninsula, Victoria, BC: Province of British Columbia, Dept. of Recreation and Conservation.

Sykora, K.V. 1990. History of the impact of man on the distribution of plant species. In di Castri, Hansen, A.J. and Debussche, M. (Eds.), Biological Invasions in Europe and the Mediterranean Basin, pp. 37-50. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Tanner, R.D., Hussain, S.H., Hamilton, L.A. and Wolf, F.T. 1980. Kudzu (*Pueraria lobata*): Potential agricultural and industrial resource. Economic Botany, 33(4):400-412.

Tanner, R.D., Hussain, S.S., Hamilton, L.A. and Wolf, F.T. 1979. Kudzu (*Pueraria lobata*): Potential agricultural and industrial resource, Economic Botany, 33(4):400-412.

Teichrob, H.D. 1996. Personal Communication. Pesticide Inspector, Agriculture and Agri-Food Canada, Government of Canada.

Theberge J.B. 1989. Guidelines to drawing ecologically sound boundaries for national parks and nature reserves. Environmental Management, 13(6):695-702.

Thetis Park Nature Sanctuary Association, 1974. Natural history of Thetis Lake Park, Victoria, BC: Thetis Lake Nature Sanctuary Association.

Thomas, L.K. 1980. The impact of three exotic plant species on a Potomac island. (National Park Service Monograph Series 13). Washington, DC: United States Department of the Interior.

Thomas, L.K. 1986. Some principles of exotic species ecology and management and their interrelationships. In Thomas, L.K. (Ed.), Proceedings of the Conference on Science in the National Parks: Management of Exotic Species in Natural Communities, 5:96-110. Fort Collins, CO: The U.S. National Park Service and the George Wright Society.

Thomas, L.K. 1997. Personal communication. Research biologist with the United States Department of the Interior, National Park Service, National Capital Region, Greenbelt National Park, Greenbelt, MD.

Tivy, J. 1982. Biogeography: A study of plants in the ecosphere. (2nd ed.). Essex, U.K.: Longman Group.

Trémolières, M., Carbiener, R., Exinger, A. et Turlot, J.C. 1988. Un exemple d'interaction non compétitive entre espèces ligneuses: le cas du lierre arborescent (*Hedera helix* L.) dans la forêt alluviale [An example of non-competitive interaction between woody plant species: the case of the arborescent liana (*Hedera helix* L.) in the alluvial forest]. Acta Oecologica Oecologia Plantarum, 9(2):187-209.

Tuan, Yi Fu. 1989. Surface phenomena and aesthetic experience. Annals of the Association of American Geographers, 79(2):233-241.

Turner, N. and Bell, M.A.M. 1971. The ethnobotany of the Coast Salish Indians of Vancouver Island, Economic Botany, 25(1):63-104.

*Tutin, T.G. (Ed.). 1968. Flora Europaea. (Vol. 2). Cambridge, U.K.: Cambridge University Press.

Tüxen, R. 1985. On the objective description of plant communities and their characterization by qualitative and quantitative attributes based on their species (taxa) composition. In Knapp, R. (Ed.), Sampling Methods and Taxon Analysis in Vegetation Science, pp. 3-5. The Hague: Dr. W. Junk Publishers.

Usher, M.B. 1988. The ecology of biological invasions: A search for generalisations. Biological Conservation, 44:119-135.

Usher, M.B. 1988. The ecology of biological invasions into nature reserves: An introduction. Biological Conservation, 44:1-8.

Veitch, D. 1997. Personal communication. Ecological Restorationist, Department of conservation, Auckland Conservancy, Auckland, New Zealand.

Vitousek, P.M. 1995. The Hawaiian Islands as a model system for ecosystem studies. Pacific Science, 49(1):2-16.

Wardle, P. 1991. Vegetation of New Zealand. New York: Cambridge University Press.

Wechsler, N.R. 1977. Growth and physiological characteristics of kudzu, *Pueraria Lobata* (WILLD.) OHWI, in relation to its competitive success. Unpublished master's thesis, University of Georgia, Athens, GA.

- Wellingham-Jones, P. 1985. Ivy, a vine and then some. Garden, pp.28-32 (July/August).
- Westman, W.E. 1990. Park management of exotic plant species: Problems and issues. Conservation Biology, 4(3):251-259.
- Weston, J. and Stirling, D. 1986. The naturalist's guide to the Victoria, British Columbia region. Victoria, BC: Canadian Cataloguing in Publication Data.
- Wherry, K. 1997. Personal communication. Landscape Planner, City of Nepean, ON.
- White, D.J. Haber, E. and Keddy, C. 1993. Invasive plants of natural habitats in Canada. Ottawa, ON: Published in partnership with the North American Wetlands Conservation Council, the Canadian Museum of Nature and the Canadian Wildlife Service, Environment Canada.
- White, D.W. and Stiles, E.W. 1992. Bird dispersal of fruits of species introduced into eastern North America. Canadian Journal of Botany, 70:1689-1696.
- Whitney, G.G. 1994. From coastal wilderness to fruited plain: A history of environmental change in temperate North America from 1500 to the present. Cambridge, U.K: Cambridge University Press.
- Williamson, M. 1996. Biological Invasions. London: Chapman and Hall.
- Williamson, M. 1997. Personal Communication. Professor, Department of Biology, University of York, York, U.K.
- World Commission on Environment and Development, 1987. Our common future. Oxford, U.K: Oxford University Press.
- Young, A. and Michell, N. 1994. Microclimate and vegetation edge effects in a fragmented podocarp-broadleaf forest in New Zealand. Biological Conservation, (67):63-72.
- Young, T. 1996. Modern Urban Parks. The Geographical Review, 85(0):535-551.
- Zimmerman, B.L. and Bierregaard, R.O. 1986. Relevance of the equilibrium theory of island biogeography and species-area relations to conservation with a case from Amazonia. Journal of Biogeography, 13:133-143.

Appendix 1: Park Boundary Reconnaissance (Field Notes and Personal Observations)

BEAR HILL REGIONAL PARK

SOUTHERN AND EASTERN BOUNDARY: BATU ROAD ENTRANCE

Arbutus seedlings and very young arbutus trees are abundant near the Batu roadside entrance into the park. Large mats of Himalayan blackberry* and considerable broom* and bracken fern are also found moving into the park. Up the slope, groves of arbutus, licorice fern and broom* grow out of rock outcrops. On the hilltop, numerous stunted Garry oak trees grow to 4 m tall with moss and broom*. Stands of fir grow at lower elevation to the east and west while arbutus grows directly to the east and south. Oak branches are brightly covered in lichen when gleaming in the sun and there are dozens of robins on this visit. [Paper cups from a multinational coffee house and beer cans from a major manufacturer litter an otherwise gorgeous view.] Moving west downward into the mixed arbutus and fir stands, oceanspray, tall Nootka rose and salal grow. Snowberry is found further west along the trail to Bear Hill Rd. Moving toward Central Saanich Rd. the vegetation is similar, with introduced blackberry* (*Rubus laciniatus*), in several locations and plentiful at the park entrance. There are no signs of any ground crawling ivy* along this part of the park, nor is it visible on any of the nearby properties.

NORTHERN AND WESTERN BOUNDARY

The north boundary adjacent Wakashan Place contains mixed Douglas-fir with occasional western redcedar and bigleaf maple. The understory is low (i.e. there is not much stratification of vegetation) composed of Oregon grape and salal, with broom* and grasses near forest edges. Bracken and sword fern, trailing blackberry and introduced blackberry* (*Rubus laciniatus*) are also common understory plants in this boundary zone. Arbutus and shrubs are common on rocky outcrops. There is no evidence of ivy*, (besides a single leaf that has drifted onto the summit of the park). Agricultural areas including small scale or hobby farms and horse keeping surround this corner of the park.

The only area where ivy* was found near this park was the corridor trail that currently links Elk Lake Park to the southern part of Bear Hill Park, off Brookleigh Rd.

NORTHEAST ELK/BEAVER LAKE PARK: NORTH FROM BROOKLEIGH ROAD THROUGH CORRIDOR TO THE SOUTH BOUNDARY OF BEAR HILL PARK

Ivy* is scant but present along the trail to 50 m north of Brookleigh Rd. in Elk-Beaver Lake Park. Ivy* is climbing and cut from very big and possibly old Douglas-fir. By 100 m or so north of the road (point zero), ivy* trails off and becomes much more sparse. Adjacent this part of the corridor the land is cleared and cultivated on the nearby home. Further north (150-250 m from road), there is no ivy* in cedar groves but it does grow sparsely adjacent the house. Where cedar predominates, there is no ivy* and moving northward still, salal and holly* rather than ivy* sprout out of Douglas-fir stumps. Ivy* is heavy at the intersection of the corridor/footpath (300 m or so north of the road) adjacent private property, although climbing in juvenile form only. There is ivy* in the footpath/corridor section; crawling up old fence posts and along both sides and outside of the footpath trail. It is most abundant and dominant on the eastern side, although also grows on the western side of the path. There is more cedar habitat further north and then past this, the slope increases quite markedly and cedars surrender to arbutus and Douglas-fir. The ivy* drops down to nil in this area and is not visible along this lower slope of Bear Hill Park.

COLES BAY REGIONAL PARK

NORTH-WESTERN BOUNDARY

A path runs adjacent most of the western part of this boundary and I describe the features here up to 6 –12 m inside the park's edge. I begin at what is now the eastern end of the path along this boundary (zero metres) and describe features as I move westward. A one metre tall, wire fence separates the park from adjacent properties. There is no sign of ivy* for the next 35 m and then two or three juvenile shoots less than 3 m long are found under a heavy cedar canopy (this will become plot#1). A further 15 m west, another patch of ivy* is found climbing several metres high and flowering (this will become plot#2). The forest and canopy are very open and disturbed compared to forested areas inside the park. This patch of ivy* is large, extending 45 m to the west at the park's edge and inside its boundary. It climbs at least 8 trees and is most heavy on the property side of the path, which is composed of gravel. There is no ivy* found south of the path, which could indicate that either the path is helping to contain its spread, other habitat factors are responsible or that some human effort is being made to control its spread south of this path. It appears that around half of the eight trees in this spot are in very poor condition. The tallest and largest tree (*Populus balsamifera*) sustains massive ivy* vines and is not dead (but the top of its crown seems to be). Looking closer at the trees, windthrow is a major cause of the thinning forest. Since this boundary faces northwest onto cleared land, it likely receives considerable wind.

Further west from where the path crosses another that goes south to the wooden footbridge, there is a successional shrub zone that is very thick and impenetrable and composed primarily of Himalayan blackberry*. There is a very small spot where juvenile ivy* is found. Just past this point, ivy* is well established on the south of the path on the north slope of the creek where it climbs six trees several metres high (this site will become plot#4). It seems to subside somewhat around 25 metres further west. The last major patch of ivy* along this boundary occurs around 140 m from the beginning of this transect (this site will become plot#3). It climbs around six trees of which one is a snag and it climbs high and reproduces on some. This patch continues west for 24 metres and is contained somewhat to the north of the path (similar to the previous large patch that was restricted to the north of the path). Ivy* is then found on a Douglas-fir snag, growing 2 metres tall and west of this the vegetation becomes thick and shrubby with lots of snowberry.

Further west, ivy* occurs in very small patches climbing stumps and close the path. Here it is a very small component of the flora and mostly occurs on the north side of the path (an non-invaded area south of the path in the woods near this point became plot#6). Ivy* continues to occur intermittently moving west along this boundary and a small juvenile patch was found on the south of the path. It decreases in frequency closer to the shoreline (20 m from steps leading down to the beach where the area becomes very open and bright).

EASTERN BOUNDARY

I describe vegetation beginning in the north-eastern corner and moving south. The corner part of this boundary is thickly forested, with cedar (*Tsuga* sp.) predominating. Further south, more deciduous tree species such as trembling aspen, occur, , , The forest is thicker on this side a shrub zone (*Rubus*?) is followed by grass that grows directly up to the residential road. Further inside the park in the northern corner is a large grove of red alder. There is no sign of ivy* in the alder.

SOUTHERN BOUNDARY

This boundary is primarily the access roadway off Iverness Rd. that culminates in a large, mowed picnic area inside the park. Douglas-fir and large trees line each side of this gravel access road. There are extensive, impenetrable mats of Himalayan blackberry* inside the park and no ivy* is found near this road. There is also a large expanse of mowed lawn with regularly spaced, recently planted small cedars (*Tsuga* sp.). Along the southern boundary of the park, ivy* is found growing along the service road.

