# Still Creek Watershed Biodiversity Conservation Case Study


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# Executive Summary

## Overview

The Still Creek Watershed Biodiversity Conservation Case Study is part of a larger project being undertaken by AXYS Environmental Consulting Ltd. (AXYS) that involves developing a spatial framework for conserving biodiversity in the Greater Vancouver Region. The framework integrates a variety of existing ecological information to create a series of maps showing important habitat areas, ecological corridors, and the relative biodiversity of the region to guide management and conservation efforts. These maps provide the ‘management picture’ for preparing and implementing the Biodiversity Conservation Strategy for the Greater Vancouver Region[1]. As part of the development of this region-wide strategy, it is proposed that case studies be undertaken to demonstrate how biodiversity conservation planning can take place at the watershed and local scale, as well. The Still Creek project is a watershed-scale case study.

Still Creek was selected for the case study by the project partners because it is a highly urbanized watershed that includes, and is near to, some habitat areas of regional importance. As well, an Integrated Stormwater Management Plan (ISMP) is being developed for this area by the City of Vancouver, City of Burnaby and the GVRD. The ISMP and other studies have provided considerable baseline information about the watershed. This project complements and builds on the work undertaken as part of the ISMP. The approach undertaken could be applied to other ISMPs which are to be prepared on all urban watersheds in the Greater Vancouver region over time as part of implementation of the GVRD Liquid Waste Management Plan.

**Goals**

The goals of the Still Creek Watershed Biodiversity Conservation Case Study are:

- To evaluate the status of biodiversity in the Still Creek watershed and develop strategies for biodiversity conservation that build on the Still Creek Integrated Stormwater Management Plan (ISMP) currently being developed;
- To demonstrate how regional-level biodiversity information developed through the “*Assessment of Regional Biodiversity and Development of a Spatial Framework for Biodiversity Conservation in the Greater Vancouver Region,*” AXYS, 2005, can inform biodiversity planning at the watershed-level;
- To test the applicability of CITYgreen[2] modeling, a tool to evaluate ecological services provided by trees and vegetated land cover, as an aid to developing biodiversity conservation strategies in the watershed; and
- To develop a model approach to biodiversity conservation planning at a watershed level that may be applied to other watersheds in the region and elsewhere.

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[1] The Biodiversity Conservation Strategy is a joint project under the Georgia Basin Action Plan. Project partners include the Greater Vancouver Regional District (GVRD), Environment Canada (through the Georgia Basin Action Plan’s Coordination Office and Canadian Wildlife Service (CWS), Province of British Columbia (Ministry of Water, Land and Air Protection (MWALP) and Ministry of Sustainable Resource Management (MSRM), and Burrard Inlet Environmental Action Program/Fraser River Estuary Management Program (BIEAP-FREMP) with input from GVRD municipalities, Simon Fraser University (Resources and Environmental Management), Douglas College Institute of Urban Ecology, Langley Environmental Partners’ Society, and the Como Watershed Group.

[2] CITYgreen is a computer model developed by American Forests (http://www.americanforests.org/resources/urban forests/analysis.php) that can be used with satellite-derived land cover data to evaluate ecosystem benefits provided by tree and vegetation coverage. The analysis examines stormwater infrastructure cost savings, water and air quality management and carbon storage values.

## Methods and Results

Development of a biodiversity conservation strategy for the Still Creek watershed involved the following tasks:

- a review of existing studies including current information on the Still Creek ISMP;
- the integration of input received during the Still Creek Watershed Biodiversity Conservation Case Study workshop (held February 2004);
- refinement of the Ministry of Sustainable Resource Management (MSRM) land cover dataset;
- development of a detailed vegetation map derived from air photos;
- the development of habitat maps for indicator species;
- the creation of a biodiversity map that shows regionally significant ecosystems;
- the development of a habitat connectivity map;
- the results of an urban ecosystem analysis using a model called CITYgreen; and
- the integration of input received from the Biodiversity Conservation Strategy Working Group.

**Data Used**

Data from a variety of sources were assembled for use during the project including: satellite-derived land cover based on 2002 Landsat 7 imagery; 2003 Baseline Thematic Mapping (BTM); 2001 land use data from the GVRD; wetlands (integrated within the land cover dataset); intertidal data (extracted from both the land cover dataset and from Canadian Hydrographic Service charts); watercourses (from the Terrain Resource Information Management (TRIM) 1:20,000 scale map sheets); slope classes (based on the 1:20,000 scale TRIM digital elevation model [DEM]); Ministry of Forests forest cover data (at a scale of 1:20,000); the 1:250,000 scale Biogeoclimatic Ecosystem Classification (BEC) coverage; and roads from the Province's 1:20,000 scale Digital Road Atlas. These data were integrated to develop a refined version of the land cover product. The refined land cover dataset was classified into ten different regional habitat types:

- agriculture;
- fresh water (includes lakes and watercourses);
- intertidal;
- ocean;
- old forest;
- young forest;
- open space/ meadow;
- shrub;
- wetland; and
- urban vegetated.

In addition, the single line streams present in the TRIM dataset were buffered by 30 metres to identify stream corridors and combined with a 30 metre buffer of all freshwater features (lakes, rivers and wetlands) to delineate potential riparian habitat.

## Habitat Types

The major habitat types for the region are shown in Figure E-1.

## CITYgreen Analysis

The land cover data was analyzed using CITYgreen to identify how the existing tree canopy impacts stormwater runoff, water and air quality, and carbon storage and sequestration. CITYgreen models the environmental and economic benefits of tree and other green land covers in terms of their ability to provide both increased health and well-being for urban residents and reduce municipal infrastructure costs. The results indicate that the current tree cover of 11.8% falls below targets established by American Forests of 15% for central business districts and 25% for urban residential zones.

## Indicator Species Analysis

The habitat types were used in conjunction with other data (e.g., slope, elevation, proximity to water) to identify potential regionally significant habitats for a number of indicator species. Indicator species are sensitive to environmental change and can be used to indicate habitat availability and quality for other associated species. The habitat maps can be used to aid in the development of management strategies for species of concern and species at risk (e.g., the Pacific water shrew). The habitat maps were based on the best information available at the time of the project, however, it should be noted that the results have not been field verified. The results of the habitat mapping indicate that the following species are present in the watershed; Great blue heron; Cooper's hawk; Douglas' squirrel; Spotted towhee and Brown creeper.

## Workshop

A workshop was held with the project Steering Committee members during which the various habitat types were rated in terms of their relative biodiversity value. These weightings were applied to the habitat type coverage to generate a weighted habitat type map for the region.

## Habitat Reservoirs and Refuges

A patch size analysis was conducted on the habitat coverage to identify areas of contiguous habitat. In other words, to map portions of the landscape that have not been fragmented by human disturbance (i.e., roads, urban development). Areas of contiguous (unfragmented) habitat identified through the patch analysis were classified based on their size (area) to identify habitat reservoirs and habitat refuges. A habitat refuge is defined as a small patch of habitat that provides food, shelter and/or other needs for wildlife. It may include human-modified ecosystems. They are not generally large enough to maintain the genetic diversity of a population. A habitat reservoir is a large area of relatively natural habitat that has sufficient size and ecological integrity to support a range of native species, including species that need interior habitats. The size of habitat reservoir depends on the species being managed for (WLAP 2004). The Project Steering Committee determined threshold sizes of habitat reservoirs and refuges as follows:

- major habitat reservoir - patch size >200 ha
- habitat reservoir - patch size = 30-200 ha
- major habitat refuge - patch size = 20-30 ha
- habitat refuge - patch size = 2-20 ha

The resulting habitat reservoirs and refuges are shown in Figure E-2.

## Figure E-1 Regional Habitat Types

## Figure E-2 Habitat Reservoirs and Refuges in the Still Creek Region

**Habitat Connectivity**

Habitat connectivity is critical to maintain biodiversity. Habitat reservoirs and refuges that are connected through habitat corridors provide for the movement of species and genetic material and for ecological functioning. Habitat connectivity was evaluated by quantifying the amount and quality of habitat within 500 metres of each habitat pixel. The higher the habitat score, the higher the connectivity rating. Figure E-3 shows habitat connectivity for the Still Creek watershed.

**Relative Biodiversity**

A relative biodiversity map was developed that represents a composite of the weighted habitat layers and the habitat refuges and reservoirs coverage (Figure E-4).

**Land Management Evaluation**

The existing park boundaries were overlaid on the relative biodiversity map and the map of habitat reservoirs, refuges and connectivity to show important areas for biodiversity falling both inside and outside of protected areas (Figure E-5).

## Figure E-3 Habitat Connectivity in the Still Creek Region

**Figure E-4 Relative Biodiversity in the Still Creek Region**

## Figure E-5 Habitat Reservoirs, Refuges and Corridors in Relation to Parks

All of the aforementioned analyses were used in developing recommendations for biodiversity conservation for the Still Creek watershed.

## Management Recommendations

Through the combined work of this project and the Still Creek ISMP the following management actions were identified to help maintain the biodiversity of the watershed.

The draft vision from the Still Creek ISMP is:

> *To protect or enhance the integrity of the aquatic and terrestrial ecosystems and the human populations they support in an integrated manner that accommodates growth and development.*

The goals and related strategies from the draft ISMP to meet this vision are:

| | |
|---|---|
| **Goal 1:** | **Protect and enhance streamside and aquatic habitats** |
| Strategy 1-1: | Maintain continuous open-channel watercourses |
| Strategy 1-2: | Improve fish access and instream habitat quality for fish and wildlife |
| Strategy 1-3: | Provide continuous streamside vegetation to protect and enhance habitat for aquatic and terrestrial species |
| Strategy 1-4: | Encourage watershed stewardship |
| **Goal 2:** | **Protect and enhance forest and trees in watershed** |
| Strategy 2-1: | Maximize tree cover in watershed |
| **Goal 3:** | **Protect and improve water quality** |
| Strategy 3-1: | Prevent contaminants from entering watercourses or stormdrains |
| Strategy 3-2: | Treat stormwater before it enters watercourses |
| Strategy 3-3: | Monitor water quality and respond to results |
| **Goal 4:** | **Maintain and increase native species biodiversity** |
| Strategy 4-1: | Protect and restore habitat reservoirs and patches |
| Strategy 4-2: | Link habitat reservoirs |
| Strategy 4-3: | Improve habitat quality and complexity for wildlife |
| Strategy 4-4: | Promote native vegetation and control of non-native species |

Details on the ISMP goals, strategies and actions are provided in Section 7.3 of the report, however, the following briefly summarizes the key strategies and actions to conserve biodiversity in the watershed. Figure E-6 illustrates the locations for key proposed strategies.

**Strategy 4-1: Protect and restore habitat reservoirs and patches**

- consider lands for conservation designation
- develop a land use plan for the area around Douglas Road
- enlarge habitats through land restoration
- focus recreation in existing disturbed areas
- consider habitat values in the management of land adjacent to the TransCanada highway

**Figure E-6 Proposed Biodiversity Management Strategies for the Still Creek Integrated Watershed Management Plan**

**Strategy 4-2: Link habitat reservoirs**

- create a 40-60m corridor along Still Creek as a greenway to connect to the Burnaby Lake habitat reservoirs
- extend Still Creek habitat corridor connecting Renfrew Ravine and the Central Park habitats
- create corridors between: Still Creek and Deer Lake Park; along Beecher Creek towards Burrard Inlet; and from Beaver Creek to Central Park
- encourage utility companies to maximize habitat potential within utility corridors

**Strategy 4-3: Improve habitat quality and complexity for wildlife**

- study and inventory natural areas
- manage natural and urban areas to maximize biodiversity
- designate wildlife refuge areas
- assess potential problem wildlife species
- promote native forest tree species and age structures
- minimize conflict between dog off-leash areas and critical habitats
- increase wetlands

**Strategy 4-4: Promote native vegetation and control of non-native species**

- assess extent of invasive vegetation and priorize removal based on benefits and resources
- create long-term pilot projects for invasive species removal
- support streamkeeper's efforts
- develop integrated land stewardship program for landowners

The CITYgreen analyses also advised the development of strategies and actions related to maximizing tree cover in the watershed (Strategy 2-1). Specific action items include:

- planting and maintaining street trees and boulevards
- encourage tree-planting and the creation of greenspace on private and public lands
- develop and implement an urban forest strategy for the watershed

## Conclusions

The following conclusions resulted from the Still Creek case study:

1. The regional scale mapping was very useful for watershed-level planning, however, it was not at a suitable level of detail for detailed site planning. At the watershed level the dataset can be used for most applications and can aid in the identification of high biodiversity areas or ‘hot spots’ where more detailed field study or mapping can be conducted. This use of the regional data in conjunction with more detailed data, as required, is a cost effective approach to biodiversity planning at the watershed level.
2. The approach of the case study can be applied to other ISMPs developed within the Greater Vancouver Region as a means of integrating biodiversity.
3. The regional scale information allows municipal staff to see how their municipality, or portions thereof, fit in the larger regional context. This is particularly relevant when managing habitat reservoirs and refuges and maintaining connectivity corridors.
4. The development of habitat maps for indicator species helps identify key wildlife habitats. The maps generated for the case study should be reviewed and field verified to ensure their accuracy.
5. CITYgreen is an effective tool for watershed level planning. As part of the Biodiversity Conservation Strategy, attainable tree canopy targets for various types of watershed conditions (based on land use) should be established to both manage biodiversity and provide information for the ISMP process.
6. The regional land cover dataset should be updated on a regular basis (e.g., every five years) to ensure the dataset represents current conditions.
7. Protected areas management targets for different habitat types should be established for the region to ensure rare and/or critical habitats are protected. This information would assist in biodiversity planning at the watershed level.

# Table of Contents

**1 Introduction ........ 1**
1.1 Project Description ........ 1
1.2 Project Goals ........ 2
1.3 Document Overview ........ 2
**2 Study Area ........ 4**
2.1 Location and Description of the Still Creek Watershed ........ 4
2.2 Regional Context ........ 4
**3 Still Creek Integrated Stormwater Management Plan ........ 12**
3.1 Overview ........ 12
3.2 Vision, Goals, and Strategies ........ 13
**4 Project Methodology ........ 14**
4.1 Review of Existing Studies ........ 14
4.2 Still Creek Watershed Biodiversity Conservation Case Study Workshop ........ 14
4.3 Refined Land Cover ........ 15
4.4 Detailed Vegetation Mapping ........ 16
4.5 Regional Biodiversity Mapping ........ 17
4.5.1 Habitat Types ........ 17
4.5.2 Habitat Rankings ........ 19
4.5.3 Habitat Patch Size ........ 19
4.5.4 Biodiversity ........ 20
4.6 Habitat Connectivity ........ 20
4.7 CITYgreen Analysis ........ 21
4.8 Input from Biodiversity Conservation Strategy Working Group ........ 24
**5 Current Status of Biodiversity in Still Creek Watershed ........ 25**
5.1 Limitations to Current Knowledge ........ 25
5.2 Species and Ecosystems ........ 25
5.2.1 Native Species and Ecosystems ........ 25
5.2.2 Species at Risk ........ 25
5.2.3 Remnant Ecosystems ........ 30
5.3 Detailed Vegetation Mapping ........ 30
5.4 CITYgreen Analysis ........ 34
5.4.1 Land Cover ........ 34
5.4.2 Air Pollution ........ 37
5.4.3 Carbon Storage and Sequestration ........ 37
5.4.4 Stormwater ........ 38
5.4.5 Water Quality (Contaminant Loading) ........ 38
5.5 Biodiversity Mapping ........ 39
5.5.1 Habitat Refuges and Reservoirs ........ 39
5.5.2 Habitat Connectivity ........ 39
5.5.3 Relative Biodiversity ........ 42
**6 Issues and Challenges ........ 44**

6.1 Issues ....44
6.1.1 Structural Changes in the Still Creek Watercourse ....44
6.1.2 Changes in Hydrology and Water Quality ....44
6.1.3 Changes in Aquatic and Terrestrial Ecosystems ....45
6.2 Challenges ....46
6.2.1 Maintaining and Restoring Habitats ....46
6.2.2 Invasive Non-native Species ....47
6.2.3 Social Values ....47
6.3 Limitations ....48
6.3.1 Information Gaps ....48
6.3.2 Study Limitations ....49
**7 Still Creek Watershed Biodiversity Conservation ....50**
7.1 Vision ....50
7.2 General Recommendations ....50
7.2.1 Habitat Reservoirs and Refuges and Connectivity ....50
7.2.2 Greenspace Management ....54
7.2.3 Management Initiatives ....58
7.3 ISMP Goals, Strategies and Actions ....58
7.3.1 Still Creek Watershed: Environment ....58
**8 Applications and Conclusions ....70**
8.1 Using the Regional Biodiversity Analyses for Watershed Planning ....70
8.2 Using Focal Species and Habitat Rules for Watershed Planning ....70
8.3 Using the CITYgreen Analysis in Watershed Planning ....71
8.4 A Model Approach for Watershed Planning ....72
8.5 Lessons Learned ....74
**9 References ....75**
**Appendix A Indicator Species Habitat Mapping ....77**
**Appendix B CITYgreen Analysis Results ....109**
**Appendix C Pacific Water Shrew (Sorex bendirii) Suitability Mapping ....123**

# List of Tables


Table 1 Regional and Detailed Vegetation Mapping Comparison ........ 16
Table 2 Habitat Type Ratings ........ 19
Table 3 Habitat Patch Size Modifiers ........ 20
Table 4 CITYgreen Land Cover Reclassification ........ 24
Table 5 Red- and Blue-listed Species Recorded Near the Still Creek Watershed (CDC 2004) ........ 29
Table 6 Vegetation Types in Hectares ........ 32
Table 7 Predominant Vegetation Classes Associated with Anthropogenic Land Use Types (AXYS 2004). ........ 33
Table 8 Predominant Vegetation Classes Associated with Natural Land Use Types (AXYS 2004) ........ 33
Table 9 American Forests Tree Canopy Goals ........ 34
Table 10 Still Creek, McIntyre-Denier and Hyland Creek Watersheds Habitat Types Summary ........ 36
Table 11 CITYgreen Analysis - Land Cover Change 1986 to 2002 ........ 37
Table 12 CITYgreen Analysis - Air Pollution Costs Change 1986 to 2002 ........ 37
Table 13 CITYgreen Analysis - Carbon Storage and Sequestration Change 1986 to 2002 37
Table 14 CITYgreen Analysis – Stormwater Savings 1986 to 2002 ........ 38
Table 15 CITYgreen Analysis - Percent Change in Contaminant Loadings ........ 38
Table 16 CITYgreen Future Scenario Comparison ........ 55
Table A-1 List of Potential Indicator Species for the Still Creek Watershed ........ 79
Table A-2 Species Associated with the Indicator Species (based on Lee and Rudd, 2003) .. 80
Table A-3 Example HSI Calculation 1 for Brown Creeper ........ 83
Table A-4 Example HSI Calculation 1 for Brown Creeper ........ 84
Table A-5 Indicator Species and Key Habitat Types for the Still Creek Watershed ........ 85
Table C-1 Pacific Water Shrew Analysis Results ........ 125
Table C-2 Areas of Pacific Water Shrew Habitat Suitability in the Still Creek Watershed 127

## List of Figures


Figure E-1 Regional Habitat Types ... iv
Figure E-2 Habitat Reservoirs and Refuges in the Still Creek Region ... v
Figure E-3 Habitat Connectivity in the Still Creek Region ... ii
Figure E-4 Relative Biodiversity in the Still Creek Region ... iii
Figure E-5 Habitat Reservoirs, Refuges and Corridors in Relation to Parks ... iv
Figure E-6 Proposed Biodiversity Management Strategies for the Still Creek Integrated Watershed Management Plan ... vi
Figure 1 Still Creek Watershed Study Area Location ... 5
Figure 2 Still Creek Watershed Detailed Study Area ... 6
Figure 3 Land Use (GVRD 2001) ... 7
Figure 4 Land Cover (MSRM 2002) ... 8
Figure 5 'Green' Land Cover (MSRM 2002) ... 9
Figure 6 Population Density in Lower Mainland ... 10
Figure 7 Parks and Golf Courses ... 11
Figure 8 Regional Habitat Types ... 18
Figure 9 Habitat Connectivity Neighbourhood Analysis ... 21
Figure 10 CDC Red- and Blue-Listed Vertebrates and Invertebrates ... 27
Figure 11 CDC Red- and Blue-Listed Vascular Plants ... 28
Figure 12 Detailed Vegetation Classes ... 31
Figure 13 Locations of Watersheds Analyzed with CITYgreen ... 35
Figure 14 Habitat Reservoirs and Refuges in the Still Creek Region ... 40
Figure 15 Habitat Connectivity in the Still Creek Region ... 41
Figure 16 Relative Biodiversity in the Still Creek Region ... 43
Figure 17 Still Creek Watershed Relative Biodiversity, Parks and Golf Courses ... 51
Figure 18 Habitat Reservoirs, Refuges and Corridors in Relation to Parks and Golf Courses ... 52
Figure 19 CITYgreen Moderate Best Practices Scenario Target Areas ... 56
Figure 20 CITYgreen Optimal Best Practices Scenario Target Areas ... 57
Figure 21 Proposed Biodiversity Management Strategies for the Still Creek Integrated Watershed Management Plan ... 59
Figure 22 Beaver Creek / Central Park Tertiary Corridor from the City of Burnaby ... 60
Figure 23 Beecher Creek / Burrard Inlet Tertiary Corridor from the City of Burnaby ... 61
Figure 24 Overview of the Biodiversity Assessment and Spatial Framework for the Greater Vancouver Region ... 73
Figure A-1 Red-legged Frog Habitat Suitability ... 86
Figure A-2 Great Blue Heron Habitat Suitability (Breeding and Foraging) ... 87
Figure A-3 Cooper's Hawk Habitat Suitability ... 88
Figure A-4 Douglas' Squirrel Habitat Suitability ... 89
Figure A-5 Spotted Towhee Habitat Suitability ... 90
Figure A-6 Northern Harrier Habitat Suitability ... 91
Figure A-7 Pileated Woodpecker Habitat Suitability ... 92
Figure A-8 Brown Creeper Habitat Suitability ... 93
Figure A-9 Indicator Diversity ... 94
Figure C-1 Pacific Water Shrew Habitat Analysis ... 126

# Abbreviations

AXYS ........ AXYS Environmental Consulting Ltd.
BIEAP ........ Burrard Inlet Environmental Action Program
BTM ........ Baseline Thematic Mapping
CDC ........ Conservation Data Centre
CWS ........ Canadian Wildlife Service
DEM ........ Digital Elevation Model
FREMP ........ Fraser River Estuary Management Program
GIS ........ Geographic Information System
GVRD ........ Greater Vancouver Regional District
ISMP ........ Integrated Stormwater Management Plan
MSRM ........ Ministry of Sustainable Resource Management
MWLAP ........ Ministry of Water, Land and Air Protection
TIA ........ Total Impervious Area
TRIM ........ Terrain Resource Information Management

# 1 Introduction

## 1.1 Project Description

Biodiversity exists in all settings including non-urbanized, urban and rural areas. It is the variety of plants, animals and microorganisms, and the terrestrial, aquatic and marine ecosystems of which they are a part. Greater Vancouver's biodiversity includes, and is supported by, the network of natural areas, urban forests, riparian and foreshore areas, and public and private open spaces that provide vital functions, habitat and connectivity across the region. For example, the Fraser River Estuary and Burrard Inlet provide internationally significant habitat for salmon and migratory birds. The mountains and watersheds of the North Shore are important ecological reservoirs for many sensitive species and are used to collect clean drinking water. Agricultural lands throughout the region produce food for local and export markets and also provide habitat for wildlife. At the neighbourhood level, street trees, parks and even backyards contribute to a regional biodiversity network.

