Regional District of Central Okanagan Forest Health Strategy - Regional Parks

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REGIONAL DISTRICT OF CENTRAL OKANAGAN

URBAN FOREST HEALTH STRATEGY

Strategies for Forest Health Management in the RDCO Parks System

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Executive Summary

The Regional District of the Central Okanagan (RDCO) initiated this project in response to the high level of tree mortality in the RDCO parks system. In 2000, the Parks and Recreation Department began the process of addressing the need to develop a forest health management plan for regional parks. At that time, the primary focus was given to tree pests and tree pathogens in high priority regional parks. Fire hazard assessment and a fire hazard management plan were secondary components of this process. Several studies were completed between 2000 and 2004 and these provided some short and long term management recommendations as guidance for managing regional parks. However, in past few years, several large scale events have occurred in the Okanagan Valley that have had significant impacts on the regional parks and the surrounding lands that could not have been anticipated when the above mentioned studies were commissioned. As a result of these events, reforestation, multiple tree removals, thinning and hazard tree removal will continue to be required extensively throughout the park system in the coming years in order to maintain public safety and restore ecological integrity. The primary purpose of this project is to develop a master plan document that ties together an urban forest health strategy for the entire parks system. This strategy has been developed in consideration of the past, present and perceived future forest health status of southern interior forests and aims to provide parks managers with the tools and the flexibility to manage parks for healthy trees and forests that will maintain the high social and environmental values of the parks system in perpetuity.

An overview assessment of the current state of forest health within the Regional District of the Central Okanagan Parks indicates that a large portion of the protected areas network is being attacked by Western Pine Beetle and that these same forests are highly susceptible to the Mountain Pine Beetle (MPB) epidemic that is just beginning to impact the Region.

Tree species other than pine are being attacked by both primary and secondary insects which are benefiting from regional drought and/or the impacts of long-term fire suppression, which has altered the historical structure and function of the dry forest ecosystems of the Central Okanagan. These changes in forest structure and function will likely be exacerbated by further changes in regional climate over the coming decades.

A large number of the Regional Parks have high tree densities, which make them vulnerable to crown fire. Many of these same areas are embedded within the wildland urban interface and are a risk to human safety and property. High tree densities also increase competition for moisture and nutrients resulting in greater insect and disease susceptibility.

Several of the regional parks visited contained hazard trees (any tree or part of a tree that, if it were to fall, might hit a target such as people or property [Dunster and Dunster 1996]) that are in close proximity to high human traffic. These trees are considered a substantial liability to the RDCO and need to be addressed within the context of a broad hazard tree assessment, inventory, and management program.

Over the next ten to fifteen years, it is expected that wide spread forest mortality due to beetle outbreaks and other forest insects and diseases, in combination with drought, will dramatically alter the forested landscape of the Okanagan. The wide-spread mortality of parkland forests is expected to have a significant environmental impact on vegetation, local hydrology, and fish and wildlife. The historic static management philosophy will not address the need to restore, regenerate and remove large quantities of woody biomass that, if left unchecked, will result in a significant wildfire and human hazard in many of the RDCO parks. A dynamic, adaptive management philosophy is required to address the numerous challenges that park managers will face over the coming decade.

The varied types and complex ownership of RDCO parks within the central Okanagan complicates park management's ability to effectively deal with the forest health problem. Restrictions associated with the *Forest Act* and other Acts like the *Federal Fisheries Act* may preclude timely, cost effective treatment of the wide scale mortality expected over the coming years.

Disposal of dead or diseased woody biomass is expected to become a huge challenge within the Okanagan Valley. This is a problem that will impact all levels of government in the region and one that requires a cooperative strategy with all stakeholders in order to be successful.

Summary of Key Recommendations

The following key recommendations were singled out based on activities that are likely to require changes to existing RDCO parks forest health management processes or additional resources in order to implement. More details on these recommendations are contained within the Action Plan. Additional recommendations not listed in this table (non-key recommendations) can either be implemented within the existing RDCO parks forest health process or subsequent to the implementation of key recommendations.

#	Key Recommendations
	Operational Pest Management
1	Develop an integrated weed management plan for RDCO parks based on WeedsBC (2002) 'Seven Steps to Managing Your Weeds' publication.
2	Educate urban forestry staff on the identification of forest health factors.
3	Cooperate and coordinate on forest health factor occurrences and management options with adjacent stakeholders including, but not limited to, the City of Kelowna, Westbank First Nations, BC Parks, the Ministry of Agriculture and the Ministry of Forests.
4	Based on best management practices, develop Standard Operating Procedures for determining responses to urban forest pests.
5	Use Qualified Professionals to develop and implement prescriptions, and/or undertake hazard tree removals as new forest pest outbreaks occur or as deemed necessary by RDCO parks.
6	Plan for ongoing maintenance.
	Mountain and Western Pine Beetle
7	Based on best management practices, develop Standard Operating Procedures (SOPs) for detection and removal of infested pine.
8	Use a Qualified Professional to Identify polygons containing beetle kill and to develop and implement treatment prescriptions.

#	Key Recommendations
9	Plan for ongoing maintenance.
	Wildland Urban Interface
10	Use existing wildfire hazard mapping and an expanded hazard mapping process (e.g., a complete and updated RDCO community wildfire protection plan) to identify and map all ingrowth and fire hazard rated areas.
11	Heavily used trail networks within RDCO parks, where ecologically appropriate, should be thinned and understory fuels removed up to 5-metres on each side of the trail network.
12	Based on best management practices, develop Standard Operating Procedures (SOPs) for hazard reduction treatments (thinning and/or prescribed fire).
13	Adopt a standard for fuel management in parks and green spaces.
14	Use an appropriately Qualified Professional to develop and implement treatment prescriptions.
15	Plan for ongoing maintenance.
	Hazard Tree Removal, Tree Removal and Maintenance
16	Develop a danger tree assessment program within the Regional Parks Department.
17	Develop a Terms of Reference for tree inventory based on best management practices.
18	Develop Standard Operating Procedures for tree removal in riparian areas and sensitive ecosystems, particularly fish bearing streams, based on best management practices.
19	Use an appropriately Qualified Professional to annually inventory hazard trees in the parks system and to prescribe tree removals.
20	Develop a regular maintenance schedule that is suitable to meet targets for hazard tree treatment within one year of identification.
21	Work with other local governments within the region to develop a comprehensive debris disposal strategy.
	Reforestation and Ecosystem Restoration
22	Develop Standard Operating Procedures for tree replacement and planting that are based on best management practices.
23	Develop a seed collection program for RDCO parks stock. This could be achieved either through collections by RDCO parks staff or volunteers, purchase of existing seed surpluses or by contracting seed collection externally.
24	Develop and regularly update a working plant list in order to plan for stock orders and seed collection.
25	Use an appropriately qualified professional to identify, map, prescribe and implement treatments for ingrowth and encroachment areas.
26	Plan for ongoing maintenance.
	Access
27	Develop an access plan that details where both permanent and temporary access are appropriate for required management activities.
28	Where fire control access could be improved, consider widening specific trails to 3.2 meters (the width required for small emergency vehicle access).
	Standards for New Parks and Greenspaces
29	Ensure that parkland acquired from developers has been treated to mitigate wildfire hazard and forest health issues.
	Public Education/ Managing Public Expectations
30	In consultation with the City of Kelowna, develop a regional approach to communicating about forest health issues, particularly in terms of wildfire and mountain pine beetle impacts, and implement the approach on the RDCO website and through press releases.
31	Develop signage and web-based information that explains the objectives and benefits of forest health treatments.
32	Encourage public participation in reforestation/restoration programs.
33	Acknowledge and publicize contributions to urban forestry by citizens, businesses, institutions and community groups on the RDCO website and in press releases.
	Land Tenure/Ownership
34	Work towards consolidation of ownership of the various tenure types within the parks system.

#	Key Recommendations
35	Work with the Province to streamline the removal of dead and/or susceptible trees on Crown Land within the parks system
36	Contact the Tenure and Revenue Division of the Kamloops Forest District to discuss appropriate harvesting licence options such as Community Salvage Licences and Licences to cut within RDCO parks in the short term.
37	Investigate the potential for lobbying the Province regarding a solution to the high costs borne by municipalities undertaking treatments for forest health and fuel mitigation purposes on Crown Land when full stumpage applies.
38	Work with the appropriate landowners to streamline the removal of dead and/or susceptible trees on non-RDCO and non-Crown titled land within the parks system.
	Monitoring and Adaptive Management
39	Develop an annual monitoring program to assess current and changing forest health, the success of forest regeneration and or restoration treatments, and changes to key forest attributes like stand density, crown closure, surface fuel which are linked to forest fire hazard.
39.1	Develop and maintain a computerized spatial inventory of weed distribution.
39.2	Develop and maintain a computerized spatial inventory of urban trees including records of any damage or tree removal.
39.3	Develop and maintain a computerized spatial inventory of pest distribution. Monitor insect populations and disease centres annually. Collect data for the spatial forest pest inventory as part of the tree inventory.
39.4	Monitor mountain pine beetle flight periods annually.
39.5	Conduct an annual hazard tree inventory.
39.6	Conduct a coarse scale ground survey of tree mortality annually.
39.7	Conduct tree regeneration surveys 1, 3, 5 and 10 years post planting to determine whether additional planting or spacing is required.
39.8	A new forest cover type inventory should be conducted at a scale of 1:5,000 or finer.
39.9	The Sensitive Ecosystem Inventory and Terrestrial Mapping should be updated to cover the entire RDCO parks system.
39.10	Identify heritage trees (old trees, ceremonial plantings) or significant trees (large, rare, unusual species) in the inventory and consider bylaws for their protection.
39.11	Track crew maintenance hours and make performance targets for maintenance crews.
39.12	Coordinate inventory data collection and updates through municipal staff. Work with the municipal GIS department to design the format for the spatial data collected.
39.13	Use appropriate tree inventory software.
40	Use monitoring, inventory results, policy changes, new research data and pest management to update the Urban Forest Health Management Plan every five years
41	Develop life expectancies of different tree species and particular damage trends for tree species based on inventory data. Use this data to update working documents for planting and forest health agents on an annual cycle.
	Coordination Between Departments
42	Define the roles and responsibilities of RDCO parks staff in terms of data management, plan development and monitoring.
43	Aim to further improve coordination of information sharing and funding opportunities with the City of Kelowna, Westbank First Nations, BC Parks, the Ministry of Agriculture and the Ministry of Forests
44	Review interdepartmental procedures and policies to determine whether any further efficiencies can be achieved through improved communication or policy changes.
	Budgeting and Funding Sources
45	Apply for access to funding for beetle/fuel treatments and/or wildfire protection planning through the UBCM.
46	Investigate funding through the HCTF for ecosystem restoration treatments, monitoring and sensitive ecosystem inventory mapping.
47	Investigate local and overseas market opportunities, primarily for ponderosa pine and chips.

#	Key Recommendations
48	The RDCO should investigate the potential for carbon accounting and how this could benefit RDCO parks in the future. This should include investigating emissions trading systems and appropriate brokers, and documenting past and future reforestation/restoration activities that have increased tree growth in order to prove carbon eligibility in the future.

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1.0 Introduction

The southern interior of British Columbia is currently experiencing a period of major landscape level change resulting from the impact of various forest health factors. The deteriorating health of southern interior forests can, to a large degree, be attributed to management practices that have facilitated forest ingrowth and encroachment, and the growth of large, homogeneous forest stands across the landscape (see the glossary for definitions of these terms). As a result, southern interior forests have become more susceptible to tree mortality from drought, fire, insects and pathogens. Events such as the 2003 Okanagan Mountain Park Fire, the current Western Pine Beetle outbreak and the unprecedented Mountain Pine Beetle Epidemic are causing landscape level change on a scale that has never before been recorded in BC. Southern interior forests have and will continue to experience the full brunt of these events so long as forest stand structure and climate conspire to create the hazardous forest health conditions we see today. The challenge for natural resource managers is to implement strategies that will promote the development of forest stand structures that are more resilient to pressure from biotic and abiotic forest health factors. The current state of knowledge supports several strategies for achieving this objective. However, numerous knowledge gaps exist so it is of fundamental importance that strategies be implemented using an adaptive management framework. If an adaptive framework is not used, resource managers are liable to repeat the mistakes of the past.

The Regional District of the Central Okanagan (RDCO) initiated this project in response to the high level of tree mortality in the RDCO parks system. Existing management strategies were not comprehensive enough to deal with the large scale events that have impacted the parks system and surrounding areas in recent years. Reforestation, multiple tree removals, thinning and hazard tree removal will continue to be required extensively throughout the park system in the coming years in order to maintain public safety and restore ecological integrity. The primary purpose of this project is to develop a master plan document that ties together an urban forest health strategy for the entire parks system. This strategy has been developed in consideration of the past, present and perceived future forest health status of southern interior forests and aims to provide parks managers with the tools and the flexibility to manage parks for healthy trees and forests that will maintain the high social and environmental values of the parks system in perpetuity.

1.1 Organization of the Document

This document is organized into the following sections:

Section 1: Introduction to the report including terms of reference and project objectives.

Section 2: An overview of the parks system including existing planning and policy information.

Section 3: A description of the study area based on the current available data.

Section 4: An action plan containing recommendations for managing forest health.

Section 5: A summary of best management practices for managing urban forest health.

Section 6: A description of the relevant abiotic and biotic forest health factors that are active in RDCO parks.

Section 7: A glossary of technical terms used in this report.

Section 8: A list of references used to write this report.

1.2 Terms of Reference

The terms of reference for this project were to:

1. Develop the Urban Forest Health Strategy and Management Plan for the RDCO parks system of regional, Westside and eastside parks that:

    a. Provides a broad visionary and strategic overview of best management practices for the District's park system, as directed by guiding principles of forest sustainability, forest succession and ecosystem management.

    b. Considers the immediate and future impacts on the forested parks by: climatic conditions, global warming, trends and predictions on forest health issues, and the constraints placed upon the District's park management options.

    c. Considers, but is not limited by the constraints and limitations on the District's ability to manage its parks because government regulations, policies and park conditions are subject to change over time.

    d. Provides detailed, comprehensive and practical management plan recommendations and guidelines for managing parks based on best practices for forest and ecosystem sustainability. Recommendations are guided but not limited by the constraints, limitations, and previously commissioned studies on park management options.

2. Prepare rehabilitation/reforestation plans for Mission Creek Regional Park and Woodhaven Nature Conservancy that:

    a. Provide specific recommendations on park restoration resulting from stand deterioration and disturbances due to hazard tree removal, salvage logging, insect/disease infestation, forest fires, urban interface work and user impacts.

Terms of reference item 1 is dealt with in the main body of this document. Terms of reference item 2 is dealt with in Appendices 1 and 2.

1.3 Objectives of the Forest Health Strategy

1. To develop a strategy for parks that will assist in managing, maintaining and perpetuating a lifestyle for the community's and citizens' continued enjoyment.

2. To facilitate the development of a forested parks system that is healthy and resilient to future drought, pest and disease outbreaks.

3. To enhance and conserve the pine-dominated landscapes and grasslands of the parks system.

4. To mitigate existing forest health issues and therefore fire hazard in the parks system using ecologically appropriate ecosystem restoration methods.

5. To provide a strategy for hazard tree management that maintains visitor and worker safety while having a low impact on sensitive ecosystems.

6. To facilitate RDCO staff ability to implement suitable management options for major pests and diseases in RDCO parks.

2.0 Parks System Overview

2.1 Spatial Overview

The RDCO Parks and Recreation Department operates and maintains a park system totalling 1,311 ha within the Central Okanagan (Figure 1). The parks include 28 regional parks (1,171 ha), 100 Westside community and neighbourhood parks (121 ha) and 8 eastside community parks (19 ha) and 9 recreational facilities.

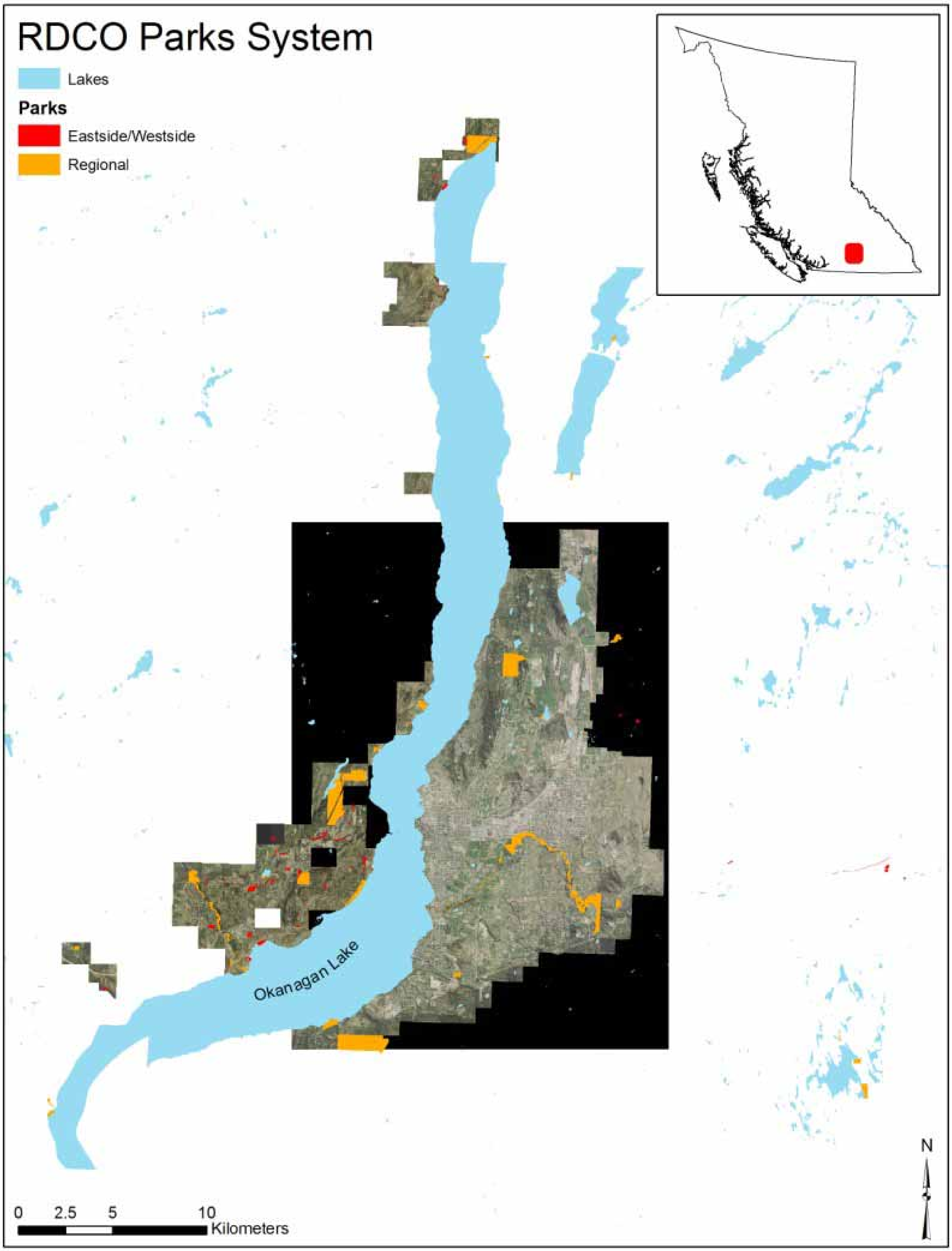

Figure 1. Overview Map of the RDCO Parks System.

The following topographical description of RDCO lands is reproduced from the "Environmental Protection Discussion Paper" (RDCO 2002):

> *The Central Okanagan region lies at the heart of the Okanagan Valley. The Valley itself is a deep glacial formed trench running north/south, bound by forested uplands known to the east as "Okanagan Highlands" and to the west as "Thompson Plateau". Okanagan Lake is about 120 kilometres long and averages 3.5 kilometres wide, narrowing through the Central Okanagan mid-section, and supporting on its shores the communities of Kelowna, Peachland and the "Westside".*
>
> *Central Okanagan's "Regional District" boundaries follow heights of land on the east and western flanks of the valley trench. The land rises from Okanagan Lake elevation of 1120 ft (342 m) to the upland plateaus at 5000 ft (1500 m) and mountain peaks over 6000 ft.*
>
> *The topographic features of the land have shaped the form of human settlement, and become hard reality in the design of human settlement, highways and other services in the Central Okanagan. By and large, settlement has occurred and is anticipated to continue occurring within the valley bottom and lower elevation bench lands.*

2.2 Current Applicable Policy

The "**Regional Parks Extended Service Establishment Bylaw No. 410, 1990**" established Regional Parks as an extended service under the provision of the Local Government Act (then called the Municipal Act). A Regional District is authorized, by the Local Government Act, to provide this service. The Park (Regional) Act R.S. Chapter 354 (repealed in 2003) required the Regional Board to designate a Regional Park Plan as an Official Regional Park Plan. The "**Official Regional Park Plan Designation Bylaw No. 884, 2000**" designates "Our Regional Parks – The Central Okanagan's Plan for the Regional Parks System" as the "Official Regional Park Plan of the Regional District of the Central Okanagan". The Official Plan provides a broad vision and stewardship policies for the regional parks system. Additional bylaws and provincial and federal legislation further regulate park management in terms of usage rules, environmental protection, riparian area management and land acquisition. Links to the relevant legislation can be found in Appendix 3.

2.3 Park Types

Table 1. Summary table of broad park types and primary management objectives

Park Type	Park Class	Primary Management Objective/s
Regional	Conservation Park	Habitat conservation
Regional	Natural Park	Raise awareness/knowledge of natural environment/conservation/recreation
Regional	Recreation/Cultural/Waterfront Park	Recreation
Regional	Trails/Greenways	Recreation and habitat links between

Park Type	Park Class	Primary Management Objective/s
		greenspaces
Westside/Eastside	Community	Passive community functions (e.g., urban plaza, historic facilities, cemeteries, tourism attractions)
Westside/Eastside	Neighbourhood	Open space, playgrounds, passive recreation, sportsfields
Westside/Eastside	Linear	Off-road transportation linkages for pedestrians, cyclists and/or equestrians
Westside/Eastside	Waterfront	Access and use of Okanagan Lake
Westside/Eastside	Athletic	Outdoor recreation facilities
Westside/Eastside	Open space – Natural	Conservation, stewardship, viewscape, geotechnical stability

Table 1 summarizes the park types and classes contained within the RDCO parks system. The following sections provide more detailed definitions of these park types and classes. For the purposes of this report, park classes are grouped according to the level of response required to address forest health issues in that park. The groupings are based on the assumption that park classes managed for intensive recreation warrant the highest level of response in order to adequately maintain public safety, facilities, visual quality and public enjoyment. The park classes are approximately grouped as follows:

- Group A = Includes predominantly athletic, waterfront, cultural, recreation, trails, linear, neighbourhood and community parks and warrants the highest level of response. Area totals 512.5 ha.
- Group B = Includes predominantly conservation, natural, and open space - natural and warrants a moderate level of response. Area totals 798.5 ha.

However, not all parks will fit exactly within Group A or Group B simply based on their Park Class classification. Some may be stratified into areas of both Group A and Group B, or some may be reclassified based on park management objectives. For example, Mission Creek Regional Park is classed as a natural park but is listed as a Group A park due to its importance within the RDCO parks system. Table 2 indicates Group A and/or Group B for each RDCO park and Figure 2 maps this data.

Table 2. Alphabetical listing of park group by park name.

Park Name	Group	Park Name	Group	Park Name	Group	Park Name	Group
Anders	A	Fintry Access #1	A	Mission Creek Greenway	A	Smith Creek	A
Antlers Beach	A	Fintry Access #2	A	Mission Ridge	B	Smith Creek Trail	A
Aspen	B	Fintry Access #3	A	Morningside	B	Smith Creek Walkway	A
Avondale	A	Gellatly Heritage	A	Mount Boucherie	B	Smith Ridge	A
Bayvista	A	Gellatly Nut Farm	A	Mount Boucherie Sports Fields	A	Springer	A

Park Name	Group	Park Name	Group	Park Name	Group	Park Name	Group
Bear Creek Boat Launch	A	Glen Abbey	A	Okanagan Centre Safe Harbour	A	Star	B
Bertram Creek	A	Glen Canyon	A	Okanagan Lake Forest Rec Site	A	Stephens Coyote Ridge	B
Black Canyon	A	Glen Eagles Walkways	A	Oriole	A	Stonegate	B
Bouleau Lake	B	Glenrosa	A	Paula	A	Sunnyside	A
Bowen Creek Corridor	B	Glenrosa Cemetery	A	Pebble Beach	A	Sunset Ranch Park	A
Bridle Hill	A	Glenway	A	Philpott Trail	A	Sunview	A
Broadview	A	Gregory Road Walkway	A	Pine Point	A	Three Forks	A
Carate	A	Harold	A	Powerline Walkway	A	Timothy	A
Carrall	A	Horizon	A	Ranch	A	Traders Cove	A
Casa Loma Access #2	A	Issler	A	Raymer Bay	A	Vineyard	A
Casa Loma Beach	A	Joe Rich Community Hall	A	Reiswig	A	Webber Road Community Centre	A
Casa Loma Dock	A	Johnson Bentley Aquatic Centre	A	Robert Lake	B	Webber Road Walkway	A
Casa Palmero	B	Jonagold	A	Rock Ridge	B	Westbank Community	A
Casa Rio	A	Kalamoir	B	Rose Meadow Park	B	Westlake Community	A
Cedar Mountain	B	Kaloya	A	Rose Valley	B	Westridge	B
Cinnabar Creek	B	Killiney Beach	A	Rose Valley Community	A	Westside Aquatic - Boat Launch	A
Coldham	B	Killiney Community Hall	A	Rose Valley Pond	B	Westside Aquatic - CNR Wharf	A
Connemara	A	Kinsmen	A	Rosewood	B	Westside Aquatic - Kent	A
Constable Neil Bruce Sports Fields	A	Kopje	A	Saddle Ridge	A	Westside Aquatic - Marina	A
Copper Ridge	A	Lakeshore Road	A	Sandstone	B	Westside Aquatic - Powers Point	A
Daves Creek Corridor	A	Lakeview Cove Walkway	A	Scenic Canyon	B	Westside Aquatic - Rotary Beach	A
Davidson Creek	A	Last Mountain	A	Scotty Creek	A	Westside Aquatic - Rotary Trails	A
Deer Ridge	A	Lindsay Court Walkway	A	Shannon Highlands Park	B	Westside Aquatic - Willow Beach	A
Devon	A	Marjorie Pritchard Memorial	A	Shannon Lake	A	Westside Aquatic - Yacht Club	A
Dupuis	A	McCulloch /	A	Shannon Lake	A	Westside	A

Park Name	Group	Park Name	Group	Park Name	Group	Park Name	Group
		Hydraulic Lake Forest Rec Site		Tennis Courts		Seniors Centre	
Dupuis Boat Launch	A	McCulloch Station	A	Shannon Lake Trails	A	Whispering Hills	A
Eain Lamont	A	McDougal Creek	A	Shannon Ridge	A	Wild Rose	B
Eleanor Reece	A	McIver	A	Shannon View Walkway	A	Wildhorse	A
Ellison Estates Trail	A	McMorland	A	Shannon Way	B	Woodhaven Nature Conservancy	B
Ellison Primary	A	Mill Creek	B	Shannon Woods	A	Smith Creek	A
Faulkner Creek	B	Mission Creek	A	Shetler	A	Smith Creek Trail	A

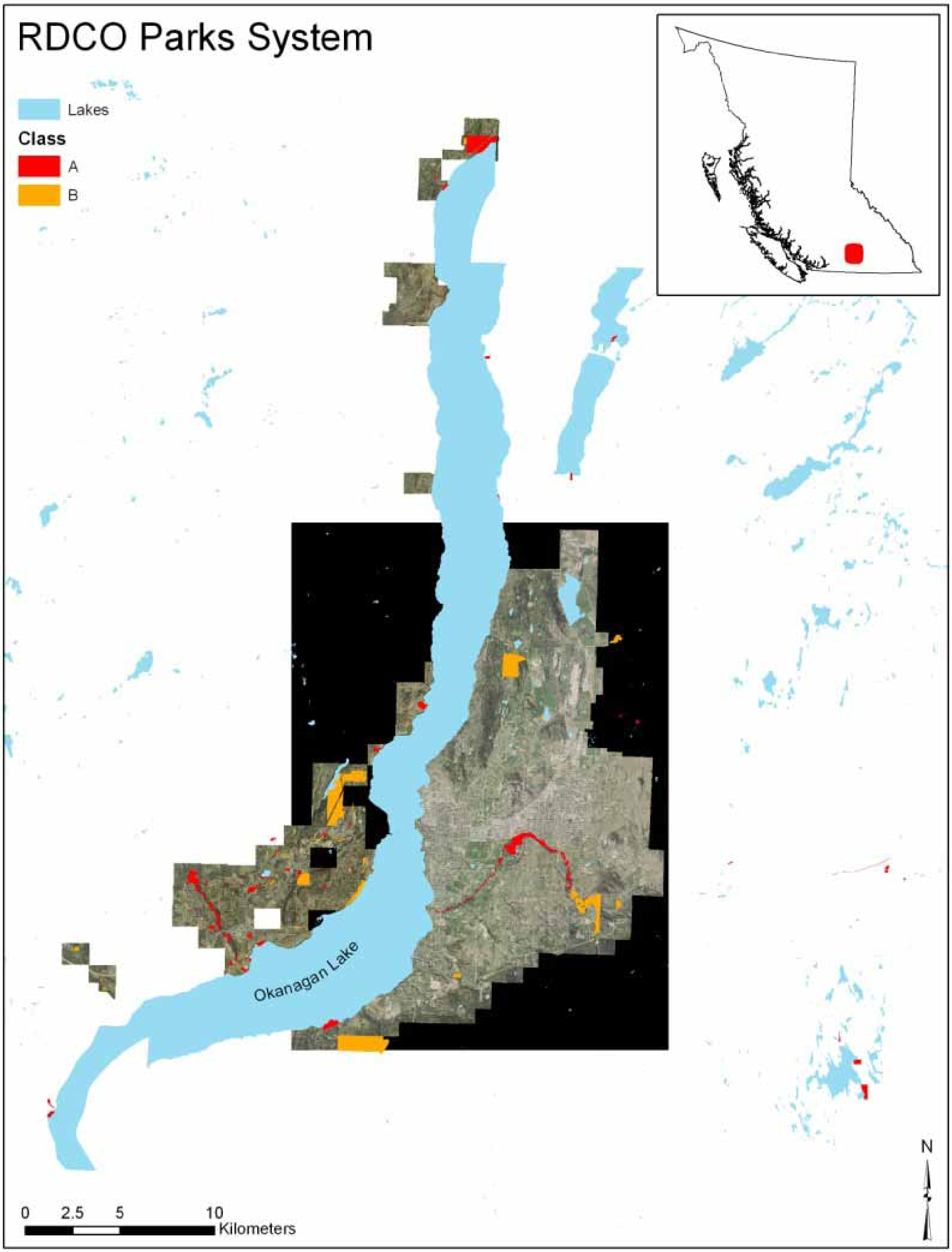

Figure 2. Overview of the RDCO parks system by park class groupings.