THE PARK IN GENERAL

There is a massive amount of ivy* near the picnic area, particularly on the south side and near the service road. Ivy* is found throughout this park in suitable habitats. In the interior of the park near the slopes of the creek it is not abundant but it occurs. There is evidence of cutting from large arbutus and Douglas-fir trees near the western end of the Beach Trail and juvenile ivy* is found scattered throughout the woods along this trail, particularly on the south side. South of the Beach Trail, approximately 40 m from the south edge of the park it appeared that there was no ivy* and this became the site of plot#5.

DEVONIAN REGIONAL PARK

WEST BOUNDARY

Directly against a cleared field, the west boundary is an ecotone of shrubs, tall grasses and broom*. Directly inside the forest, fir, trailing blackberry, snowberry and small herbs are common. Daphne-laurel*, ferns, rose (*Roseaceae*) and bigleaf maple occur in parts, but the canopy is predominantly fir. There is no evidence of any ivy* along this boundary.

THE PARK IN GENERAL

One, metre-long shoot of ivy* was found growing at the base of a fir tree, north of the main entrance trail, approximately 100 m from the highway and mid way between the east and west boundary (approximately 40-60 metres south-west of the public washrooms).

ELK-BEAVER LAKE REGIONAL PARK

NORTH BOUNDARY: ELK LAKE

PAT BAY HIGHWAY AT HAMSTERLEY ROAD TO THE NORTHWESTERN PARKING LOT

Patchy stands of Douglas-fir, cleared underneath and planted with lawn grow near the Highway intersection with Hamsterley Rd. Cedar and clusters of unmowed/uncleared vegetation and shrubs containing snowberry, young big leaf maple, wall lettuce*, Himalayan blackberry*, daphne-laurel*, holly*, ivy*, bracken fern and the occasional arbutus are found closer to the small parking lot off Hamsterley Rd. At the west corner of this parking area, there is a small stand (less than 15 trees) of deciduous trees and fir with uncleared vegetation closer to ground level. Within this stand, ivy* is a dominant part of the ground flora, grows greater than 10 m tall, heavily loaded with fruit. Moving toward the larger, northeast parking lot off Brookleigh Rd., there is considerably less natural vegetation and more human activity (i.e. numerous large buildings, children's playground and a large expanse of mowed lawn). Closer to the shoreline, there are willow and grass communities with no visible ivy*. West of the large parking lot, there are small patches of woodland with willows and aquatics near Elk Lake's shoreline. Ivy* is present on the shoreline side of the forest, which a path runs through. However, it is more dominant to the north of the path, closer to the park's edge, where the trees and forest are larger

and further from the water. Within this forest, ivy* is a dominant part of the vegetation, growing with Oregon grape, Indian plum, holly*, oceanspray, bracken fern, snowberry and many mushrooms (in late fall). Ivy* climbs a large number of the trees in this region.

The heaviest areas of ivy* in these woods appear to be where canopies are slightly more open and on the housing side of the park. Simple flat areas of ground also seem to have more ivy* than do some of the bumpier areas or hollows with less ivy*. *Rubus laciniatus* grows in these woods with hairy honeysuckle, holly* and the common dominants. Ivy* cover is very high at the north edge growing very high up trees. There are many areas where ivy* appears to be very abundant under bigleaf maple but then there are exceptions to this around also. It is curious to know what results in patchily scattered distributions. The slightest variables (gullies, ditches, streams, cedars, footpaths, even tiny nearly undetectable things like small bits of trampled vegetation not to mention the general limiting factors) together may limit ivy*'s spread and create what I now see.

Further west, in the nearby forest composed of fir, big leaf maple and the occasional cedar, there is a huge area where virtually every tree within at least a 40X40 m patch is climbed by ivy*. In this patch, ivy* climbs trees from three to greater than 20 m, fruits on most of them and is the primary ground cover. Nearer to the lakeside, holly*, Oregon grape and sword fern occur without ivy*. Moving further west, salal begins to occur. Inside the forest past the salal, a very large Douglas-fir tree (greater than 5.5 m in circumference) is climbed by ivy* [what would be the long term future of this tree if climbed by a giant liana?]. Ivy* vines grow to 8 cm in diameter further west of this large tree. West of the four-mile marker, I found large vines (5.8 cm in diameter) on the Lake side of the path on an arbutus tree in an arbutus and cedar grove near the shoreline. This is one of the only areas near the shoreline on this side of the park where ivy* was both abundant and mature.

NORTHERNMOST PARKING LOT OFF BROOKLEIGH ROAD

Cedar is the predominant tree species in this corner of the park. Ivy* does occur sporadically, although does not appear to have much success climbing and flowering. Hairy honeysuckle is a fairly abundant creeping plant throughout the small woods on the lakeside of Brookleigh Rd. Ivy* is sparse, yet it is somewhat difficult to find non-invaded areas that are not entirely under cedar cover or habitat. I found one small area that contains Douglas-fir (this becomes the site of one of the non-invaded plots). There is ivy* to the north-east and to the west of the plot and it is 10 m south of Brookleigh Rd. and approximately 60-80 m south-east of the parking lot. Further west; west of the boat launch and parking area, salal is abundant and ivy* grows near trees near Brookleigh Rd.

EAST BOUNDARY

PAT BAY HIGHWAY SOUTH OF HAMSTERLY RD. TO EAGLE BEACH

This is a very narrow/thin parcel of terrestrial park that lies between the highway and Elk Lake. It contains mixed trees and shrubs. Ivy* is among the species that grow here; climbing and flowering in various locations.

SOUTHEAST PAT BAY HIGHWAY PARKING LOT AT BEAVER LAKE TO BEAVER LAKE ROAD AND ELK LAKE DRIVE INTERSECTION

Habitat near the parking area is wet and marshy and on this visit, there are three piles of dumped out potting soil and dead houseplants. Some salal grows in the nearby understory. Between the two paved access roads along Beaver Lake Rd., there are tall pillars of ivy* climbing fir and ivy* is very thick and the predominant ground cover. Directly nearby in forested areas, I do not see any ivy* but do find abundant Oregon grape, oceanspray, salal and

holly* trees. Moving east, there is occasional sword fern and bracken fern, trailing blackberry under fir and oceanspray and the occasional cedar. Along a path that runs closer to the highway, there is still no evidence of ivy*. There are numerous cedar seedlings, which may account in part for the sparse invasion. Further south, I reached a slightly open area or gap in the canopy covered in needles under nearby fir and cedar. There was no climbing ivy* but a few sprigs or shoots on the forest floor. Near this area of cedar (approximately 70 m from the highway and 100 m from the parking lot), there is another moist/wetland area with considerable ivy* and vanilla leaf with sword fern in open areas. There is an oasis of light penetrating this spot which is surrounded by an otherwise dimly lit cedar forest. In the area directly around this gap, ivy* climbs about a half dozen trees to a maximum height of approximately 8 m and is still juvenile in form. This overall patch of invasion is approximately 20X30 m. Moving nearer to the noisy highway within edge habitat, there is little ivy*. This now brings me to the paved south part of Beaver Lake Rd. where horse chestnut saplings are shooting up and pressed against the trunks of redcedar inside the park near the roadway. Near the highway and in the southeast corner of park, ivy* is a part of the flora, comprising perhaps 10-20% of the overall lower stratum.

WEST BOUNDARY OF BEAVER AND ELK LAKES BEAVER LAKE ROAD NORTH TO LINNET LANE

There is a large amount of reproductive ivy* growing near the houses southeast of the ponds, climbing trees southwest of the Equestrian centre. Douglas-fir, Indian plum, red huckleberry, oceanspray and juvenile and reproductive ivy* are dominant plants along the roadside and along the northward outside path on the park's west boundary. Ivy* is very heavy and thick south in the woods. Licorice fern and broom* grow on rockier areas and rattlesnake plantain is common in the woods. Horsekeeping is the primary adjacent land use with small farms to the west. The habitat is very open and there is abundant light. Ivy* is very abundant, flowering along the trail. Tiny leafed ivy* grows in wet depressions, while larger more robust ivy* grows elsewhere. Ivy*, daphne-laurel* and holly* forms communities in grand fir, and grow also with sword fern, salal, huckleberry, Indian plum and trailing blackberry. Licorice fern and ivy* form a thick bed along a hillbank on the west side of the path further north. Yet further north of this, there is far less ivy* and more salal. The habitat in this boundary, is primarily grand fir and Douglas-fir. Ivy* subsides to virtually nil by approximately 200 m north of Beaver Lake Rd., where homes and properties are not directly against the park boundary. [Along the inner path, ivy* grows in spots on trees directly at the west lakeside of Beaver Lake. In these invaded areas, cottonwood are not climbed but trembling aspen are heavily covered by flowering ivy*.] Overall, this boundary is heavily invaded on the south side and is sparsely and non-invaded northward toward Linnet Ln.

THIN STRIP OF PARK NEAR NARROWEST PART OF ELK AND BEAVER LAKES NORTH TO LINNET ROAD

An old railway used to run along this area. Ivy* occurs in approximately 7-8 spots along this section. A couple of patches of ivy* are found at the latitude of or adjacent Eagle Beach, a few more are found along areas where there are numerous deciduous trees growing up to the lakeside on the south-west 'extension' (or extended part) of Elk Lake. There is an interruption in the park boundary where private property extends to the lakeshore and ivy* is abundant on both sides of this area. Here, ivy* ground cover is thick and vines grow to 2 cm in diameter inside the park and flowers on vines 6 cm in diameter nearby and outside the park. Ivy* is taking over two large trees on the hilltop to the west in this area. The thin part of the boundary on the lakeside portion of the trail contains mostly deciduous trees and where they grow particularly thick, there is usually no sign of ivy*. Most ivy* along this boundary grows on the property side of the path

rather than along the lakeside. Perhaps the path acts as a physical barrier to the vegetative spread of ivy* and/or perhaps it does not enjoy the lakeside / riparian zone.

SOUTH BOUNDARY: BEAVER LAKE
ELK LAKE DRIVE WEST ALONG BEAVER LAKE ROAD

Mixed cedar grows north of Beaver Lake Rd. nearer Elk Lake Dr. and in it there is ivy*, although it appears less rigorous than in other areas. Cedar appears to keep ivy* cover down but it does not appear to be hindering Oregon grape cover, as it seems to when litter is thick. Oregon grape is common and often the only understory plant under cedar in this area. Moving west, there is considerably more Douglas-fir habitat, although more disturbed and used, near the south parking area along Beaver Lake Rd. Here, and in the woods south-east of Beaver Beach, ivy* is a part of the flora. From Elk Lake Dr. to around Colquitz Creek - throughout this part of the south boundary - ivy* is found pretty much everywhere where there is Douglas-fir. Behind Colquitz Creek, deeper inside the woods, is a less disturbed area with large areas of very big sword fern covering ground in gaps under Douglas-fir. Otherwise, these Douglas-fir woods are filled with ivy*.

FRANCIS-KING REGIONAL PARK

WESTERN BOUNDARY:

The forest has been cleared between Thetis Lake and Francis-King Parks as part of BC Hydro Right of Way. The dominant vegetation near the northern part of this boundary is various small trees and shrubs consisting mostly of broom*, Nootka rose, oceanspray, Himalayan blackberry* and other blackberry (*Rubus* sp.), salal, grasses and small herbs on rock outcrops and the occasional red alder. Moving south between Thetis Lake and Francis King Parks and toward the middle and lower parts of Francis-King Park, I found no evidence of ivy* whatsoever under the high power electric wires of this cleared, disturbed scrubby habitat.

EAST BOUNDARY NORTHWARD

The south part of the park's east boundary are fairly undisturbed and do not have any traces of ivy*. The descriptions below follow northward from the intersection of Munn and Prospect Rds., where there is more anthropogenic influence. Descriptions include vegetation between the park border and Centennial Trail with distances following along the park's border.

0-100 M FROM MUNN AND PROSPECT RD NORTHWARD:

The small, triangular road median/traffic island at the intersection of Munn and Prospect Rds. has been invaded by ivy* (ivy* grows 2 m tall on Garry oak with 2 cm thick vines here). On the north side of Munns Rd. inside the park, there is a small (approximately 15 m diameter) open clearing of meadow with Garry oak and Douglas-fir. Numerous grasses, very young oaks, bracken fern, snowberry and trailing blackberry are found and there are also many outcrops of rock. Further north (up to 35 m), the grove turns to nearly exclusively oak meadow with numerous young oaks, north of which there are more Douglas-fir, baby Douglas-fir and bigleaf maple with a huge patch of abundant oceanspray, a pine tree, sword fern, lettuces and trailing blackberry. The openness of the boundary near the road continues northward, with roadside species in that habitat and forest and oak grove species inside the park. This first section of park ends with very highly steeped slopes with broom* nearer the road boundary, with grand fir, bigleaf maple, Garry oak and sword fern further inside the park.