Collectively, these ecosystems and the complex plant and animal communities they support regulate our climate, clean our freshwater and atmosphere, maintain the water cycle, treat wastes, generate soils, pollinate crops and recycle nutrients while creating a magnificent setting and numerous recreational opportunities. Biodiversity also helps ecosystems adapt to unanticipated pressures such as climate change, pest infestations and flooding. Humans are part of the equation since biodiversity is a key characteristic of sustainability and is essential to the health and livability of the region.

The Still Creek Watershed Biodiversity Conservation Case Study is part of a larger project being undertaken by AXYS Environmental Consulting Ltd. (AXYS) that involves creating a spatial framework for conserving biodiversity in the Greater Vancouver Region. The framework integrates a variety of environmental data and associated attributes to create a series of maps that illustrate important habitat areas, and a regional biodiversity map that shows existing green spaces and corridors, biodiversity hot spots, and other areas that can be targeted for special management and conservation efforts. These maps will provide the management picture for preparing and implementing the Biodiversity Conservation Strategy for the Greater Vancouver Region.[1] As part of the development of this region-wide strategy, it is proposed that case studies be undertaken to demonstrate how biodiversity conservation planning can take place at the watershed and local scale. The Still Creek Project is a watershed-scale case study.

Still Creek was selected for the case study by the project partners because it is a highly urbanized watershed that includes, and is near to, some habitat reservoirs of regional importance. As well, an Integrated Stormwater Management Plan (ISMP) is being developed for this area. The ISMP and other studies have provided considerable baseline

[1] The Biodiversity Conservation Strategy is a joint project under the Georgia Basin Action Plan. Project partners include the Greater Vancouver Regional District (GVRD), Environment Canada (through the Georgia Basin Action Plan's Coordination Office and Canadian Wildlife Service (CWS), Province of British Columbia (Ministry of Water, Land and Air Protection (MWALP) and Ministry of Sustainable Resource Management (MSRM), and Burrard Inlet Environmental Action Program/Fraser River Estuary Management Program (BIEAP/FREMP) with input from GVRD municipalities, Simon Fraser University (Resources and Environmental Management), Douglas College Institute of Urban Ecology, Langley Environmental Partners' Society, and the Como Watershed Group.

information about the watershed. This project complements and builds on the work undertaken as part of the ISMP. The approach undertaken could be applied to other ISMPs which are to be prepared on all urban watersheds in the Greater Vancouver region as recommended through the GVRD Liquid and Waste Management Plan.

## 1.2 Project Goals

The goals of the Still Creek Watershed Biodiversity Conservation are:

- To evaluate the status of biodiversity in the Still Creek watershed and develop strategies for biodiversity conservation that build on the Still Creek Integrated Stormwater Management Plan (ISMP) currently being developed;
- To demonstrate how regional-level biodiversity information developed through the "Assessment of Regional Biodiversity and Development of a Spatial Framework for Biodiversity Conservation in the Greater Vancouver Region," AXYS, 2005, can inform biodiversity planning at the watershed-level;
- To test the applicability of CITYgreen[2] modeling, a tool to evaluate ecological services, as an aid to developing biodiversity conservation strategies in the watershed; and
- To develop a model approach to biodiversity conservation planning at a watershed level that may be applied to other watersheds in the region and elsewhere.

## 1.3 Document Overview

The Still Creek Case Study has been divided into a number of sections:

- Section 1 provides an overview of the Biodiversity Conservation Strategy and outlines how the goals of the Still Creek study apply.
- Section 2 describes the watershed and how it fits in the context of the Greater Vancouver Region.
- Section 3 provides an overview of the Still Creek ISMP.
- The fourth section describes the steps taken to complete the case study and outlines the methods specific to various analyses conducted to help assess the biodiversity of the watershed.
- Section 5 presents the current baseline state of the watershed by detailing the results of the various analyses including; habitat connectivity maps; identification of habitat reservoirs and refuges; biodiversity mapping; and the results of an analysis to quantify the economic benefits of tree cover.
- The sixth section reviews some of the issues and challenges affecting the Still Creek watershed in the context of the current baseline conditions.
- Section 7 presents a number of recommendations generated from the results of this study in conjunction with the goals, strategies and actions from the ISMP.

[2] CITYgreen is a computer model developed by American Forests (http://www.americanforests.org/resources/urban forests/analysis.php) that can be used with satellite-derived land cover data to evaluate ecosystem benefits provided by tree and vegetation coverage. The analysis examines stormwater infrastructure cost savings, water and air quality management and carbon storage values.

- Section 8 discusses how the Regional Biodiversity Conservation Strategy information can be applied to watershed planning.
- References for the project are provided in Section 9.

In addition to the sections described above, three appendices accompany the report:

- Appendix A - Indicator Species Habitat Maps;
- Appendix B – CITYgreen Analysis Results; and
- Appendix C – the City of Burnaby’s Pacific water shrew suitability mapping.

# 2 Study Area

## 2.1 Location and Description of the Still Creek Watershed

The Still Creek watershed (2,822 hectares) lies in the Greater Vancouver Regional District, in the municipalities of the City of Vancouver and City of Burnaby (Figure 1).

Still Creek rises in Central Park (Burnaby) and drains north and west through culverts and underground pipes to Renfrew Ravine in Vancouver. It then heads eastward back into Burnaby, flowing underground, through culverts and ditches, and through a semi-natural valley, to eventually drain into Burnaby Lake and subsequently to the Brunette River (Figure 2).

The major remaining tributaries are Beecher and Guichon creeks. Many smaller creeks (such as Chubb Creek) have been channelized, diverted or culverted, and other tributaries have been extensively piped and culverted.

Originally, this area was covered by rainforest, with extensive lowland swamps and marshes. These peat bogs and nutrient rich soils encouraged settlement by 19$^{th}$ century homesteaders, and the creek was gradually straightened, channelized and dredged. Further 'improvements' in the early 20$^{th}$ century resulted in additional excavations of the channel so that it could convey more water and control stormwater runoff (Coast River Environmental Services Ltd. 2004).

The watershed is now heavily urbanized with the predominant land uses being residential, commercial, and industrial (Figure 3). The current population (over 100,000 people) is expected to increase to 150,000 in the coming years. There are few remaining greenspaces, and the total impervious area is approaching 80%. In some areas, such as in the Grandview Boundary Industrial Area, total impervious area approaches 100%. This high level of imperviousness has considerable impacts on stream flow, water quality, and habitat suitability. Only 26% of the creek course has any remaining riparian forest cover, and only 4.6% of the stream length has riparian forest wider than 30 metres (Coast River Environmental Services Ltd. 2004). Figure 4 and 5 illustrate the results of the Ministry of Sustainable Resource Management's (MSRM) land cover mapping project. While the watershed is in close proximity to areas of green space (e.g., Deer and Burnaby lakes, Burnaby Mountain) the watershed itself is highly developed.

## 2.2 Regional Context

The Still Creek watershed is in and adjacent to the most heavily urbanized portion of BC's Lower Mainland (Figure 6).

**Figure 1 Still Creek Watershed Study Area Location**

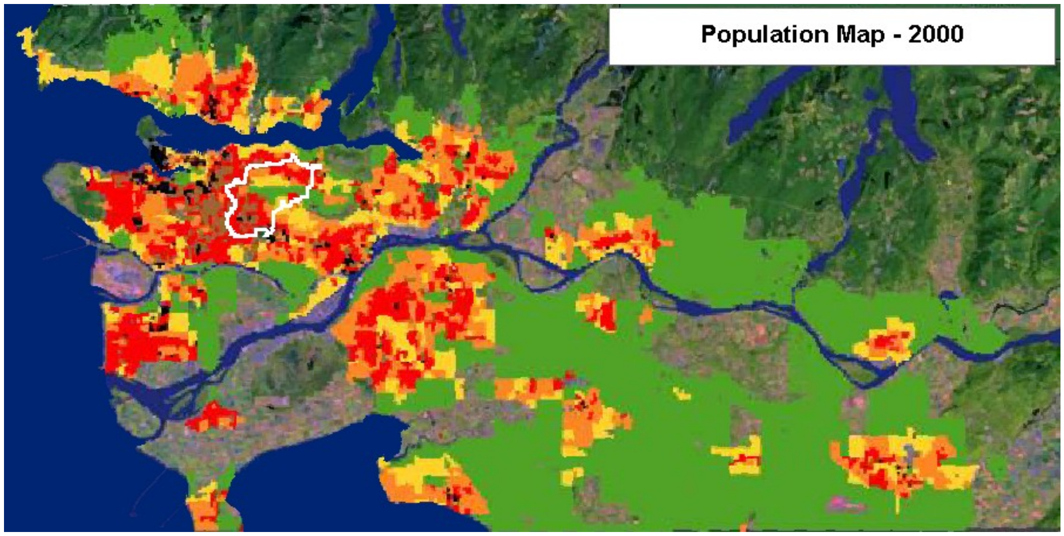
**Figure 2 Still Creek Watershed Detailed Study Area**

**Figure 3 Land Use (GVRD 2001)**

**Figure 4 Land Cover (MSRM 2002)**

**Figure 5 'Green' Land Cover (MSRM 2002)**

**Figure 6 Population Density in Lower Mainland**




(Note: Black and red represent the highest density populations, yellow and green are less densely populated.)
Source: Georgia Basin Action Plan 2004.

As mentioned previously, despite its urbanized status, Still Creek is located close to a number of significant greenspaces. The creek drains southeast into the Brunette River through Burnaby Lake, connecting to nearby parks such as Robert Burnaby Park and Burnaby Lake Park and out to the Fraser River. To the northeast of the watershed are greenspaces such as: Burnaby Mountain Golf Course; Burnaby Mountain Conservation Area (surrounding Simon Fraser University); and Burrard Inlet. Southwest of the watershed are Deer Lake, Central Park (part of which is in the watershed), Fraserview Golf Course, Everett Crowley Park, and the north arm of the Fraser River (Figure 7).

**Figure 7 Parks and Golf Courses**

# 3 Still Creek Integrated Stormwater Management Plan

## 3.1 Overview

There have been several studies of all or parts of the Still Creek watershed. Of particular interest to the development of a watershed biodiversity conservation strategy is the Still Creek Integrated Stormwater Management Plan (ISMP), which is currently being developed through a partnership of the GVRD, City of Vancouver and City of Burnaby.

The GVRD Liquid Waste Management Plan includes a policy that member municipalities will undertake integrated stormwater management planning on all urban watersheds in the region. This approach focuses on conducting land use planning in conjunction with stormwater management planning in order to protect environmental values while facilitating development. The ISMP recommendations should be integrated into other planning documents such as Official Community Plans and park plans.

The Still Creek ISMP includes five components:

- environment;
- recreation;
- water resources;
- drainage system modeling; and
- erosion and sediment control.

The environmental component of the Still Creek ISMP was developed by a project team that included representatives of the GVRD, the cities of Burnaby and Vancouver, environmental regulatory agencies, and stakeholders. Opportunity for public input is provided through a series of open houses.

Part of the development of the ISMP involves preparation of an Environment Support Document (Coast River Environmental Services Ltd. 2004). This document provided a review and summary of existing information on riparian and aquatic habitats in the Still Creek watershed; identification of critical or sensitive habitat types (with an emphasis on fish and fish habitat); a review and assessment of environmental concerns together with recommendations for environmental measures and strategies; and identification of opportunities for restoration and enhancement. Although the primary emphasis of this report is on the aquatic and riparian habitats and fish species, its recommendations address broader biodiversity issues across the watershed, recognizing that what happens in upland areas ultimately impact the creek and its tributaries.

The visions, goals, strategies and actions of the ISMP address the environmental health of Still Creek and its tributaries. Recommendations from the Still Creek case study are intended to complement and enhance the recommendations made in the ISMP that relate to biodiversity conservation.

## 3.2 Vision, Goals, and Strategies

The vision from the ISMP is:

> *To protect or enhance the integrity of the aquatic and terrestrial ecosystems and the human populations they support in an integrated manner that accommodates growth and development.*

The goals and related strategies from the draft ISMP to meet this vision are:

| | |
|---|---|
| **Goal 1:** | **Protect and enhance streamside and aquatic habitats** |
| Strategy 1-1: | Maintain continuous open-channel watercourses |
| Strategy 1-2: | Improve fish access and instream habitat quality for fish and wildlife |
| Strategy 1-3: | Provide continuous streamside vegetation to protect and enhance habitat for aquatic and terrestrial species |
| Strategy 1-4: | Encourage watershed stewardship |
| **Goal 2:** | **Protect and enhance forest and trees in watershed** |
| Strategy 2-1: | Maximize tree cover in watershed |
| **Goal 3:** | **Protect and improve water quality** |
| Strategy 3-1: | Prevent contaminants from entering watercourses or stormdrains |
| Strategy 3-2: | Treat stormwater before it enters watercourses |
| Strategy 3-3: | Monitor water quality and respond to results |
| **Goal 4:** | **Maintain and increase native species biodiversity** |
| Strategy 4-1: | Protect and restore habitat reservoirs and patches |
| Strategy 4-2: | Link habitat reservoirs |
| Strategy 4-3: | Improve habitat quality and complexity for wildlife |
| Strategy 4-4: | Promote native vegetation and control of non-native species |

# 4 Project Methodology

Development of a biodiversity conservation strategy for the Still Creek Watershed was based on the following:

- a review of existing studies including current information on the Still Creek ISMP;
- the integration of input received during the Still Creek Watershed Biodiversity Conservation Case Study workshop (held February 2004);
- refinement of the MSRM land cover dataset;
- development of a detailed vegetation map derived from air photos;
- the development of habitat maps for indicator species;
- the creation of a biodiversity map that shows regionally significant ecosystems;
- the development of a habitat connectivity map;
- the results of an urban ecosystem analysis using a model called CITYgreen; and
- the integration of input received from the Biodiversity Conservation Strategy Working Group.

## 4.1 Review of Existing Studies

The Still Creek watershed has been the subject of numerous studies, which have provided a large amount of baseline data. The project team reviewed a variety of sources of information relating to the Still Creek watershed and its regional context, including:

- Integrated Stormwater Management Plan: Still Creek Watershed. Volume 3: Environment Support Document (Coast River Environmental Services Ltd. 2004).
- Brunette Basin Watershed Plan (Brunette Basin Task Group 2001).
- Biological Inventory of Still Creek, Burnaby (Sampson and Watson 2004).
- Study of Native Vegetation in Renfrew Ravine (Blaney et al 2001).
- Livable Region Strategic Plan and 2002 Annual Report (Greater Vancouver Regional District 1996, 2002).
- Greater Vancouver Regional Greenway Vision (Greater Vancouver Regional District 1999).
- Burnaby Lake Rejuvenation Project: Vegetation and Wildlife Assessment (Robertson et al. 2002).
- Official Community Plans and neighbourhood/local area plans for the Still Creek watershed from the City of Vancouver and City of Burnaby.

## 4.2 Still Creek Watershed Biodiversity Conservation Case Study Workshop

As part of the development of the case study, a one-day workshop was held at the Burnaby Lake Sports Complex in Burnaby in February 2004 as a means of bringing together a range of interested and knowledgeable individuals to exchange information and ideas on creating a biodiversity conservation strategy for the watershed. Workshop participants included representatives of local, regional, and senior governments, streamkeeper groups, academic interests, and local residents.

The following activities were undertaken during the workshop:

- a review of existing environmental data and preliminary habitat mapping for the region and a discussion concerning their applicability to the watershed;
- a review of the preliminary results of the CITYgreen analysis (CITYgreen is a tool to analyze the benefits of the urban forests with regards to the affects of stormwater runoff, water quality, air quality and carbon storage and sequestration.);
- a discussion of issues and challenges regarding biodiversity conservation in the watershed;
- a discussion of appropriate biodiversity conservation objectives that could be integrated into the ISMP for Still Creek;
- the selection of suitable indicator species for mapping important habitat and ecosystems, and for monitoring biodiversity conservation efforts in both the Still Creek watershed and the GVRD;
- a discussion of the development of appropriate rules for mapping habitat for each indicator species at both the watershed and regional level;
- the identification of opportunities for developing habitat connectivity; and
- a discussion of actions and strategies that could be used to achieve biodiversity conservation objectives.

The input received during the Still Creek workshop is reflected throughout this document. A full workshop report (AXYS and Cullington 2004), and list of participants is available from the GVRD Policy and Planning Department and on the project website at http://www.gvrd.bc.ca/growth/biodversity.htm.

## 4.3 Refined Land Cover

MSRM's land cover dataset, derived from 15 metre satellite imagery, was used as the base for identifying regional scale habitat types. This was done by incorporating information from various ancillary datasets (e.g., the 2001 GVRD land use coverage, Baseline Thematic Mapping, roads) to derive a more ecologically relevant classification. For example: forest pixels falling in an urban land use (e.g., residential) were assigned to the class 'urban trees'; grass in a residential land use was assigned to the class 'lawns and gardens', whereas grass in an agricultural land use was identified as 'cropland'. Full details on the classification scheme are provided in an associated report: *Assessment of Regional Biodiversity and Development of a Spatial Framework for Biodiversity Conservation in the Greater Vancouver Region*.

It should be noted that the maps derived from the land cover data within this printed report do not reflect the full resolution of the data due to the limitations of paper size and differences between print devices. When the digital coverages are used within a GIS, specific areas can be viewed in much greater detail by 'zooming in' on an area of interest. Large format maps of the regional biodiversity analyses are also available through the GVRD Policy and Planning Department.

## 4.4 Detailed Vegetation Mapping

Detailed vegetation mapping to augment the regional scale land cover was conducted to refine the habitat types used in the connectivity analysis (see Section 5.5.2). In addition, the detailed vegetation mapping provides current baseline information. Areas of contiguous, vegetation, representing suitable habitat availability, were delineated from 2002 air photos. The approximately 560 hectares of vegetated land within the watershed were mapped, representing approximately 20% of the watershed. The vegetation classification was based on land use and vegetation types with additional modifiers to further describe age, size, structure and species composition of the vegetation. The vegetation mapping includes approximately 1000 polygons of a variety of natural and anthropogenic land use and vegetation types. The full report is available through GVRD Policy and Planning.

The detailed vegetation mapping was derived from air photo interpretation. Attributes assigned to each polygon included land use, vegetation class, age and size, structure, and, where possible, species. In comparison, the regional land cover provides information on land use and a more generalized vegetation class. For example, at the regional scale an area would be identified as coniferous forest, whereas the detailed dataset would store the following information for the location – conifer, mature, closed, Douglas fir. Table 1 provides a comparison of how the different mapping scales could be applied to municipal and or regional applications.

**Table 1 Regional and Detailed Vegetation Mapping Comparison**

| | Regional Scale | Detailed Mapping |
|---|---|---|
| **Applications** | • Watershed assessments<br>• Regional planning<br>• Habitat connectivity<br>• Habitat patch size<br>• ISMP (e.g., identification of core habitats)<br>• Species at risk assessment (e.g., Pacific water shrew)<br>• Wildlife habitat mapping | • Local area planning<br>• Site planning<br>• Identification of sensitive vegetation and habitats<br>• Management and identification of invasive species<br>• Species at risk assessment (e.g., Pacific water shrew)<br>• Wildlife habitat mapping |
| **Methods** | Interpretation of satellite imagery (e.g., Landsat) with verification from air photos and/or field visits. | Interpretation of orthophotos (stereo pairs) with verification from field visits. |
| **GIS Product** | Raster (grid) product with cell size being a function of the source imagery (e.g., Landsat imagery would typically result in a 15-25 metre cell size). | Polygonal coverage |
| **Area/Cost Comparison Based on $25,000*** | 350,000 to 400,000 hectares<br>Note that the 2002 land cover dataset is currently available at no charge for all municipalities in the GVRD. | ~ 5,000 hectares |

* The cost estimates provided are for comparison purposes and are only approximate estimates. Costs will vary based on the diversity of vegetation types, data costs and the amount of field verification. There are also economies of scale associated with vegetation mapping particularly related to satellite image interpretation. Costs have been provided to give the reader an idea of the amount of area that could be mapped for a given amount.

The decision to develop a detailed vegetation coverage should be evaluated based on the goals of the project or application. Obviously, detailed mapping is significantly more expensive than mapping conducted at the regional scale, however, if detailed species and structural stage information is required going to this level of detail will be required. In practical application a reasonable approach would be to identify key areas of concern using the regional scale information and, if more detailed or recent data were required for these areas, then conduct detailed mapping for these 'hotspots'.

## 4.5 Regional Biodiversity Mapping

Subsequent to the development of the refined land cover dataset, an assessment was undertaken to map relative biodiversity at a regional landscape level. This biodiversity mapping consisted of the following components:

- assigning each land cover pixel a habitat type;
- ranking the habitat types through a pairwise comparison;
- identifying habitat 'reservoirs and refuges' by conducting a patch size analysis to identify areas of contiguous habitat; and
- integration of these components to develop a relative biodiversity map for the region.

The methodology for this mapping is discussed below.

### 4.5.1 Habitat Types

The refined land cover classification was reclassified into different major habitat types:

- agriculture;
- fresh water (includes lakes and rivers);
- intertidal;
- ocean;
- old forest;
- young forest;
- open space/ meadow;
- shrub;
- wetland; and
- urban vegetated.