2.3.1 *Regional*

The following classes and definitions are reproduced from Bylaw No. 884. The four classes of regional parks are separated primarily by the degree of protection afforded to the environment and the intensity of recreation use. In addition, individual parks are zoned into five management areas depending on the predominant nature of the landscape. These park management zones are: 1) special preservation; 2) ecosystem; 3) natural environment; 4) outdoor recreation; and, 5) park services.

2.3.1.1 *Conservation Parks*

Managed for the protection or enhancement of habitat values of vegetation and wildlife. The provision of recreation may occur but is subordinate to habitat values. Natural processes may take their natural course and management practices may occur at the detriment of aesthetics or public access.

2.3.1.2 *Natural Parks*

Provide opportunities for increasing awareness and knowledge of the natural environment of the Okanagan Valley. These areas must contain regionally significant features of geology, physiography, vegetation communities, or wildlife habitat.

2.3.1.3 *Recreation/Cultural/Waterfront Parks*

Provide varied forms of more active recreation. These parks primarily focus on meeting the aquatic recreation needs of the regional and/or preserve unique cultural landscapes. The management emphasis within Regional Recreation/Cultural Parks will be intensive outdoor or interpretive program day use.

2.3.1.4 *Trails (Greenways)*

Regional Trails will be established to link provincial, regional and major municipal parks throughout the Central Okanagan. Development of the Regional Trail System will require collaboration with municipal and provincial park partners as well as non-government organizations in the acquisition and development of “greenway” systems that provide both recreational and habitat links to other open spaces.

2.3.2 *Westside and Eastside Parks*

The following classifications are reproduced from the Westside Parks and Recreation Master Plan but are considered appropriate for Eastside Parks in these categories also.

2.3.2.1 Community

Community parks support passive functions that serve the entire community. Examples of these functions include urban plazas, institutional/cultural/historic facilities, places of community identity/gathering, beautification initiatives, public cemeteries and public tourism attractions. These parks should be centrally located and easily accessible.

2.3.2.2 Neighbourhood

Informal open space, playgrounds, passive recreation amenities and sportsfields (though generally only singular and of a lower standard than community park facilities) to serve a specific neighbourhood. In higher density neighbourhoods, the level of service and intensity of park development should, pending neighbourhood consultation, be higher than in lower density neighbourhoods. Smaller school sites can function as a neighbourhood park provided adequate facilities are in place and there is a joint-use agreement. The location and distribution of neighbourhood parks should be determined in part on the ability of a neighbourhood resident to be within a 5-minute walk of a neighbourhood park.

2.3.2.3 Linear

To provide off-road transportation linkages for pedestrians, cyclists and/or equestrians. Linear parks generally include developed and usable trails and pathways on public land, utility rights-of-way or road rights-of-way closed to vehicle access. Linear parks generally do not include sidewalks along developed roads or the trails and paths in other types of parks or open spaces.

2.3.2.4 Waterfront

To provide access to an use of Okanagan Lake for residents of the entire Westside and/or for specific Westside neighbourhoods. Waterfront parks support a range of uses (e.g., swimming, sunbathing, picnicking, walking, boat launching and passive recreation). Additional facilities may include playgrounds, washrooms, sport courts and on or off-street parking. Waterfront parks should have relatively flat and usable land above the high water mark and be able to provide safe and reasonable access to the water

2.3.2.5 Athletic

The primary role of athletic parks is to accommodate outdoor recreation facilities (e.g., athletic sportfields, running track, tennis complex) that meet the community's major needs for active recreation and organized outdoor sport. Larger school sites can function as a community park provided that adequate facilities are in place and there is a joint-use agreement. A central and/or easily accessible site is preferred.

2.3.2.6 Open Space

Natural

Natural opens spaces have a variety of functions, including ecological conservation, environmental stewardship, management of hazardous areas (e.g., steep slopes) and view protection. Natural open spaces include those areas of public land in a relatively natural condition that provide the above functions but are not classified as one of the other types of park spaces.

2.4 Management of RDCO parks

Regional District parks are an extended service provided to both municipalities and unincorporated areas by the RDCO. The regional, Westside and eastside parks system does not exist in isolation but compliments parklands held by other jurisdictions.

The Parks Advisory Committee reports to the Regional Board on regional parks, community parks, linear parks, regional parks and recreation facilities, recreation programs, youth programs and heritage. The Westside Parks and Recreation Commission reports to the Parks Advisory Committee, advising it on parks and recreation issues that are specific to the Westside Electoral Area.

Director of Parks and Recreation position is enabled under RDCO Bylaw 900 and is, among other duties, responsible for supervision and management of the Parks and Recreation Department and staff, the implementation of Board directives and the enforcement of parks and facilities bylaws.

2.5 Planning and Operations

Director of Parks and Recreation develops and recommends policies and procedures for parks operation and budget administration. Rules and regulations for park operation are governed by RDCO Bylaw 1105 – Community Parks, RDCO Bylaw 1106 – Regional Parks and Bylaw 1107 – Recreation Facilities. RDCO Planning Services has an environmental coordinator and environmental technologist on staff. RDCO Inspection Services has a Bylaw Enforcement Officer for noxious weed control on staff. Parks staff work and consult with the aforementioned staff members when undertaking parks planning & operation activities.

2.6 Park Land Tenure Type and Ownership

The following lists a breakdown of RDCO park area by ownership and tenure type.

RDCO Titled (429.8 ha)

- 429.8 ha under ownership of the RDCO.

Crown Land (653.3)

- 355.8 ha under a Licence of Occupation agreement with the Province.
- 78.7 ha under a Crown Lease.
- 13.5 ha under an Aquatic Licence.
- 73.9 ha under a Crown Grant.
- 131.4 ha under Management Contract.

Private Land (132.1 ha)

- 0.4 ha under a Licence of Occupation agreement with Tolko.
- 131.7 ha under a lease from the Central Okanagan Parks and Wildlife Trust.

Other (95.7 ha)

- 1.3 ha under Easement.
- 0.6 ha under Management Contract with the DLC.
- 73.2 ha under Management Contract with the City of Kelowna.
- 1.2 ha under Management Contract with the LID.
- 0.1 ha under Park Use Permit
- 1.9 ha under Road Permit
- 7.7 ha under Statutory Right of Way
- 0.3 ha under Verbal Agreement
- 9.3 ha under a lease from School District #23.

3.0 Study Area Description

The study area encompasses 145 parks and recreation facilities covering just over 1,300 ha within the RDCO. Of these parks, 95 are forested or partially treed with a total area of 1,262 ha. The RDCO is located in the central section of the Okanagan Valley in south central British Columbia. The valley is a glacial formed trench between the Okanagan Highlands and the Thompson Plateau.

The parks fall within a region of tremendous biodiversity almost unmatched within British Columbia and Canada. Many species and plant communities at risk inhabit this area. Distinct plant communities and associations in this ecosystem corridor are found in few other places within North America. The region is an important physical link between the grasslands and dry forest ecosystems in Central BC, the desert grasslands of south Okanagan and the 'Great Basin' of the Pacific Northwest (RDCO 2002). The parks are primarily located in the hot, dry, low and mid elevation areas of the RDCO. These areas also represent those with the highest biodiversity and facing the greatest pressure from human development.

The parks are surrounded by a variety of land use types including agricultural, residential, commercial, and forested. Natural areas in the RDCO face intense pressure from agriculture and human development. The RDCO has one of the highest population growth rates in the country with a predicted annual growth rate of 2%. By 2020 the population is expected to have climbed from 150,000 to 230,000 (RDCO 2002).

Within the RDCO, 8.72% of the landbase falls within parks or reserves, but only 4% (1060 ha) of this can be considered to be capable of supporting natural integrity (RDCO 2002).

3.1 Description of the Regional Ecology of the Parks

The study area supports a variety of site types including wetlands and riparian areas, grassland, shrub and meadow steppe, and deciduous, mixed and coniferous forests. The site types vary in moisture and nutrient contents and therefore represent a unique array of growing conditions. Over many thousands of years specific plant communities have adapted to these conditions. Therefore the plant, shrub and trees species found in a grassland site type may be entirely different than those found in a coniferous forest site type.

Understanding the ecology within a park is critically important for making sound management decisions. The introduction of alien species, both intentional and unintentional can have serious detrimental effects on ecosystem dynamics. They may out-compete native species, resulting in degradation or loss of plant communities and wildlife habitat. As well as having potential devastating ecological consequences, intentional introductions of alien species may prove to be an economic failure since introduced species may not survive in growing conditions for which they are not adapted. In addition, native plant species provide both terrestrial and aquatic habitat value for native fish and wildlife. Managing natural areas with a sound understanding of the regional ecology and with the intent of restoring and enhancing the existing ecosystems will assure the greatest chance of long-term ecological health.

3.1.1 Biogeoclimatic Ecosystem Classifications

The ecosystems of this area are specially adapted to the climatic conditions within the RDCO: dry, hot summers and cool winters with low snowfall. The Biogeoclimatic Ecosystem Classification (BEC) system is an ecological classification used in British Columbia. The RDCO parks fall within three biogeoclimatic (BGC) zones: the Ponderosa Pine (PP), Interior Douglas-fir (IDF) and Montane Spruce (MS) Zones. The majority of parks are within the PP and IDF BGC zones (Table 3) which, on a provincial scale, have only 5.0% of their forested land base protected, amongst the lowest proportion of protected area in the Province, while the MS has 7.1% protected (MoFR, 2004).

Table 3. Area summary of biogeoclimatic variants within RDCO parks.

BGC Variant	Total Area (ha)	Relative Percent
PP xh1/xh1a	796	60
IDF xh1/xh1a	474	37
IDF mw1	3	1
MS dm 1	30	2
Total	1311	100

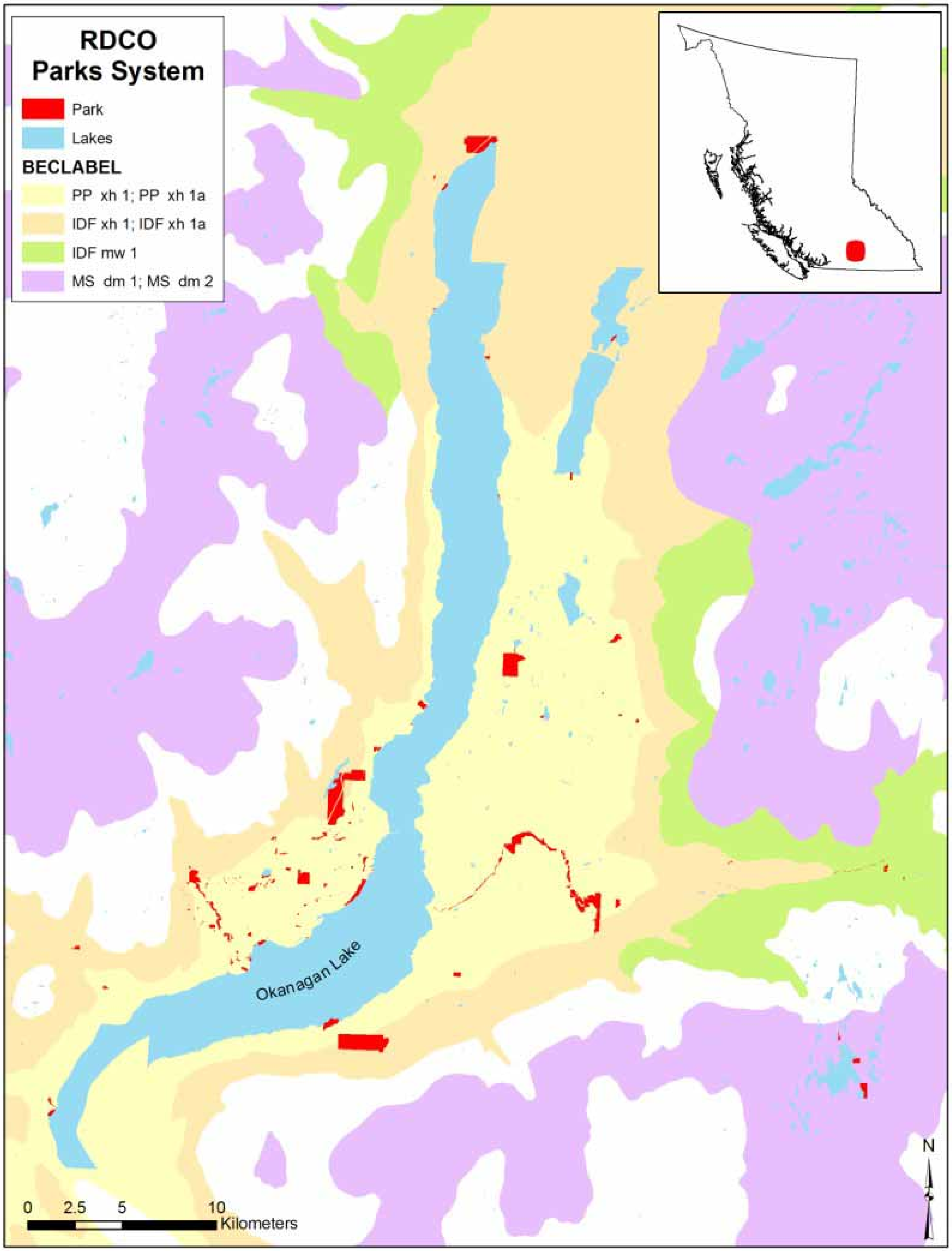

Figure 3. Overview map showing BEC zones that apply within the RDCO system.

These three zones can be further divided into five biogeoclimatic variants occurring within the parks. BGC variants represent specific climatic and geographic characteristics with distinct vegetation types (Lloyd *et al*., 1990). The following five sections, adapted from Lloyd *et al*. (1990), describe the characteristics of each BGC variant in terms of their typical stand types and species of trees, shrubs and herbs.

3.1.1.1 Ponderosa Pine very dry hot variant (PP xh1/xh1a)

The PP xh1 is the driest forested zone in the province. It is characterized by open ponderosa pine stands, with little to no shrub cover. The herb layer is dominated by bluebunch wheatgrass and lesser amounts of arrow-leaved balsamroot, Idaho fescue and timber milk-vetch. Drier sites have very low-density stands and big sagebrush will accompany bluebunch wheatgrass in the shrub layer. Wetter sites include Douglas-fir and trembling aspen with a more developed understory shrub layer. Mosses are usually absent or sparse. The PPxh1a represents a grassland phase.

3.1.1.2 Interior Douglas-fir very dry hot variant (IDF xh1/xh1a)

The IDF xh1 has a relatively long growing season with common moisture deficits. It is characterized by open stands of Douglas-fir and ponderosa pine and a sparse shrub layer dominated by birch-leaved spirea. The herb layer is dominated by pinegrass. Drier sites are more open and include shrubby penstemon, Saskatoon and bluebunch wheatgrass as additions to the shrub layer. Wetter sites may include paper birch and a more developed shrub layer of Douglas maple, snowberry, red-osier dogwood and black gooseberry with a more developed herb layer. The IDF xh1a represents a grassland phase.

3.1.1.3 Interior Douglas-fir moist warm variant (IDF mw1)

The IDF mw1 has a relatively long growing season with common moisture deficits. It is characterized by lodgepole pine, western larch and paper birch stands in which Douglas-fir and western red cedar may develop in the understory potentially becoming climax species. There are well-developed shrub, herb and moss layers commonly composed of Douglas maple, birch-leaved spirea, falsebox, twinflower, prince's pine, and feathermoss. Drier sites are open Douglas-fir stands with occasional ponderosa pine. Bluebunch wheatgrass may be added in the understory with a sparse moss layer. Wetter sites are denser, may not include Douglas-fir and have a more open shrub layer with a prominent herb layer and sparse moss layer.

3.1.1.4 Montane Spruce dry mild variant (MS dm1)

The MS dm1 has cold winters and short, warm summers. It is characterized by stands and lodgepole pine, white spruce and subalpine fir with a moss dominated understory. Drier sites have more open lodgepole pine stands and an understory dominated by the herb layer. Wetter sites may additionally have horsetails and sedges.

3.1.2 *Sensitive Ecosystems*

A sensitive ecosystem inventory (SEI) was carried out in the Central Okanagan for the RDCO between 2000 and 2001 to document these ecosystems and improve land management decision-making. SEI data exists for all but 20 RDCO parks (478 ha). SEIs represent seven ecosystem types that are relatively unmodified and ecologically fragile or are recognized as being provincially rare (Iverson and Cadrin 2001). The seven ecosystem types are: wetlands, riparian, old forest, grassland, broadleaf woodlands, coniferous woodlands, and sparsely vegetated (rock outcrops, talus etc.). These ecosystems provide highly valuable patches of natural areas within the developed landscape that are critical to the survival of numerous species. Many sensitive ecosystems and wildlife habitats within the RDCO have already been lost or degraded, illustrating the critical importance of maintaining the ones that remain, some of which can be found in RDCO parks.

3.1.3 *Rare and Endangered Species*

Dozens of rare and endangered species and plant communities are known to occur in the RDCO (RDCO 2002). The Conservation Data Center element occurrence spatial data show several red and blue listed species known to inhabit area within RDCO Parks. Some of these species and plant communities are listed in Table 4 and Table 5. It should be noted that these lists are incomplete and many more species and plant communities at risk likely exist in RDCO parks.

Table 4. Element occurrences of red and blue listed species in RDCO parks.

Scientific Name	Common Name	Status
Crepis atribarba ssp atribarba	Slender hawksbeard	Red Listed
Verbena hastata var scabra	Blue vervain	Red Listed
Salix amygdaloides	Peach-leaf willow	Red Listed
Otus kennicottii macfarlanei	Western screech-owl, macfarlanei subspecies	Red Listed
Verbena hastata var scabra	Blue vervain	Red Listed
Recurvirostra americana	American avocet	Red Listed
Melanerpes lewis	Lewis's woodpecker	Blue Listed
Euderma maculatum	Spotted bat	Blue Listed

Table 5. Red listed plant communities within the BGC variants of RDCO parks.

BGC Variant/Site Series	Common Name	Status
IDFxh1/00	black cottonwood - Douglas-fir / common snowberry - red-osier dogwood	Red
IDFxh1/00	trembling aspen / mock-orange	Red
IDFxh1/00	trembling aspen / common snowberry / mountain sweet-cicely	Red
IDFxh1/00	western redcedar - Douglas-fir / false Solomon's seal	Red
IDFxh1/02	Douglas-fir - ponderosa pine / bluebunch wheatgrass	Red

BGC Variant/Site Series	Common Name	Status
IDFxh1/06;IDFxh1/07;PPxh1/07	Douglas-fir / common snowberry - birch-leaved spirea	Red
IDFxh1/06;IDFxh1/07;PPxh1/07	Douglas-fir / common snowberry - birch-leaved spirea	Red
IDFxh1/08	Douglas-fir / Douglas maple - red-osier dogwood	Red
IDFxh1a/91	Idaho fescue - bluebunch wheatgrass	Red
IDFxh1a/91	Idaho fescue - bluebunch wheatgrass	Red
IDFxh1a/92;IDFxh1a/94;PPxh1/03	big sagebrush / bluebunch wheatgrass - arrowleaf balsamroot	Red
IDFxh1a/92;IDFxh1a/94;PPxh1/03	big sagebrush / bluebunch wheatgrass - arrowleaf balsamroot	Red
IDFxh1a/92;IDFxh1a/94;PPxh1/03	big sagebrush / bluebunch wheatgrass - arrowleaf balsamroot	Red
IDFxh1a/93;PPxh1/00K	bluebunch wheatgrass - arrowleaf balsamroot	Red
IDFxh1a/93;PPxh1/00K	bluebunch wheatgrass - arrowleaf balsamroot	Red
IDFxh1a/97	prairie rose / Idaho fescue	Red
IDFxh1a/97	prairie rose / Idaho fescue	Red
IDFxh1a/98	trembling aspen / common snowberry / Kentucky bluegrass	Red
IDFxh1a/98	trembling aspen / common snowberry / Kentucky bluegrass	Red
MSdm1/Gs02	Nuttall's alkaligrass - foxtail barley	Red
PPxh1/00	big sagebrush / bluebunch wheatgrass	Red
PPxh1/00	threetip sagebrush / bluebunch wheatgrass - arrowleaf balsamroot	Red
PPxh1/00K;IDFxh1a/93	bluebunch wheatgrass - arrowleaf balsamroot	Red
PPxh1/06	Douglas-fir / common snowberry / pinegrass	Red
PPxh1/08	Douglas-fir - water birch / Douglas maple	Red

3.1.4 Wildlife Values

The ecosystems within the RDCO contain a variety of habitat types supporting a diverse array of species. Within the Okanagan sub-region there are over 300 species of birds, 74 species of mammals, 9 species of amphibians, 11 species of reptiles, and 10,000 to 20,000 species of invertebrates (MoE). Some species are unique to the Okanagan. Many wildlife population levels are at risk, often due to habitat fragmentation and pressure from human development.

Any management actions taken within natural areas should consider the habitat requirements of resident wildlife. In particular, the habitat needs of species at risk should be carefully examined in order to minimize negative impacts and maximize habitat restoration and enhancement. A wildlife survey is a critical initial step in the development of any management prescriptions.

Certain attributes within a forest provide important habitat for multiple species. Coarse woody debris (fallen branches, fallen trees and stumps) offers habitat for mammals, amphibians, and invertebrates as well as certain mosses and fungi (Steeger *et al*. 1998; Fuchs 1999; Stadt 2001). Approximately one-quarter of all wildlife species in BC utilize tree snags (standing dead and dying trees) as habitat (Machmer and Steeger 1995), such as cavity nesting birds and woodpeckers. Another important attribute is landscape heterogeneity, i.e. the distribution and abundance of varying forest types (in terms of age), plant communities and natural areas and other land use types (Perry 1994). A wildlife species often utilizes different landscape types depending on time of day and time of year.

3.2 Succession and Disturbance History

The process of gradual or rapid change in the composition and structure of the vegetation over time is termed succession. Succession occurs either as a result of developmental changes in the ecosystem over time, or as the result of a disturbance event. The sequence of communities is termed seres and each stage is termed seral. A successional environment follows a characteristic sequence of plant communities that occupy and replace each other over time. Following disturbance, pioneer species colonize a site and then, over time, these species are replaced by later seral, generally shade tolerant species. Eventually the site reaches a 'climax' vegetation stage, which is more or less self-maintaining. The length of time succession takes to reach climax in the absence of disturbance, and the exact sequence of communities that colonize a site will vary. If disturbance occurs, then it will generally move a site back to an earlier successional stage. While most climax tree species are shade tolerant, ponderosa pine is not. However, it is very tall and long-lived, which means that in some ecosystems it forms a component of the climax vegetation.

The BEC system is classified in terms of climax or near climax vegetation. All sites, regardless of their successional status are classified in terms of their potential climax. In terms of RDCO parks, the relevant BGC zones are the bunchgrass (BG), ponderosa pine (PP) and interior Douglas-fir (IDF) zones. This classification indicates the climax plant species in these zones. Ponderosa pine is a late seral or climax component of all three zones, and for this reason, it is ecologically appropriate to maintain ponderosa pine and other naturally occurring species on southern interior landscapes.

Disturbance is a natural component of an ecosystem, playing an essential role in shaping and maintaining ecosystem processes (Turner and Romme 1994; Christensen *et al*.1996; Rogers 1996; Foster *et al*. 1998). Natural disturbance can come in many different forms (e.g. avalanches, wind, wildfire, insects, and disease).

The more frequent a disturbance, the more adapted all components in an ecosystem will become to its effects. For example, in areas of historic frequent fire, species develop adaptations to fire while in areas of very low fire frequency, most species have few adaptations (Agee 1993). Ponderosa pine is adapted to high frequency, low severity fire. It has thick bark to withstand surface fire and increases its growth rate in the years following a fire. Douglas-fir is more resistant to fire than most other conifer trees. Some plants have protective coverings over critical plant parts to withstand fire, such as grasses with belowground protective tissue. Some species take advantage of, or even require fire for reproduction. Fire may trigger seed release, provide optimal soil conditions for germination or stimulate flowering or fruiting in plants and shrubs (Pyne *et al*. 1996).

Disturbance, whether from fire, insects or other sources creates diversity across the landscape in forest structure, tree age, and species composition, hence increasing landscape heterogeneity. Greater complexity has been shown to benefit overall forest health, biodiversity and site productivity (Turner *et al*.1989; Rodriguez and Torres-Sorando 2001). Tree mortality from disturbance provides an input of coarse woody debris and snags, which will benefit wildlife by increasing available habitat (Morrison and Raphael 1993; Clark *et al*. 1998; Brown *et al*. 1998).

3.2.1 Disturbance within the IDF and PP BGC zones

In the IDF and PP BGC zones, fire, drought, insect defoliators, bark beetles, stem rusts, needle casts, and root rot are common natural disturbance agents (Wong *et al*. 2003; Lundquist and Negron 2000; Wong 2001). Disturbance agents vary in frequency and severity. In terms of wildfire, the IDF and PP historically experienced frequent, low to mixed severity fires. Low severity fire is characterized by surface fire while mixed severity fire is characterized by the replacement of less than 75% of dominant vegetation (cite).

Various studies analyzing fire scars on trees, logs, snags and stumps in the IDF have shown that before European settlement, fires occurred anywhere from every 5 to 44 years on average, varying within that range depending on geographic location (Gray *et al*. 1998; Blackwell *et al*. 2001; Riccius 1998; Iverson *et al*. 2002; Daniels and Watson 2003). One study in the PP showed that historically, the area experienced frequent, low-severity fires every 9 to 28 years on average (Riccius 1998).