100-200 M NORTHWARD:

Douglas-fir and Garry oak with big leaf maple continue to predominate and grow with snowberry, trailing blackberry and bracken fern. Further north (from 110-150 m) there is abundant Garry oak, many of which are young, with broom*, grasses and trailing blackberry and the occasional Douglas-fir. North of this primarily oak meadow and to the end of this section, there continues to be Garry oak but with scattered young and older bigleaf maple, (a large patch of huge bracken fern from 157-165 m), snowberry, Nootka rose, trailing blackberry, oceanspray and near the end of this section, grand fir seedlings.

200-300 M NORTHWARD:

This section of boundary turns northward and much of the vegetation is thus exposed to an east-facing edge, instead of a more south-western exposure. Garry oak, broom*, bigleaf maple, grand fir, snowberry and salal are found here. Further inside the park, Douglas-fir is climbed by ivy*. Open areas with rock are found along this section (225-275 m) containing broom* and grasses, young arbutus, licorice fern and abundant broad-leaved stonecrop (*Sedum spathulifolium*) on rocks, bindweed (*Convulvulus* sp.), Douglas-fir and Garry oak further inside the park with oceanspray. Ivy* grows under grand fir (at 279 m) further inside the park with Oregon grape and snowberry, while salal grows closer to the roadside. The last part of this section contains ivy* with 3 cm diameter vines, Himalayan blackberry*, salal, Nootka rose and sword fern. Ivy* forms approximately a 20 m patch and ends at the end of this boundary (at 299 m).

300-400 M NORTHWARD:

This section contains less rock and is darker with more wet forest species than the previous. The first part of the section is comprised of bigleaf maple, Douglas-fir, salal, blackberry (*Rubus* sp.), bracken fern, Oregon grape, oceanspray and Nootka rose and a very tall pillar of ivy* growing on a Douglas-fir approximately 75-100 m deeper inside the park (at 315 m). Garry oak trees grow near a park trail (at 324 m). Douglas-fir, bracken fern, oceanspray, salal grow and a patch of ivy* is found (between 330-348 m). Ivy* grows 4 cm vines on Douglas-fir near bigleaf maple and Oregon grape and is in reproductive form here. Groves of red alder and western red cedar then begin to appear with snowberry and sword fern, baldhip rose and trailing blackberry and these trees continue to be prevalent northward (to about 370 m). Bigleaf maple, arbutus, abundant Saskatoonberry and rockier habitat are then found along much of the rest of this section. Broom* is abundant near the clearings with Douglas-fir, bigleaf maple and salal elsewhere.

400-550 M FROM MUNN AND PROSPECT RD.:

The dominants along the first part of this section are Douglas-fir, grand fir, bigleaf maple, salal, oceanspray, bracken fern and trailing blackberry. Ivy* climbs dead shrubs (around 430 m) but is otherwise scarce on the ground. Further north (420-450), Pacific crab apple are found and Garry oak and arbutus become more prevalent. This vegetation is followed by another area of different forest species including abundant Saskatoonberry, Douglas-fir, bigleaf maple and oceanspray with salal, Oregon grape and bracken fern. There are very tall and steep hills inside the park (at around the 460-470 m point of this transect) with more grand fir and salal. Further north, holly* begins to appear further towards the end of this section. Further north and to the end of this section, the forest remains predominantly grand fir, bigleaf maple, Oregon grape, salal and oceanspray. Opposite to the park boundary, housing is no longer found, trees are no longer cleared but broom* continues to appear closer to the roadside and outside the park border.

HORTH HILL REGIONAL PARK

EAST BOUNDARY: ACCESS VIA END OF HEDGEROW ROAD

Western redcedar, grand fir, bigleaf maple, blackberry (*Rubus* sp.) and Nootka rose are dominant and no ivy* was found inside this part of the park.

WEST BOUNDARY

The north part of the west boundary, from Hillgrove Rd. to Laurel Rd. is primarily western redcedar with occasional patches of mixed fir. South of Laurel Rd., Douglas-fir and bigleaf maple are dominant. South of Cypress Rd., western redcedar begins to dominate again moving toward the parking area. Plot one was placed in a stand of Douglas-fir typical of this type of habitat inside the park near Cypress Rd.

SOUTH BOUNDARY

The southern boundary consists of a strip of cleared trees and vegetation in the form of a dirt road that separates the two forested parcels of park; the north main parcel described here and a smaller, triangular parcel to the south that is not described yet containing somewhat similar vegetation. Forest on either side of this road allowance is primarily grand fir and western redcedar and bigleaf maple with Garry oak growing on infrequent exposed rocky areas. Just inside the woods along the road and in open parts, Devil's club is common and western trumpet honeysuckle climbs shrubs in bright open parts, flowers pointed south along the open road. Inside the forested parcel, a parking area marks the south-west corner of the park and here, western redcedar and Douglas-fir are dominant with some mature and young red alder and bigleaf maple. There is ivy* near the main parking area behind the signs, growing sparse in juvenile form under redcedar. Within the next 50 m or so east of this inside the forest, Douglas-fir is dominant, growing small trunks in thick stands with sword fern and Oregon grape dominating the understory. There is nettle and common hawthorn along the footpath. 50-150 m east of the south-west corner of the park, there are large thick stands of red alder with bigleaf maple and Indian plum. More western redcedar and grand fir are found further east and further inside the park.

OVERALL

Interior parts of Horth Hill Park at low elevations around the hill are largely composed of western redcedar habitat and the hill is mostly vegetated. In many areas where western redcedar is very homogenous, there is no understory or sparse to abundant Oregon grape. On rockier exposed slopes, meadow with sparse Garry oak, mixed grasses and mixed camas are dominant. The only area where ivy* was found was in forest near the main south-west parking area behind park signs.

KNOCKAN HILL PARK

SOUTH BOUNDARY NEAR WEST BURNSIDE RD.

The cottage is located on the western side of the property, close to neighbouring homes and approximately 60 m away from West Burnside Rd. A garden grew around the home in this part of the park and the efforts to restore its vegetation and fairly elaborate waterfall system are ongoing. Considerable vegetation in this part of the park, particularly on the western side, is ornamental and part of the garden. Fir, cascara, Garry oak are common trees. Ivy* vines attain

very large diameters here and were trained to grow on rocks. Plot #4 was located in this part of the park.

EASTERN BOUNDARY

Slightly below the hilltop, there is widespread ivy* in an area of fir and big leaf maple. Plot #1 was situated in this stand. Further down and near the housing, the forest is disturbed considerably. Numerous trees have been cut for trails and possibly other uses. Holly* and ivy* are very abundant, and there is also considerable grand fir, Indian plum, sword fern, snowberry and deciduous trees. Some small pockets of forest seem to contain somewhat less ivy* than do other pockets (hence the rationale for plot # 6, located approximately 30 m north of the wooden footbridge on the main entrance trail). However, for the most part, where there is canopy and soil, ivy* grows. The lower (southern) part of this boundary is primarily Douglas-fir and mixed broadleaf trees.

HELMCKEN ROAD AND WESTERN BOUNDARY ON THE NORTH PARK PARCEL

The park is currently shaped like the letter "T" and the north parcel of park would correspond to the cross on the "T". Major populations of licorice fern grow in the rocky parts, particularly in the west part of this area. Small oaks grow lower down slope, nearer Helmcken Rd.

SOUTH-SOUTH-WEST FACING BOUNDARIES AND EASTERN BOUNDARY ON THE NORTH PARK PARCEL:

The west side, near the path to High St., is a more open, grassy meadow. [This trail is loaded with Himalayan blackberry* as one moves closer to the centre of the park] Ivy* and holly* are found on the eastern part of this boundary (north of the street called Tall Tree Place).

NORTH-EASTERN BOUNDARY

Currently, lots are being sold and very new homes are being constructed adjacent this edge of park. [Information brochures and market pamphlets boast the proximity and beauty of the public, Knockan Hill Park. Yet, all the community's roads post signs that they are "privately owned" and only to be used by owners and their guests; which encloses and restricts public access on the north boundary of the park.] Most of the north part of the park is a rock outcrop, containing oak meadow and occasional arbutus (e.g. the west side). Outside the park, bulldozing of bedrock is ongoing for housing construction. [The residential road here has been named Lianne Place, an apt homonym for an abundant species within this park.] Inside the park, mats of Himalayan blackberry* grow close to the housing, as well as along many of the park's trails in more open areas, and daphne-laurel* is often abundant directly against or underneath these mats. Lower down, east of Jean Place (near the north east corner of the park), there is a large stand of tall oaks that is thickly invaded by ivy*. Many large vines are found in this area and ivy* fruits on many of the nearby trees, growing to approximately 6 - 10 m tall (this is a sampling plot location). There is also a very old home near this area.

Ivy* is found throughout Knockan Hill Park with the exception of rocky slopes and hilltop meadows that are becoming heavily overgrown by broom*. [Interestingly, some rock crevices that appear to have a small amount of soil development contain clusters of gnarly little Garry oaks surrounded by thick, lush, feathery beds of licorice fern. However, other similar clusters of oaks are surrounded entirely by thick, tall broom*. Whether broom* may be displacing the beds of licorice fern or simply filling a different niche is difficult to determine from this inspection. Most areas with less soil appear to contain broom*, the tiniest seedlings (e.g. less than 10 cm tall) of which are wedged into the rocks so deeply, they are near impossible to dislodge.]

[Small parks like Knockan Hill are still extremely important to the network of protected areas and natural habitats within the urban environment. They provide habitat for small mammals, birdlife, wildflowers, flora, arthropods and other small fauna and if successful in the long term, place for these species to evolve and respond to changing environmental conditions.]

LONE TREE HILL REGIONAL PARK

The western boundary adjacent Millstream Rd. is described from the parking area, moving north. The vegetation is primarily Grand fir with Salal and Oregon grape, Arbutus, broom* and grasses on dry, exposed rocky areas and Western redcedar and fir further inside the park (e.g. around 20 m from the road). Overall, the western boundary zone continues to alternate between grand fir, cedar and rocky exposed areas. Western red cedar appears to be a dominant tree species in areas of more developed soils, while Arbutus and Garry oak dominant on slopes. ivy* was not found anywhere along this boundary or on the western side of this park, either along the roadside, parking areas, along trails, off trails or in groves of cedar. The more remote nature of this park, combined with relatively few homes nearby the park and the prevalence of cedar may have thus far helped spare it from the incursion of various ornamental plants (with the exception of broom*).

MILL HILL REGIONAL PARK

SOUTH BOUNDARY: ATKINS ROAD

[The parcel of forest south of the road is not described in this section]. North of the road, there is streambed and riparian habitat on the east side, a ravine deeper inside the park in the centre and forest on the western edge. At low elevation near Atkins Rd., bracken fern are abundant with wet areas containing skunk cabbage and moist areas containing vanilla leaf, Oregon grape and other common plants. Ivy* was found in one area only, near the ravine and approximately 25 m from a nearby house around the centre part of the south boundary. Here, ivy* consisted of several short (less than one metre long) shoots in juvenile form with small (up to 4 cm in diameter) light-veined leaves. It grew under a canopy of western redcedar, Indian plum and nearby fir, with herb robert* (*Geranium robertianum*), holly* seedlings, daphne-laurel*, Cooley's hedge-nettle, Pacific bleeding heart, saxifrage and mountain sweet-cicily. On the far east side of the south boundary, large Douglas-fir with oaks and arbutus grow with salal, broom*, bracken fern and tall Oregon grape, in a slightly open environment (i.e. a bright forest with gaps).

EAST BOUNDARY

Behind the parking areas and further north off the summit trail, Garry oak and arbutus grow on rocky areas with grand fir and Douglas-fir at lower elevation or on more developed soils. In many parts, particularly further north, the forest structurally full and rich with western trillium, pockets of red elderberry, baldhip rose, pathfinder (*Adenocaulon bicolor*) and vanilla leaf among the understory plants. The boundary becomes more exposed further north at higher elevation with more rocky outcrops (Douglas-fir and bigleaf maple yielding to arbutus and Garry oak). Quite a bit further north, there is a predominantly Douglas-fir forest on the north part of the east side towards Thetis Lake Park and the Trans Canada Highway. Bracken fern, trailing blackberry, bigleaf maple in gaps, oceanspray, snowberry and Nootka rose, carrots (*Apiaceae*),

Oregon grape, Devil's club, thimbleberry and hairy honeysuckle are common in forested parts of the boundary. No ivy* is found.