In addition, the single line streams present in the TRIM dataset were buffered by 30 metres to identify stream corridors and combined with a 30 metre buffer of all polygonal freshwater features (lakes, rivers and wetlands) to generate a potential riparian habitat type. The resulting coverage identified potential habitats throughout the region (Figure 8).

## Figure 8 Regional Habitat Types

### 4.5.2 Habitat Rankings

A workshop was held with the project Steering Group members during which the various habitat types were rated in terms of their relative biodiversity value using professional judgment through a pairwise comparison. The pairwise comparison simplifies the rating process as only two habitat types are compared at a time. A mathematical formula is then applied to normalize the relative ratings for each habitat type. The final weighting values are presented in Table 2. These weightings were applied to the habitat type coverage to generate weighted habitat types for the region. While this approach relies on professional opinion, results were largely consistent with a trial run and it is useful for broad classification of the relative biodiversity value of different habitats.

**Table 2 Habitat Type Ratings**

| Habitat Type | Pairwise Weighting Value |
|---|---|
| Old Forest | 0.224 |
| Intertidal | 0.224 |
| Wetland | 0.224 |
| Lake/River/Potential Riparian | 0.133 |
| Ocean | 0.133 |
| Young Forest | 0.072 |
| Shrub | 0.049 |
| Agricultural | 0.033 |
| Urban Vegetated | 0.022 |
| Open Space (e.g., school yards, playing fields, airport lands) | 0.016 |

### 4.5.3 Habitat Patch Size

A patch size analysis was conducted on the habitat coverage to identify areas of contiguous habitat. In other words, to map portions of the landscape that have not been fragmented by human disturbance (i.e., roads, urban development). The patch analysis was not differentiated by habitat type. If a pixel was classified as potential habitat (e.g., it was attributed with a habitat type) it, and its adjacent habitat pixels, were designated as a patch. Areas of contiguous (unfragmented) habitat identified through the patch analysis were classified based on their area attribute to identify habitat refuges and habitat reservoirs.

A habitat refuge is defined as a small patch of habitat that provides food, shelter and/or other needs for wildlife. It may include human-modified ecosystems. They are not generally large enough to maintain the genetic diversity of a population. A habitat reservoir is a large area of relatively natural habitat that has sufficient size and ecological integrity to support a range of native species, including species that need interior habitats. The size of habitat reservoir depends on the species being managed for (MWLAP 2004).

Based on the characteristics of the Greater Vancouver Region, existing literature (Adams and Dove, 1994; CWS 2000) and personal communications (Val Schaefer Douglas College Institute of Urban Ecology, and Biodiversity Strategy Steering Committee members), the following refuges and reservoir categories were developed for the region:

- major habitat reservoir - patch size >200 ha

- habitat reservoir - patch size = 30-200 ha
- major habitat refuge - patch size = 20-30 ha
- habitat refuge - patch size = 2-20 ha

### 4.5.4 Biodiversity

The biodiversity map represents a composite of the weighted habitat layers and the habitat reservoirs and refuges coverage. The weighted habitats are modified by patch size to refine the classification (Table 3).

**Table 3 Habitat Patch Size Modifiers**

| Patch class | Area (ha) | Patch Size Weighting |
|---|---|---|
| Urban (not habitat) | | 0 |
| Small patch | 0 - 2 | 0.2 |
| Habitat refuge | 2 - 20 | 0.5 |
| Major habitat refuge | 20 - 30 | 0.8 |
| Habitat reservoir | 30 - 200 | 0.9 |
| Major habitat reservoir | >200 | 1.0 |

Larger patches of habitat received a higher relative biodiversity value than smaller patches based on the following formula:

**Weighted Habitat Value x Patch Size Weighting = Relative Biodiversity**

The following three examples illustrate how the relative biodiversity values are calculated for different habitat types with varying patch sizes:

1. A 250 hectare patch of Old Forest habitat
   Weighted Habitat Value (Old Forest) = 0.224
   Patch Size Weighting (Major habitat reservoir) = 1.0
   ***Relative Biodiversity = 0.224 x 1.0 = 0.224***

2. A 13 hectare patch of Old Forest habitat
   Weighted Habitat Value (Old Forest) = 0.224
   Patch Size Weighting (Habitat refuge) = 0.5
   ***Relative Biodiversity = 0.224 x 0.5 = 0.112***

3. A 22 hectare patch of Agricultural habitat
   Weighted Habitat Value (Agriculture) = 0.033
   Patch Size Weighting (Major habitat reservoir) = 0.8
   ***Relative Biodiversity = 0.033 x 0.8 = 0.026***

## 4.6 Habitat Connectivity

Habitat connectivity is a qualitative term describing the degree to which natural ecosystems are linked to one another to form an interconnected network. The degree of interconnectedness and the characteristics of the linkages vary in natural landscapes based on topography and natural disturbance regime. Breaking of these linkages results in ecosystem fragmentation (MWLAP 2004) and thus potentially reduces the biodiversity of a region. To model the connectivity of habitat within the Greater Vancouver Region a GIS neighbourhood analysis was conducted to quantify the amount and quality of habitat within 500 metres of each pixel. The result was used as a measurement of habitat connectivity. Pixels surrounded by other pixels with high habitat ratings received a higher relative score than those not adjacent to high habitats (Figure 9).

**Figure 9 Habitat Connectivity Neighbourhood Analysis**

**High connectivity**

| | | |
|---|---|---|
| 2 | 3 | 4 |
| 2 | 27 | 4 |
| 3 | 5 | 4 |

**Low connectivity**

| | | |
|---|---|---|
| 1 | 1 | 2 |
| 0 | 4 | 0 |
| 0 | 0 | 0 |

## 4.7 CITYgreen Analysis

CITYgreen is a software package developed by American Forests. The software is an extension to ESRI's ArcMap GIS package and therefore requires ArcMap to function. The application uses land cover information to model the environmental and economic benefits tree canopy provides within a defined area. The results inform land use decision making by providing quantitative information concerning how much treed and other green land covers are worth in terms of their ability to both provide increased health and well being for urban residents and reduce municipal infrastructure costs. The software assesses how urban forest cover impacts: stormwater runoff; water quality; air quality; and carbon storage and sequestration.

CITYgreen is a modeling tool that allows existing land covers to be summarized for a given area. It allows a community or municipality to identify what their existing tree canopy cover is and model alternative development scenarios enabling tree canopy targets to be developed to help meet environmental and quality of life goals. Once these goals have been established policies and budgets can be put in place.

CITYgreen is capable of developing two levels of analysis based on the type of land cover data available:

1. Regional Ecosystem Analysis – Uses land cover data that has been derived from small scale satellite imagery (i.e. Landsat Imagery). The scale of analysis that would typically be used at the city or watershed level.
2. Green Layer Analysis – Uses land cover data that has been derived from large scale imagery (i.e. high-resolution imagery or orthophotos). The area that would typically be used is the city block or community level.

The Still Creek Watershed was assessed at the Regional Ecosystem scale using the Landsat-derived land cover dataset developed by MSRM. Two time periods, both at the same scale, were analyzed to allow trends to be identified. The analysis was performed on the 1986 and 2002 land cover classifications for the watershed.

CITYgreen models four parameters within any particular analysis scenario. All four models have specific data input needs that can either be derived from the datasets supplied with the software or from user supplied datasets. The four models and input requirements are as follows:

**1. Stormwater Runoff Reduction**

As outlined in the CITYgreen software manual (American Forests 2004), the CITYgreen stormwater runoff analysis allows a user to map urban land cover features (e.g., grassland, trees, buildings and impervious surfaces) and determine the percentages of each land cover feature. Land cover percentages are then combined with average precipitation data, rainfall distribution information, percent slope, and hydrologic soil group, to estimate how trees affect runoff volume, time of concentration, and peak flow. In addition, the program estimates the additional volume of water, in cubic feet, that would have to be managed if trees were removed when comparing two scenarios (current conditions versus no vegetation). This volume estimate is associated with an economic estimate that reflects the cost per cubic foot to build a retention pond to manage the runoff. The software also enables different land cover and precipitation scenarios to be modeled to determine acceptable development or conservation practices. The stormwater runoff analysis is not intended to be used to design stormwater management facilities, culverts or ditches but rather, to estimate the effects of vegetation, particularly trees, on runoff volume and peak flow.

<u>Data required for analysis:</u>

- Land cover

<u>Values acquired from data within CITYgreen and/or user definable:</u>

- Slope (derived from the TRIM digital elevation model [DEM])
- Hydrologic soil group (very pervious, somewhat pervious, somewhat impervious and very impervious). The defaults values for a ‘somewhat impervious’ watershed were selected for Still Creek
- 2-year / 24-hour rainfall information (entered based on Environment Canada’s precipitation records for the closet weather station - Burnaby Mountain)
- Rainfall distribution type (the Pacific Northwest was selected to represent the Vancouver region from a U.S. Rainfall Distribution map included with CITYgreen)

**2. Water Quality**

As per the CITYgreen manual (American Forests 2004), the water quality model calculates the effect of land cover on the amount of pollutants and suspended solids in surface water runoff. The model is based on a storm event calculation to determine how land cover affects the runoff from a typical 2 year, 24-hour storm. The model uses a curve numbering system: modeled pollutant loadings are matched to the closest of a number of curve numbers stored within CITYgreen. The effect of land cover type on the Event Mean Concentrations (concentration of pollutants in runoff during a typical storm event) is determined for the following pollutants:

- Nitrogen

- Phosphorus
- Suspended solids
- Zinc
- Lead
- Copper
- Cadmium
- Chromium
- Chemical Oxygen Demand (COD)
- Biological Oxygen Demand (BOD)

Data required for analysis:

- Land cover

Values acquired from data within CITYgreen and/or user definable:

- Slope (from the TRIM DEM)
- 2-year / 24-hour rainfall information (from Environment Canada precipitation records for the Still Creek area)

**3. Air Quality**

CITYgreen estimates the amount of pollution being deposited within a given area based on pollution data from the nearest city (or alternatively a user selected city from a list of 55 US cities with available pollution removal rates that have been incorporated into the CITYgreen software) and then estimates the annual air pollution removal rate based on the area of tree and/or forest canopy. The analysis considers the following pollutants:

- Nitrogen dioxide
- Sulfur dioxide
- Ozone
- Carbon monoxide
- Particulate matter less than 10 microns

To determine the dollar value associated with these pollutants, economists calculate the indirect costs borne by society for rising health care expenditures and reduced tourism revenue. The Public Services Commission in each state sets the actual indirect costs for various air pollutants. As Seattle was selected to represent the Vancouver region, the values reported are based on Washington State cost estimates. The air pollution estimates generated from CITYgreen are designed for urban and suburban forests, as a result, analyses run on rural areas may over estimate the benefits of tree cover.

Data required for analysis:

- Land cover

Values acquired from data within CITYgreen and/or user definable:

- Seattle was selected from the list of available cities as it was thought to most closely represent the Vancouver region

**4. Carbon Storage and Sequestration**

As per the CITYgreen manual (American Forests 2004), the carbon module quantifies the role of urban forests in removing atmospheric carbon dioxide and storing carbon. The model multiplies a per unit value of carbon storage by the area of canopy coverage to estimate annual sequestration (the rate carbon is removed) and the current storage in existing trees.

Data required for analysis:

- Land cover

CITYgreen requires the land cover data is assigned to its own classification scheme. As a result, the MSRM land cover information had to be re-classified prior to running any of the CITYgreen analyses. Table 4 details the original land cover classes for both the 1986 and 2002 data with the corresponding CITYgreen land cover assignment.

### Table 4 CITYgreen Land Cover Reclassification

| 1986 / 2002 Land Cover | CITYgreen Land Cover |
|---|---|
| Broadleaf | Trees |
| Coniferous Mixed | Trees |
| Grass Herb | Open Space – Grass/Scattered Trees |
| Highly Reflective | Urban |
| Shadow | Unclassified |
| Shrub | Shrub |
| Soil | Cropland: Fallow |
| Urban Dense | Urban: Commercial/Business |
| Urban Mixed | Urban: Residential |
| Urban Shadow | Urban |
| Water | Water |

## 4.8 Input from Biodiversity Conservation Strategy Working Group

Throughout the project, guidance was provided by the Biodiversity Conservation Strategy steering committee and working group. The project team made several presentations to keep the working group apprised of progress, and the working group provided comments on various draft materials.

# 5 Current Status of Biodiversity in Still Creek Watershed

## 5.1 Limitations to Current Knowledge

Our ability to effectively conserve biodiversity is constrained by a number of things. Perhaps most importantly we lack an adequate understanding about what biodiversity is and all that it encompasses. We have some knowledge of what species and ecosystems we need to consider, but our awareness and understanding of more complex biodiversity components, such as genetic variability and ecosystem processes, is very limited. We can, therefore, only really discuss biodiversity in terms of vertebrates, plants, and ecosystems. Even here though, our understanding of species-specific habitat use and requirements is restricted. Information for many local species or species groups such as macro-invertebrates, small mammals, and migratory birds is currently very limited. All of these factors constrain our ability to conduct biodiversity assessments and develop comprehensive conservation initiatives. How we measure biodiversity can also be debated. Do we assess it in terms of number of species; types of species; amount of biomass; or all of these? While the problem may appear daunting due to the complexity of so many interrelated factors, a common sense assumption provides a reasonable solution: if we conserve a diversity of habitats, adequate sizes of each type, and ensure habitats are connected and ecosystem functions are maintained, we will be able to maintain our existing biodiversity.

Towards the goal of quantifying the existing conditions in the Still Creek Watershed, AXYS assembled data from a variety of sources and mapped the known information. The results are presented in the following sections.

## 5.2 Species and Ecosystems

### 5.2.1 Native Species and Ecosystems

Two native fish species are still present in Still Creek: cutthroat trout, threespine stickleback. Chum and coho salmon are apparently extirpated. In streams such as Beecher, Guichon and Crabapple creeks, coho, cutthroat, peamouth chub, threespine stickleback have been recorded (Coast River Environmental Services Ltd. 2004). Appendix A provides a list of other species which includes a variety of birds, mammals, herptiles and insects that may potentially be found in the watershed based on an analysis using indicator species.

### 5.2.2 Species at Risk

The Conservation Data Centre (CDC) tracks species at risk to facilitate their management and protection. Species are rated as either red-listed (indigenous species, subspecies and natural plant communities that are extirpated, endangered or threatened) or blue-listed (indigenous species, subspecies and natural plant communities of special concern). The CDC records show that a total of 15 red- and blue-listed vertebrate species, eight invertebrate species and 40 vascular plant species have been recorded in the GVRD; however, none of these records occur within the Still Creek watershed (CDC 2004). Five blue-listed species – one vertebrate, one invertebrate (Figure 10), and three vascular plants (Figure 11) - have been located at sites near the watershed (Table 5). Local naturalist groups (e.g., the Still Creek Streamkeeper's) have also reported numerous plant and wildlife species including a number which are relatively rare.

**Figure 10 CDC Red- and Blue-Listed Vertebrates and Invertebrates**

**Figure 11 CDC Red- and Blue-Listed Vascular Plants**

**Table 5 Red- and Blue-listed Species Recorded Near the Still Creek Watershed (CDC 2004)**

| | Species | Status | Location | Records |
|---|---|---|---|---|
| **Vertebrates** | Brassy minnow (Hybognathus hankinsoni) | Blue-listed | Deer Lake | One record from 1956 |
| | | | Burnaby Lake | Five records; last recorded in 1959 |
| **Invertebrates** | Blue dasher (dragonfly) (Pachydiplax longipennis) | Blue-listed | Trout Lake | One record from 1996 |
| | | | Burnaby Lake | Five records from 1992 to 1996 |
| **Vascular Plants** | False-pimpernel (Lindernia dubia var. anagallidea) | Blue-listed | Burnaby Lake | Variable population of 20-30 plants recorded between 1983 and 1999 |
| | Large Canadian St. John's-wort (Hypericum majus) | Blue-listed | Burnaby Lake | 40 plants recorded in 1994 |
| | Rice cutgrass (Leersia oryzoides) | Blue-listed | Trout Lake | Recorded in 1991 |

Other sources have reported the following species of concern as occurring within the Still Creek watershed (Coast River Environmental Services Ltd. 2004; Sampson and Watson 2004):

- cutthroat trout (*Oncorhynchus clarki clarki*) blue-listed
- Great Blue Heron (*Ardea heordias fannini*) blue-listed
- Double-crested Cormorant (*Phalacrocorax auritus*) red-listed

Other red- and blue-listed species which may occur in the watershed include (BC Species and Ecosystem Explorer 2004):

- Pacific water shrew (*Sorex bendirii*) red-listed
- common woodnymph (*Cercyonis pegala incana*) (butterfly) blue-listed
- propertius duskywing (*Erynnis propertius*) (butterfly) blue-listed
- great arctic (*Oeneis nevadensis*) (butterfly) blue-listed
- Nez Perce Dancer (*Argia emma*) (dragonfly) blue-listed
- yellow-legged meadowhawk (*Sympetrum vicinum*) (dragonfly) blue-listed

Additionally, Robertson et al. (2002) recorded the following species of concern near the watershed at Burnaby Lake:

- Red-legged frog (*Rana aurora*) blue-listed
- Painted turtle (*Chrysemys picta)* blue-listed
- Western pond turtle (*Clemmys marmorata*) red-listed
- Western Grebe (*Aechomophorus occidentalis*) red-listed

- American Bittern (*Botaurus lentiginosus*) blue-listed
- Green Heron (*Butorides virescens*) blue-listed
- Short-billed Dowitcher (*Limnodromus griseus*) blue-listed
- Peregrine Falcon (*Falco peregrinus anatum*) red-listed
- Band-tailed Pigeon (*Columba fasciata*) blue-listed
- Barn Owl (*Tyto alba*) blue-listed
- Short-eared Owl (*Asio flammeus*) blue-listed
- Purple Martin (*Progne subis*) red-listed

### 5.2.3 Remnant Ecosystems

The largest remaining areas of intact ecosystems within the Still Creek watershed include the northern portion of Central Park, and the northwestern portion of Burnaby Lake Park. Smaller patches of remnant ecosystems exist in Renfrew Park, Renfrew Ravine Park, Broadview Park, Discovery Place, Beecher Creek and Beecher Park, Kensington Park, and Halifax Park (Figure 5).

Only 26% of the native riparian forest along Still Creek remains intact, and only 5% of the creek course has a riparian buffer wider than 30 m (Coast River Environmental Services Ltd. 2004). This loss of the riparian buffer and the amount of existing urban development has fragmented and limited the extent of natural green corridors within the watershed. Small sections of remnant ecosystems which could function somewhat as green corridors are located along Renfrew Ravine, and Beecher and Still creeks.

## 5.3 Detailed Vegetation Mapping

Detailed vegetation mapping was conducted for 560 hectares of vegetated land within the Still Creek watershed (Figure 12) (approximately 20% of the watershed) (AXYS 2004). Two land use categories—anthropogenic and natural—were used for mapping vegetation. The anthropogenic land use category included areas of vegetation adjacent to transportation corridors, and residential, industrial, recreational, and institutional sites. The natural land use category included forests, swamps, marshes, and riparian zones; however, some riparian zones were included in the anthropogenic land use category because they had been modified from their original states into linear drainage ditches and canals. In some cases, combinations of two vegetation types have been used to further describe the vegetation class. In these instances, the first vegetation type represents the dominant class, while the second represents the secondary vegetation.

The results of the detailed vegetation mapping indicate that the majority of the mapped area is made up of maintained grass, grass and shrub, and tree and grass complexes, representing anthropogenically altered land use types (Table 6). However, a significant portion of the study area was covered by natural deciduous forests and shrub communities, represented by forested, riparian, and swamp land use types, respectively.

## Figure 12 Detailed Vegetation Classes

## Table 6 Vegetation Types in Hectares

| Vegetation Type | Area in Hectares |
|---|---|
| conifer | 10.4 |
| conifer and deciduous | 0.4 |
| conifer and shrub | 0.7 |
| deciduous | 104.1 |
| deciduous and conifer | 2.6 |
| grass | 107.8 |
| grass and shrub | 128.1 |
| grass and soil | 0.3 |
| grass and tree | 67.6 |
| herb and shrub | 1.1 |
| shrub | 60.4 |
| shrub and grass | 2.3 |
| shrub and soil | 2.4 |
| shrub and tree | 35.5 |
| soil | 2.9 |
| tree and grass | 1.7 |
| tree and shrub | 4.2 |

Approximately 70% of the vegetation mapped was associated with anthropogenic land uses and was made up of native and non-native grasses, shrubs, and trees found in sites ranging from disturbed areas in industrial zones to manicured or (maintained) areas near residential and recreational structures (AXYS 2004). Table 7 shows the predominant vegetation classes associated with each land use type in the anthropogenic category.

**Table 7 Predominant Vegetation Classes Associated with Anthropogenic Land Use Types (AXYS 2004).**

| Land Use Type | Predominant Vegetation Class | % Cover of Vegetation Class |
|---|---|---|
| Cemetery | Grass | 100% |
| Golf course | Grass and tree | 100% |
| Industrial | Shrub | 80% |
| Institutional | Grass | 84% |
| Recreational | Grass | 61% |
| Residential | Grass and shrub | 84% |
| Transportation corridor | Shrub | 48% |

The remaining 30% of the area mapped was comprised of vegetation associated with natural land uses. Within this category, forested areas were vegetated primarily with deciduous trees, namely alder and cottonwood, but they also contained significant proportions of big leaf maple and paper birch. Riparian areas were vegetated mainly with alder, cottonwood, and hardhack (AXYS 2004). Table 8 shows the predominant vegetation classes associated with each natural land use type.

**Table 8 Predominant Vegetation Classes Associated with Natural Land Use Types (AXYS 2004)**

| Land Use Type | Predominant Vegetation Class | % Cover of Vegetation Class |
|---|---|---|
| Forest | Deciduous tree | 87% |
| Marsh | Herb and shrub | 100% |
| Riparian | Deciduous tree | 73% |
| Swamp | Shrub and tree | 75% |

Central Park contains a mature stand of Douglas-fir, representing the majority of coniferous forest cover found within the watershed. Burnaby Lake Park, the other main forested area in the watershed, includes a diverse number of vegetation types, including hardhack swamps, birch forests, and mixed alder-cottonwood stands (AXYS 2004).