Over the past decades fire suppression has interrupted the historic natural fire regime (HNFR) (fire frequency and severity) in most forests across the province. In many ecosystems this has resulted in tree ingrowth in historically open stands and tree encroachment into areas that were historically grasslands (Blackwell *et al*. 2003). In addition, fuel loads (i.e. accumulation of needles, branches and dead fallen trees) have drastically increased. Wildfire in these ecosystems is now likely to be much more severe. Higher severity fires can have damaging ecological consequences. There may be increased nutrient losses, detrimental change in soil properties, destruction of belowground flora and fauna, and overall long-term losses to site productivity (Blackwell *et al*. 2003). These effects are in great contrast to the historical effects of frequent low severity fires in which "there was typically a nutrient flush, a vigorous plant response, and limited net change in soil properties and site productivity" (Blackwell *et al*. 2003). The HNFRs within RDCO parks are shown in Table 6 and Figure 4. The data presented in this section is derived from the Forest Investment Account project 'Developing a coarse scale approach to the assessment of forest fuel conditions in Southern British Columbia' (B.A. Blackwell & Associates Ltd. *et al*., 2003).

Table 6. Historic natural fire regimes within RDCO parks by area.

Fire Frequency	Fire Severity	Total Area (ha)	Relative Percent
0-35 Years	Low	1143	87%
0-35 Years	Mixed	120	9%
0-35 Years	Stand Replacement	48	4%

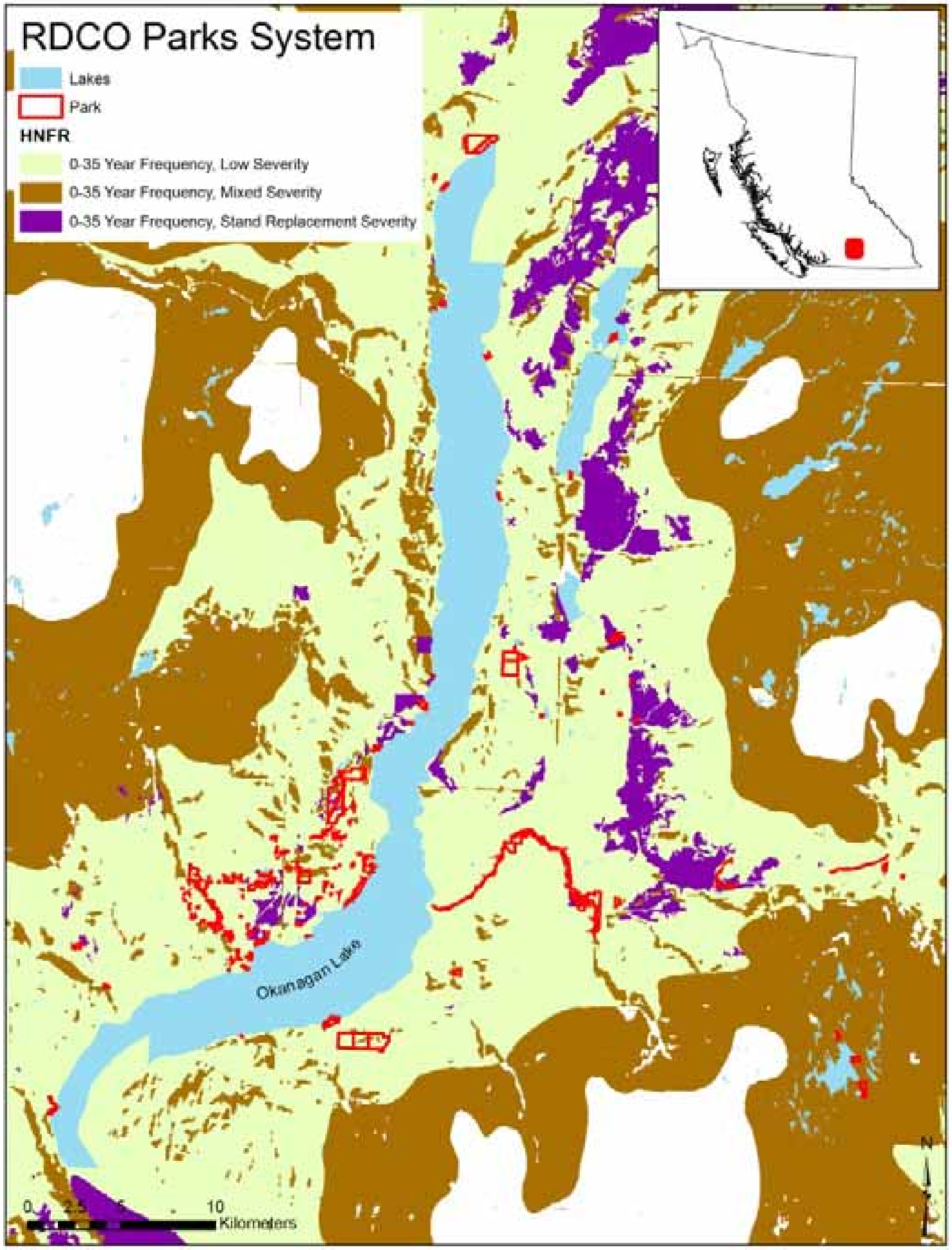

Figure 4. Historic natural fire regime in the RDCO parks system.

In the dry ecosystems of the RDCO disturbance by insects and disease and disturbance by fire can be inter-dependent, each affecting the frequency and severity of the other. This relationship becomes even more pronounced with the added affects of fire suppression and climate change. Long-term fire suppression has lead to changes in forest structure in terms of species composition, structural stage, stand age, and canopy closure. Increased stand density can lead to greater competition for moisture and nutrients, which may increase tree stress and susceptibility to insect or disease attack (Blackwell *et al*. 2003). Higher rates of insect and disease outbreak will produce greater fuel loads, increasing the severity of a fire to possible detrimental levels. Interrupting natural disturbance patterns, whether by fire suppression or salvage logging, put species that are adapted to post-disturbance habitats at risk and potentially vulnerable to local extinction depending on the degree of disruption to ecosystem attributes (Stadt 2001).

Figure 5. Historic photo showing tree density in a ponderosa pine forest.

The degree of departure from the historic state of an ecosystem is known as its condition class. Stands in condition class 1 are the least departed from their historic state. These stands can be maintained within their HNFR with prescribed fire or natural wildfires. Stands in condition class 2 are moderately departed from their historic state and there is a moderate risk of losing key ecosystem components. These stands could benefit from restoration in the form of prescribed fire or mechanical/hand treatments. Stands in condition class 3 have significantly departed from their historic state and stand characteristics have been altered considerably from their historic range. If a wildfire were to occur, it's size, severity and intensity may be far greater then historical levels. These stands could benefit from restoration treatments but may have to be treated mechanically before fire can be re-introduced given the potential for high severity fire and risk of escape. Condition classes within RDCO parks are shown in Table 7 and Figure 6.

Table 7. Condition classes within RDCO parks by area.

Condition Class	Total Area (ha)	Relative Percent
1	652	50%
2	6	<1%
3	387	30%
No Data/Non-Productive	265	20%

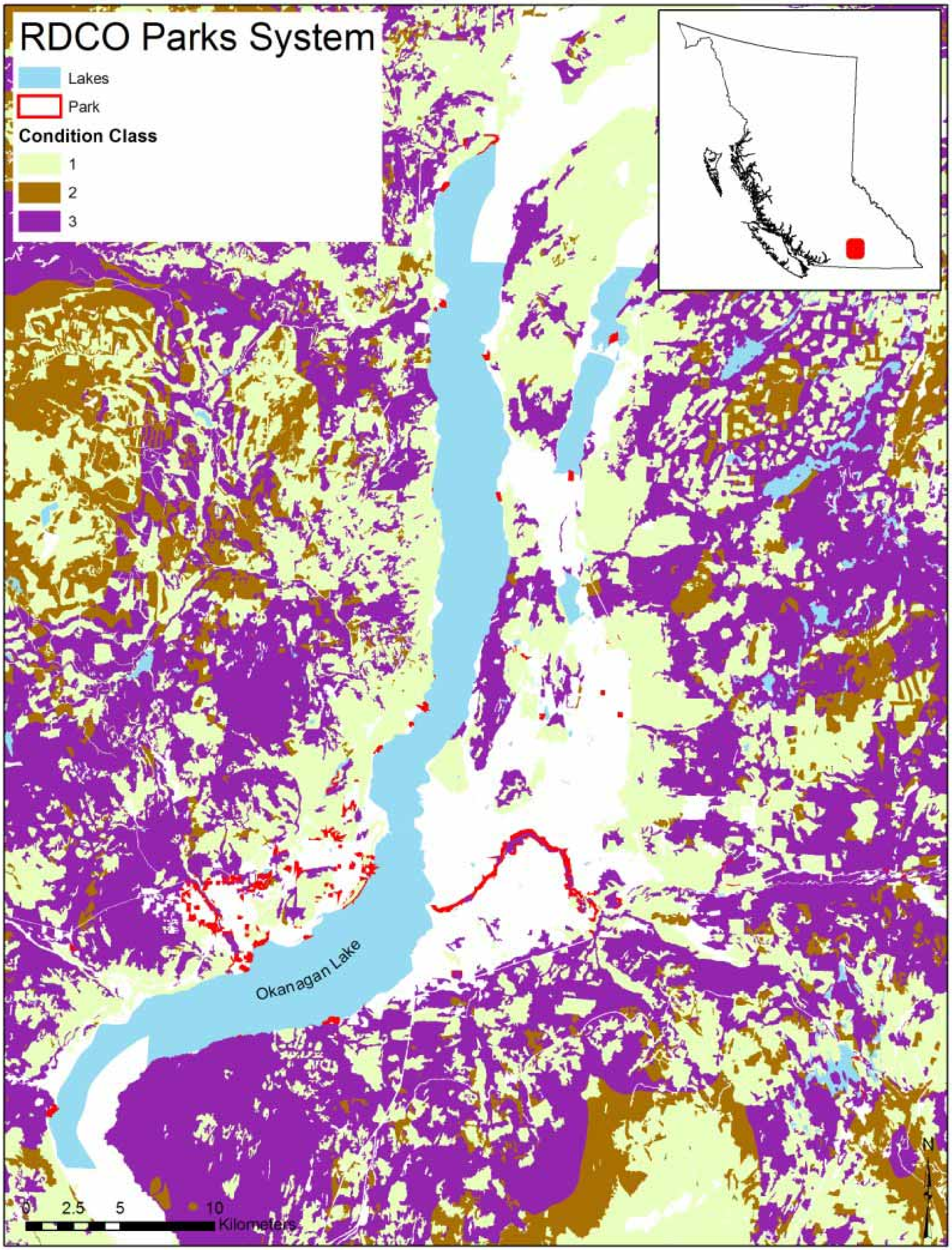

Figure 6. Condition class in the RDCO parks system.

3.3 Climate Change

The 2002 environment discussion paper (RDCO 2002) describes the current climate of the Central Okanagan as follows:

> *Generally warm and sunny summers with low humidity and rainfall, and generally cloudy winters with more substantial snowfall in upper elevations characterize the climate of the Central Okanagan. Depending on elevation, growing periods (frost free days) can range annually from a mere 19 days in frost pockets at high elevations to 150 days in Kelowna.*
>
> *Annual precipitation ranges from about 12 inches (30 cm) in the valley bottom to 40 inches (100 cm) measured at higher elevations east of Kelowna. The low amount of rainfall at valley bottom produces a net loss of runoff water in that the amount of evaporation (including from the surface of Okanagan Lake) and evapotranspiration (from plants) exceeds the amount of water replenished by precipitation.*

There has long been controversy surrounding the subject of climate change in terms of the extent and cause of the earth's current warming trend. It is beyond the scope of this report to argue the case for or against a particular stance on climate change and numerous papers on this topic can be accessed in the literature. This discussion will focus on the potential impacts of climate changes based on several general long-term trends and patterns identified for mid and high latitudes of the Northern Hemisphere continents in the Intergovernmental Panel on Climate Change Third Assessment Report (IPCC 2001). These are:

- Nighttime temperatures will increase more rapidly than daytime temperatures (*i.e.*, a decrease in diurnal temperature range) resulting in a lengthening of the freeze–free season.
- Summer temperatures are likely to increase slightly on average but winter temperature increases will tend to be greater.
- Winter and spring precipitation levels will increase.
- Summer precipitation will remain near current levels.
- Increased summer drying will occur over most mid-latitude continental interiors and increase the associated risk of drought.
- Droughts and floods associated with El Nino events will intensify in many different regions.
- Higher CO^2 levels will affect photosynthesis but the effect will be moderated by the influence of other climatic and environmental factors.
- Extreme climatic events will increase in frequency. For example:
    - Increase in the frequency of heavy precipitation events;
    - Reduction in extreme low temperatures with a smaller increase in the frequency of extreme high temperatures;
    - Higher maximum temperatures, more hot days and heat waves; and,
    - Higher minimum temperatures, fewer cold days, frost days and cold waves.

3.3.1 *Potential Impacts*

The vegetation responses to the factors listed above are not yet well understood. In addition, there is likely to be substantial regional variation in the patterns and trends listed above. It is possible that higher CO^2 levels will cause increased photosynthesis resulting in increased growth (Roy *et al*. 2001; Johnston 2004). However, other climatic and environmental factors may counteract this effect by limiting availability of other essential resources, increasing respiration rates or altering growing conditions. Higher spring, fall and winter temperatures are likely to result in a longer growing season (Zhou *et al*. 2001) and this may influence the timing of key life cycle events such as leaf flush and flowering (Beaubian and Freeland 2000). Although summer rainfall is anticipated to stay near current levels on the whole, there is likely to be an increase in the frequency of extreme high temperatures and heat waves, and a higher risk of drought in the southern interior (IPCC 2001). High temperatures will increase levels of evaporation and transpiration, and ultimately lower soil moisture levels (Johnston 2001). Therefore, even if summer rainfall is maintained at current average levels, higher temperatures could limit water availability and cause moisture stress.

The distribution of vegetation across the landscape is also likely to change in response to a changing climate. Williams and Liebhold (2002) found that the distribution of pine is likely to move north due to climate change. Hebda (1997) hypothesized that grasslands would expand in the southern interior and the forest area would be reduced. Allen and Breshears (1998) found that extreme weather events such as drought caused a rapid shift in vegetation due to extensive mortality of ponderosa pine at drier, lower elevations. The effects of the drought were more severe because of ingrowth and the high density of the forests (Allen and Breshears 1998). The competition for water was high, resulting in drought stress, which made the trees more susceptible to bark beetle attack and increased the level of tree mortality. The authors concluded that even brief climatic events could have long lasting ecosystem effects in semi-arid forests and woodlands (Allen and Breshears 1998).

Invasive plants may respond positively to climate change depending on whether they can take advantage of the altered environmental conditions (Dukes and Mooney 1999). Existing weeds may become more prevalent or new exotic species could become weeds. It is likely that biodiversity will change as ecosystems lose their components that are most sensitive to changes in climate (Fleming and Candau 1998). Management techniques must be flexible to these changes so that overall ecosystem health and function are protected. It will not necessarily be appropriate to make efforts to protect or maintain an individual species at a particular location, but rather to be open to how sites are changing across the landscape. Other species may become important in providing ecosystem benefits on these sites and management decisions must support this potential. That being said, when managing areas for ecological values it is appropriate to work with the species that occur naturally in the region. The active introduction of exotic species has the potential to create major weed issues, change soil nutrient regimes, change soil moisture regimes, reduce habitat suitability and alter natural disturbance regimes. Higher temperatures and more frequent drought conditions may also result in longer fire seasons and an increase in the frequency of fires (Dale 2000; Johnston 2004). For this reason, it is likely to be important to manage for species that are adapted to survive drought and frequent fire in order to minimise fire severity and the potential for catastrophic wildfire.

It is anticipated that, if current climate change trends continue, insect herbivore populations will be substantially impacted. Temperature is likely to be the dominant driver of change in insect populations and tree responses as it influences insect development, survival, range and abundance (Bale *et al*. 2002). Many insect species, including the western and mountain pine beetles, will benefit from warmer winter temperatures because of:

- higher rates of overwinter survival
- fewer frost events
- longer summer season for growth and reproduction
- moisture stressed trees with less resistance to attack

It is also possible that some insect populations will be negatively affected by increasing temperatures in southern and low-elevation regions because the extended summer season (Carrol *et al*. 2003). It is thought that the timing of critical life stages between herbivores and their host plants or between predators and prey may be upset by a longer summer season (Carrol *et al*. 2003; Volney and Fleming 2000). For example, defoliating insects that require new spring buds as a food source must synchronise their development with that of their hosts in order to survive (Volney and Fleming 2000). If development timing changes in host or insect, then that synchrony is interrupted and a food shortage could cause substantial insect mortality.

The short life cycle, mobility, reproductive potential and physiological sensitivity to temperature (*i.e.,* insects are cold blooded) will mean that the distribution of many insects could change in a relatively short period of time as they take advantage of new climatically suitable habitats (Ayres and Lombardero 2000; Carroll *et al*. 2003). Insect species with large geographical ranges will tend to be less affected than those with small ranges (Bale *et al*. 2002). This is because insects with a larger range already exist over more varied climates. It is also likely that changes in tree physiology and the number of natural enemies, mutualists and competitors will impact insect populations, both positively and negatively, although it is not yet clear exactly where and how this impact will be evident (Ayres and Lombardero 2000). Some insect populations are likely to benefit more than others meaning that some currently innocuous insects may become major pest in the future while current major pests may become less important (Fleming and Volney 1995).

A number of authors have forecasted the potential impacts of climate change on populations of specific insects. A couple of these scenarios are presented below.

Carroll *et al*. (2003) present the following hypothesis for the mountain pine beetle:

> *In the past, large-scale mountain pine beetle outbreaks collapsed due to localized depletion of suitable host trees in combination with the adverse effects of climate (Safranyik 1978). The results*

> *of our investigation suggest that in the absence of an unusual weather event (i.e., an unseasonable cold period or an extreme winter), the current outbreak may not entirely collapse as in the past. Expansion by the beetle into new habitats as global warming continues will provide it a small, continual supply of mature pine, thereby maintaining populations at above-normal levels for some decades into the future.*

Fleming and Volney (1995) presents the following hypothesis for spruce budworm:

> *… evidence suggests that weather events can play a significant role in catastrophic declines in population density on a regional scale. As the climate warms, as it appears to have in the Spruce Woods case, the frequency of late spring frosts will decline and population densities will remain high for longer periods in northern white spruce stands...if the climate becomes generally warmer and drier, with more frequent droughts, some increase in spruce budworm survival and fecundity can be expected. This may have little effect on the insect's population dynamics other than to produce some increase in average densities over the long term. At the other extreme, however, synergistic interaction between drought induced changes in host plant quality and drought induced changes in the insect's thermal environment may allow the budworm to improve its performance to the point that it can escape natural enemy regulation more easily. Under these circumstances, outbreaks may become more frequent (Mattson and Haack, 1987) and more severe.*

The scenarios quoted above are based on modelling results and available knowledge. However, the relationships between insect population, hosts, mutualists and predators under a changed climate are still largely unknown due to the high number of variables operating in these environments. As more information becomes available, better modelling will be possible and scenarios are likely to be refined or revised. It is also possible that plant pathogens will benefit from changed climatic conditions that weaken plants and favour pathogen life cycles; however, to date there is little information available on climate change and forest pathogens.

3.4 Hydrology

3.4.1 Regional Hydrology

There are four large lakes within the study area: Okanagan, Kalamalka, Wood and Duck Lakes. Turnover rates to replace water in these lakes are significant (Lake Okanagan turnover rate is 57 years), illustrating the critical importance of maintaining water quality (Province of BC 1972). The Okanagan Basin itself, is a tributary to the Columbia River in the United States. There are four major tributaries that account for 50% of the water input to Okanagan Lake. These include Mission, Mill, Peachland and Powers Creeks. There are productive fish spawning channels associated with Mission Creek, Vernon Creek, and Power Creek (RDCO 2002).

Numerous wetlands, marshes and riparian areas are scattered throughout the RDCO. Their numbers have been rapidly decreasing over the past century since the majority of agriculture and human development has occurred on the flat valley bottom where they were once prominent.

3.4.2 Effects of Disturbance on Hydrology

Generally forested areas readily absorb water and surface runoff rarely occurs outside of stream channels. When forest cover is removed, surface flow and below ground water tables will increase. This occurs for several reasons. The primary reason is tree canopy is no longer there to intercept and evaporate precipitation or transpire the moisture. In addition, increased amounts of solar radiation will reach the ground causing more rapid snowmelt and soil thawing (in colder seasons). The water storage potential of the soil is then exceeded (Scherer and Pike 2003).

As well as forest harvesting, natural disturbance from fire or insect outbreaks have been shown to increase water quantity (Bethlahmy 1975; Chen and Bondar 1984; Potts 1984). The degree of increased water quantity and resulting high water tables and overland flow depends on the degree of tree canopy removal, the degree to which understory vegetation is acting as a precipitation interceptor and the time of year. Conversely, the establishment of forest cover on a previously non-vegetated or non-treed area will decrease water quantity (since the newly established trees will intercept precipitation that was previously un-intercepted). Changes to water quantity in terms of above and below ground flow can affect the recharge rate of ground water (Roed 1995), effect water quality, and can cause terrain stability issues.

Water quality, whether in terms of suitability for recreation, human consumption or wildlife habitat, can be influenced by forest harvesting and natural disturbances. Channel erosion, tree blowdown, fire and landslides can all change nutrient and sediment levels (Harr and Fredriksen 1988).

Any management planning should examine and understand the local hydrology of an area. Care must be taken to minimize detrimental changes to water flow (quantity), maintain water quality, prevent soil erosion and avoid causing terrain stability issues.

3.5 Forest Cover

Vegetation resource inventory data is collected in order to map the provincial forest resource. It is collected using both photo interpretation and ground sampling. The 2002 Vegetation Resource Inventory (VRI) data indicates that 62 parks are forested. However, from observations in the field and from orthophotos, it is clear that the VRI data is incomplete. Parks such as Kalamoir and Mission Ridge are not recorded as forested in the VRI data. VRI data is not accurate for RDCO parks, primarily because it is designed to cover provincial forest lands and not lands within municipal boundaries. In those parks that do have VRI coverage, the data is coarse scale and there is inadequate ground truthing to accurately represent the actual vegetation attributes within the RDCO parks system. In summary, the spatial resolution, polygon attribute accuracy and scale of mapping for VRI is not adequate for the RDCO parks system.

Section 3.6 provides a list of forested parks based on both the VRI data and the orthophoto review. Orthophoto coverage was also incomplete so there may be several additional forested parks that are not listed. Figure 7 shows scattered VRI data coverage for the RDCO parks system.

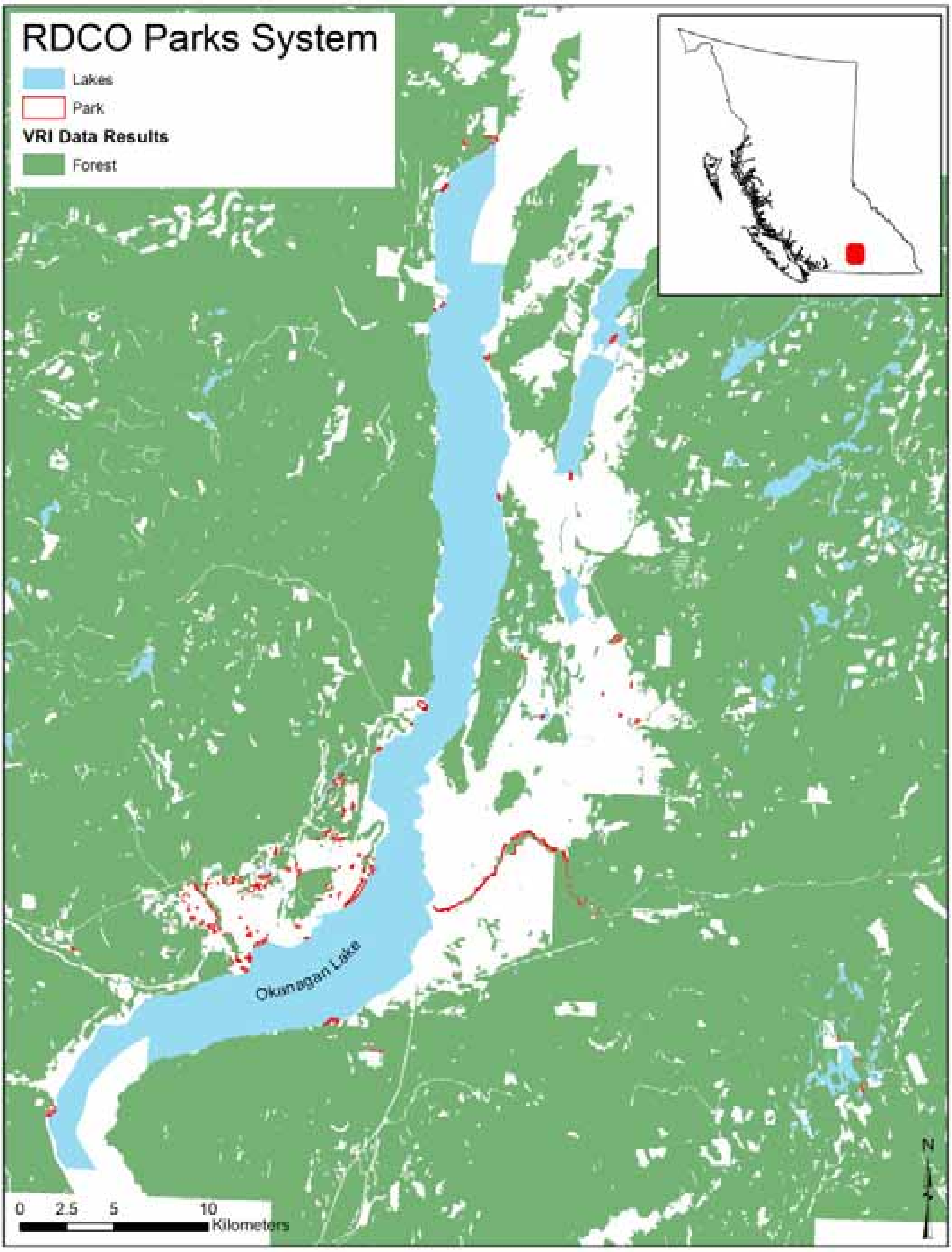

Figure 7. VRI data coverage for the RDCO parks system.

Based on the VRI Data, 61 Parks are identified as containing polygons with at least 10% pine. Of these, 51 parks have polygons containing more than 50% pine. The three forested parks that contain no pine are Mount Boucherie Sports Fields, Paula and Three Forks. The VRI data has not been updated since the 2003 wildfires during which Cedar Mountain Park and a portion of Bertram Creek Park were burnt. In addition, Woodhaven Nature Conservancy is shown as containing more than 50% pine, which was not found to be the case during the field review for this project. These findings indicate that the VRI data is both incomplete and inaccurate for the RDCO parks system. The VRI data results for dominant species by hectares of RDCO park are listed in Table 8.

Table 8. Dominant species by hectares of RDCO park based on VRI data.

Species Code	Common Name	Latin Name	Dominance in Hectares
AC	poplar	*Populus balsamifera*	7
ACT	black cottonwood	*Populus balsamifera ssp. Trichocarpa*	21
E	Birch species	*Betula sp.*	3
FD	Douglas-fir	*Pseudotsuga menziezii*	309
FDI	interior Douglas-fir	*Pseudotsuga menziezii var. glauca*	70
PL	lodgepole pine	*Pinus contorta*	27
PLI	lodgepole pine	*Pinus contorta var. latifolia*	1
PY	ponderosa pine	*Pinus ponderosa*	415

3.6 Summary of Forested Parks as of 2006

Appendix 4 is a table of forested parks derived from VRI and orthophoto interpretation. Due to missing data and inaccuracies in the VRI data, it is likely that this table is incomplete. However, for planning purposes it would be useful to develop a refined list similar to Appendix 4 when better vegetation data is available in order to plan treatments and for budgeting purposes. For example, those parks with a large component of pine are likely to have the greatest treatment requirements in the next few years due to bark beetle impact. Those parks with complex tenure are likely to require more intensive planning in order to successfully carry out treatments. This data would be best compiled in GIS so that it could be easily mapped and queried for developing coarse treatment budgets and prioritizing parks for forest health assessments.