WEST BOUNDARY

On the west part of the boundary near Leggit Rd. and inside the calypso trail, there is predominantly Douglas- and grand fir with western redcedar and occasional bigleaf maple. The east boundary becomes sloped quite steeply further north where it opens into a gnarled oak and arbutus ecosystem dominated also by Scotch broom*. Land use outside the park includes unbuffered residential areas on the south part, a trailer park further north and parkland or semi-natural areas north of this on the hill slope.

THE PARK IN GENERAL

There is a limited amount of streambank and fir-western redcedar forest habitat in the south part of the park, restricted further by parking lots and internal development. Arbutus, Garry oak and broom* are very abundant on slopes. Disturbance and exotic invasive plants (besides broom*) are more abundant in the south park boundary. Mill Hill Park also has beautiful gnarled Garry oak and fir meadows on the hilltop, wildflower and camas meadows and also at higher elevation, open fir woodlands with abundant salal and ponds (interesting combination of features and plants).

MOUNT DOUGLAS PARK

NORTH AND EAST BOUNDARIES:

EAST OF PARKING LOT, BEGINNING APPROX. 50 M EAST OF CREEK AND ENDING AT THE EAST BOUNDARY (Transect #1)

A mixed forest of Douglas-fir, Western redcedar with the occasional bigleaf maple grows along this boundary. There is abundant Oceanspray, snowberry, sword fern, ivy*, daphne-laurel* and holly*. Ivy* grows throughout this area, especially on flat ground and climbs high up fir, particularly in areas that are fairly open and bright. Most leaves are triangular/trifoliate when climbing, although some are also more ovate in this area, which is fairly typical.

NORTHEASTERN BOUNDARY: NORTH OF ASH ROAD (TRANSECT #2)

Douglas-fir and grand fir, bitter cherry and bigleaf maple are dominant on the south part of this section, near Ash Rd. Ivy* is found in this area climbing cherry. Snowberry and sword fern are common throughout this section and red-osier dogwood is abundant directly along the roadside behind a strip of lawn borders the edge near the road. Further north toward the shoreline (between 50 and 100 m from Ash Rd.), there is more grand fir, western redcedar and Oregon grape and ivy*. Past this (to 150 m), Douglas-fir and bigleaf maple with ivy*, holly*, daphne-laurel*, Himalayan blackberry*, snowberry and trailing blackberry are found before a trembling aspen grove (to 200 m) with grand fir. Behind the last house, a Douglas-fir and bigleaf maple forest with oceanspray, Oregon grape, holly*, daphne-laurel*, ivy*, trailing blackberry and sword fern are common. Ivy* is thus common within woods along this boundary section (as are daphne-laurel* and holly*).

NORTHEASTERN BOUNDARY: SOUTH OF ASH ROAD (TRANSECT #3)

Douglas-fir and bigleaf maple are common along this section, as is redcedar, particularly in the centre (half way to the south tip of the park). On the north part of this section, near Ash Rd., Himalayan blackberry* and red-osier dogwood are abundant along the path (a path runs inside

the park boundary – several metres from the border). Ivy* is very abundant along this boundary, growing to considerable height (up to 10 metres) and flowering on numerous trees, particularly directly against the edge of the park near housing, where it is bright and open. Bracken and sword fern, snowberry, and trailing blackberry, holly* and willow are common throughout the section of boundary as are stinging nettle, Himalayan blackberry* and grasses in more open areas and the occasional red elderberry and Pacific ninebark (*Physocarpus capitatus*).

SOUTHERN BOUNDARY (TRANSECT #4)

This short (85 - 90 m) tip of park has had large trees cleared and considerable light is penetrating the forest from all sides. The vegetation directly along the park's border is broom* and snowberry. Ivy* is heavy further inside, under Douglas-fir, bigleaf maple, large holly* trees and Indian plum and vines grow to around 3 cm in diameter. There is considerable human disturbance, including numerous trails, trampled vegetation and a small, moving camp belonging to a man who has been living inside this part of the park for several months. Tall, Douglas-fir, bigleaf maple and holly* trees, cascara and Indian plum are dominant vegetation, and snowberry, Oregon grape, holly* and ivy* form the predominant understory plants. At the end of summer, ivy* is in most parts the most abundant ground cover in this region. Grey squirrels live here also, jumping branches high up Douglas-fir.

SOUTHEASTERN BOUNDARY (TRANSECT #5)

The forest in this area is also Douglas-fir, bigleaf maple with abundant holly*. Ivy* is very abundant along this side of the park and house yards blur into the park boundary. Some of the smaller ivy* vines (e.g. under 3 cm in diameter) have been cut along this boundary. Ivy* flowers on most trees in this region, although rarely on holly*, where only trees with few branches and bare trunks are climbed. Ivy* vines greater than 6 cm in diameter climb numerous trees in this area (from 100-200 m north of the park's south tip). Vines near houses in this area are huge and braided (e.g. one has 5 cm vines weaved into and on top of 9 cm vines). The largest ivy* (39 cm in circumference) was found approximately 130 m north of the park's south border. This boundary appears to have considerable human disturbance and dumped garden clippings, compost and garbage (old tires, old machinery, scrap plastic, rusty cans, lids, wheels, bottles and the omnipresent fast food packaging). I also found several peculiar spots (less than one metre wide and round in form) where all vegetation and detritus appears to have been singed bare, almost as if the efficacy of herbicides or other defoliant were being tested, although I cannot be certain this is the cause. There are dozens of various birds but none today (November 6, 1997), appear to be eating ivy* becoming heavy with this year's fruit.

SOUTHWESTERN BOUNDARY (TRANSECT #6): FROM SOUTH TIP OF PARK TO JUST NORTH OF ADJACENT CLEARED AGRICULTURAL LAND

The forest is primarily Douglas-fir and bigleaf maple with abundant holly*. At the south tip of the park, huge mats of Himalayan blackberry* grow along the west side of the path. Inside the park, ivy* is heavy with small (<1 cm diameter) vines. Half way between the east and west border or in the center of this 'peninsula', the lower portion is less invaded by ivy*. However further north in the wider section (approximately 200 m north from the south tip of the park), ivy* becomes very heavy and reproductive. What I believe is the tallest and largest ivy* bloom (for lack of a better word) engulfing a Douglas-fir in this centre section had vines 4 cm thick with nearby Western redcedar pulled down and covered by reproductive ivy*. It would appear that from one third to one half of trees in the bottom few hundred metres of this 'peninsula' of the park are covered by ivy*. On the park's western edge, agricultural areas and broom* back onto a more open forest inside the park and ivy* becomes patchily distributed and less dominant. It is

difficult to find any non-invaded areas of Douglas-fir along the southern part of this boundary (e.g. up to 200-300 m north of the south tip of the park).

Further north than this, areas that appear non-invaded often on closer inspection of fir trees have ivy* shoots beginning to climb at their base. Overall, the northern part of this boundary appears to be less invaded but does contain numerous seedlings and small, inconspicuous sprouts, which may indicate ivy* is beginning to slowly spread to this part of the park. I found many little ivy* seedlings in an area and sampled it more intensely (seedling plot). The northern part of this boundary contains widespread holly*, Douglas-fir, bigleaf maple and Western yew with an understory predominated by Oregon grape and snowberry. There are few ivy* seedlings in the areas of thick Oregon grape but many sprout on open, spongy beds of mosses on the forest floor and on logs. Helleborine (*Epipactis helleborine*) is also plentiful in shady areas and a very large, thick (nearly impenetrable) stand of mature holly* is found approximately 600 m north along this boundary.

Ivy* is also absent in a very pretty area comprised exclusively of approximately fifty large, sword fern plants that grow in a clearing under a canopy gap with no shrubs or middle strata. It seems ivy* is often not very effective at smothering or climbing onto species of fern if they are sufficiently large. However, close by, where sword fern grow with holly* and elderberry, ivy* is found. Besides these large homogenous patches of Oregon grape and sword fern and severely trampled parts where trails converge, ivy* is found either young or mature throughout this boundary zone. Another area where no ivy* occurs is close to the base of the hill next to where adjacent cleared agricultural land ends and forest begins. This area, appearing similar in disturbance to the south-west tip of the park, has five large fir that have fallen inside the park (to the east); likely windthrow. The canopy is under 10% closed and a large area has opened up the west near which there are numerous live maples.

NORTH BOUNDARY: CADBORO BAY ROAD, SOUTH OF SHORELINE (TRANSECT #7)

Cadboro Rd. runs parallel and through the north boundary of the park and is very close to the shoreline in areas. As a result and for consistency, the section south of this road was examined. This also allowed me to assess vegetation within the contiguous portion of the park that has presumably been less affected by the bisection of the road. Red cedar is the predominant vegetation along this boundary. Although the area appears moist, numerous dry, rocky and exposed outcrops contain arbutus. There is very little ivy* invasion along this section of the park. The ivy* that is present is found only in three locations. First, at the parking lot at the far east of the boundary near Ash Rd., second, in one spot approximately 150-200 m west of this and third, adjacent the apartment complexes at the far west of the boundary section.

MOUNT WORK REGIONAL PARK

Given that I had never yet found evidence of ivy* growing near roadsides, trails or off trails in this park, only two main areas were searched rigorously for its presence. Neither the transect searched at Fork Lake residential area, nor the transect near Durrance Lake and Durrance Rd. parking areas had any signs of this plant. Trees in the Durrance Lake boundary section included cedar, fir and other coniferous species, while those along the Fork Lake boundary section included mixed fir and Garry oak. None of the houses in either location appeared to be landscaping with ivy*.

THETIS LAKE REGIONAL PARK

EAST BOUNDARY OFF HIGHLAND ROAD AND WATKISS WAY

Ivy* is very abundant and dense in the woods near the parking area. In these woods, ivy* grows mainly on fir and is found covering and pulling down young big leaf maples. Snowberry, Oregon grape, holly* and daphne-laurel* are the predominant woody plants. Grasses and many small herbs are also found under the canopy. The old island highway is now a dirt path (30-60 m or so north of the now expanded island highway) that follows the southern main parcel of the park. The small, isolated parcels of park that lie south of the highway are not described. Moving west along the old highway toward Thetis Lake, fir and the occasional maple are found with rock outcrops and meadow that contain more arbutus and Garry oak.

The second edge of park described is the eastern boundary directly west of Highland Rd. Here, new housing is currently being built and extending northward. Moving north inside the park from the parking area, the major distribution of thick ivy* extends approximately 40-50 metres north and then subsides for another 30-40 metres before another patch is found. North of the second patch, the new housing begins and salal replaces ivy* as the dominant understory woody plant and coloniser of fallen trees and stumps. North of this, rockier grounds occur with oaks and arbutus, but no ivy* is found. Both of these areas are lands within the original Nature Sanctuary, protected since 1958.

WEST BOUNDARY OFF PHELPS ROAD NEAR THEANOR ROAD

The forest in this location is situated west and adjacent to a residential road. Most of this section of park is composed of fir with occasional red cedar and further north, numerous big leaf maple saplings. Oceanspray, Himalayan blackberry*, snowberry, Oregon grape, salal, rose, Scotch broom*, bracken fern and sword fern are common in the area. A very large-leaved unidentified exotic plant was found growing in a wet or marshy spot just inside the park. There is no ivy* within this section of the park.

NORTH BOUNDARY OF THETIS LAKE PARK

A small transect along the northern boundary of Thetis Lake park, accessed via Highland Rd. was investigated for any signs of ivy*. Scotch broom* is prevalent adjacent the highway throughout this area but no ivy* was found in the forest. Fir and fir seedlings with some Western red cedar and an understory comprised primarily of salal, Oregon grape are the dominant large plants with carpets of mosses underneath.

SOUTH BOUNDARY ON WEST SIDE: BELLAMY ROAD

The edge of park near the north end of Bellamy Rd. was searched. Cedar, salal and broom* (particularly along roadsides and clearings) is the primary vegetation. However, no ivy* was found in this part of the park.

UPLANDS PARK

SOUTH-WEST BOUNDARY (ALONG DORSET RD.)

0-50 M FROM LINCOLN RD.:

The southwestern boundary of Uplands Park borders on a ditch four metres from a road adjacent residential settlement. Moving west inside the park along Dorset Rd., there is willow and large mats of Himalayan blackberry* climbed by morning glory. Further inside (approximately 25 m from the park's edge), Nootka rose and snowberry are found. Also at

approximately the same distance inside the park and 20-30 m from Lincoln Rd., there is a grove of trembling aspen. Nearby there are patchily distributed individual aspen trees with Himalayan blackberry* and Scotch broom* closer to the park's edge. Forty to fifty metres west from Lincoln Rd., Daphne-laurel*, grasses, Scotch broom* and English hawthorn* are abundant further inside the park's boundary and Himalayan blackberry*, hawthorn and maple (*Acer* sp.) are found closer to the park's edge.