## 5.4 CITYgreen Analysis

The results of the CITYgreen analysis are presented in Appendix B. The tables presented below summarize differences between the 1986 and 2002 time periods and provide 2002 results for a suburban (Hyland Creek) and greenfield (McIntyre-Denier) for comparative purposes (Figure 13). An associated report: An Assessment of Regional Biodiversity and Development of a Spatial Framework for Biodiversity Conservation in the Greater Vancouver Region, expands the analysis to include six watersheds with different land uses in the region for comparative purposes. It should be noted that the currency values in the tables have been converted to Canadian dollars using a $1.20 conversion factor. The results presented in the appendix are in US funds.

### 5.4.1 Land Cover

American Forests has developed Urban Tree Canopy goals for metropolitan areas (Table 9). The recommendations come from 20 years of analysis interpretation of tree coverage (American Forests web site).

**Table 9 American Forests Tree Canopy Goals**

| CITYgreen Land Uses | Metropolitan Areas East of the Mississippi and the Pacific Northwest | Metropolitan Areas in the Southwest and dry West |
|---|---|---|
| Average tree cover counting all zones | 40% | 25% |
| Suburban residential zones (low density residential) | 50% | 35% |
| Urban residential zones (high density residential) | 25% | 18% |
| Central business districts | 15% | 9% |

**Figure 13 Locations of Watersheds Analyzed with CITYgreen**

Table 10 presents a summary of land cover for the three different watersheds that have been provided for comparative purposes:

- The Still Creek watershed is an urban watershed being predominantly residential (40.4%) and urban (39.4%), with urban vegetated habitats (10.3%), open space (4.7%) and young forest (3.7%) making up the majority of the remainder.
- The McIntyre-Denier watershed is classified as a 'greenfield' watershed, consisting predominantly of young (69.1%) and old (25.1%) forest.
- Hyland Creek is a suburban watershed with 25.7% tree canopy.

In addition to the temporal comparison, CITYgreen analyses have been generated for each of the three watershed types (for the 2002 scenario) to put the Still Creek land cover and analysis results in context.

**Table 10 Still Creek, McIntyre-Denier and Hyland Creek Watersheds Habitat Types Summary**

| | Still Creek (2002) | | McIntyre-Denier (2002) | | Hyland Creek (2002) | |
|---|---|---|---|---|---|---|
| **Habitat type** | **Area** | **% of Total** | **Area** | **% of Total** | **Area** | **% of Total** |
| Agriculture | 0.0 | 0.0% | 0.0 | 0.0% | 131.6 | 9.4% |
| Fresh water | 0.0 | 0.0% | 0.6 | 0.1% | 0.0 | 0.0% |
| Intertidal | 0.0 | 0.0% | 0.0 | 0.0% | 0.0 | 0.0% |
| Ocean | 0.0 | 0.0% | 0.1 | 0.0% | 0.0 | 0.0% |
| Old forest | 0.0 | 0.0% | 168.9 | 25.1% | 0.0 | 0.0% |
| Open space | 132.1 | 4.7% | 4.6 | 0.7% | 90.5 | 6.5% |
| Residential | 1,146.6 | 40.4% | 0.0 | 0.0% | 395.4 | 28.2% |
| Shrub | 44.4 | 1.6% | 2.2 | 0.3% | 49.4 | 3.5% |
| Urban | 1,117.4 | 39.4% | 10.8 | 1.6% | 314.7 | 22.5% |
| Urban vegetated | 291.4 | 10.3% | 21.3 | 3.2% | 215.7 | 15.4% |
| Young forest | 105.3 | 3.7% | 465.1 | 69.0% | 202.7 | 14.5% |
| **TOTAL AREA** | **2,837.2** | **100.0%** | **673.6** | **100.0%** | **1,399.9** | **100.0%** |

Table 11 summarizes changes in total impervious surface and tree cover over the seventeen year time period between 1986 and 2002. The results reflect the heavily urbanized nature of the Still Creek watershed and indicate minimal change in either variable (total impermeable surface is up by 0.4% and tree cover is down by 0.1%). Based on the habitat type summary for the Still Creek watershed and using the American Forests' tree canopy goals of 15% for central business districts and 25% for urban residential zones the 'average' tree canopy goal for the watershed has been set at 20% (representing the average of the two targets because of the relatively even distribution of urban and residential habitats). To meet an objective of 20% the tree canopy of the watershed would have to increase by roughly 8.2% from the 2002 value of 11.8% (Table 11).

**Table 11 CITYgreen Analysis - Land Cover Change 1986 to 2002**

| | Still Creek (1986) | Still Creek (2002) | Still Creek 1986 to 2002 Change | Hyland Creek (Suburban) (2002) | McIntyre-Denier (Greenfield) (2002) |
|---|---|---|---|---|---|
| Total impervious surface | 77.6% | 78.0% | -0.4% | 48.0% | 0.0% |
| Tree cover | 11.9% | 11.8% | -0.1% | 25.7% | 97.5% |

### 5.4.2 Air Pollution

The air quality analysis quantifies the level of pollutants present in the air and the health care costs associated with these levels. As indicated in Table 12, there is minimal change in costs attributed to air pollution impacts between the two time periods in the Still Creek watershed. When the Still Creek watershed is compared to Hyland Creek watershed one can see that air pollution cost difference is significant. If the tree canopy in Still Creek were the same as Hyland Creek (25.7%) the air pollution savings for the entire watershed would increase from approximately $200,000.00 per year ($70.29 per ha multiplied by the area of the watershed (2,837 ha) to approximately $430,000.00 per year ($152.66 x 2,837).

**Table 12 CITYgreen Analysis - Air Pollution Costs Change 1986 to 2002**

| | Still Creek (1986) | Still Creek (2002) | Change | Hyland Creek (Suburban) (2002) | McIntyre-Denier (Greenfield) (2002) |
|---|---|---|---|---|---|
| Annual Air Pollution Savings per Hectare | $70.87 | $70.29 | -$0.58 | $152.66 | $579.57 |

### 5.4.3 Carbon Storage and Sequestration

Change in carbon storage and sequestration are presented in Table 13 As with the other parameters, the results reflects the urbanized nature of the watershed in both time periods. The Still Creek watershed stores and sequesters less than half the same amount of carbon as the Hyland Creek watershed.

**Table 13 CITYgreen Analysis - Carbon Storage and Sequestration Change 1986 to 2002**

| | Still Creek (1986) | Still Creek (2002) | Change | Hyland Creek (Suburban) (2002) | McIntyre-Denier (Greenfield) (2002) |
|---|---|---|---|---|---|
| Total tons stored/hectare | 12.68 | 12.57 | -0.11 | 27.31 | 103.68 |
| Total tons sequestered (annually)/hectare | 0.10 | 0.10 | 0.0 | 0.21 | 0.81 |

### 5.4.4 Stormwater

Due to the relatively small change in land cover between the two time periods, the water runoff scenario is identical for both 1986 and 2002 in the Still Creek watershed. CITYgreen calculates the total stormwater management savings provided by the existing land cover (assuming that the vegetation is removed and replaced by impervious surface). The savings in both time periods is $3,549 per hectare (Table 14). This estimate reflects the cost per cubic foot to build a retention pond to manage the runoff. The stormwater savings for the Hyland Creek watershed are slightly better than those for Still Creek, however, there is a significant difference between the two developed watersheds and the largely forested McIntyre-Denier which provides approximately six times more savings per hectare.

**Table 14 CITYgreen Analysis – Stormwater Savings 1986 to 2002**

| | Still Creek (1986 and 2002) | Hyland Creek (Suburban) (2002) | McIntyre-Denier (Greenfield) (2002) |
|---|---|---|---|
| Total Stormwater Savings/Hectare | $3,549 | $3,735 | $21,107 |
| Annual Costs Over 20 Years/Hectare | $309 | $326 | $1,840 |

### 5.4.5 Water Quality (Contaminant Loading)

The water quality model estimates the change in the concentration of various pollutants in runoff during a typical storm event assuming that the existing vegetation is removed and replaced by impervious surface. Due to the relatively small change in land cover between the two time periods in the Still Creek watershed, the water quality results are identical for both 1986 and 2002. As with the stormwater runoff results above, there is far less difference between the two developed watersheds and the McIntyre-Denier watershed (Table 15), which would indicate that contaminant loadings are significantly impacted by development.

**Table 15 CITYgreen Analysis - Percent Change in Contaminant Loadings**

| Contaminant | Still Creek (1986 and 2002) | Hyland Creek (Suburban) (2002) | McIntyre-Denier (Greenfield) (2002) |
|---|---|---|---|
| Biological Oxygen Demand | 15.56 | 48.11 | 367.45 |
| Cadmium | 18.53 | 61.71 | 697.92 |
| Chromium | 21.95 | 80.17 | 2,608.78 |
| Chemical Oxygen Demand | 23.02 | 86.74 | 8,460.36 |
| Copper | 0.0 | 0.0 | 0.0 |
| Lead | 7.09 | 18.22 | 81.22 |
| Nitrogen | 9.22 | 24.73 | 121.25 |
| Phosphorus | 17.51 | 56.81 | 547.63 |
| Suspended Solids | 15.39 | 47.40 | 356.00 |
| Zinc | 5.23 | 12.94 | 53.75 |
| **Average Percentage of Change*** | **13.35** | **43.68** | **1,329.44** |

* Percentage change between existing vegetation when compared to its removal and replacement with impervious surface.

## 5.5 Biodiversity Mapping

The methods used to develop the various biodiversity map layers are outlined in Section 4.5. Below is a summary of the results of the analyses.

### 5.5.1 Habitat Refuges and Reservoirs

The growth in the region has led to the creation of more isolated fragments of suitable living space for wildlife (Schaefer 2004). As a result, the identification and maintenance of habitat refuges and reservoirs is essential to maintaining the region's biodiversity. A habitat refuge is defined as a small patch of habitat that provides food, shelter and/or other needs for wildlife. It may include human-modified ecosystems. They are not generally large enough to maintain the genetic diversity of a population. A habitat reservoir is a large area of relatively natural habitat that has sufficient size and ecological integrity to support a range of native species, including species that need interior habitats. The size of habitat reservoir depends on the species being managed for (WLAP 2004). Based on the characteristics of the Greater Vancouver Region and personal communication with (Val Schaefer Douglas College Institute of Urban Ecology, and Biodiversity Strategy Steering Committee members), the following refuges and reservoir categories were developed for the region:

- major habitat reservoir - patch size >200 ha
- habitat reservoir - patch size = 30-200 ha
- major habitat refuge - patch size = 20-30 ha
- habitat refuge - patch size = 2-20 ha

Figure 14 illustrates the locations of key habitat refuges and reservoirs in the Still Creek watershed. While there are a number of habitat refuges throughout the watershed, the majority of habitat reservoirs, with the exception of a portion of Burnaby Lake Park, are predominantly outside its boundaries. Habitat refuges include: Renfrew Ravine; Renfrew Killarney, Rupert, Beecher, Halifax and Broadview parks; the Discovery Park Conservation Area; Beecher Creek Ravine; and the riparian habitats at the western end of Deer Creek. There are two major refuges in the watershed: Kensington Park; and the central portion of the Still Creek corridor. Portions of Central, Deer Lake and Burnaby Lake parks are classified as habitat reservoirs. The fact that Still Creek feeds into Burnaby Lake is of particular importance because, although only a portion of the park is within the watershed, the majority of the park is classified as a major habitat reservoir.

### 5.5.2 Habitat Connectivity

Figure 15 displays the results of a habitat connectivity model that was run on the habitat types map layer. The map shows the existence of potential wildlife movement corridors along the southern shoreline of Burrard Inlet, in the Burnaby Mountain area, and along the Brunette River. It will be critical to maintain/enhance the corridor along Beecher Creek as it ties the habitat in the Still Creek watershed to the north shore. The Still Creek corridor runs in an east/west direction across the watershed, connecting to the Burnaby Lake habitat reservoir. It represents a major corridor through the watershed. It also provides the only link to the Renfrew Ravine habitat refuge. The connection at the southern edge of the watershed between the Beaver Creek/Deer Lake area and Central Park represents the only major connection between the Still Creek watershed and habitats along the Fraser River in Richmond and New Westminster.

**Figure 14 Habitat Reservoirs and Refuges in the Still Creek Region**

**Figure 15 Habitat Connectivity in the Still Creek Region**

### 5.5.3 Relative Biodiversity

The relative biodiversity map (Figure 16) illustrates key habitats and greenspaces throughout the watershed based on the results of the biodiversity analysis (see Section 4.5). Areas with the highest biodiversity values (shown in dark green on the map) are located in Burnaby Lake Park, the central section of Still Creek, in Beecher Creek Ravine, Renfrew Ravine, Renfrew Park, and in patches scattered throughout the Discovery Park Conservation Area. Other sites that are important to biodiversity conservation but which have relatively lower biodiversity values (shown in lighter green and yellow) or represent smaller patches of habitat, include: Kensington; Central, Broadview, Halifax, Killarney and Rupert parks; and the Beecher and Still creeks watercourses. Other sites with similar or lower biodiversity values (shown in yellow) are scattered throughout the watershed.

**Figure 16 Relative Biodiversity in the Still Creek Region**

# 6 Issues and Challenges

In maintaining and enhancing the biodiversity of the Still Creek watershed, there are many issues, challenges and opportunities that present themselves. *Issues* are the problems contributing to the loss of biodiversity in the watershed – such as poor water quality. *Challenges* are the difficulties that will have to be overcome as we work to enhance biodiversity – such as funding limitations. *Opportunities* are the possibilities that will help us to maintain and enhance biodiversity – such as a redevelopment that can incorporate stream daylighting.

## 6.1 Issues

### 6.1.1 Structural Changes in the Still Creek Watercourse

Significant structural changes in the natural watercourse of Still Creek have occurred since the time settlers began to homestead in the watershed. Sections of the creek have been straightened, channelized, and dredged, and many of the smaller tributaries have been diverted and/or culverted as the need to increase water conveyance capacity and control stormwater runoff grew in response to increasing population pressure in the area. Much of the original stream course has been enclosed, and some of the smaller tributaries of Still Creek now function as stormwater drainage ditches (Coast River Environmental Services Ltd. 2004). These changes in the natural structure of the watercourse have affected such things as the normal hydrological function of the watershed and its ability to support viable, sustainable vegetation communities and wildlife populations.

### 6.1.2 Changes in Hydrology and Water Quality

***Increased TIA and Changes in Water Quantity***

Due to urban development, almost 80% of the Still Creek watershed now consists of total impervious area (TIA) (Section 5.3); in some areas, such as the Grandview Boundary Industrial Area, TIA is almost 100% (Coast River Environmental Services Ltd. 2004). The loss of natural floodplain to urban development and TIA, and the structural changes that have occurred in the natural watercourse of Still Creek, have caused significant changes in the natural hydrology of the watershed. Flooding is now a major issue of concern along the lower reaches of Still Creek (Coast River Environmental Services Ltd. 2004).

***Changes in Water Quality***

Urban development, increased TIA, and structural changes in the natural watercourse of Still Creek have also caused changes in the water quality. Throughout much of the watershed, water quality is poor. Additionally, channelization and the loss of riparian habitat along the creek system has resulted in increased water temperatures and decreased dissolved oxygen levels, while enclosure of much of the natural watercourse has altered natural biophysical processes such as gas exchange (Coast River Environmental Services Ltd. 2004).

***Pollution***

Hydrocarbons and heavy metals from industrial activities, roads, parking lots located along the stream course are the most common contaminants, but residential runoff of household detergents, lawn fertilizers, and herbicides have also contributed to a decline in water quality. Additionally, channelization and the loss of riparian habitat along the creek system has resulted in increased water temperatures and decreased dissolved oxygen levels, while enclosure of much of the natural watercourse has altered natural biophysical processes such as gas exchange (Coast River Environmental Services Ltd. 2004).

### 6.1.3 Changes in Aquatic and Terrestrial Ecosystems

As Vancouver and Burnaby have grown, there have been losses of terrestrial habitat, changes in habitat quality, and fragmentation of terrestrial habitats within the Still Creek watershed. These in turn, can affect natural ecosystem diversity and functions, and native species diversity.

***Loss of Habitat***

Urban development within the Still Creek watershed and changes in the creek's natural watercourse have significantly altered natural aquatic habitats by causing changes in stream structural diversity and complexity, natural hydrological function, and water quality, and by causing losses in riparian habitat. A significant proportion (74%) of the natural riparian forest has been lost, and less than 5% of the total watercourse now has a riparian forest buffer that is greater than 30 m wide (Coast River Environmental Services Ltd. 2004).

***Changes in Habitat Quality and Species Diversity***

Habitat quality can be affected by such things as noise disturbances, which can disrupt natural behavioural patterns of wildlife, and by the invasion of non-native plant and animal species.

Increasing urbanization of natural areas generally results in changes in occurrence and abundance of native species. Loss of native habitat and changes in habitat quality often lead to extirpation of sensitive species or species with large home ranges (e.g., grizzly bears (*Ursus arctos*)), while the development of urban landscapes is often associated with an increase in native species that thrive in such environments (e.g., the northwestern crow (*Corvus caurinus*)). Increasing human settlement of natural areas is also often associated with an increase in non-native species, which can, in turn, result in a decrease in populations of native species. For example, introduced animal species such as the European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), and eastern grey squirrel (*Sciuris carolinensis*) often out-compete native wildlife for food and breeding sites, while invasive plant species such as Himalayan blackberry (*Rubus discolor*) and English ivy (*Hedera* sp.) compete with native species for light, space, and nutrients. In a recent study of Renfrew Ravine, one of the few remaining relatively natural habitats with the Still Creek watershed, Blaney et al. (2001) found non-native plant species in comparable amounts to native species. Invasive vegetation species such as, Himalayan blackberry and Scottish broom, exist along much of the Still Creek corridor. Purple loosestrife proliferates in Burnaby Lake Park. Overall invasives are a major issue in the watershed because they can out-compete and displace local flora.

***Habitat Fragmentation***

Habitat fragmentation can create isolated patches of wildlife habitat (see Section 5.5.1). Fragmentation also results in increased edge effects which can lead to microclimate changes within the affected habitat, and to an increase in species which are adapted to exploiting edge habitats. Additionally, fragmentation of habitat can disrupt an animal's natural movement patterns, while roads and other transportation networks can create physical barriers for various species groups such as small mammals, reptiles, and amphibians (see Section 5.5.2). Transportation corridors can also be sites of increased mortality for a number of species.

Loss and fragmentation of habitat due to urban development can also lead to isolation of plant and animal populations. This can result in lost opportunities for interbreeding among animal populations, and for the exchange of genetic information among plant populations, which in turn, can affect the ability of native plant and animal populations to sustain themselves, and can cause changes in the genetic diversity of those populations.

## 6.2 Challenges

### 6.2.1 Maintaining and Restoring Habitats

Because there are a number of challenges to conserving biodiversity in the Still Creek watershed, priorities regarding conservation need to be identified. For example, since large areas of aquatic and terrestrial habitat have been altered or lost, should priority be placed on maintaining existing habitats, enhancing them, or restoring some of what has been changed or lost? Should the aquatic environment take precedence over the terrestrial environment when it comes to defining specific management objectives for biodiversity conservation, allocating funds to meet management goals and objectives, and implementing management actions?

***Maintaining Habitats***

If emphasis is placed on habitat maintenance, then it must be acknowledged that some habitats will be difficult to maintain over time. Increasing urban development has resulted in a loss of connectivity and increased isolation of forest patches and green spaces. Forest patches that become isolated may have less ability to regenerate and maintain their structural diversity, and thus, will likely evolve to more shrub-like habitats.

Also, such things as maintenance of native vegetation in urban areas can be affected by social values. For example, crime prevention measures may call for a removal of some native vegetation in urban parks and green spaces as a means of improving sight lines. Similarly, the public's concern over the threat of urban wildfires may result in demands being made to reduce fuel loads in greenspaces by removing native understorey vegetation and ground cover. The occurrence of urban wildfire is unlikely in the Still Creek watershed given that natural greenspaces are relatively limited in extent and distribution, and that developed areas such as roads would act as fire breaks. However, wildfire threat could be a concern in other areas of the Greater Vancouver region where the urban/rural interface is relatively extensive.

Additionally, it may be difficult to maintain appropriately sized habitat areas within such an urbanized watershed. For example, it may be determined that wildlife corridors should be at least 100 m wide. This may be difficult to achieve even if existing powerline right-of-ways and transportation corridors were included as part of a wildlife corridor network. Also, if riparian buffers were required to be 30 m or greater to maintain proper ecological functioning, most of the Still Creek watercourse currently would not meet that requirement (Coast River Environmental Services Ltd. 2004).

***Restoring Habitats***

If emphasis is placed on restoration, then the questions such as “What are we restoring to?” “Can habitat connectivity be restored?” and “What types of habitats can effectively be restored, where are they located, and how much can reasonably be restored?” need to be asked before appropriate restoration objectives can be developed. Careful planning is also required. Restoration work can be costly, it must be done in the right place and with the right species if it is to be effective, it may be restricted by government management rules and regulations, and it can easily be undone (e.g., the destruction of new and costly riparian plantings by beavers).

It should be noted that some small-scale restoration work has been done in the Still Creek watershed. Activities have focused on replanting in the riparian zone, rock weir construction, bank erosion protection, and culvert placement or baffle installation. In some areas, redevelopment of industrial sites to high-density complexes have allowed riparian buffers of 30 m to be restored.

Opportunities for restoring habitats are limited though, due to the extent of existing development in the watershed (Figures 3-5). For example, opportunities to create off-channel fish habitat are restricted by existing property boundaries and infrastructure along the watercourse, and the ability to increase instream structural complexity through the addition of such things as large woody debris is limited if it interferes with stormwater flow (Coast River Environmental Services Ltd. 2004). Also, public concerns over the threat of West Nile virus may restrict opportunities to restore or create wetlands which act as breeding sites for mosquitoes. It has also been suggested that it may impossible to maintain populations of cold-water fish in watersheds where TIA exceeds 30% (Kerr Wood Leidl 2002). Although consideration is being given to reducing TIA in the Still Creek watershed, it may not be possible to achieve a target of 30% or less. The Still Creek ISMP provides goals for habitat management in the watershed that the case study builds on.

### 6.2.2 Invasive Non-native Species

Dealing with the issue of invasive non-native species can be a significant challenge for a number of reasons. First of all, goals for eradicating and/or controlling invasive species need to be established and assessed in terms of their feasibility and the effort and cost required to attain them. In some places, the costs may outweigh the benefits. Secondly, the public perception about certain invasive species may need to be considered when control programs are being developed. For example, some sectors of the public may not consider plants such as holly, blackberry, and ivy to be undesirable, and so, may object to their removal from local neighbourhood areas. Thirdly, retention of some invasive non-native species may be beneficial. For example, Himalayan blackberry can effectively restrict unwanted access to areas of sensitive habitat. Section 5.3 provides the results of the detailed vegetation mapping for the watershed.