3.7 Outlook for Forest Health and Fire Hazard

Forest health has been in relatively steady decline in southern interior BC since the early to mid 1900s and is going to be an ongoing issue for RDCO parks, particularly in the coming years of the mountain pine beetle infestation. The parks system contains substantial pine and a large area that is significantly departed from its historic conditions. In addition, there is inadequate and inaccurate inventory data, which may hinder the ability of managers to make good management decisions.

Poor forest health is intimately linked to increased fire hazard. If appropriate management strategies are implemented to improve forest health then fire hazard should also be reduced. It is particularly important to start implementing effective strategies now, not just because of the current forest health issues, but also because the human population within the RDCO boundary is forecast to increase from 150,000 to 230,000 by 2020 (RDCO 2002). This population increase will place added pressure on park usage, increase the area of urban interface and, most likely, increase the number of parks in the system. A full discussion of the biology and management options for pests of concern within the RDCO is presented in Section 6.0.

Issues of particular concern to RDCO parks in the short term are the western pine beetle and the mountain pine beetle, the ever expanding wildland urban interface (WUI), hazard trees that are a public safety risk, deforestation and reforestation, weeds and ecosystem restoration. There are numerous tools available to manage these issues, however, climate change adds a further layer of complexity to forest health management. The absence of sufficiently cold temperatures of extended duration to cause widespread mountain pine beetle mortality, and the insect's subsequent range expansion, are a current expression of a warmer climate. But exactly how and where the climate is going to change in the future, and how forest health factors will respond to changed climate conditions, are major unknowns. In addition, there needs to be a better understanding of the implications of our management options so we can learn from our mistakes. For example, pine is currently under substantial pressure from mountain pine beetle, one management option would be to remove pine and replace it with another native species that occurs in the region, such as Douglas-fir. However, in 100 years time, the mountain pine beetle will no longer be an epidemic but our past management practices may have facilitated a Douglas-fir bark beetle epidemic. For these reasons, the most appropriate strategy for future urban forest health management is likely to be a cyclical repetition of the following steps:

1. Implement best management practices for mitigating negative impacts of forest health factors;
2. Monitor;
3. Review; and,
4. Revise best management practices.

The present state of knowledge indicates that increased biodiversity in a more heterogeneous landscape will result in improved forest health in the future. While the climate is likely to continue to support an elevated population of mountain pine beetle, populations of other pests are also likely to increase if winters are warmer. In order to improve forest health and to maintain southern interior ecosystem structure and function, it is appropriate to replant with a mixture of native tree species and to manage for varied densities and ages across the landscape.

4.0 Action Plan

Urban parks are managed to provide specific services to communities and, due to fragmentation, recreation pressure and proximity to the urban interface, it is generally necessary for park managers to actively intervene in order to maintain or restore forest health and to ensure public safety in urban forests. Active management may be allowed when ecosystem structure and function has been seriously impacted or altered and human intervention is required to restore or rehabilitate ecological integrity. This action plan makes forest health management recommendations for the entire RDCO parks system. However, individual parks that undergo master plan or management plan processes should incorporate finer scale forest health planning (*e.g.,* park zones) guided by this document.

4.1 Operational Pest Management

4.1.1 Issues

- Weeds are an ongoing management concern.
- Forest insect and disease outbreaks are an ongoing management concern.

4.1.2 Goals and Objectives

Goal: Effectively manage the impact of forest pests in the RDCO parks system.

Objective:

- Inventory 100% of affected trees in Group A parks each year.
- Inventory 100% of affected trees within one tree length of trails, high use areas and facilities in Group B parks each year.
- Treat 100% of affected trees within one year of the inventory, starting with Group A parks and moving on to Group B parks.
- Establish a weed inventory for the entire parks system within one year.
- Survey areas of high tree mortality in Group B (areas outside one tree length of trails, high use areas and facilities) and Group C parks annually and prescribe tree removals where those trees pose a fire or safety hazard.

4.1.3 Recommendations

- Develop an integrated weed management plan for RDCO parks based on WeedsBC (2002) ‘Seven Steps to Managing Your Weeds’ publication.
- Use Section 6.0 Biotic and Abiotic Forest Health Factors in the Parks System as the basis of a working document to update the biology, ecology and management options for forest pests.
- See section 4.10 for inventory recommendations.
- Employ general forest health management practices:

  - Hazard Tree Removal.
  - Develop and maintain a computerized spatial inventory of weeds, pests and urban trees including records of any damage or tree removal.
  - Educate urban forestry staff on the identification of forest health factors.
  - Cooperate and coordinate on forest health factor occurrences and management options with adjacent stakeholders including, but not limited to, the City of Kelowna, Westbank First Nations, BC Parks, the Ministry of Agriculture and the Ministry of Forests.

- Direct control treatments for endemic forest pests are not recommended unless they:
  - Are at outbreak levels or are considered a disease centre.
  - Are expected to reach outbreak levels in the near future.
  - Are likely to be exacerbated by other urban forest management practices (e.g., hazard tree/tree removal in root disease locations).
  - Are having a consequence that is unacceptable to park management objectives.
- All outbreaks and invasive forest pests should be targeted for specific treatment.
- Use Qualified Professionals to develop and implement prescriptions and/or undertake hazard tree removals as new forest pest outbreaks occur or as deemed necessary by RDCO parks.
- Based on best management practices, develop Standard Operating Procedures for determining responses to urban forest pests. It is recommended that damage thresholds for eliciting a treatment response be based on whether the park falls into Group A or B. The lowest damage threshold being for Group A parks and the highest damage threshold being for Group B.
- Plan for ongoing maintenance that will reduce the probability of future outbreaks by maintaining:
  - Maintain a lower average density of stems per hectare across the landscape;
  - Maintain a diverse species composition across the landscape;
  - Maintain a diversity of age classes across the landscape.

4.2 Mountain and Western Pine Beetle Management

4.2.1 Issues

- Substantial tree mortality due to mountain pine beetle is expected over at least the next ten years.
- Mountain pine beetle populations are expected to be maintained at higher numbers than the historic average if the current warming trend continues.
- Tree removal is anticipated to be required on a large scale in order to mitigate the public safety and potential fire hazard posed by beetle killed trees.

4.2.2 Goals and Objectives

Goal: Effectively manage the impact of Mountain and Western Pine Beetle in the RDCO parks system.

Objective:

- Inventory 100% of affected trees in Group A parks each year.
- Inventory 100% of affected trees within one tree length of trails, high use areas and facilities in Group B parks each year.
- Treat 100% of affected trees within one year of the inventory, starting with Group A parks and moving on to Group B parks.
- Survey areas of high tree mortality in Group B (areas outside one tree length of trails, high use areas and facilities parks annually and prescribe tree removals where those trees pose a fire or safety hazard.

4.2.3 Recommendations

- Based on best management practices, develop Standard Operating Procedures (SOPs) for detection and removal of infested pine.
- See section 4.10 for inventory recommendations.
- For detection, due to the size of the RDCO parks area, ground surveys are deemed sufficient and stand modeling beyond an improved forest cover inventory is probably not required.
- Based on experiences of municipalities, such as Prince George, that have already experienced severe mountain pine beetle impact, 100% of mature pine in a stand are eventually killed in attacks over a succession of years. Do not consider targeted tree removal of individual beetle infested or beetle killed pine. Where mountain pine beetle is detected remove 100% of mature pine in the stand in order to: minimize damage to natural

regeneration and residual non-pine species; prevent costs associated with returning to a stand multiple times for additional tree removal treatments; and, to enable reforestation of the stand to begin as soon as possible.

- Beetle proofing is a process that involves thinning out the stand to improve tree vigour in retained trees and therefore the ability of individual trees to withstand bark beetle attack. However, when bark beetle populations are at very high levels they can successfully attack even highly vigorous trees. In addition, freshly cut stems and any residual damage created during thinning can actually attract bark beetles to the area. It is recommended that resources should not be directed at beetle proofing stands until after the mountain pine beetle epidemic has passed and tree removal treatments have been completed. In the event that park managers determine that certain stands warrant this treatment prior to the arrival of the mountain pine beetle despite the risk of treatment failure, then treatments should occur within the next 12 – 18 months and only in stands that have not yet been attacked by mountain pine beetle and that are generally healthy. Prioritize treatments in stands considered to have high value in terms of recreation use or visual quality. Candidate stands should ideally contain a minimum 30% component of species other than pine, have an average tree age of less than 80 years and an average dbh of greater than 20 cm. During treatments, be careful to minimize damage to retained trees and reduce canopy cover to 35%. Consider fertilizing retained trees to improve tree vigour.

- When undertaking tree removal to remove hazard trees or to mitigate fire hazard, undertake tree removal before beetle flight (May) or after beetle flight (September) but not during the known flight period. Monitor flight periods to adjust for any changes in flight timing due to weather anomalies. If tree removal and offsite debris disposal must occur within the flight period (*e.g.,* urgent hazard tree removal) then all bark must be removed from logs that are being transported off site.

- Tree removal treatments in winter are recommended in order to minimize impact on soils and sensitive ecosystems, and to avoid beetle flight periods.

- Use a Qualified Professional to:

    1. Identify polygons containing beetle kill and susceptible pine as either: containing beetle killed trees and susceptible pine that are not a fire hazard; or, containing beetle killed trees and susceptible pine that are also a fire hazard.

    2. Develop and implement prescriptions for either: 100% pine removal for beetle killed and susceptible pine trees; or, fire hazard reduction treatments that include 100% removal of beetle killed and susceptible pine trees.

- Plan for ongoing maintenance that will reduce the probability of future outbreaks by maintaining:

    - Maintain a lower average density of stems per hectare across the landscape;

- Maintain a diverse species composition across the landscape;
- Maintain a diversity of age classes across the landscape.

4.3 Wildland Urban Interface

4.3.1 Issues

- Development pressure within the Central Okanagan has created an extensive wildland urban interface that borders most regional parks.
- Poor forest health resulting in an increased forest fire hazard in urban forests.

4.3.2 Goals and Objectives

Goal: To improve forest health in the urban forest thereby reducing fire hazard in interface areas.

Objective:

- To thin all ingrowth areas to 35% canopy cover.
- To remove 100% of dead or diseased trees that contribute to an increased fire hazard in interface areas.

4.3.3 Recommendations

- Comprehensive planning and consideration of fuel treatments is required to ensure that fire risk associated with Regional Parks is acceptable. Similar to the ecology of Okanagan Mountain Park, historic fire suppression in combination with the current insect outbreaks has resulted in stand densities and surface fuel loadings that are considered a fire risk to the community that must be addressed. Use existing wildfire hazard mapping and an expanded hazard mapping process (e.g., a complete and updated RDCO community wildfire protection plan), identify and map all ingrowth and fire hazard rated areas.
- Prioritize areas for treatments based on proximity to urban interface, fire hazard rating and treatment difficulty. Implement fuel hazard reduction treatments that will reduce tree density. This will also improve tree vigour and stand resistance to many forest pests. However, do not initiate this program until the mountain pine beetle epidemic has subsided or the stand is already being treated to remove dead pine.
- Heavily used trail networks within RDCO parks, where ecologically appropriate, should be thinned and understory fuels removed up to 5-metres on each side of the trail network. Thinning will limit the ability of fire to spread and improve fire suppression capability throughout these heavily used corridors.

- Based on best management practices, develop Standard Operating Procedures (SOPs) for hazard reduction treatments (thinning and/or prescribed fire).
- Adopt a standard for fuel management in parks and green spaces (a proposed standard is contained in Appendix 5).
- Use an appropriately Qualified Professional to:
  1. Develop and implement prescriptions for thinning stands to 35% canopy cover (see example in Appendix 6).
  2. Develop and implement prescriptions for prescribed fire.
- Prescribed fire and the use of a curtain burner should be allowed in order to improve the cost effectiveness of fuel treatment and expand the area of treatment. Any use of fire should strictly follow smoke management guidelines to limit the health impacts of smoke.
- To reduce the probability of catastrophic wildfire plan for ongoing maintenance that will:
    - Maintain a lower average density of stems per hectare across the landscape.
    - Maintain reduced surface fire hazard across the landscape.

4.4 Hazard Tree Removal, Tree Removal and Maintenance

4.4.1 Issues

- Hazard tree inventory is lacking.
- Hazard tree treatments are currently lacking.
- Complex management requirements of hazard trees in Riparian and Sensitive Ecosystems.
- Public safety and liability concerns over existing hazard trees.
- Large-scale tree removals will be required in some areas due to forest health agents such as mountain pine beetle, fire and drought.
- The current and future insect mortality in the Central Okanagan is expected to produce wide spread mortality of both ponderosa and lodgepole pine. This mortality will create large accumulations dead and downed woody debris. In many cases, tree removal is likely to be required. The volume of this material is likely to be beyond the ability of local landfills to handle.

4.4.2 Goals and Objectives

Goals: Reduce the number of hazardous trees in RDCO parks

Objective:

- Inventory 100% of hazard trees in Group A parks each year.
- Inventory 100% of hazard trees within one tree length of trails, high use areas and facilities in Group B parks each year.
- Treat 100% of hazard trees within one year of the inventory, starting with Group A parks and moving on to Group B parks.
- Survey areas of high tree mortality in Group B (areas outside one tree length of trails, high use areas and facilities parks annually and prescribe tree removals where those trees pose a fire or safety hazard.

4.4.3 Recommendations

- The Regional District of Central Okanagan should develop a danger tree assessment program within the Regional Parks Department. Currently there is no formal policy or procedure to assess danger trees within Regional Parks. Danger trees considered a hazard to public safety and property within and adjacent to regional parks need to be addressed in a consistent program that includes annual assessments and removals within Regional District Parks.
- Develop a Terms of Reference for tree inventory based on best management practices. This should encompass data collection for an inventory of forest pests as per the Operational Pest Management Recommendations and an inventory of mountain pine beetle as per the Mountain Pine Beetle Management Recommendations. Two types of inventory should apply: in Group A parks and within one tree length of trails, high use areas and facilities in Group B parks, conduct hazard tree inventory as per best management practices; in area of Group B parks that is outside one tree length of trails, high use areas and facilities conduct coarse scale surveys from the air or on foot to identify areas of high tree mortality that pose a public safety or fire hazard.
- See section 4.10 for inventory recommendations.
- Develop Standard Operating Procedures for tree removal in riparian areas and sensitive ecosystems, particularly fish bearing streams, based on best management practices.
- Use an appropriately Qualified Professional to annually inventory hazard trees in the parks system and to prescribe tree removals.
- Develop a regular maintenance schedule that is suitable to meet targets for hazard tree treatment within one year of identification.
- Conduct hazard tree treatments as per best management practices.

- In sensitive ecosystems and high visibility areas, consider phased tree removals (removing trees over several operations). This will limit the amount of material requiring removal, make the operation less complex and maintain visual quality.
- Where safe according to an ISA certified arborist, create wildlife trees up to 5 m tall.
- In areas with difficult access that are not sensitive or high visibility, consider removing both hazard trees that require immediate removal and hazard trees that are anticipated to require removal in the near future to improve operational efficiency.
- In riparian areas, consider leaving deciduous debris on the ground for coarse woody debris. Up to 15 pieces per hectare greater than 12 cm in diameter and 3-5 m long are acceptable.
- In non-riparian areas, coarse woody debris may be left at 5-10 pieces per hectare greater than 12 cm in diameter and 3-5 m long.
- All debris in excess of coarse woody debris must be disposed of on site or removed off site for disposal.
- Work with other local governments within the region to develop a comprehensive debris disposal strategy. This strategy may include the research, planning and procurement of equipment and or facilities that can utilize and or dispose of the debris. Consideration should be given to:

    1) Purchase of a curtain burner.
    2) Joint partnership in cogeneration.
    3) Providing hog fuel to local industry.
    4) Encouraging the development of an alternate energy facility (*i.e.,* a bio-energy/pellet facility/woodchip boilers).
    5) Exporting ponderosa pine sawlogs to the United States (Washington, Montana and Idaho).
    6) Supplying woodchips to landscapers or for landscaping in RDCO parks (if landscaping, chips cannot be left at depths greater than 5 cm or concentrated over areas greater than 50 m^2 due to potential fire hazard).
    7) Supplying firewood to local retailers or free to the community (if allowing the community to pick up firewood then pick-up times should be limited so that wood is removed from the site as quickly as possible. Firewood piles should not be left on site at all between April 15th and October 15th).
    8) Mulching or composting debris for use in RDCO parks, supplying to landscapers or to the community.

4.5 Reforestation and Ecosystem Restoration

4.5.1 Issues

- Large-scale tree removals will be required in some areas due to forest health agents such as mountain pine beetle, fire and drought.
- Hazard tree removals in riparian and sensitive ecosystems.
- Degraded ecosystems due to invasive weed species or other impacts.
- There is no single, well defined plan for tree replacement.
- Due to the demand for ponderosa pine and Douglas-fir seed there may be a future shortage of available seed from the province/forest licensees.

4.5.2 Goals and Objectives

Goal: To reforest or restore ecosystems that have become degraded either as a result of forest ingrowth or encroachment, due to tree removal or other human caused factors.

Objectives:

- Except where restoring encroached areas to grassland, to reforest 100% of areas clear cut as a result of tree mortality.
- To reforest to lower stand densities by targeting canopy closure of 35% in order to create stands that are more resilient to forest health factors and more similar to historic stands.
- To reforest with a mixture of native tree species so that biodiversity is increased within the stand.
- To restore 100% of encroached areas to grassland.
- To reduce the density of trees in ingrown forests to a canopy closure of 35%.

4.5.3 Recommendations

- In Group B parks, allow natural succession to proceed with minimal intervention or disturbance unless active management is needed to enhance or maintain habitat value (e.*g.*, treating ingrowth and encroachment) or to control trees or brush that pose fire, forest health or safety hazards.
- Develop Standard Operating Procedures for tree replacement and planting that are based on best management practices. Specifically identify reforestation procedures for riparian areas that contain fish bearing streams as per best management practices.

- Develop and regularly update a working plant list such as the example template provided in Appendix 7 in order to plan for stock orders. The list should define the appropriate age, size, species distribution, location and life expectancy goals for trees planted in Group A parks and around trails, facilities and high use areas in Group B parks. The list should be updated annually based on maintenance records and tree inventory data.
- In all park areas that are on Crown Land, the RDCO must comply with legislated stocking and reforestation requirements of the Kamloops Forest District. If a Qualified Professional deems that a lower stocking standard is warranted for the purposes of wildfire protection or forest health, then this must be negotiated with the Province when the harvesting license is procured. The following applies to all non-Crown tenure parkland. In Group A parks, plant at densities that will achieve up to a maximum of 35% canopy cover. In Group B parks, use the Appendix 8 to indicate the appropriate species and planting densities for the biogeoclimatic zone. Use this appendix as a guideline. Do not exceed the target stocking standards, however, on dry sites it may be preferable to plant below the target spacing. Specific site prescriptions should clearly rationalize stocking standards. Mission Creek Restoration Plan (Appendix 1) can be used as an example.
- See section 4.10 for inventory recommendations.
- Replant to FireSmart standards around structures.
- Continue to coordinate programs for public involvement in planting.
- Continue to work with nurseries to make appropriate plant materials available.
- Develop a seed collection program for RDCO parks stock. This could be achieved either through collections by RDCO parks staff or volunteers, purchase of existing seed surpluses or by contracting seed collection externally.
- Use an appropriately qualified professional to identify, map, prescribe and implement treatments for ingrowth and encroachment areas. Implement forest restoration treatments that will reduce tree density. This will also improve tree vigour and stand resistance to many forest pests. However, do not initiate this program until the mountain pine beetle epidemic has subsided or the stand is already being treated to remove dead pine.
- Thin ingrowth areas to 35% canopy closure. Thin encroachment areas to <10% canopy closure. Attempt to combine these treatment objectives with those of fire hazard abatement treatments where possible. Large-scale thinning of dense stands should not be undertaken in the short term as this could reduce the available living forest structure that could be maintained following the beetle outbreak
- Plan for ongoing maintenance that will:
    - Maintain a lower average density of stems per hectare across the landscape.

- Maintain grasslands.

4.6 Access

4.6.1 Issues

- Access in many parks is inadequate for maintenance and fire suppression crews.
- The current and future mortality associated with both Western Pine Beetle and Mountain Pine Beetle will require extensive tree removal.
- Access planning has not been adequately implemented in the RDCO parks system.

4.6.2 Goals and Objectives

Goals: To improve current and future access in RDCO parks for maintenance and fire suppression activities.

Objectives:

- To enable temporary and permanent access in RDCO parks for the purposes of forest health maintenance activities.
- To improve access in RDCO parks for fire suppression activities.

4.6.3 Recommendations

- Develop an access plan that details where both permanent and temporary access are appropriate for required management activities. The RDCO parks department should develop an access management plan that facilitates dead tree removal and fire protection within the Regional Parks system. This plan should be focused on minimizing soil disturbance and impacts on other resource values important to the integrity of the Parks system.
- Avoid creating high-use access through sensitive ecosystems.
- To minimize the impact on soil and understory vegetation, create temporary access for tree removals and maintenance in winter when there is snow cover and the ground is frozen.
- Where fire control access could be improved in RDCO parks, and the resulting ecological impacts are considered acceptable, consideration should be given to widening specific trails to 3.2 meters (the width required for small emergency vehicle access). This should involve the removal of all obstacles such as trees and stumps but the trails should remain unpaved. Access points should be provided where they are feasible and effective. Where possible, access points should be close to hydrant locations.

4.7 Standards for New Parks and Greenspaces

4.7.1 Issues

- Developers providing land for parks to the regional district that are in a poor state of forest health.
- Fragmentation.

4.7.2 Goals and Objectives

Goal: To reduce fragmentation and to further regulate the land acquired for parks from developers.

Objectives:

- To acquire land from developers that has been 100% treated to mitigate the impacts of forest health agents as is required by the RDCO wildfire hazard assessment process.
- 100% of land acquired from developers is appropriate for Group A or Group B parkland.
- To connect existing parkland when possible.

4.7.3 Recommendations

- Prior to accepting new areas within the Regional Park system it is recommended that documentation of forest health conditions, fire hazard liability, and safety hazards is undertaken to ensure that the Parks department has a clear understanding of management issues and responsibilities, and the cost of those associated responsibilities. Clear standards for new Parks and Greenspaces are required to ensure that the Regional District has the capacity to properly manage these new areas.
- Ensure that parkland acquired from developers has been treated to mitigate wildfire hazard and forest health issues.
- Continue the development of the acquisition plan for future parkland acquisitions and/or to link green spaces to provide/preserve wildlife corridors.
- Where land from developers is unsuitable for parkland, continue the practice of pursuing funds in lieu of parkland to be spent on more appropriate acquisitions.

4.8 Public Education/Managing Public Expectations

4.8.1 Issues

- Poor public perception of high tree mortality resulting from the impacts of forest health agents such as fire, drought and the mountain pine beetle.

- Poor public perception of deforestation resulting from tree removal to mitigate tree mortality.
- Lack of public awareness around forest health issues.

4.8.2 Goals and Objectives

Goals: To improve public understanding around issues of forest health in RDCO parks.

Objectives:

- Install signage to explain treatments in high-use parks.
- Post forest health information on the RDCO parks website.
- Model good stewardship practices to provide good examples of sustainability such as forest restoration and tree friendly public works

4.8.3 Recommendations

- Use best management practices when undertaking treatments and maintenance in parks.
- Continue to provide volunteer stewardship opportunities to local community groups and schools
- In consultation with the City of Kelowna, develop a regional approach to communicating about forest health issues, particularly in terms of wildfire and mountain pine beetle impacts, and implement the approach on the RDCO website and through press releases.
- Develop signage and web-based information that explains the objectives and benefits of forest health treatments. The website should outline plans and strategies in place to address the beetle outbreak and other forest health issues. Other information, such as fire danger and treatment initiatives in Regional Parks could be maintained on the local site so that management issues specific to RDCO Parks could be easily communicated to local communities.
- Encourage public participation in reforestation/restoration programs.
- Acknowledge and publicize contributions to urban forestry by citizens, businesses, institutions and community groups on the RDCO website and in press releases.

4.9 Land Tenure/Ownership

4.9.1 Issues

- The land tenure and ownership of RDCO parks is complex making it difficult for management to clearly understand 1) legislative and regulatory responsibilities, 2) liability, and 3) operational obligations.
- Tenure agreements complicate the process for the RDCO to undertake treatment activities within parks of non-RDCO tenure.
- Timbermarks are required and stumpage applies to trees removed from Crown land within RDCO boundaries.
- Different levels of MoFR approval are required for activities within RDCO parks tenured from the Crown.
- Provincial stocking standards and reforestation obligations apply on Crown land.

4.9.2 Goals and Objectives

Goal: To simplify tenure and/or establish agreements that enable RDCO parks to carry out forest health treatments within all RDCO parks.

Objectives:

- Contact all affected owners of land managed by RDCO parks to negotiate agreements for forest health treatments on their lands.
- Review legislation and policy to determine methods for facilitating forest health treatments on non-RDCO titled lands.

4.9.3 Recommendations

- Over the coming years the RDCO should work towards consolidation of ownership of the various tenure types within the parks system. The RDCO should investigate the potential for purchasing the free-hold of private land that is within RCCO park boundaries. The RDCO should investigate the potential for conversion of all tenured Crown Land (e.g., Licence of Occupation, Crown Lease) to Free Crown Grants that include the timber on the sites in order to reduce the cost of future maintenance.
- The RDCO parks department should work with the Province to streamline the removal of dead and/or susceptible trees on Crown Land within the parks system. This process will involve acquiring Timbermarks, appropriate harvesting licenses, burning permits, reforestation responsibilities and potentially negotiating stocking standards. The RDCO and/or the City of Kelowna could investigate the Community Forest Agreement process to

manage forests on the broader landscape. However, this would be a longer-term process and may not be cost effective due to the current low demand for ponderosa pine and beetle killed timber. The RDCO should consider contacting the Tenure and Revenue Division of the Kamloops Forest District to discuss harvesting licence options such as Community Salvage Licences and Licences to cut within RDCO parks in the short term. If one license could be applied to multiple parks at one time then this would provide for greater efficiency and certainty during planning.

- The Interior Appraisal Manual will be applied to assess stumpage of all timber removed on Crown Lands within the RDCO. The RDCO should investigate the potential for lobbying the Province regarding a solution to the high costs borne by municipalities undertaking treatments for forest health and fuel mitigation purposes on Crown Land when full stumpage applies.
- The RDCO parks department should work with the appropriate landowners to streamline the removal of dead and/or susceptible trees on non-RDCO and non-Crown titled land within the parks system. If needed to reach agreement, the RDCO should consider engaging stakeholders in a mediated workshop process to derive an acceptable treatment plan within those areas.

4.10 Monitoring and Adaptive Management

4.10.1 Issues

- Current level of forest health monitoring in RDCO parks is inadequate due to resource deficiencies.
- Static approach to management does not adjust to deal with new forest health issues.
- Mistakes are not corrected over time.
- Redundancies occur as inadequate monitoring information is available to indicate the most efficient and appropriate course of action.
- Impacts of most forest health agents and the implications of current management options are not well understood.
- Current tree inventory is inadequate to effectively manage forest health in RDCO parks.
- Current VRI data is inaccurate and incomplete.
- The Sensitive Ecosystem Inventory is incomplete for the parks system.

4.10.2 Goals and Objectives

Goal: To implement a framework for adaptive management and monitoring that provides flexibility for change over time as forest health issues change over time.

Objectives:

- Develop a monitoring system that improves the ability of RDCO parks staff to make informed management decisions in a state of constant change.
- Develop working documents and plans that can be used by parks staff to implement management decisions, and that are updated over time.
- Develop a better understanding of the forest resource.