50-100 M FROM LINCOLN RD. TO HERON RD.:

Cattails are abundant near a small ditch or stream that flows 20-30 m inside the park's boundary. Closer to the road there are many English hawthorn* shrubs within trampled grassland/meadow. Maples and daphne-laurel* are found closer to the park's edge. Twenty to twenty five metres inside the park at Heron Rd., there is a cluster of snowberry shrubs surrounded by more grass and meadow.

0-100 M FROM HERON RD TO MUSGRAVE RD.:

West of Heron Rd., another stand of maple is directly inside the park. Behind the maple and further inside the park, there is a long east to west strip of Nootka rose and grasses or mowed lawn. Near the corner of Dunlevy and Musgrave Rds., there is a triangular stand of thick, barely penetrable trembling aspen and other trees; the triangular shape is the result of a path cutting through the corner of the park to join sidewalks between Dorset and Musgrave Streets. Within this stand of trees, ivy* climbs an estimated ten metres high and spreads at least around the same width, flowering in the trees' crowns. Himalayan blackberry*, snowberry and grasses surround the stand, nearer the road. Through this path, ivy* and daphne-laurel* are found near assorted and ornamental shrubs and small trees.

Overall along this boundary, no ivy* was found growing within grass-hawthorne, grass-broom* or open wet meadow communities. Ivy* was most abundant and mature within larger poplar stands.

WESTERN BOUNDARY

MUSGRAVE TO MIDLAND AND MIDLAND TO LANSDOWNE:

The dominant vegetation along the Musgrave St. section of park includes tall snowberry and Nootka rose, Indian plum, trembling aspen, hawthorn, Himalayan blackberry* mats, daphne-laurel*, mixed grasses, wet meadow and a small handful of introduced pines* (*Pinus* sp.). Hawthorn and Himalayan blackberry* increase in frequency nearing Midland St. Along the Midland St. section of park, snowberry, Himalayan blackberry* and hawthorn are common as is more wet meadow and field with large mats of Himalayan blackberry* and more Garry oak. Past the wet meadow, that also has trembling aspen and horsetails, an apple tree (*Malus* sp.) bearing very large fruit shelters ivy* underneath it. Curiously, cyclamen* has been planted in one spot near the park border; the original circular form of the potting soil still visible. Ivy* thrives on several of the large Garry oak along and further inside this boundary. The end section of this boundary section at Lansdown St., contains more hawthorn, daphne-laurel* and further north and possibly on private property, pine and spruce (*Piceae* sp.) trees.

SOUTHERN BOUNDARY: BEACH DRIVE

Vegetation along Beach Dr. behind housing includes Himalayan blackberry*, mixed grasses, ornamental hawthorn, introduced ash* (possibly European-ash - *Fraxinus excelsior*), apple (*Malus* sp. possibly *diversifolia*), hardhack (*Spiraea douglasii* spp. *douglasii*), broom* and gorse*. East of housing, near the parking areas, Garry oak meadows with mixed wildflowers and grasses, broom* meadow, daphne-laurel*, hawthorn, snowberry, Nootka rose and Sitka willow are common. Rockier habitat is found further towards the shoreline with Garry oak that become

increasingly exposed and stunted (like a krumholtz version of Garry oak) nearer the shore. Also in this region are mixed shrubs with introduced field bindweed* (*Convolvulus arvensis*), willow (*Salix* sp.), numerous woody plants like beach pea (*Lathyrus japonicus*), grasses and managed lawns with associated species like clovers (*Trifolium* sp.).

WITTY'S LAGOON REGIONAL PARK

EAST BOUNDARY

Beginning up from the shore of the lagoon and moving north toward Duke Rd. in the park boundary, mixed fir dominate with some oceanspray and Indian plum, abundant salal and snowberry, Oregon grape and ferns. In an area with a slightly open canopy, fir seedlings grow with holly*, trailing blackberry, grasses and juvenile ivy* (climbing a few trees to approximately 2 m high). North of Olympic Dr., the forest has a heavy fir canopy, fire scars and no middle stratum, Oregon grape and salal continue to dominate the understory. Forty or so metres north of Olympic Dr., a patch (approximately 10X15 m) of ivy* climbs up 9 fir trees and reaches a maximum height of around 4 m on three of them. Ivy* covers much of the understory and grows with some snowberry, salal and mosses. Further north of this, ivy* subsides and there are more bigleaf maple, sword fern and oceanspray. Approximately 130 m from Olympic Dr., open Garry oak meadow with grasses, wildflowers and broom* emerges from rock. A good portion of the next part of this boundary remains oak meadow with parts containing Douglas-fir, arbutus and snowberry. Another large patch of arbutus and Garry oak is found closer toward the highway and then fir becomes more dominant approaching Duke Rd. In summary, two areas along the south part of this boundary near the housing development contained ivy*.

NORTHWEST BOUNDARY: LAGOON TRAIL AT THE THINNEST SECTION OF PARK

On the lagoon trail, where the park narrows between nearby housing and the tide lines, a mixed forest of grand fir and Douglas-fir, western redcedar and bigleaf maple grow with red alder further east. The alder is not invaded by ivy*. Holly*, daphne-laurel* and ivy* are found scattered within the fir forest and ivy* is abundant and well established in a few areas between which it subsides. Two plots were sampled in this area. Sword and bracken fern, wall lettuce*, Oregon grape, buttercup* (*Ranunculus repens* in wetter areas) and trailing blackberry are common. Further east, salal increases as the dominant understory plant and there is no sign of invasion by ivy*. This description represents approximately 80 m along the trail. In the heavily invaded part on the west part of this section near housing, a tree toad was found, perched at eye level on a cedar tree under large ivy* foliage and vines.

NORTH BOUNDARY: METCHOSIN ROAD

There are no signs of ivy* in the conifer forest along Metchosin Rd. towards Duke Rd. Western redcedar and fir are the dominant tree species, trailing blackberry, lettuces and herbs are found. Holly* and daphne-laurel* are also absent from these woods.

TOWER POINT

The entrance to the Tower Point parcel of park is cleared for parking, containing mixed introduced grasses, bordered by Himalayan blackberry*, snowberry and buttercup (*Ranunculus* sp.). Toward the beach, ivy* is found mid-way along the corridor trail growing with rose, grasses and Himalayan blackberry*. Mixed shrubs including snowberry grow along this part of the corridor. Trees such as Garry oak and Douglas-fir with Indian plum are found up from the shoreline, also with big leaf maple on the north-east and arbutus on the south. No ivy* is found within these woodlands, however, it may have been cleared.

Appendix 2: Park Edge Types

The following tables are a summary of measurements made on maps (sources and scales indicated). A lowercase direction abbreviator indicates the part of the boundary it refers to (e.g. Ne means the eastern part of a north boundary - whereas NE indicates a northeast boundary). Values in parentheses in far right columns indicate proportion of perimeter occupied by edge type. (Notes: HDR or Higher density residential areas = lots <1500m², MDR or Medium Density Residential areas = lots ≥1500m² - <2ha, and LDR or Lower Density Residential areas = lots ≥ 2ha.)

BEAR HILL (Rectangular Parcel) (1:5000 CRD Parks Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
LDR	S	40.4	2020 (.46)
LDR	Nw	30.3	1515 (.34)
LDR	N	9.9	495 (.11)
HWY (Patricia Bay)	E	1.3	65 (.01)
Roadway adjacent LDR	N	3.4	170 (.04)
Roadway adjacent LDR	W	3	150 (.03)
Perimeter		88.3	4415

COLES BAY (1:2000 CRD Parks Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
MDR	N	17	340 (.41)
Road adjacent MDR	E	11.5	230 (.28)
MDR	S	10.4	208 (.25)
Shoreline (generalised)	W	2.4	48 (.06)
Perimeter [perimeter excluding shoreline]		33 [41.3]	826 [778]

DEVONIAN (1:5634 CRD Parks)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Agricultural and LDR	NE	16	901 (.38)
Shoreline (generalised)	ES	6.8	383 (.16)
Agricultural and LDR	SW	15.7	885 (.38)
Major roadway adjacent MDR	WN	3.1	175 (.07)
Perimeter [perimeter excluding shoreline]		41.6	2344 [1961]

ELK-BEAVER LAKE (1:5000 Saanich Map) and ready to go number of bound sections = number of locations/orientations per edge type++

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
LDR	Nw, W, SW	115.9	5795 (.47)
MDR	N, W, Ws	26.5	1325 (.11)
HDR	S, W	20.9	1045 (.08)
Roads adjacent LDR	N, S	10	500 (.04)
Roads adjacent MDR	N	12	600 (.05)
Major HWY (Patricia Bay Highway)	E	62.8	3140 (.25)
Perimeter		248.1	12,405

FRANCIS KING (1:5000 Saanich Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Semi-natural/Hydro R/W	N	14.1	705 (.16)
Road adjacent Semi-natural area	NE	3	150 (.03)
Road adjacent LDR	En	14	700 (.16)
LDR/agricultural	Es	24	1200 (.27)
Semi-natural/Hydro R/W	W	33.7	1685 (.38)
Perimeter		88.9	4440

HORTH HILL (1:2500 CRD Parks Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Semi-natural	SE	27.5	687.5 (.32)
LDR	E	7.6	190 (.09)
LDR	Ws	7.5	187.5 (.09)
MDR	W	7.5	187.5 (.09)
MDR	Wn	6	150 (.07)
Semi-natural/LDR	NW	21.5	537.5 (.25)
Road adjacent LDR	Wn	8.1	202.5 (.09)
Perimeter		85.7	2142.5

KNOCKAN HILL (1:5000 Saanich Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
HDR (newly built)	N*	7.5	375 (.19)
HDR (newly built)	E**	9.9	495 (.25)
Road adj. HDR	NE	0.8	40 (.02)
MDR	NE	2.1	105 (.05)
MDR	W	9.9	495 (.25)
MDR	Es	3.8	190 (.09)
Major roadway adjacent MDR	S	1.1	55 (.03)
LDR	W	3.1	155 (.08)
Major roadway adjacent LDR	Wn	2.1	105 (.05)
Perimeter		40.3	2015

Includes north edge of triangular parcel, does not include footpath /entrance from Jean Pl.

LONE TREE (1:5000 CRD Parks)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
LDR	N	7.8	390 (.14)
Semi-natural	E, Ne	23.4	1170 (.43)
MDR	SW	12.3	615 (.23)
Road adjacent MDR	W	11	550 (.20)
Perimeter		54.5	2725

MILL HILL (excluding small parcel south of Atkins Road) (1:7500 CRD Parks)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Semi-natural	NW & E	25.2	1890 (.49)
Semi-natural	W	8	600 (.16)
LDR	ES	2.7	202.5 (.05)
HDR	E	1.3	97.5 (.03)
HDR	N	3	225 (.06)
HDR	S	5.8	435 (.11)
Trailer park	E	4	300 (.08)
Roadway (Atkins Rd.)	S	1.3	97.5 (.03)
Perimeter		51.3	3847.5

MOUNT DOUGLAS (1:5000 Saanich Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Major Roadway adjacent HDR (Shellbourne)	E	1.7	85 (.01)
LDR	E	5.3	265 (.03)
HDR	En	1.8	90 (.01)
Road adj. HDR	En	4.2	210 (.03)
HDR	E	15	750 (.10)
HDR	Es	9.8	490 (.06)
Road adj. HDR	E	8.3	415 (.05)
Footpath	S	1.8	90 (.01)
LDR/agricultural	Ws	29.3	1465 (.19)
Road adj. LDR	W	3.4	170 (.02)
LDR/agricultural	Wn	50	2500 (.32)
Shoreline (generalised)	N	24	1200 (.16)
Perimeter [perimeter excluding shoreline]		154.5	7730 [6530]

MOUNT WORK (1:20,000 CRD Parks Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
LDR	WN	3.1	620 (.04)
MDR	Sw	3.7	740 (.04)
MDR	S	2.3	460 (.03)
Shoreline (Fork Lake)	S	1.7	340 (.02)
Road adj. MDR	N	1.5	300 (.02)
Road adj. semi-natural/LDR	N	2.5	500 (.03)
Semi-natural	NW	8.2	1640 (.09)
Semi-natural	W	20	4000 (.23)
Semi-natural	S	9.7	1940 (.11)
Semi-natural	E	31.2	6240 (.35)
Semi-natural/LDR	Ws	1.2	240 (.01)
Semi-natural/LDR	Se	2.9	580 (.03)
Perimeter		88	17,600