### 6.2.3 Social Values

***Balancing human and ecological needs***

Between 1986 and 2001, the population of the GVRD increased by 8.5% to almost two million, and is expected to increase to 3,000,000 by 2031 (GVRD Policy and Planning

Department 2002, Kerr Wood Leidl. 2002). With this type of growth comes the increasing challenge of balancing development values with the need to conserve biodiversity. It will not be possible to mitigate all environmental impacts through the use of tools such as Best Management Practices (Coast River Environmental Services Ltd. 2004). Conservation of biodiversity requires a long-term vision with incremental actions set to be implemented over many years.

***Conflicts with human values***

Human values may conflict with the protection of biodiversity. For example, some species are regarded as ‘problem species’ (such as raccoons and coyotes) and their reintroduction would not be welcomed. Some policies encourage the removal of vegetation. For example, FireSmart programs discourage the placement of trees close to buildings, and vegetation may be cleared along walkways to improve sightlines and reduce crime.

***Lack of understanding***

Many deleterious actions – such as putting motor oil down a storm drain – are done from ignorance rather than malicious intent. Equally, people often fail to appreciate the cumulative impact of ‘good’ decisions such as naturescaping backyards to provide additional habitat. Better understanding of the impacts of individual human activities on the watershed will be needed to enhance biodiversity, and this is not easily achieved.

On a larger scale, councils and other municipal decision-makers are often not aware of the impacts of their decisions on biodiversity in the watershed. Education of councils is also an important challenge.

## 6.3 Limitations

### 6.3.1 Information Gaps

While this case study is intended to provide strategic direction for biodiversity conservation in the Still Creek watershed, inventory, monitoring, and research are needed to increase our knowledge and understanding of a number of issues. The following are examples of the data gaps that need to be addressed in more detailed local level planning:

- What is the quality and utilization of existing habitat along the Still Creek corridor and in habitat refuges throughout the watershed?
- What are the relationships among vegetation structural diversity, species diversity, and biodiversity, in general?
- What are the habitat requirements of various species (e.g., use of urban habitats can be quite different from the use of natural habitats)?
- How do various species use corridors and how does use vary with season (e.g., breeding versus migration)?
- What is the zone of influence of disturbance around existing road corridors for various species?
- What wetland ecosystem features and functions do we need to maximize biodiversity?
- What risks are incurred from the spread of invasive species?

- Trails through greenspaces help maximize human use of, and support for, those areas, but does the social value outweigh the environmental value of fragmenting greenspaces with trail developments?
- How do we manage for unknowns such as climate change? (need for adaptive management approach) (AXYS and Cullington 2004).

### 6.3.2 Study Limitations

***Indicator Species and Habitat Rules***

As mentioned previously, indicator species habitat maps were developed to identify key habitats within the region from a biodiversity perspective (see Appendix A). This approach may have resulted in the omission of some smaller patches of habitat that may be being utilized by some of the indicator species. In addition, the habitat maps have not been field verified. As better information becomes available, the 'habitat rules' for the selected indicator species used for this project can be modified, and the maps can easily be revised to create a more accurate picture of habitat suitability, and more importantly, availability. As well, the information can be used to replicate the mapping at some future date using the same rules, to monitor and assess landscape changes over time.

***Land Cover Classification***

The satellite-derived land cover classification, developed by MSRM (Section 4.3), provides a good regional scale overview of the habitats throughout the region. However, it should be understood that the 15 metre pixel size generalizes the information to a certain degree as each pixel is assigned a value based on the predominant land cover, for example, a pixel that is 55% building and 45% trees would be assigned an urban land cover attribute. More field verification should take place to ensure the forest type (e.g., coniferous, deciduous and mixed) classifications are accurate. The land cover dataset used for this project has been modified recently by MSRM to address the forest type issue.

The regional scale information is limited for watershed level planning because, in many cases, it is not sufficiently detailed. Ideally, vegetation mapping would be conducted based on air photographs, however, for many watersheds this may be cost prohibitive because it is not just the watershed that will require mapping but a significant area outside the watershed to ensure there are no 'edge effects' associated with interpreting the information. For example, habitat refuges and reservoirs bordering the edge of a watershed may appear to be falsely smaller because they may be part of a larger habitat patch intersecting the watershed boundary.

# 7 Still Creek Watershed Biodiversity Conservation

The recommendations for conserving biodiversity in the Still Creek watershed have been divided into three components detailed in the following sections:

- vision;
- general recommendations resulting from the analyses conducted as part of this project; and
- goals, strategies and actions summarized in the ISMP document.

## 7.1 Vision

It is recommended that the vision from the Still Creek ISMP be modified slightly to encompass the watershed biodiversity strategy:

***To protect or enhance the integrity AND BIODIVERSITY of the aquatic and terrestrial ecosystems and the human populations they support in an integrated manner that accommodates growth and development***.

The vision is not to re-create the biodiversity that once existed in this area, rather it is to balance human and ecosystem needs by accommodating growth and development while trying to maintain and, where possible, enhance, the level of biodiversity that still exists.

## 7.2 General Recommendations

### 7.2.1 Habitat Reservoirs and Refuges and Connectivity

The relative biodiversity map (Figure 17) illustrates the urban nature of the Still Creek watershed, however, Still, Beecher and Beaver creeks are significant riparian corridors each providing patches of high relative biodiversity. The creeks are connected to significant, high biodiversity, habitat reservoirs just outside the watershed's boundaries at Deer and Burnaby lakes (Figure 18). As a result, protecting and/or enhancing the aquatic and riparian habitats along the creek corridors (especially where these are still in open channels) will help maintain or enhance the relative biodiversity of both the watershed and its surrounding habitats. Also of importance to biodiversity conservation is the need to maintain existing habitat reservoirs (larger, relatively intact ecosystems) and refuges (smaller ecosystems which may be significantly modified). Naturally, both these issues are a significant focus of the ISMP goals and strategies which are outlined, along with specific actions, in detail in the following section.

Existing relatively high biodiversity habitats include the following (Figure 17):

- Renfrew Park and Renfrew Ravine;
- Central Park;
- Portions of the riparian corridors and surrounding habitats associated with Still, Beecher, Guichon and Beaver creeks;
- portions of the land surrounding Discovery Place;
- Broadview Park;
- Kensington Park; and
- Burnaby Lake Regional Nature Park.

**Figure 17 Still Creek Watershed Relative Biodiversity, Parks and Golf Courses**

**Figure 18 Habitat Reservoirs, Refuges and Corridors in Relation to Parks and Golf Courses**

Habitat reservoirs are patches of habitat ranging between 30 to 200 hectares. A major reservoir is defined as a habitat patch in excess of 200 hectares. Existing terrestrial habitat reservoirs (Figure 18) within the Still Creek watershed include:

- the northern portion of Central Park;
- the lands surrounding, and to the north of Beaver Creek; and
- the northwestern portion of the Burnaby Lake Regional Nature Park (a small portion of which is part of the major reservoir surrounding Burnaby Lake).

Additional habitat reservoirs surround the watershed (Figure 14) including:

- the remainder of Burnaby Lake and Central parks;
- Deer Lake Park;
- Robert Burnaby Park;
- to the south, the Fraserview and River golf courses and Everett Crowley Park; and
- along Burrard Inlet, Montrose Park, Confederation Park, the Capitol Hill Conservation Area (includes Scenic, Harbourview, and Stratford parks), the Burrard Inlet Conservation Area, Barnet Marine Park, and the Burnaby Mountain Conservation Area.

A habitat refuge has been defined as a 2 to 20 hectare patch of habitat with a major refuge being 20 to 30 hectares in area. Existing habitat refuges within the watershed currently falling within parks include:

- Halifax Park;
- Kensington Park;
- Beecher Park;
- Rupert Park;
- Renfrew Park;
- Renfrew Ravine;
- Killarney Park; and
- Broadview Park.

Figures 16 and 17 indicate that a number of relatively high biodiversity areas fall outside protected areas identified in the parks coverage. These include the following:

- portions of the Still Creek corridor;
- Beecher Creek ravine; and
- portions of the land surrounding Discovery Place.

In addition, there are a number of habitat refuges to the west of Beecher Creek that, while only moderately important from a biodiversity perspective, do contribute to the watershed's biodiversity from a connectivity standpoint. These parcels of land represent sites that should be considered for future protection. The ISMP recommendations (Section 7.3) detail specific actions associated with these habitats.

### 7.2.2 Greenspace Management

In a heavily urbanized area like the Still Creek watershed, micro-habitats such as backyards and boulevard streets can play an important role in maintaining and enhancing biodiversity (Schaefer et al 2002). If landscaped in an environmentally-friendly way, these areas can add to existing greenspaces, and can help connect existing green corridors. The planting of street trees can also increase the amount of greenspace in an urban environment, thereby increasing both the aesthetic environment and air quality.

The 2002 CITYgreen analysis (see Section 5.4) calculated the amount of impervious surface in the watershed to be 78%. This amount of TIA has a significant impact on stormwater volumes increasing the level of runoff by 5 times or more over a natural system (interpolated from a statistic in Schaefer 2004, page 24 and references therein).

Towards the goal of quantifying the effects of potential development practices on the watershed, the following scenarios were run using the 2002 land cover within CITYgreen:

a) Moderate Best Practices – Impervious Understory – This scenario examines the effect of converting 5% of the existing ‘Urban’ and ‘Urban: Commercial/Business’ land covers to trees with an impervious understory. The scenario simulates an increase in street or boulevard tree plantings in these land uses.

b) Moderate Best Practices – Pervious Understory - This scenario examines the effect of converting 5% of the ‘Urban’ and ‘Urban: Commercial/Business’ land covers to trees with a pervious understory. This scenario simulates an increase in greenspace and tree plantings within these land uses.

c) Optimal Best Practices - Impervious Understory - This scenario examines the effect of converting 15% of the ‘Urban’ and ‘Urban: Commercial/Business’ land covers and 10% of the ‘Urban: Residential’ land cover to trees with an impervious understory. The scenario simulates a significant increase in street or boulevard tree plantings in these land uses.

d) Optimal Best Practices – Pervious Understory- This scenario examines the effect of converting 15% of the ‘Urban’ and ‘Urban: Commercial/Business’ land covers and 10% of the ‘Urban: Residential’ land cover to trees with a pervious understory. The scenario simulates a significant increase in greenspace and tree plantings within these land uses.

The changes in land use represent the transfer of the indicated percentage of a given land cover from one type to another. Table 16 presents some of the key CITYgreen parameters for each of the scenarios described above. As would be expected, Scenarios C and D increase the tree canopy significantly in comparison to the existing 2002 analysis: tree canopy increases by 8.9%. Scenario D also represents an 8.9% increase in the amount of pervious surface which significantly reduces annual stormwater costs (down $302,446.00 per year). Increasing the tree canopy has positive effects on both air pollution removal and carbon storage and sequestration with the Optimal Scenarios improving both variables by 75%. Figure 19 depicts potential target areas for the two Moderate Best Practices scenarios (options A and B), and Figure 20 shows potential target areas for the two Optimal Best Practices scenarios (options C and D). The detailed results associated with each scenario are presented in Appendix B.

## Table 16 CITYgreen Future Scenario Comparison

| Scenario | Pervious Surface (%) | Tree Canopy (%) | Air Pollution Removal | | Carbon Storage and Sequestration | | Stormwater Management Costs/Yr |
|---|---|---|---|---|---|---|---|
| | | | Kg Removed/ Yr | Dollar Value (amount saved) | Total Tons Stored | Tons Seques-tered (Annually) | |
| 2002 | 22.0 | 11.8 | 33,522 | $199,243 | 35,643 | 277 | $876,984 |
| a) Moderate Best Practices – impervious understory | 22.0 | 12.9 | 36,632 | $217,729 | 38,950 | 303 | $690,193 |
| b) Moderate Best Practices – pervious understory | 23.1 | 12.9 | 36,632 | $217,729 | 38,950 | 303 | $690,193 |
| c) Optimal Best Practices – impervious understory | 22.0 | 20.7 | 58,725 | $349,044 | 62,442 | 486 | $690,193 |
| d) Optimal Best Practices – pervious understory | 30.9 | 20.7 | 58,725 | $349,044 | 62,442 | 486 | $574,538 |

**Notes:** In some cases the results of different scenarios are identical because the degree of land cover change is not significant enough to alter the model results. Dollar values have been converted to Canadian funds using a $1.20 exchange rate.

## Figure 19 CITYgreen Moderate Best Practices Scenario Target Areas

**Figure 20 CITYgreen Optimal Best Practices Scenario Target Areas**

### 7.2.3 Management Initiatives

The following list detailed potential management initiatives that could be undertaken to promote biodiversity in the watershed:

- Seek funding for these initiatives through
  - Federal and provincial governments, (e.g., Habitat Stewardship Program, funding for COSEWIC listed species, for example the Pacific water shrew)
  - Local government contributions
  - Corporate sponsorship (e.g., in business parks)
- Invest in education programs to raise public interest and involvement in biodiversity issues.
- Encourage and increase the use of greenspaces in the watershed through measures such as improved access, enhancement, and recreation opportunities.
- Promote naturescape gardening and planting of city trees.
- Implement programs to control invasive non-native species.
- Initiate research and inventory programs on native species occurrence and habitat use, and on human-related impacts on biodiversity.
- Develop pilot projects as teaching tools about conserving biodiversity.

## 7.3 ISMP Goals, Strategies and Actions

The following section presents the goals, strategies and actions section directly from the draft Still Creek ISMP document (City of Burnaby, 2005). The ISMP project has been conducted in parallel to the Still Creek case study and the information presented below represents the integration of results from the two projects. Figures 20, 21 and 22 delineate the locations for specific strategies and actions.

### 7.3.1 Still Creek Watershed: Environment

*Vision: To protect or enhance the integrity of the aquatic and terrestrial ecosystems and the human populations they support in an integrated manner that accommodates growth and development.*

**Goal 1: Protect and Enhance Streamside and Aquatic Habitats**

Watercourses have been called "veins of life" within a landscape, as they provide rich ecological habitats and connect different parts of a watershed. The Still Creek watershed is heavily urbanized, with only 20% of the land covered in vegetation (Axys 2004). The largest vegetated portions of the watershed are mostly focused near watercourses.

***Strategy 1-1: Maintain Continuous Open-channel Watercourses***

**Rationale:** Piping watercourses eliminates habitat for fish and wildlife, and prevents water quality improvements. A minimum step for environmental management is to maintain open-channel watercourses. Further watercourse enclosures should be avoided. Daylighting a watercourse may produce significant ecological benefits, but can be very expensive and land consumptive. The plan calls for daylighting sections where significant environmental gains can be achieved. Key locations include the Still Creek mainstem, Guichon Creek through BCIT, and Beecher Creek at Goring Ave.

**Figure 21 Proposed Biodiversity Management Strategies for the Still Creek Integrated Watershed Management Plan**

**Figure 22 Beaver Creek / Central Park Tertiary Corridor from the City of Burnaby**

**Figure 23 Beecher Creek / Burrard Inlet Tertiary Corridor from the City of Burnaby**

**Actions**

a) Daylight enclosed sections of Still Creek, especially where significant environmental gains can be achieved. The long-term vision is to maintain Still Creek in an open channel up to 29th Avenue.

b) Daylight enclosed sections of tributary creeks, especially where significant environmental gains can be achieved. Potential locations include Still Creek at Falaise Park, Guichon Creek at BCIT and Beecher Creek at Goring Avenue.

***Strategy 1-2: Improve Fish Access and Instream Habitat Quality for Fish and Wildlife***

**Rationale:** Fish and wildlife habitat around watercourses have been severely degraded through vegetation loss, stream channelization, and lack of channel complexity. Fish access and passage is limited due to habitat being isolated by lengthy culverts, flumed sections, and various man-made barriers. Despite installation of a fishway, the Cariboo Dam in the Brunette River is believed to be an obstacle to migrating anadromous salmon. Native species found in the watershed include cut-throat trout and threespine stickleback - with other warm water species likely to be accessing some reaches from Burnaby Lake.

**Actions**

a) Improve all culverts within the mainstem of Still Creek and its major tributaries and remove fish obstacles, where needed to improve fish access.

b) Add instream habitat complexity and off-channel rearing and refuge habitat, to create more natural and biodiverse stream systems, as appropriate with flood management.

c) Use bioengineering techniques for flood and erosion control (as alternative to hard engineered structures).

d) Improve summer dissolved oxygen levels in Still Creek through aeration structures, such as simple aeration devices and baffle systems.

e) Assess need to improve fish access over Cariboo Dam.

***Strategy 1-3: Provide Continuous Streamside Vegetation to Protect and Enhance Habitat for Aquatic and Terrestrial Species***

**Rationale:** A wide buffer of streamside (riparian) vegetation is critical for providing food and nutrient to the stream, keeping the water cool through shading, providing habitat for aquatic and terrestrial species, and filtering contaminants from entering the stream from adjacent properties. Streamside vegetation has been severely degraded in the watershed. For the remaining open sections of the Still Creek mainstem only 26% of the length has streamside vegetation (riparian forest), and only 4.6% has streamside vegetation greater than 30m wide. Streamside vegetation is also degraded in Still Creek's tributaries, with least disturbed areas being within the Guichon Creek and Beecher Creek ravines.

For the mainstem of Still Creek, streamside habitat protection must be integrated with flood protection and provision of recreational corridors.

**Actions**

a) Prevent encroachments onto City / GVRD-owned streamside areas within the corridor.

b) Within Vancouver, development around Still Creek should follow the guidelines as set out in the ***Still Creek Rehabilitation and Enhancement Study (2002).***

c) Within Burnaby, designate a minimum 15m-wide Still Creek Conservation / Flood Protection Zone on either side of Still Creek, through the Burnaby zoning bylaw to prevent any new construction of buildings into the floodway or riparian corridor. This Flood Zone may be reduced to 10m between east of Gilmore and Boundary to reflect space constraints.

d) Within Burnaby, pursue long-term acquisition/dedication to re-establish a vegetated greenway along Still Creek for flood control, conservation, and recreation purposes. The greenway would be 15-30m in width on either side of the watercourse, and may include trails, flood management, creek maintenance and environmental features.

e) On all streams protect or enhance stream setback areas as per requirements in local area plans (e.g. Holdom Station Plan), Streamside Protection Regulation / Riparian Area Regulation measures, or plans approved through the City Environmental Review Committee.

f) Encourage landowners to 'adopt a stream' by protecting and enhancing streamside vegetation.

g) Develop an overall streamside vegetation and planting plan for the Still Creek mainstem to guide landscaping and stewardship initiatives.

h) Use existing access points to creeks as much as possible to limit further riparian encroachment.

***Strategy 1-4: Encourage Watershed Stewardship***

**Rationale:** Landowners, businesses, and residents adjacent to streams may significantly affect the quality and extent of streamside vegetation and overall stream health. In addition, landowners, businesses, and residents throughout the watershed impact the quality of water running into streams through their use of lands and control of pollutants entering drains. Similarly the amount and quality of habitat in the watershed is affected by landowners choice of landscaping and planting. Watershed stewardship is therefore a critical element for the success of the plan.

**Action**

a) Create public educational programs for watershed stewardship, including:

- protecting streamside vegetation;
- planting of native species;
- eliminating deposition and discharge of deleterious substances into the drainage system;
- protection of pervious areas;
- lawn management to maximize infiltration; and
- improved source control practices for both rain run-off quantity and quality.

**<u>Goal 2: Protect and Enhance Forest and Trees in Watershed</u>**

In urban areas, trees provide important environmental values, by intercepting and detaining rainwater, providing habitat, filtering contaminants from the air, removing carbon dioxide from the air and storing it in their biomass, shading and cooling the urban environment.

***Strategy 2-1: Maximize Tree Cover in Watershed***

**Rationale:** An analysis of the benefits of treed areas in the Still Creek Watershed assessed that the trees annually remove over 73,000 lbs (33,500 kg) of pollutants from the air, including carbon monoxide, ozone, nitrogen dioxide, particulate matter and sulphur dioxide (City Green Analysis in Axys 2005). The Still Creek trees also store a total of 35,600 tons of carbon. Maximizing tree cover will maintain these and other "ecological services" such as providing habitat, stormwater management through transpiration, and curtailing the urban heat island effect. An analysis of stormwater benefits indicated trees provide over $900,000-worth of flow detention benefits in the Still Creek watershed (City Green Analysis in AXYS 2005) as well as significant water quality benefits.

**Actions**

a) Plant and maintain street trees and boulevards throughout the watershed, including using a diversity of species.

b) Encourage tree-planting and creation of new greenspace in land redevelopment.

c) Encourage private landowners to plant native trees and vegetation on their properties (these lands may include residences, commercial lots, cemeteries, etc).

d) Encourage schools to add planting to school yards.

e) Develop and implement an urban forest strategy for the watershed.

## Goal 3: Protect and Improve Water Quality

Water quality in Still Creek is poor and is deemed to be a main limiting factor to aquatic life (Coast River 2004). Nonetheless water quality has improved significantly in recent decades, due to more stringent environmental standards and monitoring. Further significant water quality improvements are expected through implementing actions in this plan. Hydrocarbons and heavy metals are major pollutants, due in large part to the high automobile and truck traffic in the watershed. From residential areas, household detergents (car washing activities) and lawncare products (herbicides, fertilizers etc) and sanitary-stormsewer crossconnections contribute to the poor water quality. In addition, lack of streamside vegetation cover, channelization and fluming have led to high water temperatures, which contribute to low dissolved oxygen. Long enclosed sections of the channel restrict gas exchange and other biophysical processes that could improve water quality.

***Strategy 3-1: Prevent Contaminants from Entering Watercourses or Stormdrains***

**Rationale:** The most effective means of protecting water quality is to prevent contaminants from entering watercourses and stormdrains in the first place.

**Actions**

a) Establish non-point source pollution control and spill management best practices for private land owners.

b) Continue with cross connection inspection (CCTV, smoke testing and dye testing).

c) Enhance major culvert inspection and maintenance program.

d) Improve and increase frequency of catch basin cleaning and street sweeping practices.

e) Research benefits and challenges of infiltrating catchbasins.

f) Continue to encourage landowners to adopt “cosmetic herbicide/pesticide-free landscaping” on a watershed-wide basis.

g) Conduct targeted and coordinated pollution-prevention education programs (i.e., industry-specific education materials prepared for the Byrne Creek program).

h) Continue to provide training programs for City staff and private contractors on best management practices during land management.

i) Encourage landowners to use stormwater BMPs with multiple benefits (e.g. green roofs and trees for reducing heat island effect, swales to promote groundwater infiltration).

j) Continue with existing source control programs.

k) Eliminate street flushing.