4.10.3 Recommendations

- Historically RDCO Parks has statically managed its park system, allowing natural processes to influence vegetation development with limited or no active management. Given the forest health challenges that RDCO now faces it is recommended that RDCO Parks adopt a policy of adaptive management which provides managers with the tools to undertake active management.
- Develop an annual monitoring program to assess current and changing forest health, the success of forest regeneration and or restoration treatments, and changes to key forest attributes like stand density, crown closure, surface fuel which are linked to forest fire hazard. Specifically:
    - Develop and maintain a computerized spatial inventory of weed distribution.
    - Develop and maintain a computerized spatial inventory of urban trees including records of any damage or tree removal.
    - Develop and maintain a computerized spatial inventory of pest distribution. Monitor insect populations and disease centres annually. Collect data for the spatial forest pest inventory as part of the tree inventory.
    - Conduct an annual hazard tree inventory as per best management practices and recommendations made in Sections 6.1 - 6.4. Record, at minimum, spatial location, species, age, health, size, maintenance/treatments and record of removal. Conduct this inventory on an annual cycle.
    - Conduct a coarse scale ground survey of tree mortality annually.
    - Monitor mountain pine beetle flight periods annually.

  - Conduct tree regeneration surveys 1, 3, 5 and 10 years post planting to determine whether additional planting or spacing is required.
  - A new forest cover type inventory should be conducted at a scale of 1:5,000 or finer as per best management practices to update information on species distribution, stand structure, and other important ecological attributes. This inventory should replace the existing VRI data and should be used to determine, in part: insect and disease susceptibility; fire hazard and risk; appropriate silviculture and regeneration strategies; and, development of appropriate active management plans and strategies.
  - The Sensitive Ecosystem Inventory and Terrestrial Mapping should be updated to cover the entire RDCO parks system. This data should be used to determine, in part: potential environmental impacts; maintenance of terrain stability; and maintenance of water quality.
  - Identify heritage trees (old trees, ceremonial plantings) or significant trees (large, rare, unusual species) in the inventory and consider bylaws for their protection.
  - Track crew maintenance hours and make performance targets for maintenance crews.
  - Coordinate inventory data collection and updates through municipal staff. Work with the municipal GIS department to design the format for the spatial data collected.
  - Investigate the use of tree inventory software. Review the software being used by the City of Kelowna and the District of North Vancouver to determine whether these programs might be suitable for use within RDCO parks. Use appropriate tree inventory software to track tree history, hazard trees, forest pest occurrences, mountain pine beetle occurrences, tree removals, maintenance history, maintenance schedules, calls from the public and costs.

- Use monitoring, inventory results, policy changes, new research data and pest management to update the Urban Forest Health Management Plan every five years. Update the plan in the opposite cycle to the five yearly parks 'System Plan' update listed under Section 6 of the Official Regional Park Plan (Bylaw No. 884).

- Develop life expectancies of different tree species and particular damage trends for tree species based on inventory data. Use this data to update working documents for planting and forest health agents on an annual cycle.

- Define the roles and responsibilities of RDCO parks staff in terms of data management, plan development and monitoring.

- Use monitoring data to determine which planting densities have achieved the appropriate balance between seedling survival and desired spacing.
- Use monitoring data to analyze the success/failure of restoration treatments in relation to specific disturbance events such as drought, fire and insect/disease attack.
- Use monitoring data to analyze population increases in forest pests to determine appropriate actions.

4.11 Coordination between Departments and with other Agencies

4.11.1 Issues

- Knowledge gaps
- Funding
- Redundancies due to unknowingly collecting data or undertaking work that has already been completed by another department or agency.

4.11.2 Goals and Objectives

Goals: To have regular and open communication between departments and agencies whose actions have implications for the RDCO parks system.

4.11.3 Recommendations

- Aim to further improve coordination of information sharing and funding opportunities with the City of Kelowna, Westbank First Nations, BC Parks, the Ministry of Agriculture and the Ministry of Forests. For example, investigate the options for sharing equipment costs such as a curtain burner with the City of Kelowna and Westbank Fire Rescue or cost sharing of treatments that provide benefits to multiple agencies.
- Review interdepartmental procedures and policies to determine whether any further efficiencies can be achieved through improved communication or policy changes.
- Continue knowledge sharing through participation in the beetle taskforce.
- Where appropriate, continue to support and engage community associations such as the:
    - BC Lake Stewardship Society
    - Lake Country Environmental Society.
    - BC Wildlife Federation
    - Lake Country Watershed Roundtable.
    - Brenda Mines Monitoring Committee.

- Trepanier Linear Creek Park Society.
- Central Ok Environmental Advisory Committee.
- Nature Trust of BC.
- Central Okanagan Naturalists Club.
- Oceola Fish & Game Club.
- Central Okanagan Parks and Wildlife Trust
- Okanagan Nation Fisheries Commission.
- Central Okanagan Resource Stewards.
- Okanagan Nation Natural Resources Commission.
- Clean Our Okanagan Lake Okanagan.
- Region Wildlife Heritage Fund Society.
- Earthcare Society Okanagan.
- Similkameen Parks Society.
- Endangered Wildlife Festival Society.
- Peachland Sportsman's Club.
- Friends of BC Parks.
- Return of the Peregrine Falcon Society.
- Friends of Brandt's Creek.
- Science & Stewardship for Community & Kids Society.
- Friends of Knox Mountain Park.
- Science & Technology Council.
- Friends of Mission Creek.
- Sierra Club of Western Canada.
- Friends of the South Slopes.
- Smart Growth Coalition.
- Gellatly Bay Trails and Parks Society.
- Society Promoting Environmental Conservation.
- Go Green Coalition.
- Trepanier Creek Monitoring Committee.
- Kelowna & District Fish & Game Club .
- Western Canada Wilderness Committee.
- Kelowna Geology Committee.

4.12 Budgeting and Funding Sources

4.12.1 Issues

- Current budgets and resource allocations to forest health in RDCO parks are likely to be inadequate to mitigate forest health issues in RDCO parks in the short-term.
- Ongoing maintenance will be required to mitigate forest health issues in RDCO parks in the long-term.
- Trees provide numerous non-economic values (ecological services) such as carbon sequestration, reducing runoff and flooding, improving air and water quality that are not reflected in park budgets.
- External funding sources are currently available for treatments.
- Much RDCO funding is in the form of one-off grants for specific projects.

4.12.2 Goals and Objectives

Goal: To develop a budget for RDCO parks that adequately funds the treatments required to mitigate forest health issues.

Objectives:

- To utilize available external funding to enable forest health treatments.
- Develop a budget for approval by the regional board that adequately accounts for a short term increase in forest health treatments and a long term requirement for ongoing maintenance.

4.12.3 Recommendations

- The Union of BC Municipalities (UBCM) and the Ministry of Forests and Range (MoFR) (http://ground.hpr.for.gov.bc.ca/) have provided $5 million in funding for municipalities undertaking fuel treatments and wildfire protection planning. This money is available on a first come, first served basis. For fuel reduction treatments that are also beetle tree removals, this funding will pay for 75% of the treatment costs. For wildfire protection planning, this funding will provide up to $15,000 for the plan as long as this is matched by the municipality. The 25% treatment costs and matched planning costs that the municipality must contribute can be 'in-kind' contributions. In-kind contributions include costs such as staff time, equipment and volunteer time. The RDCO should investigate applying for UBCM funding to mitigate the cost of beetle tree and fuel hazard treatments. Where possible, 'in-kind' contributions should be maximized in order to reduce the monetary burden on the RDCO, particularly where stumpage must be paid.

- The Habitat Conservation Trust Fund (HCTF) provides funding for projects that can demonstrate one of the following: 1) conserve or enhance biological diversity, fish, fish habitat, wildlife or wildlife habitat; 2) acquire or manage lands for the conservation or enhancement of a population of a species of fish or wildlife and its habitat; and, 3) increase understanding, knowledge and awareness of fish or wildlife and their habitat or of the trust fund, through promotions, education or other programs. The RDCO should investigate the potential for funding through the HCTF for projects that focus on ecosystem restoration either as treatments or in terms of sensitive ecosystem inventories and monitoring.

- The RDCO should continue to investigate and invest in the preparation of applications for external funding from the groups mentioned above as well as other opportunities. Examples of other opportunities include the Tree Canada Foundation funding that aided the development of this project and the yearly Service Canada (formerly HRDC) crew work.

- The RDCO should investigate local and overseas market opportunities, primarily for ponderosa pine and chips in order to offset the costs of treatments and potentially generate some revenue to fund future treatments. There was a blanket exemption from the Softwood Lumber Agreement for the export of ponderosa pine from the Southern Interior Forest Region. However, this exemption expired on December 31st, 2006. Exemptions are generally put in place when timber is in surplus to the needs of domestic timber processing facilities. The RDCO may be able to apply for an exemption. If necessary, the RDCO should investigate whether there is future potential for ponderosa pine sawlog export to sawmills in the US as an alternative to the local market. The MoFR Kamloops Regional office (the current export officer is Chris Shallow) can provide current information for this process.

- Only one staff member is assigned full time to forest health management in RDCO parks. Future budgets should account for the additional support that is likely to be required for hazard tree assessments and the development of tree removal prescriptions and treatments (*i.e.*, ISA arborist, Professional Geoscientist, Professional Forester, Certified Faller).

- Attempt to define economic and environmental benefits derived from the ecological services provided by the parks to rationalize a budget for forest health treatments and ongoing maintenance.

- Carbon sequestration is an element of minimizing the impacts of Greenhouse Gas Emissions and global climate change. The excessive release of CO^2 into the atmosphere has been identified as a major contributing factor to global warming. Forests exchange CO^2 through the processes of photosynthesis, respiration, decomposition and through emissions resulting from fire, insect and disease attack, and tree removal. The United Nations Framework Convention on Climate Change requires that Canada report changes in net forest carbon stocks. Forest carbon stocks that are recognized by the Kyoto Protocol include above-ground biomass, below-ground biomass, litter, dead wood, and organic soil carbon. Canada is still in the process of developing a National Forest Carbon Monitoring, Accounting and Reporting System. While carbon accounting systems are still in the early stages of development, it is likely that they will play an increasing role in natural resource management. Under the Kyoto Protocol, ratifying nations will be bound to specific caps on the amount of emissions that they can release. This emission limit will be meted out to companies and other organizations as credits. If an organization uses less than its allotted credit, it will be eligible to sell that credit to another organization that needs additional credit. Ultimately, organizations that sequester carbon through tree planting and other activities that increase carbon biomass could use profits from the sale of carbon credits to offset the cost of those activities. The RDCO should investigate the potential for carbon accounting and how this could benefit RDCO parks in the future. This should include investigating emissions trading systems and appropriate brokers, and documenting past and future reforestation/restoration activities that have increased tree growth in order to prove carbon eligibility in the future.

5.0 Best Management Practices for Forest Health

5.1 Tree Inventory

There is no preeminent best management practices document for tree inventory in BC. However, there are numerous resources available online. These can be found in the Compendium of Best Management Practices for Canadian Urban Forests[1]. The inventory types likely to be most appropriate within RDCO parks are:

- A hazard tree inventory: data recorded each tree in areas that are high use (walking paths and park facilities)
- A partial inventory/cover type survey: for the entire parks system that uses orthophotos or aerial photos in combination with ground truthing to identify more accurate forest cover polygons.

5.1.1 Standards for Good Practice Hazard Tree Inventory

- Undertake an annual cycle of tree inventory that covers all trees within one tree length of high-use areas (walking paths and park facilities);
- Use a professional forester, professional forest technologist, or ISA certified arborist to undertake annual tree inventory;
- Train urban forestry staff in the "Wildlife Danger Tree Assessor's Course"[2] so that they can recognize existing and potential wildlife trees and distinguish between safe and hazardous trees when carrying out normal maintenance activities. This will enable the collection of supplemental data and scheduling of timely maintenance activities for trees that are damaged following weather events such as lighting or high winds.
- Standardize inspection procedures:
    - Use the "BC Dangerous Tree Assessment Process" (Manning *et al*. 2002) to assess tree danger;
    - Use GPS of sub-metre accuracy to locate all trees included in the inventory;
    - Record data on standard forms that contain all the desired inventory attributes. The following attributes are important to record:
        - Species (common and scientific name)
        - Size: DBH, height, crown cover

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[1] http://www.tcf-fca.ca/programs/urbanforestry/cufn/resources_bmp.html#_Toc126753319
[2] http://www.for.gov.bc.ca/hfp/training/00016/index.htm

    - Condition: danger tree rating, any maintenance requirement
    - Damage: Insect infestations, disease symptoms, injuries and required response (e.g., tree removal, pruning)
    - Management/maintenance: record need to fertilize, apply fungicide/insecticide, prune, repair curb, remove stump/tree, water.
    - Site characteristics: Condition and health of the soil, proximity to utilities, proximity to facilities
    - Signature/heritage trees: Identify special trees that require more intensive management

- Enter data into tree inventory software that can perform functions to enable efficient management of urban trees (*e.g.,* inventory records, maintenance tracking, costs, complaints, maintenance scheduling, planting planning); and
- Assign responsibility of data management to one department or employee to ensure continuous and complete entry of data into the existing system.

5.1.2 Standards for Good Practice Partial Inventory/Cover Type Surveys

- Undertake a five-yearly cycle of partial inventory/cover type survey for the entire RDCO parks system;
- Use a qualified professional to undertake the survey;
- Standardize data collection procedures:
    - Use the Ministry of Forest and Range Vegetation Resource Inventory Standards and Procedures[3]
- Enter data into software that enables analysis for species composition, percentage cover and age. Data should be used to plan for probability of and responses to insect and disease outbreaks, identify changes in forest cover over time and planning for reforestation/restoration activities.
- Assign responsibility of data management to one department or employee to ensure continuous and complete entry of data into the existing system.

[3] http://www.for.gov.bc.ca/hts/vri/standards/index.html

5.2 Hazard Tree Treatments

The British Columbia's Best Management Practices for Hazard Tree and Non-Hazard Tree Limbing, Topping or Removal[4] and the Compendium of Best Management Practices for Canada's Urban Forests should be used to guide hazard tree treatments. In summary, good management practices of hazard tree treatments are:

- If trees are suspected of being hazardous, have them assessed by a qualified professional arborist who is also a certified Wildlife Danger Tree Assessor, to determine the presence and nature of the hazard.
- Train urban forestry staff in the "Wildlife/Danger Tree Assessor's Course"[5] so that they can recognize existing and potential wildlife trees and distinguish between safe and hazardous trees when undertaking maintenance to treatments in the urban forest.
- Conduct maintenance on a regular annual cycle and when required following severe weather events such as lightning and wind storms.
- Use an ISA certified arborist for danger tree removals or complex hazard tree treatments (*e.g.*, treatments in sensitive ecosystems, topping trees for wildlife, treatments requiring climbing apparatus).
- Ensure that equipment is cleaned before being transported between treatment sites. This will minimize the likelihood of spreading weeds and pathogens between sites.

5.2.1 Hazard Tree Treatments in Riparian Areas

The following best management practices are reproduced from British Columbia's Best Management Practices for Hazard Tree and Non-Hazard Tree Limbing, Topping or Removal[6] for riparian areas:

- Removal of trees and shrubs from riparian areas is not considered a best management practice for the proper functioning of streams, lakes and wetlands. However, in urban and rural settings where development has occurred in and around riparian areas, conflicts between preserving riparian vegetation and the safety of human life and property may occur. In such cases, first consideration should be given to finding long-term solutions that address human safety issues while maintaining healthy riparian habitats.
- To ensure your proposed works meet the requirements of applicable legislation:

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[4] http://wlapwww.gov.bc.ca/okr/documents/BMPTreeRemoval_WorkingDraft.pdf
[5] http://www.for.gov.bc.ca/hfp/training/00016/index.htm
[6] http://wlapwww.gov.bc.ca/okr/documents/BMPTreeRemoval_WorkingDraft.pdf

- Limit vegetation clearing for access to and within your work area to the area required to work safely.

- Consider other options when contemplating the need to remove vegetation. It is very often not the best choice for fish and wildlife habitat and species.

- Wildlife trees are important for many wildlife, bird, and amphibian species. You should avoid vegetation removal or management activities that will affect trees used by all birds and other wildlife while they are breeding, nesting, roosting or rearing young (*e.g.,* owls nest in winter/early spring, some species nest more than once a season so nests may be occupied in late summer. Also some owls and other bird species may use nest cavities in winter for thermal protection). Section 34(a) of the Wildlife Act protects all birds and their eggs, and Section 34(c) protects their nests while they are occupied by a bird or egg Nesting periods can be identified by a qualified professional or another source is the book Birds of the Okanagan Valley, British Columbia by Cannings et.al. 1987.

- Section 34(b) of the Wildlife Act protects the nests of eagles, peregrine falcons, gyrfalcons, ospreys, and herons year-round. This means that a tree or other structure containing such a nest must not be felled, even outside of the breeding season for these species.

- Section 6 of the BC Wildlife Amendment Act, 2004, pertaining to species at risk and/or the Species at Risk Act may also be applicable to vegetation management activities.

- If you are proposing to limb, top or remove trees, have the trees within the riparian area assessed by an appropriately qualified professional biologist to determine the presence and status of bird nests. If trees are suspected of being hazardous, then also have them assessed by a qualified professional arborist who is also a certified Wildlife Danger Tree Assessor, to determine the presence and nature of the hazard.

- These assessment results should be retained for your records.

- Where topping the tree or removing the dead limb can remove the danger, opt for doing this rather than removing the entire tree, leaving as much trunk height as is reasonable to maintain safety. Stubs favoured by cavity nesting birds may be created by cutting trees at 3 to 5 meters above the ground. For further information on human safety issues associated with stub wildlife trees, contact the Workers Compensation Board of BC.

- Where an entire hazard tree(s) must be removed from a riparian area bordering a water body that supports fish and/or wildlife habitat, then tree replacement criteria should be applied. For information on replacement tree criteria required by Provincial and Federal agencies see the following website: http://srmwww.gov.bc.ca/sry/csd/downloads/forms/vegetation_riparian/treereplcrit.pdf ; or, refer to the Tree and Shrub Replacement Criteria for Fisheries and Oceans Canada (Salmon Arm Subdistrict). Plant native trees, shrubs and herbaceous plants ecologically suited to the site conditions (*i.e.*, suited to the biogeoclimatic subzone and site series) to revegetate the site and replace impacted riparian vegetation. Often adjacent undisturbed riparian areas can be used as reference areas for suitable species.

- Retain large woody debris and the stubs of large diameter trees onsite where it is safe to do so. These are important for preserving fish habitat and wildlife populations. Tree trunks may be left on the ground as wildlife habitat within the riparian zone. Up to 15 pieces per hectare greater than 12 cm in diameter and 3-5 m long are acceptable.

- Where required, small branches and limbs may be removed offsite to reduce fire hazard.

- Trees should be limbed, topped or felled to avoid falling in a stream, lake or wetland area where accumulations of fine materials and branches may block flows. While larger materials are an important component of fish habitat, the position of the larger materials left in the stream is important. These materials can deflect flows and create new erosion patterns which can be a concern in urban areas. If larger materials are left in the channel to provide complexity to fish habitat then potential impacts to neighbouring properties should be assessed. If smaller material does inadvertently end up in a waterbody, then it should be removed to a location from which it will not re-enter the waterbody during high water. Removal of tree materials from stream, lake or wetland areas should be completed in a manner that does not disturb fish habitat or aquatic organisms

- Trees may be felled across or into a waterbody only where no other method of tree removal is possible because of safety reasons (e.g., to protect fallers, buildings etc.).

- Removal of felled trees should be completed in a manner that does not damage riparian vegetation or bank or bed areas of streams, lakes or wetlands. Alternatives to falling whole trees include falling trees in sections and/or crane-assisted removals.

- If your proposed works pose risks to fish habitat, then these works should take place during the instream works reduced risk timing window approved for your region. To find out what the timing window requirements are for your area, check the regional website at http://wlapwww.gov.bc.ca/okr/wateract/workwindows.html. Wherever possible, schedule vegetation removal and management activities within period of least risk for breeding birds and within the instream works timing window.

- To demonstrate compliance with these BMPs and to demonstrate due diligence in meeting the requirements of applicable legislation - you should compile a short report of completed works, including a photo record of the work site before and after vegetation removal and management activities. This information may be requested during follow-up monitoring by BC MoE or DFO staff.

- All equipment used for vegetation removal and management should comply with best practices to prevent the discharge of deleterious substances into waterbodies. Monitoring of riparian areas should be completed on a regular basis so that hazard trees can be identified and managed during reduced risk timing windows for breeding birds and least risk to fish habitat (instream least risk windows).

5.3 Operational Pest Management Practices

The Integrated Pest Management Manual for Landscape Pests in British Columbia[7] and the Compendium of Best Management Practices for Canada's Urban Forests should be consulted to provide guidance for practicing operational pest management. The following summary is derived from these sources. In this section, the term 'pest' refers to weeds, insects and diseases. Good practices for pest management involve:

- Training urban forestry staff in identification of pests.
- Defining responsibilities for integrated pest management to ensure a coordinated response.
- Dividing the landscape into site categories according to the level of maintenance they require. For example, the Integrated Pest Management Manual for Landscape Pests in British Columbia recommends dividing sites into three categories:
    - Group A — High level of service: high value, high visibility or high maintenance sites.
    - Group B — Moderate level of service: medium visibility or moderate maintenance sites.
    - Group C — Low level of service: low profile or low maintenance sites.
- Updating urban forest health strategy every five years.

[7] http://www.env.gov.bc.ca/epd/epdpa/eripm/landshtm/Content.htm

- Undertaking pest site assessments and mapping in areas of concern on an annual basis to record:
    - Soil conditions
    - Microclimate conditions
    - Site usage patterns
    - Pest species present
    - Plant species on site
    - Individual tree health
- Determining the appropriate level of action based on:
    - The acceptable level of damage.
    - The location of the infestation (in what site category).
    - The current level of infestation.
    - The most effective timing for treatments.
- Setting realistic objectives that are achievable.
- Collecting available background site information such as tree inventory data, planning documents, forest health surveys, treatment results on similar sites and staff knowledge.
- Collecting relevant information on the biology of the pest including:
    - Life cycles and biology.
    - Range of host plants that may be affected.
    - Conditions that favour the pests.
    - Conditions that prevent pest development.
    - Natural enemies of the pests.
- Reviewing all possible treatment techniques that promote healthy vegetation and control pests. Where possible, use ecologically benign treatments that focus on long-term preventative measures and reduce the need for insecticide/pesticide/fungicide treatments. Investigate:
    - Past treatment effectiveness.
    - How treatment works.

    - Use limitations.
    - Cost and availability of treatments.
    - Toxicity or use restrictions.
    - Regulatory requirements.
    - Minimizing risk to human health and the environment.
- Consider treatments including:
    - Biological control:
        - Encouraging natural predators.
    - Cultural control
        - Avoiding mechanical injury of trees.
        - Reducing stand density.
        - If irrigating, water around the outer canopy or drip line, not near the trunk (it can promote rot).
        - Prune infested limbs outside of beetle flight periods.
        - Dispose of debris appropriately so it cannot provide host material for forest pests.
        - Plant resistant species.
    - Chemical control
        - Insecticides/fungicides/herbicides
- Reviewing availability of resources required to successfully implement the treatment.
- Educating the public about integrated pest management activities.
- Developing park design guidelines that consider preventative measures for potential pest issues and maintenance issues. For example, build clearly defined paths that enable access for maintenance crews and discourage the creation of informal paths by hikers or bicycle riders.
- Monitoring the outcomes of the treatment and evaluate pest management programs annually to:
    - improve monitoring methods and record sheets;

  - refine the appropriate level of action;
  - identify equipment you need to modify or purchase; and,
  - determine and act on staff training needs.

5.4 Forest Health Monitoring

Tree inventory data provides some forest health monitoring by indicating the cause of damage to individual trees. However, this information only exists where hazard tree assessments are conducted. The Compendium of Best Management Practices for Canada's Urban Forests and Ministry of Environment Guidelines and Best Management Practices[8] provide some guidance for monitoring. The following summary is derived from these sources. Good practices for monitoring are:

- Develop monitoring programs for:
  - Monitoring pests.
  - Effectiveness monitoring for forest health treatments.
- Design monitoring programs with clear objectives and identify performance criteria and targets for both short- and long-term objectives.
- Design monitoring programs so that the results can be summarized at periodic intervals and applied to the refinement of management measures.
- Performance criteria at the landscape level should include: no net loss of sensitive ecosystems; no net loss of species richness; no increase in the spread of introduced species.
- Performance criteria may include:
  - a statistically significant decline in relative abundance of particular species over several years
  - disappearance of sensitive species from the complement of species
  - addition of introduced species
  - outbreaks of forest health agents
  - tree mortality rates
- Incorporate effectiveness monitoring into forest health mitigation treatments to ensure that the measures are functioning as expected.

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[8] http://www.env.gov.bc.ca/wld/BMP/bmpintro.html

- Use monitoring as a tool within adaptive management.
- Review and summarize results of monitoring programs at set, periodic intervals and refine and modify management or mitigation measures as appropriate

5.5 Tree Removal

The Environmental Best Management Practices for Urban and Rural Land Development in BC[9] and Strategies for Maintaining or Recruiting Habitat in Areas Affected by Mountain Pine Beetle and other Catastrophic Events[10]. The following summary is derived from these sources. Good practices for tree removal involve:

- Conduct a detailed site inventory prior to tree removal:
    - Identify Forest Health Factors on the site.
    - Gather available information from community or regional level mapping and inventories. Sources include local government environmental atlases, Sensitive Ecosystem Inventories, Conservation Data Centre, Fish Wizard, Sensitive Habitat Inventory and Mapping, Ministry of Water Land and Air Protection regional websites and other regional and local information sources.
    - Review available information to determine whether additional information needs to be gathered.
    - If the available information is inadequate, have a detailed bio-inventory of the site prepared by a Qualified Professional (RPF or RPBio). The report should include identification of all environmentally sensitive areas, important wildlife habitats, wildlife corridors, the presence of any species at risk, recommended buffers, links to adjacent greenspaces, slope hazards, site hydrology, soil morphology and other information.
    - Provide any findings of species at risk to the CDC and regional MoE species at risk staff.
    - If community level information is not available, use air photos or other means to identify ecological values.
- Develop prescriptions for tree removal that:
    - Prescribe a silvicultural system that:

[9] http://wlapwww.gov.bc.ca/wld/documents/bmp/urban_ebmp/urban_ebmp.html
[10] http://www.env.gov.bc.ca/wld/documents/fia_docs/mpb_habitat_maintenance_recruiting_strategy.pdf

        - Is appropriate for achieving objectives to mitigate the forest health impact or ecosystem degradation.
        - Is sensitive to the goals and objectives of land use management on the site.
        - Considers site access limitations.
        - Considers soils, season, existing and target stand structure, forest type and ecology.
    - Include an assessment of geotechnical hazard by a Professional Geoscientist (P.Geo) if slope hazard is identified during the site inventory.
    - Include measures to minimize the potential impact of forest health factors. For example, removal of stumps in Armillaria disease centres or appropriate debris management to reduce host material for Douglas-fir bark beetle.
    - If prescribing thinning, consider the use of prescribed fire following treatments.
    - Include measures to minimise the impact on sensitive ecosystems.
    - Include an assessment of windthrow hazard.
    - Consider the protection and retention of natural regeneration.
    - Include Coarse Woody Debris (CWD) and wildlife tree targets:
        - Where safe to do so, retain some standing live trees and dead trees (snags) up to 5 m in height.
        - Retain a range of tree diameters (starting at 20 cm dbh and greater) and decay classes (subject to worker safety requirements). Coniferous trees decay classes 2-6 and deciduous tree decay classes 2-4 are preferred for retention.
        - Retain CWD on site in a way that mimics its natural distribution of randomness and connectivity, with some clumping and layering.
        - Where present, maintain and/or recruit a mixture of both coniferous and deciduous CWD. Coniferous CWD decays slower than deciduous CWD, providing ecological benefits for a greater period of time; however, deciduous CWD provides important short-term ecological benefits.
- Ensure that equipment is cleaned before being transported between treatment sites. This will minimize the likelihood of spreading weeds and pathogens between sites.