THETIS LAKE (1:15,000 CRD Parks Map)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Semi-natural/Hydro R/W	all	75.8	11.370
HWY	S	6.4	960
HDR	Sw	8	1200
MDR	Es, Sw	2.8	420
Road adjacent HDR	Es	6.5	975
Road adjacent semi-natural area	N	1.3	195
Shoreline (McKenzie Lake - generalised)	N	1.7	255
Other	W, S	2.9	435
Perimeter		105.4	15.810

* Includes south edge of triangular parcel

UPLANDS PARK (1:2500 Oak Bay Park Map by T.C.Bradshaw)

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Main (parcel north of Beach Drive)			
HDR	N, E & S	60	1500 (.42)
Road adjacent HDR	S, W, E	27	675 (.19)
Cattle Point (parcel south of Beach Drive)			
HDR	Ne	5.4	135 (.04)
Shoreline	E & S	45	1125 (.31)
Footpath	Ws	6	150 (.04)
Perimeter [perimeter excluding shoreline]		143.4	3585 [2460]

WITTY'S LAGOON (1:5000 CRD Parks) consisting of two separate parcels of land

Edge Types / Adjacent Landscape type	Locat'n / Orient'n	Approx. Length on Map (cm)	Approx. Length on Ground (m)
Main parcel			
MDR	SW	13.5	675 (.09) (.07)
Road adjacent LDR	N, NW, Wn	14	700 (.09) (.08)
MDR	E	12.1	605 (.08) (.07)
LDR/agricultural	N, Nw, Wn	47	2350 (.31) (.26)
Shoreline (generalised)	all	63	3150 (.42) (.35)
Perimeter [perimeter excluding shoreline]		149.6	7480 [4330]
Tower Point Parcel			
HDR	N & W	5	250 (.16) (.03)
Road adjacent HDR	NW	1.2	60 (.04) (.01)
LDR/agricultural	N & NE	9.8	490 (.31) (.05)
Shoreline (generalised)	S	16	800 (.50) (.09)
Perimeter [perimeter excluding shoreline]		32	1600 [800]
Combined Perimeter of both parcels [combined perimeter excluding shoreline]		181.6	9080 [5130]

Values in far right parentheses of last column indicate the proportion of perimeter occupied by each edge type when both parcels are combined together and treated as one.

Appendix 3: Analysis of Park Boundary Segments by Edge Type

The total number of discrete segments of a park's border adjacent each land use/landscape type are shown in italics in this appendix. Values below those in italics indicate the total length in metres of boundary segments. For example, three sections of Bear Hill Park's border were adjacent lower density residential/agricultural areas, representing approximately 91% or 4030metres of this park's total perimeter (last column). The bottom row summarizes land use/landscape type categories in all parks by total number of boundary segments (italics), total length in metres (values below italics) and the proportion of total (summed) perimeters of all parks (in parentheses).

Park	Residential			Roadways and Other Accessways						Other	Semi-Natural			Perimeter (m)
	HDR	MDR	LDR/ Agric'l	HDR	MDR	LDR	Semi-Nat'l	Major HWY	foot-path		Vegetated	Veg./LDR	Shoreline	
Bear Hill			3 (.91) 4030			3 (.07) 320		1 (.01) 65						4415
Coles Bay		2 (.66) 548		1 (.28) 230								1 (.06) 48		826
Devonian			2 (.76) 1786	1 (.07) 175								1 (.16) 383		2344
Elk-Beaver	2 (.08) 1045	3 (.11) 1325	5 (.47) 5795	1 (.05) 600	2 (.04) 500		1 (.25) 3140							12,405
Francis-King			1 (.27) 1200		1 (.16) 700		1 (.03) 150			2 (.54) 2390				4440
Horth Hill		2 (.16) 337.5	2 (.18) 377.5		1 (.09) 202.5					1 (.32) 687.5	1 (.25) 537.5			2142.5
Knockan Hill	2 (.68) 870	3 (.39) 790	1 (.08) 155	1 (.02) 40	1 (.03) 55	1 (.05) 105								2015
Lone Tree Hill		1 (.23) 615	1 (.14) 390		1 (.23) 550					1 (.43) 1170				2725
Mill Hill	3 (.20) 757.5		1 (.05) 202.5				1 (.65) 97.5			2 (.65) 2490				3847.5
Mount Douglas	3 (.17) 1330		3 (.51) 4230	2 (.8) 710		1 (.02) 170						1 (.16) 1200		7730
Mount Work		3 (.07) 1200	1 (.04) 620	1 (.02) 300			1 (.03) 500			4 (.78) 13,820	3 (.04) 820	1 (.02) 340		17,600
Thetis Lake	2 (.07) 1200	4 (.03) 420		2 (.06) 975			1 (.01) 195	5 (.06) 960		2 (.03) 435		1 (.01) 255		15,810
Uplands	3 (.46) 1635			3 (.19) 675								1 (.31) 1125		3585
Witty's Lagoon		2 (.17) 1280	3 (.31) 2350			3 (.09) 700						1 (.42) 3150		7480
- Tower Point	2 (.16) 250		1 (.31) 490	1 (.04) 60								1 (.50) 800		1600
Total	17 (.08) 7087.5	20 (.07) 6515.5	23 (.24) 21626	9 (.02) 2460	5 (.02) 1910	13 (.03) 2697.5	3 (.01) 942.5	7 (.05) 4165	2 (-) 240	3 (-) 735	20 (.36) 31,927.5	4 (.02) 1357.5	8 (.08) 7301	88,965

Appendix 4: Ivy Stem and Host Data (Raw)

PARKS	PLOT#	CANOPY	SP.	CONDIT.	CIRC	HEIGHT	IVY	STEM	DIA
Coles Bay	1	60	blm		45				
Coles Bay	1	60	grfir		180	5.40	juv		.50
Coles Bay	1	60	redald	dead	200				
Coles Bay	1	60	wrced		150	.85	juv		.50
Coles Bay	1	60	wrced		130				
Coles Bay	1	60	wrced		160	1.00	juv		.50
Coles Bay	1	60	wrced		80				
Coles Bay	2	35	blm		60	2.50	juv		.70
Coles Bay	2	35	blm		100	8.50	adu		1.00
Coles Bay	2	35	blm		90	8.50	adu		1.00
Coles Bay	2	35	blm		190	4.50	juv		1.00
Coles Bay	2	35	grfir	dying	130				
Coles Bay	2	35	grfir		270	6.90	adu		1.00
Coles Bay	3	5	blm		270				
Coles Bay	3	5	blm	dead	160	4.50	juv		1.50
Coles Bay	3	5	D-fir	dead	120	7.10	adu		4.00
Coles Bay	3	5	D-fir		150	5.40	adu		2.00
Coles Bay	3	5	D-fir	dead	240	3.50	juv		.50
Coles Bay	4	65	blkcot		388	7.00	juv		2.00
Coles Bay	4	65	D-fir		280	4.80	juv		.50
Coles Bay	4	65	conif		175	5.80	juv		.50
Coles Bay	4	65	grfir	galls	53	3.50	juv		1.50
Coles Bay	5	15	D-fir		210				
Coles Bay	5	15	grfir	dead	45				
Coles Bay	5	15	Goak	dead	149	.50	juv		.20
Coles Bay	5	15	grfir	dead	91				
Elk-Beaver	6	60	blm		44	13.00	juv		1.50
Elk-Beaver	6	60	D-fir		152	24.40	adu		3.50
Elk-Beaver	6	60	blm		66	16.00	juv		1.25
Elk-Beaver	6	60	blm		42				
Elk-Beaver	6	60	D-fir		118	27.40	adu		4.00
Elk-Beaver	6	60	blm		31	8.50	juv		1.50
Elk-Beaver	6	60	D-fir		120	8.50	juv		6.50
Elk-Beaver	6	60	blm		40	2.75	juv		.50
Elk-Beaver	6	60	blm		95	5.60	juv		.50
Elk-Beaver	6	60	D-fir		140	1.00	adu		6.00
Elk-Beaver	7	80	D-fir		121	18.00	adu		2.50
Elk-Beaver	7	80	D-fir		186	3.00	juv		1.50
Elk-Beaver	7	80	D-fir		108				
Elk-Beaver	7	80	D-fir		105				
Elk-Beaver	7	80	D-fir		60	3.50	juv		.50
Elk-Beaver	7	80	D-fir		203	4.50	juv		1.00
Elk-Beaver	7	80	D-fir		62				
Elk-Beaver	7	80	D-fir		154	8.80	juv		1.50
Elk-Beaver	7	80	D-fir		178	5.60	juv		1.25
Elk-Beaver	7	80	D-fir		52	13.00	adu		3.50
Elk-Beaver	7	80	D-fir		77	15.80	adu		4.00
Elk-Beaver	7	80	D-fir		144	5.00	juv		1.50
Elk-Beaver	8	85	grfir		52				
Elk-Beaver	8	85	D-fir		181	4.50	juv		1.00
Elk-Beaver	8	85	D-fir		72	5.00	juv		1.50
Elk-Beaver	8	85	D-fir	dead	58	4.50	juv		1.20
Elk-Beaver	8	85	grfir		65	5.00	juv		1.50
Elk-Beaver	8	85	grfir	dead	50	3.00	juv		.50
Elk-Beaver	8	85	grfir		62				
Elk-Beaver	8	85	D-fir		107				
Elk-Beaver	8	85	D-fir	dead	75				
Elk-Beaver	8	85	D-fir		66				

PARKS	PLOT#	CANOPY	SP.	COND.	CIRC	HEIGHT	IVY	STEM
Elk-Beaver	8	85	D-fir		162	7.10	juv	1.20
Elk-Beaver	8	85	D-fir		55	7.50	juv	1.50
Elk-Beaver	9	80	D-fir		113	13.60	adu	4.00
Elk-Beaver	9	80	D-fir		285	15.50	adu	4.50
Elk-Beaver	9	80	grfir		165	5.60	juv	.50
Elk-Beaver	9	80	D-fir	dead	63	8.00	juv	2.00
Elk-Beaver	9	80	D-fir		197	4.00	juv	2.75
Elk-Beaver	9	80	grfir	dead	65	7.80	juv	1.00
Elk-Beaver	9	80	D-fir		178	3.00	juv	.50
Elk-Beaver	9	80	D-fir		70	2.20	juv	.50
Elk-Beaver	9	80	D-fir	dead	74			
Francis-K	10	40	arbu	dying	250	4.30	adu	15.00
Francis-K	10	40	Goak		150	9.30	adu	7.00
Francis-K	10	40	Goak		140	9.30	adu	7.00
Francis-K	10	40	Goak		100	9.30	adu	2.80
Francis-K	10	40	Pcraba		58	2.90	adu	2.50
Francis-K	11	65	D-fir		175	18.40	adu	9.00
Francis-K	11	65	D-fir		170			
Francis-K	11	65	D-fir		193			
Francis-K	11	65	D-fir		180			
Francis-K	11	65	D-fir		90			
Francis-K	12	75	D-fir		150	13.20	juv	3.00
Francis-K	12	75	D-fir		185			
Francis-K	12	75	D-fir		45			
Francis-K	12	75	arbu		45			
Francis-K	12	75	D-fir		170	4.50	juv	1.50
Francis-K	12	75	D-fir		125	10.20	adu	5.00
Francis-K	12	75	D-fir		80			
Francis-K	12	75	D-fir		180	18.90	adu	7.00
Francis-K	13	65	D-fir		140	3.00	juv	.50
Francis-K	13	65	D-fir		75	16.50	adu	7.00
Francis-K	13	65	D-fir		100	16.50	adu	5.00
Francis-K	13	65	D-fir		65	21.50	adu	2.00
Francis-K	13	65	D-fir		125	21.50	adu	5.00
Francis-K	13	65	D-fir		90	16.10	adu	8.00
Francis-K	13	65	D-fir	dead	75			
Francis-K	13	65	grfir		35			
Francis-K	14		D-fir		330	6.90	juv	3.00
Francis-K	14		grfir		310	6.90	adu	2.00
Francis-K	14		grfir		300	3.40	juv	.50
Francis-K	14		blm		45	2.10	juv	.50
Francis-K	14		redald		60			
Francis-K	14		unid	snag	90			
Francis-K	14		blm		25			
Francis-K	15	90	Goak		65			
Francis-K	15	90	Goak		53			
Francis-K	15	90	Goak		44			
Francis-K	15	90	D-fir		276	9.50	adu	4.50
Francis-K	15	90	D-fir		315	9.30	adu	4.00
Francis-K	15	90	blm		36			
Francis-K	16	80	D-fir	dead	35			
Francis-K	16	80	D-fir		165			
Francis-K	16	80	D-fir		135	9.00	adu	2.00
Francis-K	16	80	D-fir		40	.30	juv	.50
Francis-K	16	80	D-fir		126	1.75	juv	.50
Francis-K	16	80	D-fir		203			
Knockan H	17	20	D-fir		180	4.50	juv	2.00
Knockan H	17	20	D-fir		180	3.50	juv	3.50