***Strategy 3-2: Treat Stormwater Before it Enters Watercourses***

**Rationale:** Despite efforts at source control, some contaminants will still be washed down stormdrains from road and other surfaces. Strategy 3-2 focuses on seeking to remove some contaminants before they enter into watercourses.

**Actions**

a) Develop neighbourhood-scale water quality treatment ponds at strategic locations in the watershed that will also provide improved runoff quantity control.

b) Seek opportunities to integrate biofiltration and water quality improvement facilities within existing land uses (i.e., parks, landscaping, etc.) - e.g. Burnaby Lake Sports Complex.

c) Develop an approach and standards for disposal of stormwater run-off from contaminated sites or sites under remediation.

***Strategy 3-3: Monitor Water Quality and Respond to Results***

**Rationale:** Monitoring will highlight trends in water quality and can show the successes of water quality improvement programs.

a) Continue with the GVRD and municipal fecal coliform monitoring program.

b) Use measures of benthic invertebrate presence and abundance to monitor stream health.

c) Review the federal discharge criteria of 75 mg/ml TSS above background level for wet weather flow conditions from construction and development sites.

d) Continue chemical analysis of water quality (including MOG, ICP scan, TSS).

**<u>Goal 4: Maintain and Increase Native Species Biodiversity</u>**

As human communities have grown in the Still Creek watershed, native ecology and biodiversity has declined. Impacts include:

- loss of habitat (only 20% of the watershed is currently vegetated);
- changes in habitat quality (only 6% of the watershed is vegetated with ‘natural” vegetation - the rest is human-impact landscapes such as street trees, playing fields, and cemeteries);
- loss of species that need large or undisturbed habitats (e.g. northern harrier, red-legged frog, pileated woodpecker, deer, bear, and other large mammals) - to be replaced by species that are more tolerant to human disturbances or can live in smaller habitat fragments (e.g. coyotes, crows, spotted towhee); and
- increases in the amount of non-native "invasive" vegetation (e.g. Himalayan blackberry, Japanese knotweed, policeman’s helmet).

However, despite the significant urbanization, the watershed still has a role to play from a regional biodiversity perspective. Goals for regional biodiversity planning include protecting large intact areas of habitat (reservoirs and refuges), protecting and creating linkages and corridors between these areas, maintaining the quality of the habitats within these areas, and preventing contaminants from entering adjacent areas. Protecting and enhancing these values is challenging in an urbanized watershed, but the following strategies seek to maximize opportunities for biodiversity.

***Strategy 4-1: Protect and Enhance Remaining Habitat Reservoirs and Refuges***

**Rationale:** The watershed is close to several large ***habitat reservoirs*** (habitats over 30 hectares in size) that are important for regional biodiversity - Burnaby Lake, Central Park, Deer Lake, and Burnaby Mountain. Edges of the first two of these reservoirs are within the watershed. The habitat reservoirs are important as they are large enough to contain both edge and interior habitats and are home to a wide diversity of plants, wildlife, birds and other species. The Still Creek watershed also contains smaller habitat patches - or "***refuges***" (habitats that are 2-30 hectares in size). These refuges will experience disturbance from adjacent urban areas due to their small size and lack of interior habitat, but they will provide habitats for some native species that are resilient to disturbance, do not need large habitat areas, and / or may be able to migrate to other refuge or reservoirs (e.g. spotted towhee).

**Actions**

a) Investigate designating remaining habitat reservoirs and refuges as parks or conservation areas. Lands to be considered for conservation area designation include lands south of Still Creek between Westminster and Willingdon, and the Beecher Creek corridor.

b) Conduct a land use plan for area around Douglas Road, and consider the concept of extending the Still Creek Conservation Area west to Royal Oak right of way, through habitat restoration for environmental and flood cell purposes.

c) Enlarge habitat reservoirs and refuges through land restoration sites (e.g. 8 acres of rehabilitated industrial lands around Chub Creek at the Madison sites).

d) Focus recreation in existing disturbed areas, in order to minimize further habitat fragmentation.

e) Encourage the BC Ministry of Transportation to consider habitat values in management of lands adjacent to TransCanada (e.g. replace grass embankments with native shrubs and trees, wildflowers, meadows).

***Strategy 4-2: Connect habitat reservoirs and refuges***

**Rationale:** Urban areas such as Still Creek are characterized by severe habitat fragmentation, with habitat reservoirs and refuges isolated from each other. Linkages between reservoirs and refuges are critical to allow for interbreeding and genetic diversity. The more plentiful the linkages, the easier species can connect and interbreed. In urban areas, species movement is constrained by both the distance between habitat patches and urban infrastructure (i.e., roads, rail-lines, pipes, etc) that cross habitat patches, limiting the ability of terrestrial species to migrate. The most successful species will therefore be those that can fly between patches or who can travel across the urban landscape (e.g. coyotes).

Width requirements for the corridor will vary among species, but the Biodiversity Conservation Strategy for the Greater Vancouver Region suggests a hierarchy of corridors with primary corridors for small mammals being over 50m in width, secondary corridors being 20-50m wide (providing some routing, but not optimal conditions) and tertiary corridors being small fragmented areas that are tied together by street trees, backyards, etc. While tertiary corridors will not serve all species, they can play a role - for example bird movement can be enhanced by provision of habitat through the urban landscape (e.g., uncut meadow areas at highway interchanges, backyard habitat, vegetation within stream corridors and ravines, hedgerows, etc).

Restoring corridors within an urban landscape is very challenging, as the land has already been closely subdivided and designated for specific private and public land uses. Key opportunities for creating corridors are outlined below.

**Actions**

a) Focus restoration efforts on creating a 40-60m primary or secondary corridor along Still Creek as a Greenway to connect the Burnaby Lake habitat reservoir with the habitat refuges around Willingdon Ave. Develop concept within a land use plan for Douglas Road area, and integrate corridor creation with flood management and recreation works.

b) Extend the Still Creek habitat corridor west through Vancouver as a secondary corridor to connect with other greenspaces (e.g. the Chubb Creek parklands).

c) Create a tertiary corridor connecting Still Creek with Renfrew Ravine, Trout Lake Park, Central Park, Champlain Heights, Everett Crowley Park, and the East Side Crosscut through watercourse enhancement projects, backyard habitat programs and street tree plantings.

d) Create a secondary / tertiary corridor between Still Creek and Deer Lake Park (through BCIT, Discovery Park and Guichon Ravine). Potential projects include:

- habitat creation as part of the BCIT land use plan,
- forest enhancement works at Discovery Park,
- street tree planting, and

- backyard habitat programs in adjacent neighbourhoods.

e) Create a secondary / tertiary corridor along Beecher Creek up towards Burrard Inlet Potential projects include:

- stream restoration as part of the Holdom Area Plan implementation,
- habitat enhancement works in Beecher Creek ravine and Kensington Park,
- street tree planting, and
- backyard habitat programs in adjacent neighbourhoods.

f) Create a tertiary corridor connecting Beaver Creek to Central Park, through backyard habitat programs and street tree planting.

g) Encourage Utility Companies (e.g., BC Hydro, Terasen) to maximize habitat potential of lands within utility corridors (e.g., locating bioponds in Rights of Way).

***Strategy 4-3: Improve Habitat Quality and Complexity for Wildlife***

**Rationale:** The quality of habitat will dramatically affect the types and quantities of species using natural areas. Key opportunities for improving habitat quality are outlined below.

**Actions**

a) Study and inventory natural areas to better understand species usage (i.e., rare and endangered species, such as the Pacific Water Shrew).

b) Manage natural and urban areas to maximise value for biodiversity (e.g., vegetation management, bird boxes, bat boxes, bee houses).

c) Designate protected refuge areas for wildlife breeding and rearing purposes (e.g., some parts of Burnaby Lake Regional Nature Park). Restrict access to the areas (seasonally or permanently).

d) Assess potential problem wildlife species (e.g., beaver, mosquitoes, Canada geese) and develop appropriate management strategies. For example, to control mosquitoes (and West Nile Virus concerns), use integrated pest management approaches.

e) During forest management, promote diversity of native forest tree species and age structures. Retain stumps, snags (wildlife trees), and coarse woody debris for cavity nesting birds.

f) Minimize conflict between dog off-leash areas and critical habitat areas.

g) Increase areas of wetland in watershed.

***Strategy 4-4: Promote Native Vegetation and Control Non-native Species***

**Rationale:** Like many urban areas, Still Creek Watershed is rife with non-native invasive vegetation. This vegetation can smother native plants and biodiversity and may not provide suitable habitat for native wildlife species. However, dealing with invasive vegetation can be a significant challenge as control is extremely resource intensive and needs to occur over a long period of time. The following actions are proposed to start to address this problem:

**Actions**

a) Assess extent of invasive vegetation and create priorities for removal based on potential habitat benefits, available resources (e.g. partnerships with streamkeepers and the public), and long-term planning.

b) Create long-term pilot projects for invasive species removal (e.g. Southern Discovery Parks (Himalayan blackberry and Beacon silver), Burnaby Lake (purple loosestrife)).

c) Support streamkeepers' efforts at native planting and invasive weed removal initiatives (i.e., policeman's helmet, purple loose strife, polygonum, blackberry, Scotch broom).

d) Develop an integrated land stewardship program for landowners to raise issues of biodiversity in the watershed and provide training on:

- Native planting for backyards instead of ornamental species, particularly on lands adjacent to watercourse ravines.
- Control dumping of yard waste (including non native species) within ravines.
- Promote integrated pest management and reduce public dependency on chemical lawn care products.

# 8 Applications and Conclusions

## 8.1 Using the Regional Biodiversity Analyses for Watershed Planning

When used in conjunction with the locations of parks and other protected areas, and city-owned lands, the regional biodiversity datasets developed through the "Assessment of Regional Biodiversity and Development of a Spatial Framework for Biodiversity Conservation in the Greater Vancouver Region" (AXYS 2005), can aid planners in making more informed decisions with regard to conservation planning and management and future acquisitions. The results of the analyses allow the amount of various habitat types, reservoirs and refuges to be quantified. In addition, municipal planners can view how their municipality or portions thereof fits in the large regional context. This has applicability when managing habitat refuges and reservoirs and maintaining connectivity corridors.

The regional dataset provides a consistent baseline for the entire GVRD. The information is particularly useful identifying key habitat refuges and reservoirs, biodiversity 'hotspots', and connectivity corridors. In addition, it permits various portions of the region (e.g., municipalities, watershed or protected areas) to be compared easily and accurately using a consistent base.

What the regional scale data allows the municipal or regional planner, or other user to do is quickly identify key habitats that either may require additional protection or management. When used in conjunction with local knowledge, areas requiring detailed mapping, management or study can be easily identified. This approach has the benefit of reducing the costs associated with watershed planning. Watershed scale datasets can use the regional scale information for the entire area of interest and supplement this information with more detailed 'watershed-scale' data for key habitats or hotspots. When applying the regional scale information to the watershed level it is, however, crucial to consider the local context (e.g., the specific climate, terrain, indicator species applicable to the watershed of interest).

## 8.2 Using Focal Species and Habitat Rules for Watershed Planning

To effectively implement management strategies at the watershed level, planners need information relevant to key land parcels such as, habitat types, key wildlife and plant species, species or plant communities of conservation concern (e.g., red- or blue-listed) and management recommendations associated with these resources. The indicator species approach (see Appendix A) helps identify key habitats and the species utilizing these areas provided that:

- the indicators selected accurately represent the watershed and the associated species present;
- the habitat requirements of the indicator species are known, thereby allowing an accurate set of habitat rules to be developed; and
- the data available allow the habitat requirements to be modeled accurately.

At the regional scale, the indicator species habitat maps facilitate the identification of key habitats and/or areas of concern. At the watershed-scale this provides another information layer to support decision-making. As above, when used in conjunction with local area knowledge, areas requiring further study and/or management can be easily identified. Ideally, the key species known to be present, or with a high probability of being present, would be stored as an attribute of each land parcel in the watershed. The use of indicators is one tool to help achieve this goal, however, it is crucial that any desktop exercise be verified by local knowledge and/or field study to verify the results.

The regional scale data provides baseline information to aid in the management of Species at Risk Act (SARA) species. The mapping, in conjunction with more detailed local scale mapping for critical areas, helps determine the abundance and distribution of species throughout the region. In addition, planners are more readily able to identify, and consequently manage, threatened habitats. By comparing data from different time periods, trends in population and distribution can also be examined.

## 8.3 Using the CITYgreen Analysis in Watershed Planning

CITYgreen provides an effective management tool for watershed level planning. Its use is most applicable when assessing trends in land cover changes over time or modeling potential future development scenarios to quantify the impacts of land use on the landscape and the specific parameters being assessed. When interpreting the results, it is important that the user have a thorough understanding of what is being assessed and that the results are based on a modeled scenario. It would also be useful for the user to compare current conditions to a predetermined management target to assess the benefit of the proposed tree cover. Ideally, as part of the Biodiversity Conservation Strategy, attainable tree canopy targets would be developed for various types of watersheds (based on land use) throughout the GVRD to both manage biodiversity and provide information for the ISMP process.

For some models (e.g., air pollution), CITYgreen matches the model results to a pre-determined curve number (functionally a class) and, as a result, small changes between scenarios may not be significant enough to warrant a change in the curve assignment and therefore some of the results (e.g., water quality and water quantity) may be identical between model runs. The use of curve numbers may also make differences between areas appear greater or smaller if the characteristics of the area put it on the cusp of a curve number class.

The air pollution estimates generated from CITYgreen are designed for urban and suburban forests, as a result, analyses run on rural areas may over estimate the benefits of tree cover.

CITYgreen is an American product and model default values (e.g., precipitation units) are provided for only US cities. Ideally, future versions of the software would incorporate data for Canadian cities. Reports generated by the software display results in US currency and in the US System of Measures, as a result, if users want metric values or Canadian currency the results must be converted manually. This is inconvenient and introduces the possibility of error. Again, ideally future versions of the software will allow the user to select the metric units.

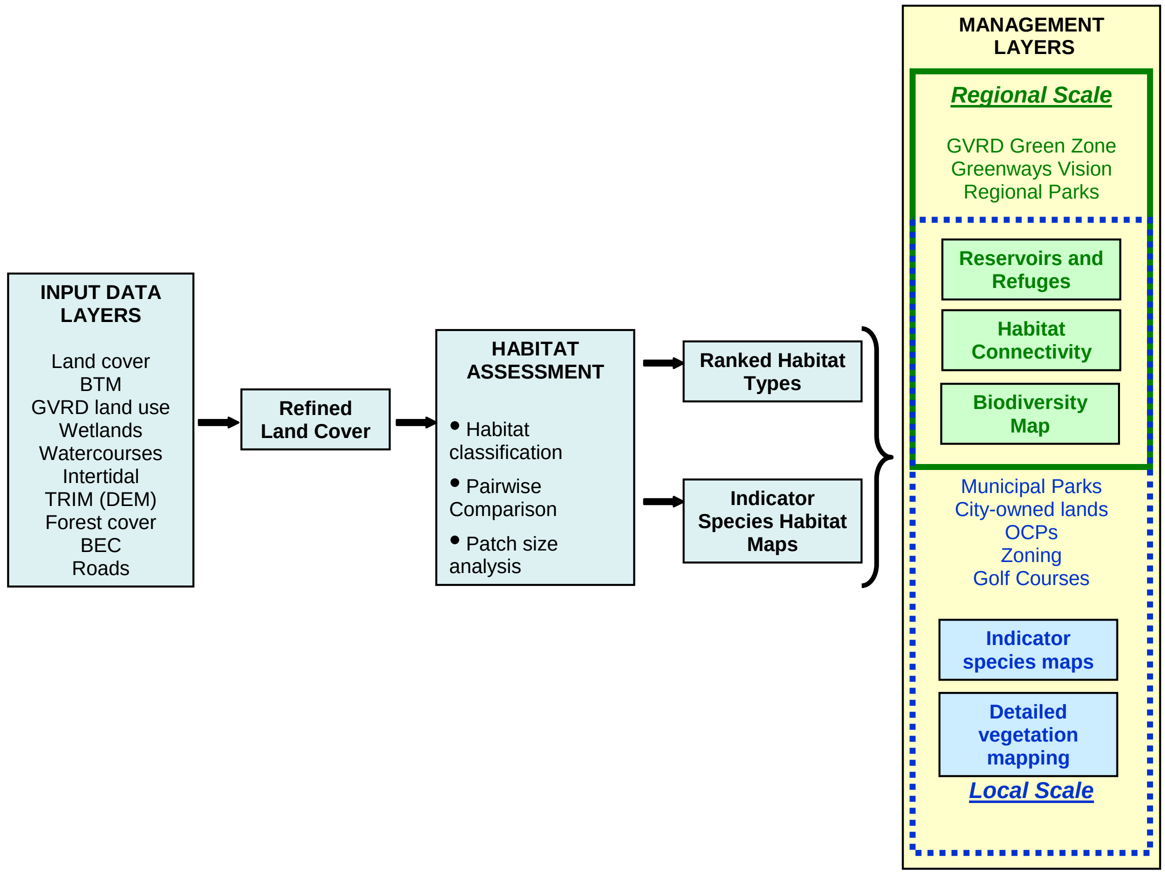
## 8.4 A Model Approach for Watershed Planning

An overview of the GVRD's Spatial Framework is presented in Figure 24. The goal of the Spatial Framework is to integrate both regional and local (e.g., municipal or watershed levels) scale data to facilitate the exchange of information between the GVRD and its member municipalities. The analyses completed so far have been at the regional scale, with some local scale mapping (e.g., the detailed vegetation coverage) having been conducted for the Still Creek watershed. It is anticipated that the regional scale data will overlap with local scale planning initiatives as illustrated in the figure. Functionally, the regional scale information provides broader landscape and ecosystem-level data to assist more detailed local scale planning.

The Spatial Framework documents the major steps required to generate both regional and local scale management layers:

- integration of the input data layers;
- development of a refined land cover classification;
- habitat assessment;
- development of habitat maps (ranked habitat maps for the regional scale and indicator species habitat maps for local scale planning); and
- assembly and application of various management layers for both regional and local scale planning.

**Figure 24 Overview of the Biodiversity Assessment and Spatial Framework for the Greater Vancouver Region**



## 8.5 Lessons Learned

1. The 2002 land cover dataset is a very useful product for biodiversity planning. It should, however, be updated on a regular basis to help quantify the amount of change resulting from urban expansion and development and help manage this change.

2. Detailed vegetation mapping.

   While the information resulting from the detailed vegetation mapping was useful and fed into the ISMP, in the future, in a watershed as heavily urbanized as Still Creek, the regional scale dataset resulting from this project could be used to identify key locations requiring detailed mapping. This would allow detailed mapping effort and funds to be maximized in those locations where it is most needed.

3. As GIS-based analyses become more integrated in the municipal and regional planning processes, local and regional planners will need to become informed about the capabilities and limitations of GIS, particularly related to data quality and scale, and the interpretation of modeled results.

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# Appendix A Indicator Species Habitat Mapping

# A.1 Habitat Mapping for Indicator Species

## A.1.1 Limitations

The indicator species habitat maps are derived from habitat models and, as with any model, there are a number of limitations that must be considered when interpreting and using the maps. These include the following:

- The indicator species habitat maps were developed to identify key habitats within the region from a biodiversity perspective. This approach may have resulted in the omission of some smaller patches of habitat that may be being utilized by some of the indicator species.
- The habitat models were based on available research, however, not all of this research was specific to the Greater Vancouver Region.
- The habitat maps have not been field verified.

As a result of these limitations, the results of the indicator species analyses were not used in the biodiversity assessment mapping. However, they do provide useful information to guide biodiversity planning and therefore they have been provided in the following appendix. As better information becomes available, the ‘habitat rules’ for the selected indicator species used for this project can be modified, and the maps can easily be revised to create a more accurate picture of habitat suitability and, more importantly, availability. As well, the information can be used to replicate the mapping at some future date using the same rules, to monitor and assess landscape changes over time.

The model multiplies the scores for various habitat requirements rather than adding the values. This approach ensures that unsuitable habitats receive a score of ‘0’, however, it can result in very low habitat scores (particularly for those species having a large number of habitat characteristics). As a result, the habitat suitability indices are reclassified into bins (‘High’ [0.75 – 1.00], ‘Moderate’ [0.50 – 0.74] and ‘Low’ [0.01 – 0.49]) to ensure all viable habitats are mapped. It should be noted that the data could be reclassified into different classes or species-specific classes as more information becomes available.

## A.1.2 Selection of Indicator Species

Indicator species are used to assess the suitability of habitat for both themselves and other associated species. The assumption is that habitat quality and biodiversity are directly associated (Schaefer, 2004). The indicator species habitat maps have been generated as reference layers and are independent from the biodiversity analysis. The maps have been provided as an information layer to help identify those habitats being utilized by a diverse number of species. Because they are sensitive to environmental health, and ecosystem integrity and quality, indicator species can act as barometers of environmental change, similar to a canary in a coal mine. Indicator species can provide us with information to:

- assess current conditions in a particular area;
- identify and map areas that would benefit from maintenance or restoration efforts; and/or
- monitor the effectiveness of conservation/restoration efforts that are implemented.

The selection of which species to use as indicators of habitat quality can be based on various criteria. For the purposes of assessing, monitoring, and conserving biodiversity in the Still Creek watershed, indicator species that were representative of a particular ecosystem type, or of the relationship among types were selected. These species are also common and widely distributed, or have unique or limited distributions. Additionally, most are relatively easy to monitor and some of their basic habitat requirements are known. Based on the work of Lee and Rudd (2003), which identified a broad suite of indicator species for the Greater Vancouver Region, and discussions held during the Still Creek workshop, a group of indicator species that were considered to be most appropriate for maintaining and/or enhancing/restoring the various ecosystem types within the Still Creek watershed were selected (Table A-1). Table A-2 provides a list of the species associated with each of the indicator species under consideration which has been derived based on the work of Lee and Rudd, 2003.