5.6 Reforestation

The Tree Canada Guide to Tree Planting[11], Guidelines for Tree Species Selection and Stocking Standards for British Columbia (Silviculture Interpretations Working Group 1994) and the Compendium of Best Management Practices for Canada's Urban Forests should be consulted to provide guidance for reforestation. The following summary is derived from these sources. Good practices for reforestation involve:

- Select trees that are appropriate for the site in which they are being planted. Consider:
    - Site usage
    - Location
    - Tree function
    - Site ecology (moisture regime, soils, topography, microclimate)
    - Climate
    - Disturbance
    - Diversity
    - Forest health agents
    - Tree characteristics (e.g., size, form, fruits, rooting depths, wind firmness, drought tolerance, shade tolerance)
- Before planting, store trees in a shady location and take actions to minimize tree stress during transport.
- Plant in an uneven distribution that mimics the distribution if natural regeneration (e.g., Figure 8).

[11] http://www.treecanada.ca/publications/guide.htm

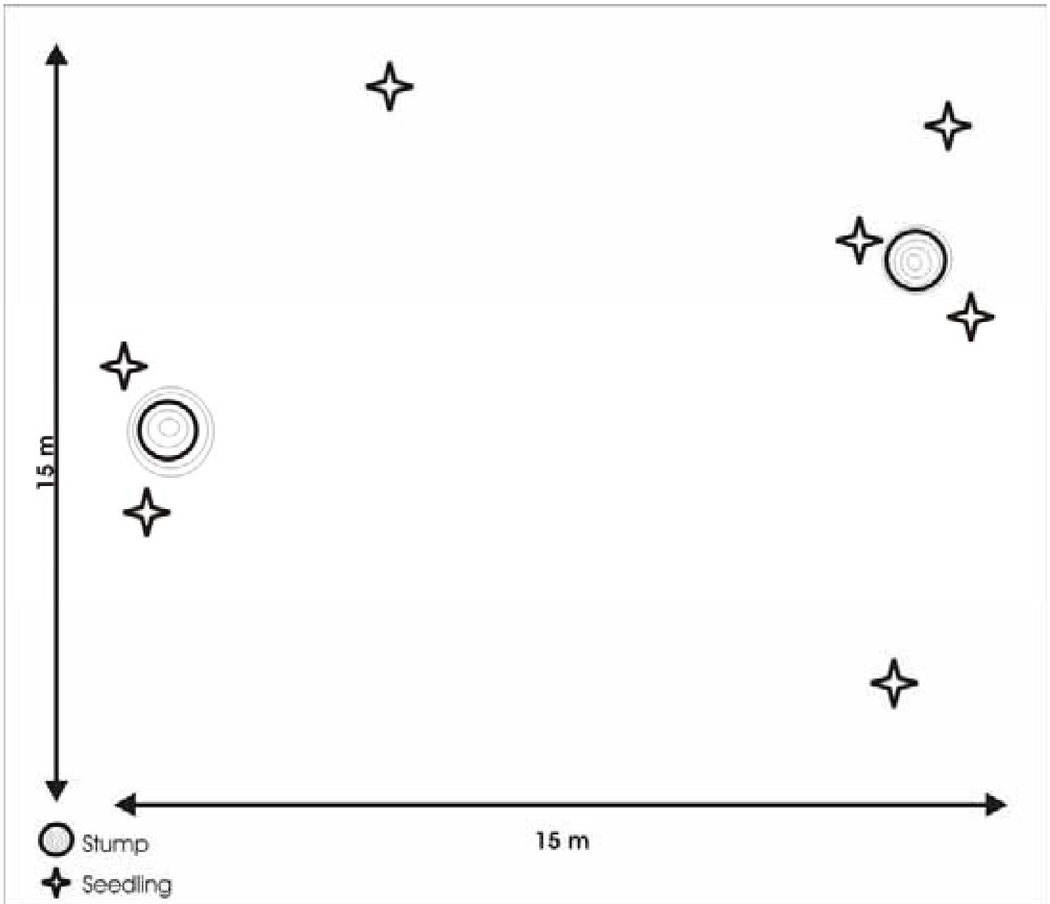

Figure 8. Diagrammatic example of irregular spacing and density.

- In Group B parks, use the Appendix 8, which is adapted from the Guidelines for Tree Species Selection and Stocking Standards for British Columbia, as guidelines to indicate the appropriate species and planting densities for the biogeoclimatic zone.
- In terms of site preparation, determine the level of preparation based on site visibility, usage and available resources. Ideally:
    - Remove weeds.
    - Completely excavate the planting cavity and backfill seedlings to top of plug.
    - When planting, firm the soil but do not pack it.
    - Water seedlings weekly where possible.
    - Fertilize seedlings.

5.7 Debris Disposal

There is no preeminent best management practices document for woody debris disposal from management of urban forests in BC. Good practices for debris disposal involve:

- Retaining adequate woody debris on site to meet CWD objectives but not so much that it will create a fire or insect hazard.
- Not deliberately placing tree removal or hazard tree debris in streams or riparian areas unless explicitly recommended by a qualified professional for riparian ecosystem restoration or enhancement.
- If treating during bark beetle flight periods, debarking beetle infested trees (green attack) prior to their transport from the site.
- The following options exist for woody debris disposal:
    - Burning in a Curtain Burner.
    - Chipping and leaving on site.
    - Chipping off site and utilizing the chips as hog fuel or in landscaping.
    - Pile and burning on site.
    - Composting.
    - Utilizing in cogeneration plants.
    - Utilizing as firewood.
    - Utilizing as mulch.

5.8 Ecosystem Restoration and Enhancement

British Columbia's Environmental Best Management Practices for Urban and Rural Land Development in British Columbia[12], Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia[13] and Integrating Ecosystem Restoration into Forest Management[14] should be used to guide ecosystem restoration treatments. The following summary is derived from these sources. Good practice for ecosystem restoration and enhancement are:

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[12] http://wlapwww.gov.bc.ca/wld/documents/bmp/urban_ebmp/urban_ebmp.html
[13] http://www.env.gov.bc.ca/wld/BMP/herptile/bmpherptile.html
[14] http://www.serbc.info/resources/file_repository/Ecosystem_Restoration.pdf

- Work with appropriate qualified professional to develop site restoration plans for the specific sites being restored. This will include determining the appropriate state to restore the ecosystem to.
- In areas managed primarily for habitat values, allow natural succession to proceed with minimal intervention or disturbance unless active management is needed to enhance or maintain habitat value or to control trees or brush that pose fire, forest health or safety hazards.
- Avoid and minimize the use and spread of alien vegetation, especially invasive plant species.
- Discourage the occurrence and spread of invasive species. Active control methods include hand clearing, pruning, mowing, digging and planting of appropriate native species to replace or shade out invasive species.
- Support the restoration of natural disturbance regimes in local forests so that fuel loadings and the risk of crown fires are reduced.
- Revegetate or reforest disturbed areas.
- Increase forest tree diversity by planting a mix of species.
- Work with local nurseries to propagate trees of desired species and progeny for reforestation.
- Develop seed collection programs for species with potentially scarce seed supplies.
- Manage for stand structure that includes CWD and wildlife trees.
- Employ treatments to reduce density of forest ingrowth or encroachment including, but not limited to, thinning and prescribed burning or clearing of trees from historic grassland areas.
- With an appropriately qualified professional, investigate options for prescribed burning.
- When acquiring new parklands, aim to connect or increase the area of existing parks and greenspaces.
- Rehabilitate tracks or roads that are not required for maintenance activities.
- Restrict access to sensitive areas.
- Educate the public about ecosystem restoration and/or enhancement.

5.9 Access Management

British Columbia's Environmental Best Management Practices for Urban and Rural Land Development in British Columbia[15], Best Management Practices for Amphibians and Reptiles in Urban and Rural Environments in British Columbia[16] and Best Management Practices for Recreational Activities on Grasslands in the Thompson and Okanagan Basins should be used to guide access management. The following summary is derived from these sources. Good practices for access management are:

- Divide the landscape into site categories according to the appropriate level of access for recreation use.
- Design trails to enable access for park maintenance crews and, where a fire hazard exists, fire fighting resources.
- Avoid or minimize trail construction in environmentally sensitive areas (*e.g.*, right next to or through riparian areas).
- Design trails to avoid fragmentation of the environmentally sensitive areas.
- Where trails are required, design the trail system to minimize impacts on environmentally sensitive areas, for example, by using boardwalks or placing natural barriers to restrict people to the main trail.
- Restrict access by use of coarse woody debris, plantings, signs and fencing.
- Educate the public about the importance of keeping to trails in order to prevent damage to the surrounding ecosystems.
- Recognize the potential for increased invasive species occurrences associated with access and plan for their effective management.
- When building or maintaining trails, roads and routes, build and maintain trails with a focus on minimizing soil disturbance/erosion:
  - Maintain a firm trail surface.
  - Ensure proper trail placement, design, and management.
  - Ensure that soils can withstand the impacts created by mountain biking and cycle touring.
  - Avoid steep downhill sections, especially where a trail is multi-use.

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[15] http://wlapwww.gov.bc.ca/wld/documents/bmp/urban_ebmp/urban_ebmp.html
[16] http://www.env.gov.bc.ca/wld/BMP/herptile/bmpherptile.html

- Where steep areas cannot be avoided, or are desired, use erosion prevention measures such as water bars, and curves.

6.0 Biotic and Abiotic Forest Health Factors in the Parks System

The following table and subsequent descriptions are based on those forest health factors that are currently of concern or note in the RDCO parks system. The descriptions include an overview of the forest health factor, susceptible tree species and management options for these pests. These are the best available management options for each forest health factor at this time and may be subject to change as new information or technology becomes available. For recommended management options, see the Action Plan section of this report. Ongoing monitoring and assessment on a park by park basis will be required to identify management options for forest health factors as they become a concern.

Table 9 summarizes the forest health factors and available management options that are discussed in more detail in the following sections. There are several general management options that apply across the parks system, regardless of the forest health factor/s active in a park. These are:

- Hazard Tree Removal
- Developing and maintaining a computerized spatial inventory of urban trees including records of any damage or tree removal
- Educating urban forestry staff on the identification of forest health factors
- Monitoring insect populations and disease centres
- Cooperation and coordination on forest health factor occurrences and management options with adjacent stakeholders including, but not limited to, the City of Kelowna, Westbank First Nations, BC Parks, the Ministry of Agriculture and the Ministry of Forests.

If no other options are feasible or effective, chemical insecticides/fungicides/herbicides may be options for the protection of high value individual trees where ecological risk is assessed to be acceptable and policy, bylaws and legislation enable their use. However, chemicals should be used conservatively. Only ever consider the use of chemical treatments that are allowed under legislation and in specifically prescribed circumstances.

Table 9. Selected forest health factors and the available management options for minimizing their impact.

Forest Health Factor	BC Tree Species Affected	Tree Mortality	Generations per Year	Specific Management Options
Drought 6.1	All	Common	N/A	- Replant with drought resistant tree species - Reduce stand density to reduce competition for water - Consider watering, mulching and/or fertilizing seedlings and young trees where possible
Fire 6.2	All	Common	N/A	- Reduce stand density to reduce drought induced mortality, susceptibility to insect and disease attack and fire behaviour potential - Reintroduce fire to the ecosystem - Replant with fire resistant species - Remove accumulations of dead surface fuels. Some coarse woody debris should be retained to provide ecosystem benefits
Invasive Alien Pests and Weeds 6.3	Variable	Variable	Variable	- Develop and maintain a computerized spatial inventory of weed distribution in RDCO parks - Develop an integrated weed management plan based on WeedsBC (2002) ‘Seven Steps to Managing your Weeds’ publication - Before planting non-indigenous species, consider their potential as hosts for invasive pests or their ability to become weeds - Consider the full spectrum of available treatment options - Prepare response plans in the event that a new alien species is identified
Armillaria 6.4.1	All conifers, all hardwoods	Common	Variable	- Reforesting with a mixture of ecologically appropriate and less susceptible species such as ponderosa pine, western larch, paper birch and black cottonwood - Minimize stress to and wounding of trees - Reducing the food source by uprooting infected or susceptible root systems and stumps or by using chemical fungicides on stumps or root systems - If uprooting stumps in an infection centre, stumps should be removed in a zone extending 10 m beyond the visible margin of the disease centre. - Consider using pop-up spacing if hazard tree removal or thinning is required in disease centres

Forest Health Factor	BC Tree Species Affected	Tree Mortality	Generations per Year	Specific Management Options
Mountain Pine Beetle 6.5.1	Pine, sometimes spruce	Common	1-2	- Reforest with a mix of species and maintaining a mosaic of species and ages across the landscape - While beetle population is not yet at epidemic proportions in the Okanagan valley, beetle proofing stands by reducing density with prescribed fire and/or thinning may be an option. However, there is the potential for all remaining pine in the thinned stand being killed once the beetle population increases - Use physical barriers to protect individual high value trees - Fall and burn on site
Douglas-fir Beetle 6.5.2	Douglas-fir sometimes western larch	Common	1-2 Sometimes 1 generation in two years if summer temperatures are cool	- Reforest with a mix of species and maintaining a mosaic of species and ages across the landscape - Beetle proofing stands by reducing density with prescribed fire and/or thinning. However, if pine is retained in the stand, mountain pine beetle may cause tree mortality post treatment - Use physical barriers to protect individual high value trees - Fall and burn on site - Dispose of Douglas-fir slash and debris using pile and burn or chipping and transport off site
Western Pine Beetle 6.5.3	Ponderosa pine	Common	1-2	- Reforest with a mix of species and maintaining a mosaic of species and ages across the landscape - Beetle proof stands by reducing density with prescribed fire and/or thinning - Use physical barriers to protect individual high value trees - Fall and burn on site
Red Turpentine Beetle 6.5.4	Most commonly pine but other conifer genera are susceptible	Not common	1-3 Sometimes 1 generation in two years if summer temperatures are cool	- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape - Beetle proofing stands by reducing density with prescribed fire and/or thinning

Forest Health Factor	BC Tree Species Affected	Tree Mortality	Generations per Year	Specific Management Options
Western Spruce Budworm 6.6.1	Primary host is Douglas-fir but will attack some true firs, spruce, and larch	Common if there are successive years of attack	1	- Reforest with a mix of species and maintaining a mosaic of species and ages across the landscape - Reintroduce prescribed fire and/or thinning to maintain open, single level stand structure and to prevent dense Douglas-fir regeneration
Douglas-fir Tussock Moth 6.6.2	Douglas-fir and true firs. Sometimes ponderosa pine and larch may be attacked	Common	1	- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape - Thinning using prescribed fire or mechanical thinning to reduce stand susceptibility
Elytroderma Needle Cast 6.7.1	Ponderosa pine and lodgepole pine	Uncommon	Variable	- Pruning of infected branches or whole tree removal of severely infected trees - Reforest with a mix of species and maintaining a mosaic of species and ages across the landscape - Thin using prescribed fire or mechanical thinning to reduce stand susceptibility
Douglas-fir Dwarf Mistletoe 6.8.1	Primarily Douglas-fir Sometimes grand fir and spruce	Uncommon	1 – assuming annual seed release although germination may not occur	- Pruning of infected branches or whole tree removal of severely infected trees if falling branches or trees are likely to be a hazard - Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape - Managing for even aged stands
Hardwood Pests and Diseases 6.9	Variable	Uncommon	Variable	- Not listed in this report. General management options previously listed in the text apply.

6.1 Drought

Past studies have identified drought mortality in a number of parks within the system (Pherotech 2001). Drought mortality was also observed by the authors of this report during the 2006 field visit to Woodhaven Nature Conservancy.

Put simply, plants require water for transpiration, nutrient uptake and transport, structural support and biochemical reactions. Transpiration is the most water intensive process in plants and involves the evaporation of water mainly through open stomata on plant leaves. Stomata must be open to enable the uptake of carbon dioxide from the air for photosynthesis. Without photosynthesis, plants are unable to convert light to chemical energy and synthesize carbohydrates for growth. Oxygen is also released during photosynthesis. Drought conditions (lower precipitation) limit the available soil moisture and higher temperatures increase the rate of transpiration by increasing the rate of water evaporation through stomata.

Plant responses to drought are complex and vary within and between species. In general, responses include damage to root systems, a weakening of plant defences as resources are diverted to survival and reduced growth rates. Plants under drought stress often show symptoms such as wilting, yellowing and dieback. Some species are better adapted to surviving in moisture limited environments than others. Adaptations that enable survival under moisture limited conditions include:

- the ability to respond to water stress by closing and opening stomata quickly with fluctuations in water availability so that photosynthesis is maximized and water loss is minimized
- Stomata open at night
- Sunken stomata
- Thickened cuticles to reduce water loss from leaf surfaces
- Hairs on the leaf surface to reduce water loss from leaf surfaces by reducing air movement
- Reduced leaf size or increased thickness reduces the leaf surface area from which water can be lost
- Deep root systems for access to deep water tables
- Large surface root systems to quickly absorb rainfall

Western redcedar is thought to be less drought resistant than ponderosa pine and Douglas-fir (Jackson and Spomer 1979) and this was supported by the authors' observations in the Woodhaven Nature Conservancy. Ponderosa pine in drought prone areas is able to open and close stomata relatively quickly with changes in water availability (Zhang *et al*. 1997). Plants are also less tolerant of drought when young and for this reason, when replanting, mulching or watering plants may be of benefit where it is practicable.

The forest health implications of drought in the southern interior are direct tree mortality as a result of drought stress or an increased rate of insect or pathogen induced mortality due to increased susceptibility to attack as a result of drought stress. To minimize tree mortality in drought conditions, management should focus on:

- replanting with drought resistant species
- reducing stand density to reduce competition for water
- considering watering, mulching and/or fertilizing seedlings and young trees where possible

6.2 Fire

As has already been discussed, southern interior ecosystems historically experienced frequent low severity fire or mixed severity fire regimes. Climate change may increase the length of the fire season and potentially increase fire frequency. Deteriorating forest health in the southern interior has resulted in forest stands that are ingrown and that tend to exhibit more extreme fire behaviour than was historically seen in the southern interior. In addition, increased input of dead woody material due to drought or pest induced tree mortality could increase the amount of woody fuel in the forest. Extreme fire behaviour, if beyond the resource capabilities of fire fighting agencies, can lead to out of control catastrophic wildfire that has adverse environmental, social and economic consequences.

Mountain pine beetle is anticipated to contribute substantial dead woody fuel to forests of the southern interior. Immediately following mountain beetle pine attack there is an increase in dead fine fuels in the canopy. This poses an immediate fuel hazard but is only likely to persist for a couple of years. In addition, the increase in shrubs and herbs in the understory may actually decrease surface fire behaviour. Up to 15 years after pine beetle attack, the rate of large deadfall increases, altering the fuel complex, and therefore, the fire behaviour. This change is associated with an increased fire hazard, which is of the utmost concern in BC. Natural fire regimes in pine forests vary depending on climate and site. In general, the regime would either be stand replacing or mixed severity (Arno *et al*. 2000). Mixed severity regimes are characterized by infrequent stand replacing fires and more frequent non-lethal fires (Arno *et al*. 2000). Under historic fire regimes, fuel accumulation would be limited between fires because of low wood productivity (Gara *et al*. 1985). The limited surface fuels would generally result in non-lethal fires that creep along the ground. However, long periods of fire suppression coupled with MPB caused deadfall is likely to result in a higher rate of fuel accumulation and possibly more frequent, stand replacing fire. Other forest health agents are likely to further contribute to the rate of fuel accumulation in southern interior forests.

In the past, agents of disturbance were viewed as a threat to the health of the valuable forest resource. Standard policy has been to suppress all wildfire and eliminate forest pests. In pine forests, this has resulted in unstable forests that are increasingly susceptible to physical and biological stresses. Managing forests by mimicking natural disturbances has become widely accepted. Prescribed fire is a management tool that mimics the ecological process that has historically shaped these forests. Fire can kill forest pests or alter their habitat depending on the fire behaviour and on the fuel characteristics.

To improve forest health, minimize the potential for catastrophic wildfire and the potential for tree mortality as a result of fire, management should focus on:

- reducing stand density to reduce drought induced mortality, susceptibility to insect and disease attack and fire behaviour potential
- reintroducing fire to the ecosystem
- replanting with fire resistant species
- Removing accumulations of dead surface fuels. Some coarse woody debris should be retained to provide ecosystem benefits.

6.3 Invasive Alien Pests and Weeds

Invasive alien pest and plant species cause problems in parks because they can adversely affect or replace native species and cause a reduction in ecosystem integrity through the interruption of natural ecosystem processes. An alien species is defined as

> *…one that enters an ecosystem beyond its historic range, including any organisms transferred from one country or province to another* (Environment Canada 1994).

Particular attention must be given to alien species that are widespread, well established and able to become dominant in an environment.

Invasive alien pests can be introduced in wood packaging or through the transport of live plants (Humble and Allen 2004). Urban forests are susceptible to introductions because of their proximity to importing warehouses and urban centres. Humble and Allen (2004) also noted that non-indigenous species planted in urban forests could contribute to the initial establishment of invasive alien pests.

Invasive alien weeds are prevalent throughout British Columbia and have major environmental and economic impacts (WeedsBC 2002). The BC Weed Control Act (RSBC 1996) states that:

> *Every occupier shall control, in accordance with the regulations, noxious weeds growing or located on land and premises, occupied by him*

Currently, there are 48 species listed as noxious under the Act[17]. Regional District of Central Okanagan Bylaw No. 179, 1979[18] applies within RDCO except on continual slopes steeper than 45 degrees. Schedule A of Bylaw No. 179 lists the noxious weeds covered under this bylaw. The aforementioned bylaw requires that owners and occupiers limit the growth of noxious weeds to a height of 20.32 centimetres.

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[17] http://www.qp.gov.bc.ca/statreg/stat/W/96487_01.htm and http://www.qp.gov.bc.ca/statreg/reg/w66_85.htm.
[18]http://www.regionaldistrict.com/docs/bylaws/Consolidated%20Bylaws/Consolidated%20Noxious%20Weeds%20Bylaw%20179.pdf

To minimize the impact of existing and potential invasive alien pests and weeds management should focus on:

- developing and maintaining a computerized spatial inventory of weed distribution in RDCO Parks
- developing an integrated weed management plan for RDCO parks based on the WeedsBC (2002) 'Seven Steps to Managing Your Weeds' publication
- before planting non-indigenous species, considering their potential as hosts for invasive pests or their ability to become weeds
- considering the use of the following treatment options:
    - Prevention
    - Physical strategies
    - Cultural strategies
    - Biological control where the risk of ecological impact is assessed to be acceptable
    - Grazing where the risk of ecological impact is assessed to be acceptable
    - Chemical herbicide or pesticide treatments where ecological risk is assessed to be acceptable and policy, bylaws and legislation enable their use
- preparation of response plans in the event that a new invasive alien species is identified

6.4 Root Diseases

6.4.1 Armillaria

The fungi genus *Armillaria* causes root rot disease in numerous coniferous and deciduous tree species. Armillaria species are members of the phylum basidiomycota. The life cycle of the genus is quite variable and reproduction can be either sexual or vegetative. There are several morphological forms that the genus can take, which enable Armillaria to survive in a variety of habitats and to infect and colonise diverse hosts and substrates (Shaw and Kile 1991). The fruiting bodies of fungi in phylum basidiomycota are basidiocarps, which have the recognisable 'mushroom' shape.

Hosts have a number of defensive responses to infection by Armillaria. These include growing a second layer of cork cells below the point of infection, exuding resin, gum or kino or biochemical compounds that can metabolise the fungi (Shaw and Kile 1991). Callus tissues may be formed in an attempt to isolate the infection and, in some cases, adventitious roots will grow to compensate for roots killed by Armillaria (Shaw and Kile 1991). These responses vary between hosts. Hosts tend to be more susceptible to infection when they are younger or when they are stressed. However, in the interior trees of all ages are attacked.

The impact of Armillaria root rots on hosts also varies. In forests, trees may experience reduced height and diameter growth, dieback, discoloration of foliage, decay of the bole or death because of Armillaria infection (Shaw and Kile 1991). Reduced growth is generally a response to the death of the root system as the infection progresses. Death of the tree most likely results from girdling the stem or the root collar, although there are a number of theories on the cause of symptoms (Shaw and Kile 1991). To confirm the presence of Armillaria root rot it is necessary to examine the root collar and lower bole of the tree for mycelial fans, rhizomorphs, basidiocarps and decay (Shaw and Kile 1991). This is particularly important in areas where drought and bark beetles are active because symptoms can look similar. Armillaria also predisposes hosts to MPB attack (Shaw and Kile 1991). This is likely because the tree is weakened by the fungal infection and, potentially, because of larger kairomone plumes released by stressed trees.

Armillaria ostoyae (Romag.) is thought to be the most common cause of root rot disease in western interior conifer forests (Shaw and Kile 1991; Mallet 1990). Douglas-fir and true fir (*i.e.,* all species within the genus Abies) are generally the most susceptible host species. Mortality resulting from root rot disease in these species tends to occur soon after regeneration and throughout the life of the stand (Shaw and Kile 1991).

Stress can add to the susceptibility of hosts by reducing tree vigour and therefore host defences. Thinning and partial cutting have been found to intensify Armillaria root disease (Morrison 2000; Cruickshank *et al*. 1997). This is because trees often become stressed immediately after the treatment and, although vigour will generally start to increase over time post-treatment, trees may become infected before vigour increases. In addition, the remaining stumps provide food for Armillaria, which can increase the potential for infection (Shaw and Kile 1991). However, if tree vigour improves post treatment, the trees are likely to be more resistant to subsequent infections. Harvesting may also increase the amount of inoculum by facilitating increased fungal growth on stumps or by transporting fungal fragments or infected material to uninfected areas. Armillaria can survive in stumps and dead roots as either rhizomorphs or mycelia for at least 50 years (Filip and Yang-Erve 1997). Transportation of logs from Armillaria infected areas is not restricted in BC or Alberta.

Prescribed fire or natural fire can influence the susceptibility of stands to Armillaria (Shaw and Kile 1991). Fire's effect on Armillaria will depend on fire intensity and frequency. It can destroy inoculum or place stress on the fungal mycelium resulting in slowed or diminished growth (Shaw and Kile 1991). If considering prescribed fire, the outcome must be such that the post-fire forest structure, species composition and tree vigour is not likely to generate a more susceptible stand. Also, if fire is used post harvesting to burn stumps, it must be of high enough intensity that it fully combusts the stump and lateral roots. However, this will still not destroy all innoculum below ground (Filip and Yang-Erve 1997; Shaw and Kile 1991). In BC, partial cutting or selection harvesting, as would be practiced for tree removal in the RDCO parks system, has been found to increase the incidence of Armillaria infection in areas where the root disease was already present (Morrison and Mallet 1996).

While all conifer species are susceptible, some are less susceptible than others. Susceptibility decreases with age in some species (Morrison and Mallet 1996). There is evidence to suggest that ponderosa pine and western larch become less susceptible with age (Morrison and Mallet 1996; Robinson and Morrison 2001). Paper birch and black cottonwood are resistant up to age 30 (Morrison and Mallet 1996).

To minimize the impact of Armillaria root disease where it has been identified, management should focus on:

- reforesting with a mixture of ecologically appropriate species such as ponderosa pine, western larch, paper birch and black cottonwood that are less susceptible to *Armillaria*
- minimizing stress to and wounding of trees
- reducing the food source by uprooting infected or susceptible root systems and stumps or by using chemical fumigants on stumps or root systems
- If the infection levels indicate a disease center, there is evidence that other insects and diseases are not the primary cause of tree mortality, and it is a priority for treatment stumps should be removed in a zone extending 10 m beyond the visible margin of the disease centre because root systems in this area are likely infected. Stumps removal should only be considered where there is no slope stability concern.
- considering pop-up spacing if hazard trees are being removed or thinning is required in disease centres – this process involves pulling diseased and surrounding trees that could carry the disease from the ground, roots and all.