PARKS	PLOT#	CANOPY	SP.	COND.	CIRC	HEIGHT	IVY	STEM
Knockan H	17	20	grfir		110	2.40	juv	1.00
Knockan H	17	20	grfir		48			
Knockan H	17	20	D-fir		177	11.00	adu	4.00
Knockan H	17	20	D-fir		145	11.00	adu	3.50
Knockan H	18	90	grfir	dead	63			
Knockan H	18	90	grfir	lying	51	3.80	adu	1.50
Knockan H	18	90	D-fir		133	4.50	juv	1.00
Knockan H	18	90	grfir		130	8.00	juv	1.10
Knockan H	18	90	grfir		253	12.00	juv	3.10
Knockan H	18	90	D-fir		140	3.80	juv	1.00
Knockan H	18	90	D-fir		109	3.80	juv	.50
Knockan H	18	90	D-fir		248	2.00	juv	.50
Knockan H	19	60	Goak	dead	66			
Knockan H	19	60	Goak	dead	59			
Knockan H	19	60	grfir		106	1.00	juv	.50
Knockan H	19	60	Goak	dead	88	3.40	juv	.80
Knockan H	19	60	grfir		140	13.00	adu	2.00
Knockan H	19	60	Goak	dead	65	13.00	adu	2.00
Knockan H	19	60	D-fir		80	13.00	adu	1.50
Knockan H	19	60	grfir		106	.50	juv	.50
Knockan H	19	60	grfir		221	1.80	juv	.50
Knockan H	19	60	D-fir		46	2.80	juv	.50
Knockan H	19	60	D-fir		122	1.80	juv	8.00
Knockan H	19	60	Goak	dead	66	.10	juv	.30
Knockan H	20	20	Goak		90	2.50	juv	4.50
Knockan H	20	20	D-fir		61	.50	juv	.50
Knockan H	20	20	Goak		55	.10	juv	.20
Knockan H	20	20	yew		45			
Knockan H	20	20	grfir	dead	205	3.70	juv	4.00
Knockan H	21	65	D-fir		167	11.00	adu	3.10
Knockan H	21	65	Goak		90	7.50	juv	1.80
Knockan H	21	65	Goak		122	6.50	juv	1.80
Knockan H	21	65	Goak		96	3.00	juv	.50
Knockan H	21	65	Goak		60	8.50	adu	2.00
Knockan H	21	65	Goak		78	12.50	adu	6.00
Knockan H	21	65	Goak		80	8.50	adu	5.00
Knockan H	21	65	Goak		134	13.50	adu	6.00
Knockan H	21	65	Goak		95	8.00	adu	1.00
Knockan H	21	65	Goak		108	10.00	adu	3.00
Knockan H	21	65	Goak		118	7.50	adu	1.00
Knockan H	21	65	Goak		42	5.10	juv	.50
Knockan H	22	5	cherry		50	4.20	juv	2.50
Mt. Doug	23	75	bcher		42	7.90	adu	3.00
Mt. Doug	23	75	D-fir		275	12.20	adu	2.00
Mt. Doug	23	75	grfir		102	3.90	adu	3.00
Mt. Doug	23	75	blm		260		adu	3.00
Mt. Doug	23	75	grfir		60		adu	.30
Mt. Doug	23	75	grfir		280		adu	3.50
Mt. Doug	23	75	grfir		250		adu	3.00
Mt. Doug	23	75	grfir		35	7.90	juv	.50
Mt. Doug	24	20	grfir		140	8.50	adu	1.50
Mt. Doug	24	20	grfir		200	11.00	adu	3.00
Mt. Doug	24	20	D-fir		180	17.10	adu	5.80
Mt. Doug	24	20	D-fir		250	15.10	adu	3.00
Mt. Doug	25	50	D-fir		225	13.60	adu	7.00
Mt. Doug	25	50	D-fir	snag	190	17.50	adu	9.50
Mt. Doug	25	50	D-fir	snag	190	28.00	adu	4.50
Mt. Doug	25	50	D-fir		310	19.50	adu	10.50

PARKS	PLOT#	CANOPY	SP.	COND.	CIRC	HEIGHT	IVY	STEM
Mt. Doug	26	65	D-fir		255			
Mt. Doug	26	65	blm		103			
Mt. Doug	26	65	D-fir		275	4.50	juv	.50
Mt. Doug	26	65	yew		35			
Mt. Doug	26	65	D-fir		158	13.70	juv	1.20
Mt. Doug	26	65	D-fir		128	11.00	adu	4.20
Mt. Doug	26	65	blm		80	14.50	juv	1.50
Mt. Doug	26	65	blm		82	4.00	juv	.20
Mt. Doug	27	10	D-fir		137	10.50	adu	3.50
Mt. Doug	27	10	Scwill		95	10.50	adu	3.20
Mt. Doug	27	10	casca		51			
Mt. Doug	27	10	yew	lying	53	1.20	juv	1.00
Mt. Doug	27	10	yew		50	6.70	juv	1.20
Thetis L	28	80	Goak		150	14.60	adu	8.00
Thetis L	28	80	Goak		94			
Thetis L	28	80	Goak	dying	60			
Thetis L	29	98	D-fir		248	15.00	adu	3.00
Thetis L	29	98	D-fir		209	16.10	adu	3.20
Thetis L	29	98	D-fir		175	18.30	adu	5.00
Thetis L	29	98	D-fir		40	7.00	adu	2.00
Thetis L	29	98	D-fir		146	26.30	adu	7.00
Thetis L	29	98	Goak		65	3.70	juv	.50
Thetis L	30	90	grfir		66	4.80	adu	2.00
Thetis L	30	90	grfir		152	13.80	adu	2.50
Thetis L	30	90	grfir	snag	55	2.70	adu	5.00
Thetis L	30	90	grfir	snag	65	5.30	adu	5.20
Thetis L	30	90	D-fir		240	16.80	adu	5.00
Thetis L	30	90	blm		125	15.00	adu	2.10
Thetis L	31	50	D-fir		175	8.60	adu	1.90
Thetis L	31	50	D-fir		70	6.50	adu	3.90
Thetis L	31	50	D-fir		105	10.60	adu	4.00
Thetis L	31	50	blm		54			
Thetis L	31	50	blm		40			
Uplands	32	60	casca		25			
Uplands	32	60	Goak		165	10.50	adu	6.00
Uplands	32	60	Goak		125	9.00	adu	4.00
Uplands	32	60	Goak		65	7.50	adu	6.00
Uplands	32	60	Goak		25	1.50	juv	.50
Uplands	32	60	Goak		150	7.50	adu	3.00
Uplands	32	60	Goak		150	10.50	adu	4.00
Uplands	32	60	Goak		115	4.00	juv	3.50
Uplands	33	70	Goak		200	15.00	adu	8.00
Uplands	33	70	traspn		75	3.70	juv	3.50
Uplands	33	70	traspn		115	5.50	adu	2.75
Uplands	33	70	traspn	dead	110	1.20	adu	6.00
Uplands	33	70	traspn		90	12.00	juv	5.00
Uplands	34	5	Goak		190	1.00	juv	.80
Uplands	34	5	Goak		130			
Uplands	34	5	Goak		45			
Uplands	34	35	Sitwil		85			
Uplands	35	35	Sitwil		65	.20	juv	.20
Uplands	35	35	Sitwil		105			
Uplands	35	35	Sitwil		110	2.00	juv	.80
Uplands	35	35	Sitwil		130	.50	juv	.80
Uplands	35	35	Sitwil		210	10.50	adu	6.50
Uplands	36	20	Goak		80	3.20	juv	1.80
Uplands	36	20	Goak		35	2.10	juv	1.00
Uplands	36	20	Goak		65	2.00	juv	.60

PARKS	PLOT#	CANOPY	SP.	COND.	CIRC	HEIGHT	IVY	STEM
Uplands	36	20	Goak		60	3.50	juv	1.80
Uplands	36	20	Goak		55	3.40	juv	1.40
Uplands	36	20	Goak		40	2.50	juv	1.30
Uplands	36	20	Goak		35	3.10	juv	.70
Uplands	36	20	Goak		35	3.50	juv	.70
Uplands	36	20	Goak		30	2.70	juv	.60
Uplands	36	20	Goak		50	3.00	juv	.20
Uplands	36	20	Goak		38	2.50	juv	.20
Uplands	36	20	Goak		35	3.10	juv	.70
Uplands	36	20	Goak		38	2.50	juv	.20
Uplands	36	20	Goak		38	5.90	adu	10.00
Uplands	36	20	Goak		85	5.70	adu	2.00
Uplands	36	20	Goak		85	4.00	adu	6.00
Uplands	36	20	Goak		77	3.40	adu	8.00
Uplands	36	20	Goak		90	3.20	adu	4.00
Uplands	36	20	Goak		70	5.90	adu	3.00
Uplands	36	20	Goak		75	5.90	adu	2.00
Uplands	36	20	Goak	dead	44	1.00	juv	.50
Uplands	36	20	Goak		44	3.50	adu	1.50
Uplands	36	20	Goak	dead	45	3.50	adu	1.50
Uplands	36	20	Goak		70	8.00	adu	5.00
Uplands	36	20	Goak		40	3.30	juv	.20
Uplands	36	20	Goak		40	3.60	juv	.20
Uplands	37	20	Goak		40			
Uplands	37	20	Goak		40			
Uplands	37	20	Goak		40	.50	juv	.10
Uplands	37	20	Goak		40	.50	juv	.10
Uplands	37	20	Goak		40	.50	juv	.10
Uplands	37	20	Goak		40	.50	juv	.50
Uplands	37	20	Goak		53	1.00	juv	.50
Uplands	37	20	Goak		50	1.00	juv	.10
Uplands	37	20	Goak		75	3.40	juv	1.50
Uplands	37	20	Goak		75	5.50	juv	1.50
Uplands	37	20	Goak		75	5.50	juv	1.00
Uplands	37	20	Goak		45	2.00	juv	.50
Uplands	37	20	Goak		45	2.00	juv	.50
Uplands	37	20	Goak		45	2.00	juv	.50
Uplands	37	20	Goak		85	6.10	adu	4.00
Uplands	37	20	Goak		80	3.80	adu	3.00
Uplands	37	20	Goak		80	3.80	adu	3.00
Uplands	37	20	Goak		70	4.00	juv	.50
Uplands	37	20	Goak		40	2.00	juv	.50
Uplands	37	20	Goak		40	2.00	juv	.50
Uplands	37	20	Goak		40	2.00	juv	.50
Uplands	37	20	Goak		70	3.50	adu	.80
Uplands	37	20	Goak		70	3.50	adu	.80
Uplands	37	20	Goak		40	3.20	juv	3.00
Uplands	37	20	Goak		40	3.40	juv	3.00
Uplands	37	20	Goak		50	4.50	juv	2.00
Uplands	37	20	Goak		50	4.50	juv	1.00
Uplands	37	20	Goak		50	4.50	juv	3.00
Uplands	37	20	Goak		20	2.00	juv	.50
Uplands	37	20	Goak		20	1.00	juv	.50
Uplands	37	20	Goak		20	3.70	juv	.50
Uplands	37	20	Goak		40	3.00	juv	.50
Uplands	37	20	Goak		40	1.00	juv	.50
Uplands	37	20	Goak		40	2.00	juv	.50
Uplands	37	20	Goak		40	2.00	juv	.50