**Table A-1 List of Potential Indicator Species for the Still Creek Watershed**

| Ecosystem Class | Selected Indicator Species | Suitable for Management Goal of Maintaining Habitat? | Suitable for Management Goal of Enhancing/ Restoring Habitat? | Can Habitat Maps Be Created for This Species? |
|---|---|---|---|---|
| Open Water (streams and lakes) & Riparian Ecosystems | Cutthroat Trout | √ | √ | |
| | Aquatic macro invertebrates (Benthic Index of Biological Integrity) | √ | √ | |
| | Cooper's Hawk | √ | √ | √ |
| Wetland Ecosystems | Great Blue Heron | √ | √ | √ |
| | Red-legged Frog | √ | √ | √ |
| | Common Garter Snake | √ | √ | |
| Forested Ecosystems | Brown Creeper (tree species & structural diversity) | √ | √ | √ |
| | Pileated Woodpecker (large patches & connectivity of core areas) | √ | √ | √ |
| | Douglas Squirrel | √ | √ | √ |
| Urban Ecosystems | Spotted Towhee | √ | √ | √ |
| | Cooper's Hawk | √ | √ | √ |
| Herb and Grass Ecosystems | Northern Harrier | √ | √ | √ |
| | Common Garter Snake | √ | √ | |

**Table A-2 Species Associated with the Indicator Species (based on Lee and Rudd, 2003)**

| Habitat | Indicator species | Associated species* |
|---|---|---|
| Forest | Douglas Squirrel, Brown Creeper, Pileated Woodpecker | • Tailed Frog (Ascaphus truei)<br>• Northwestern Salamander (Ambystoma gracile)<br>• Red-backed Salamander (Plethodon vehiculum)<br>• Common Garter Snake (Thamnophis sirtalis)<br>• Great Blue Heron (Ardea herodias)<br>• Cooper's Hawk (Accipiter cooperii)<br>• Rufous Hummingbird (Selasphorus rufus)<br>• Red-breasted Nuthatch (Sitta canadensis)<br>• Yellow Warbler (Dendroica petechia)<br>• Black-throated Gray Warbler (Dendroica nigrescens)<br>• Townsend's Warbler (Dendroica townsendi)<br>• Black-tailed Deer (Odocoileus hemionus columbians)<br>• Black Bear (Ursus americanus)<br>• Southern Red-backed Vole (Clethrionomys gapperi)<br>• Creeping Vole (Microtus oregoni)<br>• Orchard Mason Bee (Osmia lignaria)<br>• Bumble Bee (Hymenoptera Apidae)<br>• Western Trillium (Trillium ovatum)<br>• Devil's Club (Oplopanax horridus)<br>• Western Flowering Dogwood (Cornus nutallii)<br>• Cascara (Rhamnus purshianus)<br>• Red Huckleberry (Vaccinium parvifolium)<br>• Skunk Cabbage (Lysichiton americanum) |
| Open water | Cutthroat Trout, Cooper's Hawk | • White Sturgeon (Acipenser transmontanus)<br>• Coho Salmon (Oncorhynchus kisutch)<br>• Steelhead Trout (Oncorhynchus mykiss)<br>• Long-nose/Nooksack Dace (Rhinichthys catacractae /Rhinichthys sp.)<br>• Red-legged Frog (Rana aurora)<br>• Tailed Frog (Ascaphus truei)<br>• Pacific Treefrog (Hyla regilla)<br>• Northwestern Salamander (Ambystoma gracile)<br>• American Bittern (Botaurus lentiginosus)<br>• Great Blue Heron (Ardea herodias)<br>• Townsend's Warbler (Dendroica townsendi)<br>• River Otter (Lontra canadensis)<br>• Stonefly sp. (Plecoptera sp.)<br>• Caddisfly sp. (Trichoptera sp.)<br>• Mayfly sp. (Ephemeroptera sp.)<br>• Riffle Beetle (Coleoptera Elmidae) |

Table Continued

**Table A-2 Species Associated with the Indicator Species (based on Lee and Rudd, 2003) cont'd**

| Habitat | Indicator species | Associated species* |
|---|---|---|
| Riparian | Coopers Hawk | • Red-legged Frog (Rana aurora)<br>• Tailed Frog (Ascaphus truei)<br>• Pacific Treefrog (Hyla regilla)<br>• Northwestern Salamander (Ambystoma gracile)<br>• Red-backed Salamander (Plethodon vehiculum)<br>• Common Garter Snake (Thamnophis sirtalis)<br>• American Bittern (Botaurus lentiginosus)<br>• Great Blue Heron (Ardea herodias)<br>• Northern Pintail (Anas acuta)<br>• Rufous Hummingbird (Selasphorus rufus)<br>• Yellow Warbler (Dendroica petechia)<br>• Black-throated Gray Warbler (Dendroica nigrescens)<br>• Townsend's Warbler (Dendroica townsendi)<br>• Spotted Towhee (Pipilo maculatus)<br>• River Otter (Lontra canadensis)<br>• Black Bear (Ursus americanus)<br>• Anise Swallowtail (Papilio zelicaon lucas)<br>• Orchard Mason Bee (Osmia lignaria)<br>• Bumble Bee (Hymenopter Apidea)<br>• Western Trillium (Trillium ovatum)<br>• Devil's Club (Oplopanax horridus)<br>• Western Flowering Dogwood (Cornus nutallii)<br>• Cascara (Rhamnus pursihana)<br>• Red Huckleberry (Vaccinium parvifolium)<br>• Skunk Cabbage (Lysichiton americanum) |
| Herb/Grass | Northern Harrier, Common Garter Snake | • Red-legged Frog (Rana aurora)<br>• Pacific Treefrog (Hyla regilla)<br>• Northwestern Salamander (Ambystoma gracile)<br>• Great Blue Heron (Ardea herodias)<br>• Northern Pintail (Anas acuta)<br>• Black-bellied Plover (Pluvialis squatarola)<br>• Barn Owl (Tyto alba)<br>• Short-eared Owl (Asio flammeus)<br>• Rufous Hummingbird (Selasphorus rufus)<br>• Spotted Towhee (Pipilo maculatus)<br>• Townsend's Vole (Microtus townsendi)<br>• Creeping Vole (Microtus oregoni)<br>• Anise Swallowtail (Papilio zelicaon lucas) |

Table Continued

**Table A-2 Species Associated with the Indicator Species (based on Lee and Rudd, 2003) cont'd**

| Habitat | Indicator species | Associated species* |
|---|---|---|
| Wetland | Great Blue Heron, Red-legged Frog, Common Garter Snake | • Northwestern Salamander (Ambystoma gracile)<br>• Pacific Treefrog (Hyla regilla)<br>• American Bittern (Botaurus lentiginosus)<br>• Northern Pintail (Anas acuta)<br>• Northern Harrier (Circus cyaneus)<br>• Short-eared Owl (Asio flammeus)<br>• Rufous Hummingbird (Selasphorus rufus)<br>• Marsh Wren (Cistothorus palustris)<br>• River Otter (Lontra canadensis)<br>• Townsend's Vole (Microtus townsendi)<br>• Round-leaved Sundew (Drosera rotundifolia)<br>• Yellow Waterlily (Nuphar luteum spp. polysepalum)<br>• Skunk Cabbage (Lysichiton americanum) |
| Urban | Spotted Towhee, Coopers Hawk | • Pacific Treefrog (Hyla regilla)<br>• Black-throated Gray Warbler (Dendroica nigrescens)<br>• Townsend's Warbler (Dendroica townsendi)<br>• Rufous Hummingbird (Selasphorus rufus)<br>• Anise Swallowtail (Papilio zelicaon lucas)<br>• Orchard Mason Bee (Osmia lignaria)<br>• Bumble Bee (Hymenoptera Apidae) |

* While all of the species listed in Table A-2 are associated with the indicators, not all of the associated species will be found in the Still Creek watershed. Yellow highlighted species do not occur and the green highlighting indicates those species rarely found.

### A.1.3 Development of Habitat Rules and Habitat Maps for Indicator Species

Once the appropriate indicator species were selected, habitat rules were developed for each species so that areas of important habitats and ecosystems could be identified and mapped. The habitat rules for each species were based on key habitat attributes (e.g., habitat type, proximity to water, patch size, slope, elevation) that are required by that species. Development of the habitat rules involved the following steps:

1. Conducting literature reviews to determine the habitat requirements for each species. Those habitat variables that were most relevant to the species, and which could be mapped were used in the development of the habitat rules.
2. Assigning broad categories to each habitat variable, and then ranking them from 0 (lowest) to 1.0 (highest) according to their importance to the species. For example, the most suitable habitat for the Brown Creeper was considered to be old-growth coniferous forests that have ≥ 70% canopy cover, are ≥ 28 ha in size, and are located below an elevation of 1051 metres; therefore, all these categories received a ranking of 1.0. All other categories within a habitat variable were marked down according to their suitability to the species. For instance, although Brown Creepers in BC have been recorded at elevations up to 1220 m, breeding has been recorded only at elevations up to 1050 m. Habitat located at elevations from 1051 to 1220 m therefore, was marked down to a ranking of 0.5 because it was considered not to provide suitable breeding habitat, but likely still had value in terms of other life requirements

such as foraging. Habitat at elevation > 1220 m was considered to be unsuitable for Brown Creepers, and so, was assigned a rank of 0.

The habitat characteristics and categories used, and their rankings were based on literature reviews, on the AXYS team's general knowledge of each species' habitat requirements, and on personal communications with other professional biologists and the Biodiversity Conservation Strategy steering committee and working group. The background information assembled for each species represents the best information available at the time of the study. They represent a 'first cut' at developing habitat maps for the region and it is strongly suggested that future work incorporate field surveys and site recordings to verify the accuracy of the results.

3. Calculating habitat suitability indices (HSI) for the purposes of creating habitat maps for each species. The indices were calculated for each combination of habitat characteristics for each species. For example, the HSI calculations for the Brown Creeper were as follows (see Appendix B for habitat characteristics and categories for the Brown Creeper):

HSI = HT x FA x CC x HRS x E

Where: HSI = the habitat suitability index
HT = habitat type
FA = forest age
CC = canopy cover
HRS = home range size
E = elevation

An old-growth, coniferous forest stand with ≥ 70% canopy cover that is ≥ 28 ha in size and is located below 1051 m elevation would be assigned a HSI of 1.0 based on the calculations detailed in Table A-3:

## Table A-3 Example HSI Calculation 1 for Brown Creeper

| | FA | HT | CC | HRS | E |
|---|---|---|---|---|---|
| **Habitat characteristic** | Old growth | Coniferous forest | ≥ 70% | ≥ 28 ha | < 1051 m |
| **Rating** | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Formula** | HSI = 1.0 x 1.0 x 1.0 x 1.0 x 1.0 = **1.0** | | | | |

A 60-year-old, deciduous stand that has 50% canopy cover, is 9 ha in size, and is located at 1055 m elevation would be assigned a HSI of 0.02 based on the calculations detailed in Table A-4:

**Table A-4 Example HSI Calculation 1 for Brown Creeper**

| | FA | HT | CC | HRS | E |
|---|---|---|---|---|---|
| **Habitat characteristic** | 60 years | Deciduous forest | 50% | 9 ha | 1055 m |
| **Rating** | 0.5 | 0.25 | 0.50 | 0.75 | 0.50 |
| **Formula** | HSI = 0.50 x 0.50 x 0.5 x 0.75 x 0.5 = **0.02** | | | | |

4. Creating general habitat suitability maps that delineate areas of low, moderate, and high quality habitat for each species using GIS software. Indices from 0.01 to 0.49 were used to define areas of low habitat suitability; 0.50 to 0.74 defined moderately suitable habitat; and 0.75 to 1.0 defined highly suitable habitat.

   Since forest cover data were available primarily for the North Shore only, the variables 'forest age' and 'canopy closure' could not be used to map habitats in the Still Creek watershed. Instead, surrogate variables based on satellite imagery and Baseline Thematic Mapping (BTM) were used. The variable 'urban forest', which designates large parcels of forests that are approximately >70 years old, was used in place of 'forest age', and the categories 'open canopy' (<70% canopy closure) or 'closed canopy' (>70% canopy closure) were used in place of 'canopy closure'.

   The habitat characteristics and categories used for each indicator species are presented in Appendix B. The indicator species habitat maps were developed using habitat types derived from the regional scale land cover dataset to allow important habits adjacent to, and outside, the watershed to be identified.

## A.2 Habitat Mapping Results

Habitat maps (Figures A-1 to A-9) were developed for a number of indicators species (Table A-5). The species were selected because they represent key habitats within the region. In addition, they are species where information on their specific habitat requirements is available.

The purpose of the indicator species habitat maps is to identify those habitats within the region important to each of the selected indicators and their associated species. The assumption is that if a given habitat is utilized by a greater variety of species (e.g., more of the indicators) then it is more important from a biodiversity perspective than patches used by fewer species.

The habitat maps developed were based on the best available information at the time of the project (GIS land cover data and habitat rules derived through literature review) and have not been field verified. As a result, it is anticipated that some smaller patches of habitat may have been omitted by the mapping exercise. However, it should be noted that, the purpose of the indicator species maps was to identify regionally significant habitats for a diversity of species rather than map habitats and species ranges. The existing maps provide a good baseline dataset for each of the species mapped. Ideally, through a process of more detailed vegetation mapping and field verification, the maps could be refined to allow them to be used as a decision-making tool for both biodiversity planning and management of the species (and associated species) they represent.

### Table A-5 Indicator Species and Key Habitat Types for the Still Creek Watershed

| Indicator | Key Habitat type(s) |
|---|---|
| Cooper's hawk | • coniferous, deciduous, mixed forests |
| Northern harrier | • fields, grasslands, wetlands, large patches |
| Brown creeper | • mature/old-growth coniferous forests |
| Red-legged frog | • small wetlands and still water |
| Pileated woodpecker | • large patches of mature/old-growth coniferous and deciduous forest |
| Spotted towhee | • forest/urban trees and shrubs |
| Great blue heron | • wetlands, still water, watercourses, riparian habitats, herb and grass (foraging)<br>• mature coniferous, deciduous, and mixed forests (breeding) |
| Douglas' squirrel | • old-growth coniferous forests |
| Riparian corridors, water features | • a surrogate for fish and benthic species |

Figures A-1 through A-9 illustrate the results of the habitat model development for each species. According to the model, patches of suitable habitat exist within the watershed for the following indicator species and their community associates (Table A-2):

- Great blue heron: the northwest end of Burnaby Lake Park, Central Park, and along the Still and Beecher creeks riparian corridors
- Cooper's hawk: Central and northwest Burnaby Lake parks, along Beecher Creek, Renfrew Ravine, Discovery Park (area west of Guichon Creek)
- Douglas' squirrel: Central Park
- Spotted towhee: vegetated areas throughout the watershed
- Brown creeper: Central and Burnaby Lake parks

The results of the modeling process indicate that little suitable habitat exists within the watershed for red-legged frog, northern harrier, or pileated woodpecker. It should be noted, however, that the area surrounding Burnaby Lake does provide some habitat for each of these three species, therefore, changes to Still Creek may impact these species given that the creek flows into Burnaby Lake.

In addition to the work conducted by AXYS, the City of Burnaby has generated a habitat model for the Pacific water shrew. The Pacific water shrew is a species at risk that is protected under the BC Wildlife Act and the federal Species at Risk Act. Modeling and mapping the habitat of species at risk, such as the Pacific water shrew, provides useful information for biodiversity conservation planning. The results of the City of Burnaby's study are presented in Appendix C. The indicator species habitat models and maps are useful in evaluating potentially significant habitat for many species at risk. For example, the great blue heron model and map (Figure A-2) also shows wetland habitat suitability that correlates with that of the Pacific water shrew model evaluation (Appendix C).

## Figure A-1 Red-legged Frog Habitat Suitability

**Figure A-2 Great Blue Heron Habitat Suitability (Breeding and Foraging)**

## Figure A-3 Cooper's Hawk Habitat Suitability

## Figure A-4 Douglas' Squirrel Habitat Suitability

## Figure A-5 Spotted Towhee Habitat Suitability

## Figure A-6 Northern Harrier Habitat Suitability

## Figure A-7 Pileated Woodpecker Habitat Suitability

## Figure A-8 Brown Creeper Habitat Suitability

## Figure A-9 Indicator Diversity

## HABITAT RULES – Brown Creeper (breeding and foraging habitat)

| Habitat Type (not urban or agricultural trees) | | | | Forest Age | | | Canopy Cover | | |
|---|---|---|---|---|---|---|---|---|---|
| **Coniferous forest** | **Deciduous forest** | **Mixed forest** | **All Others** | **> 95 years** | **50-95 years** | **< 50 years** | **≥ 70%** | **50-69%** | **< 50%** |
| 1.0 | 0.25 | 0.25 | 0 | 1.0 | 0.5 | 0 | 1.0 | 0.5 | 0 |

| Home Range Size | | | Elevation | | |
|---|---|---|---|---|---|
| **≥ 28 ha** | **7 - 27 ha** | **< 7 ha** | **0-1050 m** | **1051-1220 m** | **≥ 1221 m** |
| 1.0 | 0.75 | 0.0 | 1.0 | 0.5 | 0 |

**Rationale for rankings:**

Habitat Type

On the coast of B.C., frequents mature and old-growth coniferous forests dominated by Douglas-fir, western hemlock, grand fir, and western redcedar (some use of mixed forests recorded). Forages on trunks of large and medium-sized trees of all species, but prefers trees with rough bark (e.g., conifers). Forests with a diversity of tree species provide a variety of invertebrate prey items, and thus, a stable food supply.

Nineteen of 20 nesting habitats that were described in detail were in coniferous stands, only 1 was in a deciduous stand (Campbell et al. 1997)

Forest Age

On western Vancouver Island, BRCR were found in 55% of 71 stands aged >200 years old, and in 19% of 36 stands aged 50-60 years (Bryant et al. 1993). In southern Washington, BRCR were most abundant in mature forests (95-190 years old) and old-growth forests (> 200 years) (Manuwal 1991).

Canopy Closure

Tree canopy closure is considered optimal at 70%. Suitability increases linearly from 50-70%. Anything below 70% is considered unsuitable (Banks et al. 1999 – forests in west central Alberta)

Home Range Size

Territory sizes for BRCR in the Western Cascade Mountains of Oregon (Anthony et al. 1996), and in western Alberta (Farr 1995) were 1.7 ha and 6.7 ha, respectively (Banks et al. 1999). Higgelke and MacLeaod (2000) used 7 ha in their habitat suitability model for Alberta, which was slightly larger than Davis's (1978) largest estimate. Donnelly (2002) reported that in suburban and urban landscapes in the Seattle area, BRCR require forest reserves that are at least 28 ha.

Elevation

On the coast, has been reported from sea level to 1220 m; breeding has been recorded from near sea level to 1050 m (Campbell et al. 1997)

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## HABITAT RULES – Cooper's Hawk (breeding and foraging habitat)

| Habitat Type – Agricultural and Urban Trees | | | | Canopy Closure | | |
|---|---|---|---|---|---|---|
| **Coniferous forest** | **Deciduous forest** | **Mixed forest** | **All Others** | **64-95%** | **< 64%** | **>95%** |
| 1.0 | 1.0 | 1.0 | 0 | 1.0 | 0.75 | 0 |

| Forest Patch Size | | Distance to Fresh Water | | Elevation | | |
|---|---|---|---|---|---|---|
| **≥ 4 ha** | **< 4 ha** | **< 1 km** | **> 1 km** | **0-1130 m** | **1131-1400 m** | **>1400 m** |
| 1.0 | 0 | 1.0 | 0.75 | 1.0 | 0.5 | 0 |

**Rationale for rankings:**

Habitat Type

Uses coniferous, deciduous, and mixed forests, and riparian woodlands. Tolerates human disturbance and habitat fragmentation; breeds in urban settings (Rosenfield and Bielefeldt 1993).

Canopy Closure

Average canopy closure in nesting areas in North America ranged from 64% to 95% (Rosenfield and Bielefeldt 1993).

Forest Patch Size

Nests in woodlots of 4-8 ha (Rosenfield and Bielefeldt 1993). (Didn't include home range size since the species uses a mix of habitat types)

Distance to Water

Nest sites are often within 1 km of water (Rosenfield and Bielefeldt 1993).

Elevation

Nests have been found from sea level to 1130 m; during the nonbreeding season, the species is usually found below 1400 m (Campbell et al. 1990).

**References:**

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# HABITAT RULES – Douglas' Squirrel

| Habitat Type | | Forest Age | | | Territory Size | | |
|---|---|---|---|---|---|---|---|
| **Coniferous forest** | **All Others** | **≥ 200 years** | **40-199 years** | **< 40 years** | **≥ 1.0 ha** | **0.21-0.99** | **< 0.21 ha** |
| 1.0 | 0 | 1.0 | 0.75 | 0 | 1.0 | 0.5 | 0.0 |

**Rationale for rankings:**

Habitat Type

Main food items: conifer seeds, fungi. Although Carey (1995) reported that his and other studies have not shown significant differences in Douglas' squirrel abundance among young, mature, and old-growth forests, the latter may be more likely to provide required food sources for the species. For example, old-growth forests have more CWD than younger forests, and so, probably have greater abundance of hypogeous fungi (Carey 1991). Old-growth forests also have greater seed production than 40-year-old stands (Carey 1991). Multi-layered canopies of old-growth forests have other seed- and mast-producing species (e.g., maples, huckleberries) that can provide alternate food sources in years when cone crops fail (Carey 1991). For these reasons, old-growth forests were ranked higher than other stand ages.

Forest Age

Maximum seed production in Douglas-fir forests occurs when stands are between 200 and 300 years of age (Fowells 1965)

Territory Size

Territory sizes reported in the literature were 0.21 ha (Carey 1991) and 1-1.5 ha (Halloran 1999)

Elevation

**References:**

Carey, A.B. 1991. The biology of arboreal rodents in Douglas-fir forests. *In* M.H. Huff, R.S. Holthausen and K.B. Aubrey (tech. coord.). USDA For. Serv. PNW Res. Stn. Gen. Tech. Rep. PNW-GTR-276. 53pp.

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# HABITAT RULES – Great Blue Heron (foraging and breeding habitat)

### *Foraging*

| Foraging Habitat Type | | | | | Elevation | | Slope | |
|---|---|---|---|---|---|---|---|---|
| **Wetlands and Still Water** | **Intertidal** | **Watercourses and Riparian Areas** | **Herb and Grass** | **All Others** | **0 – 2100 m** | **> 2100 m** | **0-10%** | **>10%** |
| 1.0 | 1.0 | 1.0 | 0.75 | 0 | 1.0 | 0 | 1.0 | 0 |

**Rationale for rankings:**

Habitat Type

On the coast, important foraging habitat includes the GBHE frequents sheltered and shallow bays, lagoons, tidal mud flats, eelgrass beds, sloughs, marshes, lakeshores, rivers, irrigation ditches, and wet and dry agricultural fields (Campbell et al. 1990; Butler 1992). Herb and grass areas are marked down slightly because these areas are used primarily in winter, and then, mainly by juvenile birds (B. Gowans, R. Vennesland, pers. comm.).