6.5 Woody Tissues Feeders

6.5.1 Mountain Pine Beetle

The MPB, *Dendroctonus ponderosae* (Hopk.), is an endemic North American bark beetle. It is distributed throughout the province of BC up to 56 degrees latitude (Unger 1993). The eastern boundary of the MPB distribution, until recently, occurred along the southern Rockies near the Alberta-BC border (Ono 2003). However, the beetle has now crossed the Rocky Mountains in the Dawson Creek Area. The beetle's primary host in BC has been lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.), however, it attacks a variety of mostly pine species including ponderosa pine (*Pinus ponderosa* Laws), jack pine (*Pinus banksiana* Lamb.), western white pine (*Pinus monticola* Dougl. Ex D. Don) and limber pine (*Pinus flexilis* James). Spruce species can also be successfully attacked and this has been observed in Prince George by the authors in spruce hybrid Engelmann x white (*Picea engelmanii* Parry ex Engelm. *x glauca* [Moench] Voss). However, it is not thought that spruce will become a preferred host species of MPB but rather that, where beetle population pressure is high, individual spruce trees in pine dominated stands may be attacked by the beetle due to competition for suitable host trees (McLauchlan, L. pers. comm., October 5th, 2006). It is projected that the Mountain Pine Beetle will continue to kill more than 100 million cubic metres of pine each year until 2008 and then decline rapidly; killing only

5 million cubic metres per year within eight years (Eng *et al*. 2006). However, there is substantial uncertainty regarding the rate of decline. Given that much of the remaining live pine is located in the southern interior, high mortality rates can be expected in this region. Current estimates for the timber supply area place the peak year of kill in the Okanagan at 8.2 million cubic metres in 2008 (Eng *et al*. 2006). Seventy-seven percent of pine in the Okanagan "pine units"[19] are expected to be killed by 2017 (Eng *et al*. 2006). While these projections are for the Okanagan's Timber Harvesting Land Base (THLB), they provide a good indication of the likely impact of the mountain pine beetle within the Okanagan in general; if there is high pine mortality within the THLB, there is likely to be high mortality in the lands that surround it.

Not all host trees are equally susceptible to beetle attack. Large trees that are under stress tend to be more susceptible when beetle populations are at normal levels (Cole and Amman 1969; Safranyik 1989). When the beetle population builds to epidemic proportions, such as those currently being observed in BC, the beetles attack non-stressed and smaller diameter trees (Amman and Cole 1983). Several factors are needed for the beetle population to reach epidemic proportions (Whitehead *et al*. 2001), all of which have occurred in BC since the late 1990s and early 2000s. These are:

1. successive mild winters and warm, dry summers;
2. failure of direct control methods during incipient stages of the outbreak; and
3. large areas of susceptible pine.

While the MPB has been of great concern in lodgepole pine forests throughout much of BC for some time, it is in the early stages of its impact on the ponderosa pine forests of the Okanagan. According to the Ministry of Forests 2005 Forest Health Overview for the Okanagan Shuswap Forest District (MoFR 2005), the MPB has recently caused scattered mortality in 295.5 ha and 8 spot infestations of ponderosa pine in a number of areas, including Chase Creek – Harper Ranch, Glenemma and Naramata. The volume of pine killed by MPB is anticipated to peak in the Okanagan Valley by 2008 (Eng *et al*. 2006).

Susceptible pine is generally defined as 80 plus years old with a diameter at breast height (dbh) of 20 cm (Amman *et al*. 1977). These trees are susceptible to attack at endemic beetle population levels. If there is enough susceptible pine, then the beetle population can reach epidemic proportions and attack trees outside of this age and dbh range. At its current population levels, MPB has been observed attacking pine of small to large dbh and as young 10 years old. The large areas of susceptible pine in BC are thought to be a legacy of effective fire suppression and harvesting practices over the last 80 years (Whitehead *et al*. 2001). Allowing fire to burn naturally would have maintained a mosaic of age classes across the province that would be less susceptible to a landscape scale MPB outbreak. Even though harvesting disturbance has

[19] Pine units are those Timber Supply Areas where more than 10% of the merchantable volume is pine (Eng *et al*. 2006).

occurred on the landscape in that time, there has been a net decrease in the rate of disturbance overall. It is now generally understood that more heterogeneous landscapes with mosaics of age-class, stand density and species distributions and compositions are less likely to facilitate large scale MPB outbreaks.

Climate conditions also influence the size of the beetle population. Cooler climates delay brood development and increase brood mortality (Amman *et al*. 1977). Successive mild winters and warm, dry summers provide optimal conditions for the beetle's life cycle enabling high levels of reproductive success. Beetles are relatively cold hardy but this tolerance is acquired and changes over time. The cold hardiest stages are able to withstand temperatures close to - 40°C (Unger 1993; Carrol and Safranyik 2003). High beetle mortality can occur if low temperatures occur for several days, either in early summer before larvae are sufficiently cold hardy, or in late winter, when they are again less cold hardy (Carrol and Safranyik 2003). To date, the beetle's range has been limited by climate suitability, which is largely influenced by elevation and latitude (Amman *et al*. 1977). Climate change may allow the beetle to extend its range eastward and northward if winters become increasingly mild.

Apart from climate, a number of other naturally occurring factors play a role in controlling MPB populations. Several bird species, particularly woodpeckers, and several insects are natural predators of the MPB. In addition, nematodes and internal parasitic worms can inhibit the beetle's egg production. However, the effect of these predators is not sufficient to substantially impact the beetle population at its current size. Due to the scale of the current MPB outbreak, most potential host trees are susceptible to attack. This is because the density of the beetle population enables mass attack of vigorous, large diameter trees that would probably not be susceptible to infestation under lower beetle population densities. This further benefits the beetle because they are likely to gain access to a thicker, more nutritive phloem and therefore have increased reproductive success (Elkin 2001). However, as the number of large trees available for attack declines, the beetles will attack smaller diameter trees with thinner phloem. This is likely to reduce the survival rate and reproductive success of the MPB through limiting food resources, increasing competition and providing less favourable moisture conditions, and eventually resulting in a population decline.

The method by which the beetle selects and colonises its host is not precisely known. Host selection and colonization is thought to be reliant on a combination of host-produced chemicals (kairomones), beetle-produced pheromones (Bentz *et al*. 1996), visual cues and random landings. Visual cues relate to the preferential selection of large trees by the beetle. It is hypothesized that kairomones, which tend to be released in larger quantities by stressed or damaged trees (Hynum and Berryman 1980) contribute to the initial selection of the host tree by the MPB. Usually the female MPB initiates an attack on a host (Unger 1993; Bentz *et al*. 1996). The female bores into the phloem and cambium region of the host tree and releases a pheromone that attracts mostly males (Bentz *et al*. 1996). The males, in turn, release a pheromone that attracts mostly females (Unger 1993; Bentz *et al*. 1996). This leads to the mass-attack of a host tree, which enables the beetles to overcome the host's defences and successfully colonise the tree. However, understanding of species/host chemical interactions is not yet complete as studies indicate that these chemicals may cause different behavioural responses in bark beetles depending on their concentrations and combinations (Bentz *et al*. 1996; Zhang and Schlyter 2003).

The life cycle of the MPB is completed under the bark until the adults emerge, fly to living trees, attack and continue the cycle of colonization and reproduction. The female, once inside the cambial region of the tree, constructs an egg gallery (Unger 1993). Egg galleries are usually constructed vertically up the bole of the tree for approximately 30 cm and leave marks in both the bark and the sapwood (Unger 1993). The female lays her eggs in these galleries and packs them with frass. After 10-14 days the eggs hatch and the larvae feed on the phloem, fungal spores and micro-organisms (Carrol and Safranyik 2003). Under average weather conditions, the brood matures in early summer of the following year. However, cooler than average summers may result in a brood taking two years to mature (Unger 1993). Conversely, warmer than average summers can result in one adult establishing two broods in one year (Unger 1993). The larvae grow into pupae, then new adults and finally emerge as mature adults from the host by boring through the bark (Unger 1993).

A number of fungi and bacteria associated with the beetle are carried to the host tree when the beetle attacks. One of the most important associations is between the beetle and several species of blue-stain fungi. The beetles carry the fungi into the phloem and essentially inoculate large portions of the tree bole. The fungi begin to grow in the phloem soon after the beetles start construction of their galleries and then invade the xylem (Unger 1993). Occlusion of the xylem prevents the transport of water to the crown and reduces the flow of defensive allochemicals around the tree. In this way, the fungi contribute to the death of the tree by inhibiting water flow and reducing the tree's ability to defend itself against beetle attack. The reduced water flow also appears to aid the survival of developing beetles by maintaining higher than usual moisture conditions in the attacked tree during the following summer (Amman *et al*. 1977). Blue-stain fungus is also associated with the western pine beetle (*Dendroctonus brevicomis* (LeConte)).

The effect of MPB is devastating. Approximately 50,000 ha of forest in the province are affected each year (Forest Practices Board 2004). This will have consequences for social, economic and ecological values within the province. In RDCO parks, negative consequences are likely to include the loss of mature pine trees, the increased costs of tree removals and reforestation, the short term loss of recreational values in areas with heavy pine mortality, the short-term loss of watershed values and a short-term decline in visual quality. Death of pine in the forest has complex ecological consequences and will require ongoing study. Information is lacking in terms of impacts on wildlife habitat and percentage of tree survival in colonised stands (Stadt 2001). MPB plays an important role at the tree, stand and landscape level by providing:

1. substrates for saprophytic organisms responsible for decay;
2. foraging habitat for birds (*e.g.*, woodpecker);

3. forest structure in the form of standing snags and coarse woody debris;
4. litter fall and detrital material that influences nutrient cycling;
5. fuel accumulations that influence fire behaviour and fire severity; and
6. successional change that impacts on both small and large scale forest regeneration patterns.

The intimate relationship and critical role that bark beetles and fire play in natural succession of pine forests has been well documented. The pine forests that typically occupy millions of hectares in the Pacific Northwest tend to be even aged stands younger than 100 years old. This is a result of periodic wildfires, which follow high mortality from bark beetle attacks (Fellin 1979; Mitchell and Martin 1980; Koch 1996; Price 1991; Schowalter *et al*. 1981). These forests have adapted to natural rotations that tend to repeat every 100 years. It has been hypothesized that these two agents of disturbance interact to maintain the structure and function of pine forests. Fire regulates forest regeneration in space and time, which is necessary for the pine beetle, and the pine beetle regulates the turnover of patches of dead trees conducive to burning (Schowalter *et al*. 1981). Figure 9 shows an historic image of insect infestation (likely bark beetle) and in the Kelowna region.

Figure 9. 1923 photo of insect mortality on a mixed stand in Kelowna (Courtesy of BC Archives Collections – Call number: NA-05523).

In the past, agents of disturbance were viewed as a threat to the health of the valuable forest resource. Standard policy has been to suppress all wildfire and eliminate forest pests. In pine forests, this has resulted in unstable forests that are increasingly susceptible to physical and biological stresses. Managing forests by mimicking natural disturbances has become widely accepted.

To minimize the impact of mountain pine beetle, management should focus on:

- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape.
- While beetle population is not yet at epidemic proportions in the Okanagan valley, beetle proofing stands by reducing density with prescribed fire and/or thinning may be an option. However, there is the potential for all remaining pine in the thinned stand being killed once the beetle population increases.
- Falling and burning on site.

6.5.2 Douglas-fir Beetle

The Douglas Fir Beetle (*Dendrochtonus Pseudotsugae* Hopk.) is a member of the family Scolytidae in the order Coleoptera. The Douglas Fir Beetle (DFB) attacks Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) and occasionally western larch (*Larix occidentalis* Nutt.). It infests living trees, as well as downed slash and windthrow. At endemic levels, the DFB generally attacks and kills mature and over-mature trees that are predisposed due to factors such as drought stress, mechanical damage, overstocking or stress caused by other pathogens or insects. Tree mortality is not usually high unless the population reaches "outbreak" levels enabling mass attack of vigorous trees that would not be susceptible at endemic DFB population levels. The DFB population is currently at endemic levels in BC.

The complete life cycle of the Douglas Fir Beetle takes one year; however, if climatic conditions are favourable, a single female may produce two broods in one year (McMullen 1984). The DFB overwinter as mature larvae or adults. Overwintering adults emerge in the spring when daytime temperatures exceed 18ºC, while overwintering larvae become adults and emerge in May and June. For this reason, the period of DFB emergence is longer than that of MPB. Major flight times occur between April and July.

The DFB finds susceptible host tissue, secretes an aggregating pheromone, and elicits an attack. Reproduction occurs and the female bores through the outer bark. A gallery is excavated in the inner bark and ovipostion occurs. In the gallery, eggs hatch within two to three weeks. Larvae bore away from the egg gallery and feed until winter intervenes.

Similar to MPB, DFB populations can be affected by seasonal weather patterns. Late spring and early fall frosts adversely affect larval populations (Samman and Logan 2000). Conversely, prolonged warm dry weather over successive years can be beneficial to DFB populations as it allows for the production of a two broods per year. Success of the adult flight decreases with an increased amount of precipitation (Samman and Logan 2000), while wind has beneficial effects on DFB populations; it aids in dispersal of the adults and produces windthrow, a common source of food for the DFB.

In the Okanagan Shuswap Forest District, DFB mortality declined significantly overall in 2005, whereas activity increased in the form of small, scattered spot infestations in most areas in the southern part of the District. This was observed particularly in the Mission Creek, Shuttleworth Creek, Mt. Kobau, Keremeos Creek and Darke Creek areas (MoF 2005). Douglas-fir bark beetle activity was observed by the authors on drought affected Douglas-fir trees in Woodhaven Nature Conservancy.

The treatments available for MPB are also applied to DFB. However, because DFB can also successfully colonize windthrow and slash >12 cm diameter, it can be important to treat Douglas-fir tree removal debris rather than leave it on site. The options commonly available for treatment of this debris include pile and burn, and chipping.

To minimize the impact of mountain pine beetle, management should focus on:

- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape
- Beetle proofing stands by reducing density with prescribed fire and/or thinning. However, if pine is retained in the stand, mountain pine beetle may cause tree mortality post treatment.
- Falling and burning on site
- Dispose of Douglas-fir slash and debris using pile and burn or chipping and transport off site

6.5.3 Western Pine Beetle

The western pine beetle (*Dendroctonus brevicomis* LeConte) is a native species endemic throughout the range of ponderosa pine west of the Rocky Mountains. It attacks mature to old ponderosa pine but can aggressively attack and kill trees of all ages, including healthy young trees that are at least 15 cm in diameter (DeMars and Roettgering 1982). Group tree killing is common in dense, young growth ponderosa pine stands (DeMars and Roettgering 1982). More commonly, the beetle breeds in scattered, slow-growing, overmature, decadent or diseased trees and trees weekend by factors such as fire, drought, mechanical injury and stand stagnation. Mortality of these types of trees may be considered part of normal forest succession.

The life cycle of the WPB from egg, through the larval, pupal and adult stages varies in length from two months in warm weather to 10 months in cool weather (DeMars and Roettgering 1982). One to two generations may be produced per year depending upon elevation. The timing of beetle flight and attack is also influenced by elevation and in BC may occur any time from May to September (Henigman *et al.*. 2001). As occurs in other bark beetle species, the female beetle secretes an aggregating pheromone upon successfully attacking a tree, attracting other beetles and instigating a mass attack that tends to overcome a tree's natural defences. The eggs that are laid in individual niches in the sides of the egg gallery incubate from 1 to 2 weeks before hatching (DeMars and Roettgering 1982). The larvae feed in the phloem first and then proceed to mine into the middle bark where they develop through four larval stages before pupating. The egg and larval galleries are distinctive in that they are long, winding, crisscrossed and packed with frass. Finally the pupae transform into adults that emerge to attack and renew the cycle in living trees.

Adults of the WPB carry spores of a wilt causing blue-staining fungus *Ceratocystis minor* (Hedg.). The fungus grows quickly in trees attacked in early to mid summer, invading the inner bark and sapwood within a few weeks (DeMars and Roettgering 1982). This is evidenced by fading foliage, eventually turning colour to yellow and then red. In trees attacked in late summer to fall, the fungus develops more slowly and foliage fade may not be evident until the following spring (DeMars and Roettgering 1982). Tree mortality results when the flow of food and water between the roots and foliage is blocked by the girdling effect of the feeding larvae and by the dead sapwood cells killed by the blue-stain fungus.

Similar to MPB and DFB, WPB populations are affected by temperature and weather and a variety of natural enemies. Winter temperatures below -27 degrees Celsius for several days can cause heavy brood mortality in the part of the tree boles above the snowline (DeMars and Roettgering 1982). Adult dispersal is favoured by fair weather conditions. Natural enemies of the WPB such as woodpeckers and numerous species of predaceous and parasitic insects can help stabilize conditions at endemic population levels (DeMars and Roettgering 1982) but are of little consequence during outbreaks.

To minimize the impact of western pine beetle, management should focus on:

- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape
- Beetle proofing stands by reducing density with prescribed fire and/or thinning. However, if pine is retained in the stand, mountain pine beetle may cause tree mortality post treatment
- Falling and burning on site

6.5.4 Red Turpentine Beetle

The red turpentine beetle (*Dendroctonus valens*) is a pest that primarily effects pines but will attack numerous other conifers as well. It may also infest recently cut logs or stumps. Generally, it is not an aggressive beetle in terms of causing tree mortality. Repeated attacks are required before tree mortality occurs. Trees weakened by red turpentine beetle attack are, however, more susceptible to attack by other species of beetle such as MPB. While RTB is relatively widely distributed, attacks have not become epidemic and it most frequently occurs in individual trees or in localized groups of trees.

The rate of RTB development and the number of generations that may be produced per year varies with climate and temperature (Smith 1971). In northern, high elevation areas, the beetle may take up to two years to develop completely, while in southern areas at low elevations, two to three generations may be produced in one year (Smith 1971). Adult beetles fly and attack in spring to mid-summer and are distinguished as being the largest of the *Dendroctonus* species (averaging 8 mm in length). The adults burrow into the basal area of boles as well as exposed roots of trees as indicated by distinctive large reddish-brown pitch tubes. Eggs are laid in groups and the larvae remain together and feed in a mass, resulting in distinctive, large fan-shaped galleries. Fully developed adults or larvae overwinter in the tree; pupae and eggs rarely overwinter.

Red turpentine beetles prefer to attack large, old trees weakened by injury resulting from disturbances such as fire, logging or land clearing, or by drought, or by the activity of other insects or disease. Recently cut logs or stumps are also targeted. Management practices to minimize beetle damage could include careful logging, construction and land clearing to reduce injury and damage to residual trees, and the selective removal of trees infected by other pests to remove potential breeding sites.

To minimize the impact of red turpentine beetle, management should focus on:

- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape
- Beetle proofing stands by reducing density with prescribed fire and/or thinning. However, if pine is retained in the stand, mountain pine beetle may cause tree mortality post treatment

6.6 Defoliators

6.6.1 Western Spruce Budworm

Western spruce budworm (*Choristoneura occidentalis*) is considered to be the most destructive native defoliator of coniferous forests in BC (MoF 1995). Budworm outbreaks are influenced primarily by climate and weather, and consequently fluctuate in an irregular and unpredictable manner. In chronically infested stands, outbreaks may be sustained for 25 years or longer (MoF 1995). The primary hosts in southern BC are Douglas-fir. The true firs can also be impacted. In the southern interior forest region it may also attack western larch and to a lesser degree Engelmann spruce and hybrid spruce (Stock *et al.* 2005).

The western spruce budworm takes one year life to complete its cycle. The adult moths emerge and mate from late July to early August (Stock *et al.* 2005). The female moths then preferentially seek out the tallest trees, lay egg masses on the undersides of needles and die within two weeks of emergence. Within approximately 10 days, the eggs hatch into larvae (Stock *et al*. 2005) that seek shelter under bark scales or among lichen. Here they spin silken webs (hibernacula) to overwinter in. The larvae emerge in late April or May (Stock *et al*. 2005) and mine into the growing vegetative and reproductive buds. As the shoots elongate the larvae spin webbed feeding shelters around the growing tips and feed on the new foliage. The larvae develop through six instars (stages), maturing in early July, after which they pupate within the webbed foliage for approximately 10 days (Stock *et al*. 2005). In the late instar stages the larvae are voracious, wasteful feeders. Larvae dropping from the upper canopy are intercepted by the intermediate and understory trees which often severely impacted.

The susceptibility of stands to budworm damage is influenced by a number of factors including species composition, stand structure, (past harvest regime), density and degree of competition stress, as well as site conditions. The budworm favours multi-storied, older stands with a high component of Douglas-fir (greater than 80%) or Douglas-fir and true fir mixtures with dense understory trees in the drier interior Douglas-fir biogeoclimatic zones (Unger 1995; Stock *et al*. 2005). The budworm also favours stands on warm, dry sites at elevations of 350 m to 1460 m (Stock *et al*. 2005).

WSB populations are naturally controlled by climate, available hosts, food supply and predators. Early larval instars are vulnerable to wind, which can dislodge and disperse them, and to late spring frosts, which can freeze them or damage their food supply (Unger 1995). Overwintering larvae are not significantly impacted by low winter temperatures. However, very low survival rates of second instar larvae could be caused by differences in timing between larval emergence from hibernation and budburst (Unger 1995). Where outbreaks persist year after year, starvation due to foliage depletion may occur. Other natural mortality factors include parasites, animal and insect predators and viral and fungal diseases.

All age classes of host species may be attacked but immature or suppressed trees are most susceptible to mortality resulting from successive attacks. The damage resulting from WSB defoliation depends upon severity and duration of the attack and can include top kill, growth decline, tree deformity, reduced seed production resulting from damage to cone crops and, in most extreme cases, mortality (MoF 1995). If attack is sustained for four to five years then complete defoliation can occur. If these trees survive, it can then take several years for normal growth to resume (MoF 1995). Trees weakened by successive budworm defoliation may also be susceptible to attack by secondary pests such as bark beetles.

To minimize the impact of spruce budworm, management should focus on:

- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape
- Reintroducing prescribed fire and/or thinning to maintain open, single level stand structure and to prevent dense Douglas-fir regeneration

6.6.2 Douglas-fir Tussock Moth

The Douglas-fir tussock moth (*Orgyia pseudotsugata* [McDunnough])is another common and periodically destructive native defoliator of Douglas-fir in the low elevation arid Douglas-fir and ponderosa pine forests of BC. The principal host of the DFTM is Douglas-fir; however, during outbreaks, adjacent trees of other species such as ponderosa pine and western larch may also be attacked. All ages are susceptible (Henigman *et al.* 2001). Outbreaks of DFTM are cyclical in nature but tend to be smaller and localized near the edge of open range (Henigman *et al.* 2001). Outbreaks are more intense and of shorter duration than WSB. Patch infestations of up to 250 hectares are common (MoF 1995). Outbreaks tend to be approximately four years in duration and occur every 10 to 12 years before the population collapses due to natural controls and starvation (MoF 1995). DFTM is a voracious feeder of both new and old foliage and can cause significant mortality after one or two years of defoliation. Damage to surviving trees may include top-kill, growth reduction and secondary attacks by insects and fungi following severe defoliation. DFTM also has potential impacts on human health. Some individuals may develop a severe allergic reaction (tussockosis) to the hairs on larvae (Flowers 1999).

The DFTM has a one year life cycle. It overwinters in the egg stage with hairy larvae emerging in late May or early June (MoF 1995). The larvae will develop through four to six instar stages, depending on food availability. Initially they feed voraciously on the current year's foliage, causing it to turn brown. As the larvae mature later in the summer, they may feed on both current and older foliage until late July or August. The resulting defoliation is concentrated in the upper crown and outer branch tips first; moving down the crown and further back on the branches as the infestation progresses. By late July or August, the mature larvae pupate in cocoons on the underside of foliage or on the trunk and emerge as adults 10 to 14 days later (MoF 1995). The female DFTM is flightless and generally remains camouflaged on the cocoon. The males fly seeking out the pheromone emitting females. They typically mate on the same day that the female emerges (MoF 1995). Egg masses are deposited on the empty cocoon where, protected by a woolly covering, they overwinter and the cycle is repeated. Since the female moth does not fly, the primary dispersal mode is by windborne young larvae (Wickman *et al.* 1981). The larvae produce long silk threads when they drop off foliage, which, along with their hair and light weight, enables them to be carried by the wind. As a result, outbreaks of the DFMT begin as localized epicenters and spread into larger areas (MoF 1995).

Many natural controls on DFTM populations exist. At low population densities, over 90 percent of the larvae and 75 percent or more of the pupae and eggs are killed in each generation by natural control agents (Wickman *et al.* 1981). Natural mortality factors include parasitizing wasps and flies, pathogens, predation by small birds, spiders and insects and loss of dispersing larvae (Wickman *et al.* 1981). At outbreak population densities, the species specific nuclear polyhedrosis virus (NPV), in combination with other mortality factors, may play an important role in DFTM control. This virus is always present at low populations but, as it is spread by insect-to-insect contact, it can cause the rapid decline of outbreak populations (MoF 1995). The virus particles may persist in the environment for many years (Wickman *et al.* 1981). Outbreak populations of DFTM are also limited by the quantity and quality of food available. The forced consumption of older, less nutritious foliage due to early defoliation of the current year's foliage results in starvation and lowered production and survival of eggs (Wickman *et al* 1981).

To minimize the impact of spruce budworm, management should focus on:

- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape
- Thinning using prescribed fire or mechanical thinning to reduce stand susceptibility

6.7 Needle Casts

6.7.1 Elytroderma Needle Cast

Elytroderma Needle Cast (*Elytroderma deformans (Weir) Darker*) is a fungus that attacks the foliage and twigs of ponderosa pine and lodgepole pine throughout their range in BC (Henigman *et al.* 2001). Infection by this fungus ranges in severity but generally results in defoliation and branch and stem deformations that may reduce growth and predispose trees to attack by other pathogens and insects.

The disease cycle starts with the infection of current foliage by wind borne spores that are disseminated in late summer to early autumn. The fungus grows from the needle to the twig without killing either initially and without any evident symptoms until the spring of the following year when groups of needles turn bright red and die. New fruiting bodies form on the surface of dead needles in late summer and appear as elongated, dark spots. The infected needles of ponderosa pine are then cast in early fall and those of lodgepole pine are cast in late fall (Henigman *et al.* 2001). Infection from elytroderma needle cast can be perennial and systemic in twigs causing small, open upturned brooms and continually re-infecting needles which produce spores that infect other trees.

The damage from elytroderma needle cast may range from light defoliation to mortality from yearly, repeated infections. In severe cases, trees will be left with thin, ragged crowns and experience reduced growth. Trees with 30% to 60% of their crowns infected lose 52% to 65% of normal diameter growth and with more than 60% of their crowns infected, lose 93% to 99% of normal diameter (Dekker-Robertson *et al.* 2005). Young trees are more severely impacted than older trees. Young lodgepole pine up to two metres in height can be systematically infected and remain stunted (Henigman *et al.* 2001).

Predisposing agents for elytroderma needle cast include cool temperatures and high humidity in late summer and fall creating ideal conditions for infection by windborne spores (Dekker-Robertson *et al.* 2005). This disease can be more of a problem in stands on sites such as valley bottoms and near streams and lake shores, particularly as air re-circulates in the stand.

To minimize the impact of elytroderma needle cast, management should focus on:

- Pruning of infected branches or whole tree removal of severely infected trees
- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape
- Thinning using prescribed fire or mechanical thinning to reduce stand susceptibility

6.8 Dwarf Mistletoes

6.8.1 Douglas-fir Dwarf Mistletoe

Dwarf mistletoes are widespread parasitic perennial flowering plants that attack a wide variety of conifers in British Columbia. There are five species of dwarf mistletoe in BC, each specific to a principal host. The Douglas-fir dwarf mistletoe (*Arceuthobium douglasii* Engelmann) is the only species of dwarf mistletoe that attacks Douglas-fir, its principal host. Grand fir and spruce are occasionally attacked by Douglas-fir dwarf mistletoe (Finck *et al.* 1989). Douglas-fir dwarf mistletoe occurs only in the extreme southern interior of the province in the Okanagan and Similkameen Valleys, the Creston area and in some other isolated pockets (Unger 1992).

The dwarf mistletoe is an obligate parasite and as such requires a living host for support, water and nutrients, thereby causing reduced growth and vigour of the host tree. The mistletoe is spread by the explosive release of seeds in early September which generally overwinter on bark surfaces and germinate in the spring. Seeds may travel up to 15 m (Unger 1992). Depending on conditions, several years may elapse before new infections produce seeds. As the parasite penetrates and infects the bark and wood of the host tree it induces a localized swelling on the infected branch or stem and the distorted proliferation of branches commonly referred to as "witches' brooms". These brooms are typically pendulous. The plant produces aerial shoots by the second or third year and male and female flowers by the fourth or fifth year. Following pollination, mature fruit and seed develop within 14 to 18 months (Unger 1992).