PARKS	PLOT#	CANOPY	SP.	COND.	CIRC	HEIGHT	IVY	STEM
Uplands	37	20	Goak		30	5.00	juv	.80
Uplands	37	20	Amelm		25	3.80	juv	1.00
Uplands	37	20	Amelm		40	3.80	juv	1.00
Uplands	37	20	Amelm		70	3.80	juv	1.00
Uplands	37	20	casca		45	3.20	juv	.50
Uplands	37	20	Goak		45	3.00	juv	1.00
Uplands	37	20	Goak		50	3.80	adu	2.00
Witty's L	38	80	D-fir		105	1.40	juv	.50
Witty's L	38	80	D-fir		105	.80	juv	.50
Witty's L	38	80	conif	snag	50	2.80	juv	.50
Witty's L	38	80	bcher		40			
Witty's L	38	80	D-fir		60			
Witty's L	38	80	D-fir		100			
Witty's L	38	80	conif	snag	50			
Witty's L	38	80	D-fir		85	2.10	juv	.50
Witty's L	38	80	decid	dead	40	1.50	juv	.50
Witty's L	38	80	decid	dead	40	6.30	juv	1.50
Witty's L	38	80	D-fir		110	10.70	juv	1.00
Witty's L	38	80	D-fir		110	6.00	juv	1.00
Witty's L	38	80	D-fir		80	4.50	juv	.50
Witty's L	38	80	D-fir		70	7.30	juv	1.50
Witty's L	38	80	D-fir		110	.50	juv	.50
Witty's L	38	80	D-fir		70			
Witty's L	38	80	D-fir		30			
Witty's L	39	85	arbu		45			
Witty's L	39	85	D-fir		95	6.50	juv	.80
Witty's L	39	85	grfir		90			
Witty's L	39	85	D-fir		145			
Witty's L	39	85	D-fir		150	5.50	juv	.50
Witty's L	39	85	grfir		90			
Witty's L	39	85	grfir		25			
Witty's L	39	85	grfir		40			
Witty's L	39	85	grfir		85			
Witty's L	39	85	grfir		30			
Witty's L	39	85	grfir		20			
Witty's L	39	85	D-fir		135	2.70	juv	.50
Witty's L	40	50	wrced		180	2.70	juv	.50
Witty's L	40	50	D-fir		225	7.60	adu	3.00
Witty's L	40	50	D-fir		100	1.70	juv	.50
Witty's L	40	50	wrced		40	5.00	juv	1.10
Witty's L	40	50	wrced		105	6.50	juv	1.20
Witty's L	40	50	wrced		35	4.00	juv	.80
Witty's L	40	50	wrced		90	2.70	juv	.50
Witty's L	40	50	wrced		60	7.00	juv	1.00
Witty's L	40	50	wrced		20			
Witty's L	40	50	D-fir		70	3.00	juv	.50
Witty's L	40	50	wrced	lying	40			
Witty's L	41	45	D-fir		210	3.50	juv	.80
Witty's L	41	45	D-fir		188	1.50	juv	.50
Witty's L	41	45	D-fir		150			
Witty's L	41	45	grfir		180	5.50	juv	.50
Witty's L	41	45	redald		100	2.00	juv	.50
Witty's L	41	45	grfir		85			
Witty's L	41	45	grfir		150	5.50	juv	.50

**Appendix 5: (Raw Data): Cover Classes of Vegetation
and General Habitat of Sampled Quadrats**

Appendix 6: Raw Data: Short Term Horizontal and Vertical Shoot Elongation of *Hedera helix*: Frequency of Growth for Individual Shoots During 15 Day Periods in Summer, 1997

Table 1: Horizontal and Vertical (in square brackets) Shoot Elongation at Francis-King Park Site.

Growth (cm)	May 16-May 31	May 31-June 15	June 15-July 2	July 2-July 18	July 18-August 3
<1	4	3	4	4	5
1	[1]		1 [1]	1 [1]	2 [1]
2	2 [2]	3 [2]	2 [1]	2 [1]	[2]
3		1	[1]	[1]	
4	1				1
5	1	[1]			
6				1	
7		1			
8			1		
Mean \pm s.d. *	1.9 \pm 1.8 [1.7 \pm 0.6]	2.2 \pm 2.2 [3.0 \pm 1.7]	1.9 \pm 2.6 [2.0 \pm 1.0]	1.6 \pm 1.9 [2.0 \pm 1.0]	1.1 \pm 1.2 [1.7 \pm 0.6]

* <1 values counted as 0.5 for statistical calculations. Total n shoots tracked = 8 [3]

Table 2: Horizontal and Vertical (in square brackets) Shoot Elongation at Thetis Lake Park Site.

Growth (cm)	May 16-May 31		May 31-June 15		June 15-July 2		July 2-July 18		July 18-August 3	
	Site A	Site B	Site A	Site B	Site A	Site B	Site A	Site B	Site A	Site B
<1	2		2		1		4		2	
1	1		1		2		2		3	
2	3		2		1	1				
3	3		5		2		1	[1]		
4	1	[1]	1		1	[1]			1	[1]
5	3	1							1	
6	1		1					1 [1]		
7		[1]		[1]	1	[1]	3	1 [1]	2	[1]
8		[1]	1				1		1	1
9	1	1	1	1	4		2		1	1
10	1	1		[1]	1	1	2	1		[1]
11	1		1		1	[1]	1		1	
12			1	1	1				2	1
13				[1]	1	1	1		2	
14					2		1		2	
15	1			1						
16							1			
17			1							
18							1		2	
19			1						1	
20							1			
Mean \pm s.d. *	4.8 \pm 4.0	8.0 \pm 2.7 [6.3 \pm 2.1]	5.9 \pm 5.6	12.0 \pm 3.0 [10.0 \pm 3.0]	7.3 \pm 4.7	8.3 \pm 5.7 [7.3 \pm 3.5]	7.9 \pm 6.1	7.7 \pm 2.1 [5.3 \pm 2.1]	9.0 \pm 6.1	9.7 \pm 2.1 [7.0 \pm 3.0]

total n shoots tracked = Site A: 18 (May16 - July2) and 21 (July 2 – August 3)
Site B: 3 [3]

* <1 values counted as 0.5 for statistical calculations

Table 3: Horizontal Shoot Elongation at Mount Douglas Park Site.

Growth (cm)	May 15-June 1	June 1-June 16	June 16-July 3	July 3-July 19
<1				2
1		1	6	
2	1		1	
3	3	1	2	1
4	1	2		
5	1	2	2	
6	1	1	1	
7	2	1	2	1
8	1		2	
9	1		1	
10	1	1	1	1
11	1	1		
12	2		2	1
13	3	1		1
14	4		2	1
15	1	1	2	1
16	3	1	1	2
18		1	1	2
19	1	1	1	2
20	2		1	2
21	1	1		1
22	2	1		
23	1			1
24		1		1
25		1		
26	3	1		1
27				1
28				2
29		1	1	
30	1	3	1	
31		1		
32		2		1
33		1		1
34		1		
35		1		2
36		1		
37		2	1	1
38		1		1
39		1		
40			1	1
41				1
47		1		
48		1		
Mean \pm s.d.	13.9 \pm 7.5	23.1 \pm 13.3	11.6 \pm 10.5	21.5 \pm 11.2
<i>n</i>	37	37	32	32

n = total shoots tracked

Table 4: Vertical Shoot Elongation at Knockan Hill Park Site.

Growth (cm)	May 16-May 31	May 31-June 15	June 15-July 2	July 2-July 18	July 18-August 3
1	2	2	1	2	3
2	3	3	1	1	
3	1	3	5	2	1
4	3		4	1	1
5	5		3		2
6	4		3		2
7	4		3	4	4
8	2	2	1	5	4
9	2	5	2	7	6
10	2	7	1	1	5
11	2	4	2	2	1
12	2	5	3	2	2
13		4	1	2	4
14	2		3	7	2
15	1			4	2
16	1			2	2
17		1		1	1
18			1		1
19			1		1
20				1	1
21			1	1	
Mean \pm s.d.	7.2 \pm 4.0	8.9 \pm 4.1	8.2 \pm 5.2	10.6 \pm 4.8	9.9 \pm 4.7
<i>n</i>	36	36	36	45	45

n = total shoots tracked

Table 5: Horizontal and Vertical (in square brackets) Shoot Elongation (cm) for Individual Shoots. Mean \pm s.d.: Aggregated Data from All Sites.

Late May	Early June	Late June	Early July	Late July
9.7 \pm 7.7	15.4 \pm 13.7	8.9 \pm 8.7	13.9 \pm 11.7	7.1 \pm 6.1
[6.7 \pm 4.0]	[8.6 \pm 4.2]	[7.7 \pm 5.1]	[9.8 \pm 5.0]	[9.3 \pm 4.9]
<i>n</i> = 66 [<i>n</i> = 42]	<i>n</i> = 66 [<i>n</i> = 42]	<i>n</i> = 61 [<i>n</i> = 42]	<i>n</i> = 64 [<i>n</i> = 51]	<i>n</i> = 32 [<i>n</i> = 51]

Appendix 7: Photo Gallery

Figure 1: Cultivars of *H. helix*: leaf forms of a few of the ivies found in gardens and parks in Victoria, BC.



Figure 2: Ivy in urban areas of San Francisco, California.



Figure 3: New growth after clearing Knockan Hill Park trees of ivy.



Figure 4: Ivy on western yew tree, Mount Douglas Park.

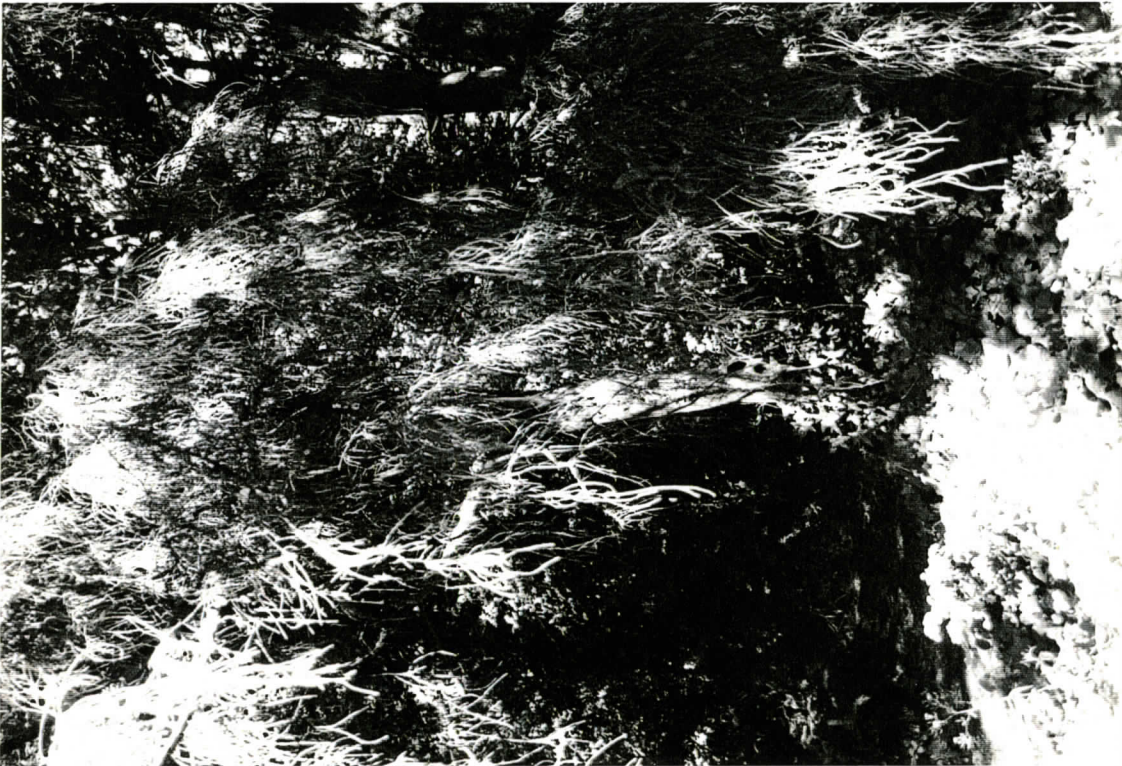


Figure 5: Ivy in grassy Garry oak meadow, Uplands Park.



Figure 6: Vertical growth of juvenile, tree-climbing shoots marked at Knockan Hill Park.



Figure 7: Ivy pillars on Douglas-fir; characteristic of Francis-King Park. Site of growth monitoring on Elsie-King Trail.



Figure 8: Shoots in the patch grow very slowly if at all throughout the growing season. They may send out searcher/runner shoots (in this case after its main shoot was broken).



Figure 9: Rootlet-covered stem at growth monitoring site in Watkiss Way boundary of Thetis Lake Regional Park.



Figure 10: Smooth stem near the Old Highway path growth monitoring site in Thetis Lake Regional Park. Note the bird's nest a metre and a half or so up the trunk.



Figure 11: Ivy "desert" inside Highland Rd. / Watkiss Way boundary of Thetis Lake Regional Park. Ivy may also displace plants that make their home on trees and stumps (e.g. ferns).



Figure 12: Ivy's mass may bring down young deciduous trees like these bigleaf maples (*Acer macrophyllum*), which are also gap colonizers and poor liana hosts in the long-term. Thetis Lake Regional Park.



Figure 13: Mount Douglas Park.



Figure 14: Few understory species remained on this forest floor after removal of ivy in a small area of Mount Douglas Park where growth was monitored. The extent to which disturbance from removing large carpets of ivy facilitates invasion of other exotic plants or increases the number or cover of native plants could be determined through an adaptive management programme.



Figure 15: Protected natural area or garden? To what extent should exotic plants in donated parkland such as Knockan Hill Park be managed or removed for native plant regeneration?