Elevation

During the nonbreeding season, GBHE have been recorded from sea level to 2100 m (Campbell et al. 1990)

Slope

Best guess based on the fact that flatter sites are associated with standing water.

### *Breeding*

| Breeding Habitat Type | | | | Forest Stand Age | | Forest Patch Size | | Distance to Foraging Habitat | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Deciduous Forest** | **Coniferous Forest** | **Mixed Forest** | **All Other Types** | **≥ 25 years** | **< 25 years** | **≥ 13 ha** | **< 13 ha** | **< 6 km** | **6 – 30 km** | **> 30 km** |
| 1.0 | 0.75 | 0.75 | 0 | 1.0 | 0 | 1.0 | 0.75 | 1.0 | 0.5 | 0 |

| Elevation | | Slope | |
|---|---|---|---|
| **≤ 1100 m** | **> 1100 m** | **0-10%** | **>10%** |
| 1.0 | 0 | 1.0 | 0.25 |

**Rationale for rankings:**

Habitat Type

Breeding colonies are usually located in mature forests (coniferous, deciduous, or mixed) that are relatively undisturbed and near suitable foraging areas (Campbell et al. 1990). Very large colonies around the lower Fraser Valley rely on large parcels of primarily deciduous (mostly red alder) forest (Vennesland and Summers 2003). Most common nest trees on the B.C. coast are red alder and black cottonwood (Butler 1991b; Gebauer 1995).

Forest Stand Age

The minimum age class of alder and fir trees used for nesting was about 25 years (Gebauer and Moul 2001)

Forest Patch Size

Based on recommendations by Vennesland and Summers (2003) that Wildlife Habitat Areas for GBHE should be approximately 13 ha, and include known and potential nest sites; however, these recommendations apply more to undeveloped areas. In the Fraser Valley, smaller patches or even solitary trees are often used for nesting (R. Vennesland, pers. comm.); consequently, patches of this size are marked down only slightly.

Distance to Foraging Habitat

During the breeding season home range extends up to 30 km from the colony, but most birds stay within 10 km (Butler 1991a, 1997). Twenty-nine of 33 colonies were located within six kilometers of their main feeding sites (Butler 1991a).

Elevation

Breeding occurs from sea level to 1100 m (Campbell et al. 1990)

Slope

Herons use breeding sites with slope >10%, but only infrequently (R. Vennesland, pers. comm.)

**References:**

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# HABITAT RULES – Northern Harrier (breeding and foraging habitat)

| Habitat Type | | | | Home Range Size | | | Elevation | | | Slope | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Herb and Grass | Wet-lands | Agricul-tural Fields | All Other Types | < 40 ha | 40-100 ha | > 100ha | 0 - 1010 m | 1011 - 2440 m | > 2440 m | 0-10% | > 10 % |
| 1.0 | 1.0 | 0.75 | 0 | 0 | 0.5 | 1.0 | 1.0 | 0.5 | 0 | 1.0 | 0 |

**Rationale for rankings:**

Habitat Type

In BC, nonbreeding habitat consists of fresh and salt water marshes and sloughs, dry upland fields, grasslands, agricultural fields and airports (Campbell et al. 1990). Breeding: most nests in BC found in marshes; others were located in emergent vegetation surrounding lakes and ponds, or in open fields with shrub growth (Campbell et al. 1990). Agricultural fields were marked down due to potential disturbances to nesting birds from crop harvesting, haying, or tilling (USFWA 2001). (Note: agricultural fields were marked up from 0.5 in earlier versions of the habitat rules due to a reviewer's concerns (June 24 review) that some important agricultural areas were missed in the preliminary mapping).

Home Range Size

Based on the fact that reviewers had observed Northern Harriers using field habitats around Deer Lake (~42 ha) and Colony Farm (~112 ha of contiguous habitat). Throughout North America, minimum home range size during the breeding season ranged from 170-15,000 ha; median = 260 ha; *n* = 8 studies (MacWhirter and Bildstein (1996)).

Elevation

In BC, NOHA have been recorded from sea level to 2440 m elevation; nests have been found from near sea level to 1010 m (Campbell et al. 1990).

Slope

Based on the fact that wetlands and agricultural fields are associated with sites with little topographic relief.

**References:**

Campbell, R.W., N.K Dawe, I.M. Cowan, J.M. Cooper, G.W. Kaiser, A.C. Stewart, and M.C. McNall. 1990. The Birds of British Columbia. Volume 2: Diurnal birds of prey through woodpeckers. Royal British Columbia Museum, Victoria, BC.

MacWhirter, R.B. and K.L. Bildstein. 1996. Northern Harrier *Circus cyaneus In:* A. Poole and F. Gill (eds.). The Birds of North America. No. 210. Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

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## HABITAT RULES – Pileated Woodpecker (year-round habitat)

| Habitat Type – Agricultural and Urban Trees | | | Forest Age | | | Canopy Closure | | |
|---|---|---|---|---|---|---|---|---|
| **Coniferous forest** | **Deciduous forest** | **Mixed forest** | **> 70 years** | **41-70 years** | **< 40 years** | **≥ 75%** | **25-74%** | **< 25%** |
| 1.0 | 0.75 | 0.75 | 1.0 | 0.75 | 0.0 | 1.0 | 0.5 | 0 |

| Home Range Size | | | Elevation | |
|---|---|---|---|---|
| **> 130 ha** | **70-130 ha** | **< 70 ha** | **0-1200 m** | **>1200 m** |
| 1.0 | 0.5 | 0 | 1.0 | 0 |

**Rationale for rankings:**

Habitat Type

Breeds in late successional stage coniferous or deciduous forests (Bull and Jackson 1995). Nest trees are usually dead and within mature or old-growth coniferous or deciduous stands (Bull and Jackson 1995). In western Washington and western Oregon, most nest trees were large diameter conifers (Bull and Jackson 1995). Roosts in hollow trees or vacated nest cavities; 86% of roost trees used in western Washington were in old-growth conifer stands (Aubry and Raley 1993).

Forest Age

In western Oregon, prefers forests >40 years old for foraging, and >70 years old for nesting and roosting (Mellen et al. 1992).

Canopy Closure

The Habitat Suitability Index developed by Schoeder (1983) assumed optimal habitats have at least 75% canopy cover: unsuitable habitats have less than 25%.

Home Range Size

Home ranges of breeding pairs in northeastern Oregon ranged from 130 to 243 ha (Bull and Meslow 1977). A minimum size of 130 ha was used for the Habitat Suitability Index developed by Schoeder (1983). Bull and Jackson (1995) state that in Washington and Oregon, the U.S. Forest Service maintains management areas of 120 ha in old-growth forests (i.e., >80 years old) for nesting plus 120 ha with >5 snags/ha for foraging; however, these data are based on results from east of the Cascade Mountains. Based on telemetry results of tagged birds followed during summer after young had fledged (home range size ranged from 267-1056 ha; mean = 478 ha (western Oregon), Mellen et al. (1992) recommended that the size of these management areas be increased by 50%.

Revisions were made to the original habitat rules based on reviewer's comments that Kilham (1976) found winter foraging range was approximately 70 ha, and that Pileated

Woodpeckers have been found nesting in Central Park (~85 ha). Minimum patch size of 130 ha used by Schroeder (1983) and reported by Bull and Jackson (1995) was used as an optimal size since this would include many of the urban forest patches in the southern part of the GVRD where breeding has been confirmed (P. Zevit, pers. comm.). Note: Kilham's findings were for Georgia and Florida, so their applicability to southwestern B.C. may be limited.

Elevation

Nests have been found from sea level to 1130 m; during the nonbreeding season, the species has been reported from near sea level to 1200 m (Campbell et al. 1990).

**References:**

Aubry, .B. and C.M. Raley. 1992. Landscape-level responses of Pileated Woodpeckers to forest management and fragmentation: a pilot study. Prog. Rep. On file at Pacific Northwest Res. Stn., Olympia, WA. *Cited in* E.L. Bull and J.A. Jackson. 1995. Pileated Woodpecker *Dryocopus pileatus*. *In:* A. Poole and F. Gill (eds.). The Birds of North America. No. 148. Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Bull, E.L., and E.C. Meslow. 1977. Habitat requirements of the Pileated Woodpecker in northeastern Oregon. J. For. 75:335-337 *cited in* R.L. Schroeder. 1983. Habitat suitability index models: Pileated Woodpecker. FWA/OBS-82/10.39. Fish and Wildlife Service, U.S. Department of the Interior, Washington, DC.

Bull, E.L. and J.A. Jackson. 1995. Pileated Woodpecker *Dryocopus pileatus*. *In:* A. Poole and F. Gill (eds.). The Birds of North America. No. 148. Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

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Mellen, T.K., E.C. Meslow and R.W. Mannan. 1992. Summertime home range and habitat use of Pileated Woodpeckers in western Oregon. J. Wildl. Manage. 56: 96-103.

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**Personal Communications:**

Pamela Zevit, Como Watershed Group

# HABITAT RULES – Red-legged Frog

| Habitat Type | | Wetland Size | | | Buffer Type | | | |
|---|---|---|---|---|---|---|---|---|
| Wetlands and Still Water | All Others | < 0.5 ha | 0.5 - 10 ha | > 10 ha | Coniferous Forest | Deciduous Forest | Mixed Forest | All Other Types |
| 1.0 | 0 | 1.0 | 0.50 | 0.25 | 1.0 | 1.0 | 1.0 | 0 |

| Buffer Age | | Buffer Size | | | Elevation | | Slope | |
|---|---|---|---|---|---|---|---|---|
| Forest > 20 years old | Forest < 20 years old | >50 m | 30-50 m | < 30 m | ≤ 850 m | > 850 m | 0-10% | > 10% |
| 1.0 | 0.25 | 1.0 | 0.5 | 0 | 1.0 | 0 | 1.0 | 0 |

**Rationale for rankings:**

Wetland Size

Based on recommended sizes for establishment of Wildlife Habitat Areas – i.e., size generally < 10 ha, and wetland complexes should include wetlands of <0.5 ha.

Buffer Type/ Age/ Size

Based on recommendations that Wildlife Habitat Areas for red-legged frogs should include a wetland network with 30 m reserve of riparian habitat beyond the high water mark, plus a 20 m management zone beyond this core area. No more than 50% of the Wildlife Habitat Area should be surrounded by forests that are < 20 years old (Maxcy 2003).

Elevation

Generally found below 850 m (Maxcy 2003)

Slope

Best guess based on the fact that flatter sites are associated with standing water

**References:**

Maxcy, K. 2003. Northern red-legged frog *Rana aurora aurora*. Pages 62 – 72 *in* Standards for Managing Identified Wildlife – Accounts. Version 2. B.C. Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, B.C.

# HABITAT RULES – Spotted Towhee (winter and breeding habitat)

| Habitat Type (forest and urban trees and shrubs) | | | | | Home Range Size | |
|---|---|---|---|---|---|---|
| **Coniferous forest** | **Deciduous forest** | **Shrub** | **Urban/Built Landscape** | **All Others** | **< 1 ha** | **≥ 1 ha** |
| 1.0 | 1.0 | 1.0 | 0.50 | 0 | 0 | 1.0 |

| Elevation | |
|---|---|
| **0 - 975 m** | **> 975m** |
| 1.0 | 0 |

**Rationale for rankings:**

Habitat Type

On the coast, the Spotted Towhee occupies brush-filled ravines, forest edges, open coniferous forests with salal understory, blackberry thickets along roadsides and field edges, and urban gardens. Forest patches used for nesting were equally divided between those dominated by deciduous trees and coastal Douglas-fir. Forest patches used for nesting were equally divided between those dominated by deciduous trees and coastal Douglas-fir (Campbell et al. 2001).

Home Range Size

Winter home range sizes reported in the literature ranged from 3.8 ha and 12.5 ha; breeding densities ranged from one male or one pair per 0.7 – 5 ha. Results were from New Jersey, Kansas, Kentucky, Montana, and California (Dobkin no date). Based on these results, a minimum home range size of 1 ha was selected.

Elevation

In coastal BC, during the nonbreeding season, the Spotted Towhee occurs from sea level to 600 m elevation; during the breeding season, it occurs up to 975 m (Campbell et al. 2001)

**References:**

Campbell, R.W., N.K Dawe, I.M. Cowan, J.M. Cooper, G.W. Kaiser, A.C. Stewart, and M.C. McNall. 2001. The Birds of British Columbia. Volume 4: Wood warblers through Old World sparrows. Royal British Columbia Museum, Victoria, BC.

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# Appendix B CITYgreen Analysis Results

# Appendix C Pacific Water Shrew (Sorex bendirii) Suitability Mapping

# Pacific Water Shrew (*Sorex bendirii*)
# Suitability Mapping

***Prepared by Robyn Wark, City of Burnaby. January 2005***

Methodology developed by: Ross Vennesland, WLAP,
Robyn Wark, City of Burnaby, and Susan Haid, GVRD

## 1. Method:

Watercourse and vegetation data for the watershed were analyzed using habitat rules based on findings from the Craig (2003) report. The analysis model considered three simple factors:

1. Elevation
2. Distance to water
3. Habitat type

| **Elevation** | |
|---|---|
| <650m | >650m |
| 1 | 0 |

| **Distance to water** | | |
|---|---|---|
| <25m | <100m | >100m |
| 2 | 1 | 0 |

| **Habitat Type** | | |
|---|---|---|
| Forest | Shrub | Grass |
| Good | Good | Low |

The following steps were used to analyze the locations of good suitability Pacific Water Shrew (PWS) habitat, and analyze level of protection afforded.

1. Identify lands under 650m in elevation (i.e. entire watershed)
2. Create 25m and 100m buffers off watercourses within the watershed.
3. Cluster existing habitat classes into grass, shrubs, and trees. (Classes have been defined through aerial photograph analysis by Axys 2004, based on 2002 orthophotos)
4. Identify areas of each vegetation class within 25m and 100m watercourse buffers.
5. Overlay map with layer of existing parks.
6. Review existing level of protection afforded to habitat areas.

## 2. Results

Potential PWS habitat within the watershed has been significantly reduced by urbanization, with some watercourse reaches enclosed, and other reaches surrounded by very little riparian vegetation. Table 1 shows the area of land within 25m and 100m of watercourses, the percent that is vegetated, and the percent that is rated as good potential suitability for PWS.

The table shows that almost 60% of land within 100m of the creeks contain no vegetation at all. Only 35% of the 100m buffer contains habitat that would be rated as good potential suitability for the PWS.

### Table C-1 Pacific Water Shrew Analysis Results

| **Buffer width from watercourse** | **25m** | **100m** |
|---|---|---|
| Watercourse buffer area (ha) | 82 | 294 |
| Vegetated buffer area (ha) | 46 | 121 |
| *% of buffer vegetated* | *57* | *41* |
| | | |
| Area of good PWS suitability habitat (ha) | 43 | 103 |
| ***% of buffer with good PWS suitability*** | ***53*** | ***35*** |
| | | |
| **Park designation** | | |
| Area of good PWS suitability habitat within park (ha) | 19 | 49 |
| ***% of good PWS suitability habitat within park*** | ***43*** | ***47*** |

Figure 1 shows the location of the 103 hectares of good potential shrew habitat within the watershed (within 100m of creeks). The figure shows that these areas are severely fragmented from each other, limiting the capability of isolated areas to support the Shrew. The scale of mapping does not show all riparian vegetation, but it does indicate the long stretches of watercourse with minimal (under 10m) of adjacent vegetation.

As noted in Table 1 and Figure 1, almost half of the good suitability habitat is within parks – with the most significant habitat located at Lower Still Creek within Burnaby Lake Regional Nature Park. The most significant area of habitat outside park is in the mid-section of Still Creek between Willingdon and Westminster Avenues.

Table 2 reviews each of the six areas of potential shrew habitat, summarizing their habitat type, connectivity to other areas, and level of protection. Recommended actions for the areas are incorporated into Section 3 of this report.

## Figure C-1 Pacific Water Shrew Habitat Analysis

## Table C-2 Areas of Pacific Water Shrew Habitat Suitability in the Still Creek Watershed

| Area | Habitat Type | Connectivity | Level of protection | Potential actions |
|---|---|---|---|---|
| **1. Lower Still Creek** | Tree and shrub – good suitability | **Good** connectivity with Burnaby Lake Regional Nature Park | **Good** – most of polygon located within Burnaby Lake Regional Nature Park | |
| **2. Still Creek between Willingdon and Westminster** | Tree between Creek and Highway #1.<br><br>Shrub north of Creek<br><br>Grass at Highway interchange | **Moderate.** Site is connected to Lower Still Creek, but there is very limited riparian vegetation between the two sites. | **Moderate – Poor**. Southern lands are City owned. | Formalize riparian area protection through ISMP.<br><br>Seek designation of lands between Creek and Highway #1 as Conservation Area.<br><br>Expand potential Conservation Area east into potential flood cell. |
| **3. Upper Still Creek** | Tree and grass – good suitability | **Poor**. Site is isolated from other habitat due to stream culverting and riparian loss. | **Good** – land is within Renfrew Ravine Park | Improve connection with rest of Still Creek through enhancement strategies |
| **4. Beecher Creek** | Tree – good suitability | **Poor - Moderate.** Limited riparian connection to Still Creek | **Moderate** – riparian lands are City owned. | Seek riparian improvements to Lower Beecher Creek through Holdom Plan.<br><br>Seek designation of corridor as Conservation Area. |
| **5. Guichon Creek** | Tree and grass – good suitability | **Poor.** Guichon Creek is culverted beneath BCIT | **Moderate.** Upper Guichon is within Wesburn Park. Mid-Guichon is within BCIT. BCIT riparian areas afforded protection through MoU with City. | Work with BCIT to protect forest areas, and daylight Guichon Creek through campus. |
| **6. Sumner Creek** | Tree and grass – good suitability | **Poor.** Creek is culverted to Still Creek. | **Good.** Forested areas are within Broadview and Avondale Parks. | - |

## 3. Recommended Best Management Practices

The following section provides recommendations for protecting and improving PWS habitat within the watershed. Recommendations are based on the draft *Best Management Practices Guidelines for Pacific Water Shrew in Urban and Rural Areas* (Craig and Vennesland 2004). The section references strategies and actions within the draft Integrated Stormwater Management Plan (ISMP) and show that if implemented collectively, there can be a net improvement in PWS habitat within the watershed.

### 3.1. Habitat protection and connectivity

Craig and Vennesland suggest a 100m buffer along suitable watercourses, with low impact activities (such as walking trails) permitted within the buffer. Much of Still Creek mainstem lacks any vegetated buffer, but the draft ISMP envisions this condition improving through Strategy 1.3 (Provide continuous streamside vegetation to protect and enhance habitat for aquatic and terrestrial species). Restored buffers would seldom reach 100m, but would more likely be 5-30m in width. Nonetheless, these buffers would provide a significant net habitat gain over the existing 0-5m buffers along many sections of the Creek.

Area 2 will be subject to some habitat loss within the 100m buffer due to land development on the north side of Still Creek. However impacts will be minimized by protecting the first 15-45m from the wetlands and the Creek as conservation area protected through covenant for both habitat and flood management purposes. The ISMP envisages significant potential habitat protection and gain on the southern side of Still Creek in Area 2 through expansion of the Still Creek Conservation Area, subject to the Douglas Road land use study. Such an expansion would offer significant potential habitat gains for the PWS.

An additional site of significant habitat gain is around Chub Creek. The ISMP and Brentwood Town Centre Plan are leading to rehabilitation of a 3.2 hectare (8 acre) area of asphalt into riparian enhancements, greenspace, wetlands, bioponds and trails (Strategy 4-1 Protect remaining habitat reservoirs and refuges).

Upper Still Creek and the Guichon, Beecher, and Sumner Creek are isolated from other habitat. The ISMP envisages improved riparian connectivity, including daylighting of Guichon Creek through BCIT, improved Still Creek connectivity through Vancouver, and enhanced riparian vegetation of Beecher Creek through the Holdom village centre (Strategy 1-2 Improve fish access and instream habitat quality for fish and wildlife).

### 3.2 Watercourse Crossings

Watercourse crossings and culverts fragment habitat. The Still Creek watershed is highly urbanized, with numerous crossings and culverts. The ISMP envisages improving this situation by reducing the length of watercourse crossings (Strategy 1-1 Maintain continuous open-channel watercourses), including daylighting proposals at Still Creek, Guichon Creek, and Beecher Creek.

### 3.3 Riparian Vegetation

Native vegetation is important to support the Pacific Water Shrew and other native species. This goal is reflected in ISMP actions in Strategy 4-3 (Improve habitat quality and complexity for wildlife) and 4-4 (Promote native vegetation and control non-native species). Potential habitat enhancement areas are also identified, including lands within Burnaby Lake Regional Nature Park along Crabapple Creek and Darnley Creek.

### 4.4 Land Stewardship

Landowners, businesses, and residents adjacent to streams may significantly affect the quality and extent of streamside vegetation and overall stream health. The ISMP therefore includes Strategy 1-4 (Encourage watershed stewardship), including promoting educational programs on protecting streamside vegetation, planting native species, and improved source control practices. These measures should all benefit potential Pacific Water Shrew habitat.

## 5. Conclusions

The analysis shows good potential habitat for the Pacific Water Shrew in Lower Still Creek within Burnaby Lake Regional Nature Park. The viability of habitat in other areas is compromised by habitat fragmentation and isolation. The watershed improvements envisaged in the ISMP, including creation of a green corridor along Still Creek, watercourse daylighting, riparian improvements, habitat enhancement, and control of invasive species should not only largely protect existing habitat, but provide an overall net gain in habitat connectivity and viability for the Pacific Water Shrew.

### References:

Craig, Vanessa (2003) *Species Account and Preliminary Habitat Ratings for Pacific Water Shrew (Sorex bendirii).*

Craig, Vanessa and Ross Vennesland (2004) *Best Management Practices Guidelines for Pacific Water Shrew in Urban and Rural Areas*

### Data sources:

AXYS (2004) Still Creek Detailed Vegetation Classes (mapped from 2002 air photos)
City of Burnaby and GVRD (2004) Watercourse mapping.