The mistletoe can attack Douglas-fir in all age classes and causes loss of vigour and growth rate reduction in excess of 40% in severely infected Douglas-fir (Unger 1992). Top kill and mortality are common results of infection, with infected trees in more open stands being more severely damaged (Finck *et al.* 1989). The weight of mistletoe brooms and the structural weakness at the site of branch and stem swellings can result in breakage of branches and stems. However, large witches' brooms can also provide habitat for animals and birds for nesting and cover (MoF 1995).

The susceptibility of Douglas-fir stands to Douglas-fir dwarf mistletoe is influenced by species composition, stand age and the vertical and horizontal height structure of the stands. Douglas-fir mistletoe is common in all-aged, mature stands of Douglas-fir where it causes severe damage while species diverse stands are less affected (MoF 1995). The rate of spread is greatest from infected overstory trees to understory trees and slower through even-aged stands of uniform height (MoF 1995). The effect of density is such that the rate of spread through open stands is 1.5X faster because of more vigorous mistletoe plants and longer seed flights (MoF 1995).

To minimize the impact of Douglas-fir Dwarf Mistletoe, management should focus on:

- Pruning of infected branches or whole tree removal of severely infected trees if falling branches or trees are likely to be a hazard

- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape
- Managing for even aged stands

6.9 Hardwood Pests and Diseases

The insects and diseases discussed above primarily affect conifer species. A number of diseases specifically affect hardwoods in the Okanagan. These include the forest tent caterpillar, fall webworm, satin moth, alder flea beetle, poplar and willow borer, leaf blotch miner, Annosus root and butt rot, cankers, rusts and blights. This report does not include a detailed discussion of these forest health factors because there are few hardwood dominated stands within the RDCO parks system and there is, at the present time, very little tree mortality associated with these forest health agents. However, outbreaks are possible and these forest health agents should be monitored on a park by park basis.

To minimize the impact of hardwood pests and diseases, management should focus on:

- Pruning of infected branches or whole tree removal of severely infected trees if falling branches or trees are likely to be a hazard
- Reforesting with a mix of species and maintaining a mosaic of species and ages across the landscape

7.0 Glossary

Abiotic: the non-living components of the environment, such as air, rocks, soil, water, peat, and plant litter.

Adaptive management: Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form–"active" adaptive management–employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.

Adventitious roots: A root that grows from somewhere other than the primary root, for example, roots that arise from stems following the death of the primary root.

Alien species: Plants, animals and micro-organisms from one part of the world that are transported beyond their natural range and become established in a new area. They are sometimes also called "exotic," "introduced," "non-native," or "non-indigenous" species. Some alien species are also invasive species.

Appropriately qualified professional: A scientist or technologist specializing in a relevant applied science or technology including, but not necessarily limited to, agrology, forestry, biology, engineering, geomorphology, geology, hydrology, hydrogeology or landscape architecture, and who is registered in British Columbia with their appropriate professional organization, and acting under that association's Code of Ethics and subject to disciplinary action by that association, and who, through demonstrated suitable education, experience, accreditation and knowledge relevant to the particular matter, may be reasonably relied on to provide advice within their area of expertise.

Aquatic ecosystem: Any body of water, such as a stream, lake, estuary or wetland, and all of the organisms and non-living components within it, functioning as a natural system.

Arboreal Lichen: A lichen species that tends to grow above ground, typically from the branches of standing trees.

Basidiocarps: A specialized spore-producing structure, especially of a fungus. The most commonly-known basidiocarps are mushrooms, but they may also take many other forms.

Best management practices (BMPs): Guidelines and Best Management Practices (BMPs) are approaches based on known science that, if followed, should allow the client to meet the required standard(s) or achieve the desired objective(s).

Biodiversity (biological diversity): The diversity of plants, animals, and other living organisms in all their forms and levels of organization, including genes, species, ecosystems, and the evolutionary and functional processes that link them.

Bio-energy: Bio-energy is energy derived from renewable sources. Energy is generated by combusting biomass materials such as wood or other biofuels. The carbon dioxide emitted from burning biomass will not increase total atmospheric carbon dioxide if this consumption is done on a sustainable basis (i.e., if in a given period of time, regrowth of biomass takes up as much carbon dioxide as is released from biomass combustion).

Biogeoclimatic zone (BGCZ): A geographical area having similar patterns of energy flow, vegetation and soils as a result of a broadly homogeneous macroclimate. Each zone is characterized by a specific type of plant species. The biogeoclimatic classification system is a hierarchical classification system of ecosystems that integrates regional, local and chronological factors and combines climatic, vegetation and site factors. The province of BC is divided into 14 broad, climatically distinct zones usually named after the dominant climax tree species. These can be more finely divided into subzones, variants and phases. BGC variants represent specific climatic and geographic characteristics with distinct vegetation types.

Bio-inventory: A detailed site assessment that documents plant communities, aquatic and wildlife habitat values, aquatic and wildlife species presence (or likelihood of presence), sensitive ecosystems, rare ecosystems, rare species, adjacent land uses and threats, site stability and flood issues, other factors affecting lot layout, and where appropriate, potential habitat enhancement/protection opportunities.

Biological control: the use of biotic agents such as insects, nematodes, fungi, and viruses for the control of weeds and other forest pests.

Biotic: Pertaining to life or living organisms.

Blowdown: A tree or trees uprooted by the wind, often referred to as windthrow.

Blue-listed species: Includes any native species, subspecies or community considered to be Vulnerable (Special Concern) in British Columbia. These species are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed species are at risk, but are not Extirpated, Endangered or Threatened.

Bole: The trunk of a tree.

Broadcast Burning: A controlled burn, where the fire is intentionally ignited and allowed to proceed over a designated area within well-defined boundaries, to reduce fuel hazard after logging or to prepare the site before planting.

Broom: The dense, abnormal proliferation of shoots and branches, usually induced by dwarf mistletoe, rust fungi, or other organisms, but sometimes in response to abiotic agents or genetic abnormalities of the host tree. Sometimes referred to as witches' broom.

Brushing: A silviculture activity done by chemical, manual, grazing, or mechanical means to control competing forest vegetation and reduce competition for space, light, moisture, and nutrients with crop trees or seedlings.

Buffer: An area of land that surrounds and protects a sensitive feature from the adverse effects of activities on, or encroachments from, adjacent land.

Cambium: A single layer of cells between the woody part of the tree and the bark. Division of these cells results in diameter growth of the tree through formation of wood cells (xylem) and inner bark (phloem).

Canker: An area of diseased tissue, often sunken, on a living stem or branch.

Canopy: The forest cover of branches and foliage formed by tree crowns.

Canopy Closure: The percentage of the ground surface covered when the canopy crown is projected vertically.

Canopy Gap: A distinct air space or hole between the foliage of the canopy crown.

Capability: The ability of the habitat, under optimal natural (seral) conditions to provide the life requisites of a species, irrespective of its current habitat condition.

Carbon accounting: associated with measuring, calculating and valuing the relative benefits of greenhouse gas mitigation measures.

Carbon sequestration: The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen and store the carbon. Fossil fuels were at one time biomass and continue to store the carbon until burned.

Closed Canopy: The condition when the crowns of trees touch and effectively block sunlight from reaching the forest floor.

Clumpy: Refers to the pattern of distribution of vegetation in an area such as a harvest opening, and can include the distribution of trees, regeneration, or shrub cover. A clumpy distribution is characterized by groups or clusters of vegetation, as opposed to uniformly or randomly distributed vegetation. "Clumpy" is often used in the context of planting and juvenile spacing treatments, and is also referred to as "patchy".

Coarse Woody Debris (CWD): Coarse woody debris (CWD) consists of fallen trees, sloughing bolewood, and other woody material on the forest floor. It is generally considered to be sound and rotting logs, stumps and branches greater than 10 cm in diameter that provide, among other things, habitat for plants, animals and insects, and a source of nutrients for soil development. Maintaining CWD after harvesting is a critical element of managing for biodiversity.

Cogeneration: Energy system that consumes a fuel to produce electricity and thermal energy in the form of steam or hot air. Cogeneration systems use heat energy that otherwise would be wasted.

Commercial Thinning: A silviculture treatment that removes or cuts stems that can be used commercially (e.g., fence posts) from an immature stand to help accelerate the growth and diameter size of the remaining stems.

Condition class (fire regime): A classification of the relative degree of departure from the natural historic fire regime of an ecosystem, ranging from condition class 1 (least departed), class 2 (moderately departed) to class 3 (significantly departed). This departure results in changes to one (or more) of the following ecological components: vegetation characteristics (species composition, structural stages, stand age, canopy closure, and mosaic pattern); fuel composition; fire frequency, severity, and pattern; and other associated disturbances (e.g. insect and disease mortality, grazing, and drought).

Conk: A hard, fruiting body that typically grows on the trunk of a tree, which contains spores of a wood-decaying fungus

Connectivity: 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.

Conservation covenant: A voluntary, written legal agreement in which a landowner promises to protect their land in specified ways. The covenant is attached to the title of land and binds future landowners to the terms of the covenant. The presence of the covenant may lower taxes by changing the assessed value of the land.

Conservation Data Center (CDC): The British Columbia Conservation Data Centre (CDC) systematically collects and disseminates information on plants, animals and ecosystems (ecological communities) at risk in British Columbia. This information is compiled and maintained in a computerized database which provides a centralized and scientific source of information on the status, locations and level of protection of these organisms and ecosystems. The CDC is part of the Environmental Stewardship Division in the B.C. Ministry of Environment. It is also part of NatureServe, an international organization of cooperating

Conservation Data Centres and Natural Heritage Programs all using the same methodology to gather and exchange information on the threatened elements of biodiversity.

Contaminated Site: An area of the land in which the soil or any groundwater lying beneath it, or the water or the underlying sediment contains: (a) a hazardous waste, or (b) another prescribed substance, in quantities or concentrations exceeding prescribed risk-based or numerical criteria or standards or conditions.

Cover type (forest): a descriptive term used to group stands of similar characteristics and species composition (due to given ecological factors) by which they may be differentiated from other groups of stands.

Critical habitat: In conservation biology, critical habitat is defined as part or all of an ecosystem occupied by a species, or population of that species, that is recognised as essential for the maintenance and long-term survival of the population. In the Species at Risk Act, critical habitat is defined as "The habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species" (Species at Risk Act, 2(1)).

Critical Winter Range: Forested habitat, usually stands of mature or old growth conifers, which provides ungulates with resources critical to survival during severe winters.

Crown: the live branches and foliage of a tree.

Curtain Burner (or Air Curtain Burner): A portable or stationary combustion device that directs a plane of high velocity forced draft air through a manifold head into a burn chamber, or earthen pit or trench made to function as the Fire Box, with vertical walls in such a manner as to maintain a curtain of air over the surface of the burn chamber and recirculating motion of air under the curtain.

CWD: See course woody debris.

CWD Decay Classes: A five-category system that describes the amount of decay that is present on a downed piece of wood >7.5 cm in diameter (i.e., class 1 is intact, hard and elevated above ground; class 5 is decayed into many small pieces with soft portions that is partly sunken into the ground).

Danger Tree (Hazard Tree): A live or dead tree whose trunk, root system or branches have deteriorated or have been damaged to such an extent as to be a potential danger to human safety.

DBH (Diameter at Breast Height): The stem diameter of a tree measured at breast height, 1.3 metres above the ground.

Deactivation: Measures taken to stabilize roads and logging trails during periods of inactivity, including the control of drainage, the removal of sidecast where necessary, and the re-establishment of vegetation for permanent deactivation.

Defoliator: an agent that damages trees by destroying leaves or needles.

Deleterious substance: Any substance that, if added to water, would degrade or alter the quality of the water so that it becomes damaging to fish or fish habitat, or becomes unsuitable for human consumption or any other purpose for which it is legally licensed (such as irrigation and livestock watering).

Dieback: The progressive dying from the tips downward or inward of shoots, twigs, tops, branches, or roots.

Direct Control: In the context of this document, direct control refers to the use of science and technology to repress forest pests, i.e., curative measures to reduce or control pests. For example, bark beetle direct control measures may include the use of pheromone traps or the application of pesticides. Direct control measures may also be applied to control forest diseases.

Disease: Tree disease refers to the deleterious effects resulting from injurious agents other than fire, insect damage or other types of wounding (e.g. animals or hail). The term covers a wide range of pathogenic infections, abnormalities, and disturbances of the normal structure and growth of a tree. The causes of tree disease are usually classified as non-infectious or infectious.

Disease Centre: Used in this document in the context of root disease; infected trees may be clumped in noticeable patches called infection centres or disease centres.

Disturbance: A discrete event, either natural or human-induced, that causes a change in the existing condition of an ecological system.

Ecological attributes: The measurable components of a forest or range ecosystem, including but not limited to: stand or range attributes, coarse woody debris attributes, ecological site description, soil description, vegetation layers, and succession interpretation.

Ecological integrity: A continuum of characteristics that a landscape should possess. These include ecosystem health, biodiversity, stability and sustainability through the maintenance of structural and functional components of the system in perpetuity.

Ecosystem: The dynamic and interrelated complex of plant and animal communities and their non-living environment. All parts of an ecosystem, including physical, chemical and biological components are interconnected: that is, they affect and are affected by all other parts.

Ecosystem features: The physical components of the ecosystem (such as snags and large woody debris) that help maintain the diversity and processes associated with a healthy ecosystem.

Ecosystem functions: The physical, chemical and biological processes that keep an ecosystem operating. Examples include infiltration of surface water, evapo-transpiration and nutrient cycling.

Ecosystem restoration: See restoration

Edge habitat: The point at which dissimilar plant communities (different vegetation types, successional stages or vegetative conditions) meet. Many species have adapted to the interface between the two habitats.

Encroachment: Any entry into an area not previously occupied, as in the encroachment of trees on historic grasslands.

Endangered: A species facing imminent extirpation or extinction.

Endemic: A disease, insect, or vertebrate animal that is native to a particular area. Often refers to the level of incidence or population numbers that are believed to occur in a native population.

Environmentally sensitive area: A term often used loosely to mean a site or area that has environmental attributes worthy of retention or special care. A more exacting definition is: any parcel of land that already has, or with remedial action could achieve, desirable environmental attributes. These attributes contribute to the retention and/or creation of wildlife habitat, soil stability, water retention or recharge, vegetative cover and similar vital ecological functions. Environmentally sensitive areas range in size from small patches to extensive landscape features. They can include rare or common habitats, plants and animals. Environmentally sensitive areas also include hazard lands.

Epidemic: A widespread and unusually high level of incidence of a disease or insect pest; generally preceded by a rapid increase in population size.

Erosion: A natural process of sediment movement as a consequence of water currents, rainfall runoff, or wind, which may be considered beneficial or detrimental, depending upon the associated environmental concerns.

Estuary: A partially enclosed body of water freely connected to the ocean, within which the seawater is diluted by mixing with freshwater and where tidal fluctuations affect stream water levels. The estuary is a dynamic system typified by brackish (mixed fresh and salt) water, variable and often high nutrient levels and by shallow water conditions often associated with marsh plants in upper tidal zones and eelgrass in lower tidal zones.

Exotic Species: A species introduced accidentally or intentionally to a region beyond its natural range. "Exotic" is a preferred synonym for "alien", "foreign", and "non-native".

Extinct: A species that no longer exists anywhere in the world.

Extirpated: A species no longer existing in the wild in Canada, but occurring elsewhere. (A species listed as provincially extirpated no longer exists in the wild in British Columbia, but occurs in other parts of Canada or other parts of the world.)

Feathering: A method of partially trimming trees so that they are windfirm (better able to resist windthrow).

Fire hazard: the potential fire behaviour for a fuel type, regardless of the fuel type's weather-influenced fuel moisture content or its resistance to fireguard construction. Assessment is based on physical fuel characteristics, such as fuel arrangement, fuel load, condition of herbaceous vegetation, and presence of elevated fuels.

Fire regime: The characteristics of fire in a given ecosystem, such as the frequency, predictability, intensity, and seasonality of fire. See historic natural fire regime.

Forest Floor: The layers of fresh leaf and needle litter, moderately decomposed organic matter, humus or well-decomposed organic residue found on the ground within a forest stand.

Forest health: A forest condition that is naturally resilient to damage; characterized by biodiversity, it contains sustained habitat for timber, fish, wildlife, and humans, and meets present and future resource management objectives.

Forest health agents: Biotic and abiotic influences on the forest that are usually a naturally occurring component of forest ecosystems. Biotic influences include fungi, insects, plants, animals, bacteria, and nematodes. Abiotic influences include frost, snow, fire, wind, sun, drought, nutrients, and human-caused injury.

Fragmentation: A process whereby large contiguous ecosystems are transformed into one or more smaller patches surrounded by disturbed areas.

Frass: Solid excrement of insects.

Fuel loading: the amount of fuel present as expressed in the weight of fuel per unit area.

Fungal Inoculation: An artificial means of introducing wood-decaying fungal spores into a live tree to increase decay and wildlife value.

Geotechnical hazard: A hazard relating to geological materials, soil mechanics, earth structures and foundations. For example, hazards may include landslides or debris flows.

Girdling: To kill a tree by severing or damaging the cambium layer and interrupting the flow of food between the leaves and the rest of the tree.

GIS: Geographic Information Systems. Analysis that combine relational databases with spatial interpretation and outputs often in the form of maps. A more elaborate definition is that of computer programmes for capturing, storing, checking, integrating, analysing and displaying data about the earth that is spatially referenced.

Grasslands: Lands where the existing or potential natural vegetation is predominantly grasses, grasslike plants, and forbs (broad-leaved plants). Often called "steppes", these ecosystems may also contain scattered shrubs and a soil crust of lichens and mosses.

Greenways: Networks of linked greenspace that provide wildlife habitat and recreational opportunities. They include trails in some areas and no public access in others. Greenways are created as part of an integrated approach to land planning, balancing the needs of human communities and natural systems.

Groundwater: Water below the surface of the ground. This water may move through underground streams and seepages.

Habitat: The place where an organism lives and/or the conditions of that environment, including the soil, vegetation, water, and food.

Habitat Matrix: A series of linked habitat areas that maintain large-scale ecological processes at the landscape level.

Hazard tree: See danger tree

Herb Layer: All herbaceous plants (regardless of height) and low woody plants <15 cm tall.

Heritage trees: Trees having historical, cultural or scenic significance.

Historic natural fire regime (HNFR): The historic pattern (frequency and extent/severity) of fire in an area in the absence of modern human intervention.

Hydrology: The science that describes and analyzes the occurrence of water in nature, and its circulation near the surface of the earth.

Impervious surfaces: Surfaces that prevent water from going into the ground, such as roofs, roads, parking lots and compact soils.

Ingrowth: Occurs in response to fire suppression activities that disrupt the natural fire regime enabling the survival of more trees than the land historically supported. Forest ingrowth can destroy habitat, encroach grasslands and provide fuel for.

Inoculum: Infectious material of a pathogen.

Instar: A stage in the development of an insect larva between periods when the larva sheds its skin in order to grow.

Integrated pest management: A decision making process that uses a combination of techniques to suppress pests including, but not limited to: planning and managing ecosystems to prevent organisms from becoming pests; identifying potential pest problems; monitoring populations of pests and beneficial organisms, pest damage and environmental conditions; using injury thresholds in making treatment decisions; reducing pest populations to acceptable levels using strategies that may include a combination of biological, physical, cultural, mechanical, behavioural and chemical controls, and; evaluating the effectiveness of treatments

Introduced species: See alien and exotic species.

Invasive species: Plants, animals and micro-organisms that colonise and take over the habitats of native species. Most invasive species are also alien (non-native) to the area, and can become predominant because the natural controls (predators, disease, etc.) that kept their populations in check in their native environment are not found in their new location.

ISA Certified Arborist: The Arborist Certification program is a voluntary process where individuals document their knowledge and competence in tree care. Certification requires:
- At least three years of field experience;
- Passing a comprehensive written examination;
- Regular attendance to recognized workshops and educational forums.

The program is self-regulated within the industry with no legal basis. It is administered by the International Society of Arboriculture.

Juvenile Spacing: A silvicultural treatment to reduce the number of trees in young stands, often carried out before the stems removed are large enough to be used or sold as a forest product. Also called precommercial thinning.

Kairomone plumes: Semiochemicals or chemical signals (volatile compounds) produced by trees which indicate their presence, identity, and suitability as a host to the benefit of another species receiving the chemical e.g. bark beetle. Kairomones tend to be produced in larger quantities by stressed or injured trees. Kairomones from trees and pheromones from bark beetles influence many behavioural actions of a bark beetle during its life cycle.

Ladder fuels: Fuels that provide vertical continuity between ground fuels and the crowns of trees, contributing to the ease of a tree igniting.

Landing: An area modified by equipment that is designed for accumulating logs before they are transported.

Landscape Level: The level of forest management at which ecosystem processes, habitat types and seral stage distribution are managed for large, geographically separate areas.

Leave Trees: All trees, regardless of species, age, or size, remaining on a harvested area as a result of a predetermined silviculture prescription to address a possible range of silviculture or resource needs.

Management Guideline: Generally accepted non-legislated guidance and management recommendations based on the best available data and expert opinion.

Mature Forest: The stage at which trees in a narrowly even-aged stand attain full development, particularly in height and seed production.

Microclimate: Generally the climate of small areas, especially insofar as this differs significantly from the general climate of the region. Stands often create microclimates.

Mycelium (pl. Mycelia): The vegetative feeding structure of a fungus composed of a mass of interwoven hyphae (fine, threadlike filaments) and considered distinct from the fruiting body.

Natural Disturbance Regime: The historic patterns (frequency and extent) of fire, insects, wind, landslides and other natural processes and disturbances in an area.

Old Forest: Over-mature, structurally complex stands consisting of live and dead trees of various sizes, species, composition, and age class structure.

Orthophotos: A completely rectified copy of an original photograph. All variations in scale and displacements, due to relief, have been eliminated, hence the name ortho (correct) photography.

Outbreak: A recently detected pest population or a sudden significant increase of an established pest population in an area.

Overstory: Foliage within the shrub and canopy layers of a forest stand that obstruct sunlight from reaching the forest floor.

Partial Harvesting: A general term referring to silvicultural systems other than clearcutting, in which only selected trees are harvested.

Patchy: Refer to definition of Clumpy.

Pathogen: A living organism that incites disease in a host.

Perennial: A woody or herbaceous plant that lives from year to year.

Pest: An organism on a particular site that is determined to be damaging or interfering with resource management objectives (i.e., weeds, insects, disease organisms).

Pesticide: A micro-organism or material that is represented, sold, used or intended to be used to prevent, destroy, repel or mitigate a pest, and includes (a) a plant growth regulator, plant defoliator or plant desiccant, (b) a control product under the Pest Control Products Act

(Canada), other than a device that is a control product, and (c) a substance that is classified as a pesticide by regulation.

Pheromones: A chemical secreted by an animal, especially an insect, that influences the behaviour or development of others of the same species, often functioning as an attractant of the opposite sex.

Phloem: One of the conducting tissues of vascular plants through which products of photosynthesis are transported; located adjacent to the cambium or inner bark.

Plant community: A unit of vegetation with a relatively uniform species composition and physical structure. Plant communities also tend to have characteristic environmental features such as bedrock geology, soil type, topographic position, climate, and energy, nutrient and water cycles.

Polygon: A closed geometric entity used to graphically represent area features with associated attributes.

Pop-up spacing: Pop-up spacing is a method which simultaneously removes root disease inoculum from the soil while conducting stand management operations. This method uses a small feller buncher or excavator to "pop-up" infected trees (saplings) from the ground, roots and all, to prevent the spread of root disease (particularly *Armillaria*). By the time root contacts re-establish, the saplings may be large and vigorous enough to resist infection.

Prescribed Burning: The knowledgeable application of fire to a specific unit of land to meet predetermined resource management objectives.

Pruning: The manual removal, close to or flush with the stem, of side branches, live or dead, and of multiple leaders from standing, generally plantation-grown trees.

Recruit: To restore forage or other habitat attributes to previous natural equilibrium levels. Recruit can also be used in the context of enhancement, which means to increase forage or other habitat attributes above previous natural equilibrium levels.

Red-listed species: Includes any indigenous species or subspecies (taxa) or plant community that is considered to be extirpated, endangered, or threatened in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered of limiting factors are not reversed.

Regeneration: The renewal of a tree crop through either natural means (seeded on-site from adjacent stands or deposited by wind, birds, or animals) or artificial means (by planting seedlings or direct seeding).

Remediation: "Remediation" covers all stages of contaminated site management from preliminary investigations, through implementing remediation procedures, to final monitoring.

Restoration: The return of an ecosystem or habitat to its original community structure, natural complement of species and natural functions.

Retention: To retain or save a portion of the original stand in a cluster or clump.

Rhizomorph: A thread or cord-like structure made up of hyphae, frequently produced by *Armillaria* spp.

Riparian: an area adjacent to a stream, lake, pond or wetland where water influences the vegetation.

Riparian ecosystem: A terrestrial ecosystem where the vegetation complex and microclimate conditions are the product of combined presence and influence of perennial and/or intermittent water, associated high water tables, and soils that exhibit some wetness characteristics. The riparian ecosystem is influenced by, and exerts an influence on, the associated aquatic ecosystem.

Riparian Management Area (RMA): An area, the width as determined in accordance with standards described in the Forest Practices Code Operational Planning Regulations, which is adjacent to a stream, wetland or lake. The RMA consists of a riparian management zone (RMZ) and, depending on the riparian class of the stream, wetland or lake, a riparian reserve zone (RRZ). The riparian class is determined by the attributes of the stream, wetland or lake, as well as the adjacent terrestrial ecosystems. Attributes include channel width, size (area) of the wetland, presence of fish, domestic water use, and gully status (stream gradient and sidewall slope).

Riparian Reserve Zone (RRZ): The portion of a riparian management area that borders the stream channel. RRZs are determined by the stream class and associated attributes (see RMA). Forest management activities are restricted in RRZs.

Selective Harvesting: The removal of certain trees in a stand as defined by specific criteria (species, diameter at breast height, height or form).

Seral Stage: Any stage of development of an ecosystem, from a disturbed, unvegetated state to a climax plant community.

Sensitive ecosystem: An ecosystem that is rare and/or fragile. Rarity is a primary feature of sensitive ecosystems. It can be the result of human-related activities over the last 150 years or a measure of limited natural occurrence in terms of distribution and density. Fragility is a measure of an ecosystem's sensitivity to a range of disturbance factors that could lead to ecosystem decline or loss of ecosystem health or integrity.

Shrub Layer: All woody plants <10 m and >15 cm tall.

Silvicultural system: A planned program of treatments throughout the life of the stand to achieve stand structural objectives based on integrated resource management goals. A silvicultural system includes harvesting, regeneration and stand-tending methods or phases. It covers all activities for the entire length of a rotation or cutting cycle.

Silviculture: The theory and science of controlling the establishment, growth, composition, health and quality of forests and woodlands.

Silviculture Prescription: A site-specific, integrated operational plan to carry out one or a series of silviculture treatments.

Single Tree Selection: A silvicultural system that removes mature timber either as single scattered individuals or in small groups at relatively short intervals.

Site preparation: The treatment of the soil and ground vegetation to prepare the soil surface as a favourable seedbed for either naturally or artificially disseminated seed or for planted seedlings.

Slash: The residue left on the ground as a result of forest and other vegetation being altered by forest practices or other land use activities.

Slope stability: Susceptibility of a slope to erosion and slides.

Small Group Selection: A silvicultural system that removes mature timber in a small area or grouping, typically <0.5 ha in size.

Snag: A standing dead tree.

Snag Classes: A nine-category system that describes the amount of decay that is present on a standing tree (i.e., class 1 is a live tree with no rot or decay present; class 9 is a fully decayed stump partially incorporated into the forest floor).

Soil Moisture Regime: The available moisture supply for a soil relative to other sites and soil types.

Soil Nutrient Regime: The available nutrient supply for a soil relative to other sites and soil types.

Spacing: The removal of undesirable trees within a young stand to control stocking, to maintain or improve growth, to increase wood quality and value, or to achieve other resource management objectives. Also see Thinning.

Species at risk: A species that has been defined as 'at risk' by either the federal or provincial government. Federally listed: The federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC) maintains a list of species listed as extirpated, endangered, threatened or of special concern. These species are protected under the Species at Risk Act. Provincially ranked: The British Columbia government maintains a ranking of species considered to be "red-listed" and "blue-listed" in this province.

Stand Attribute: A measurable component of a forest stand, i.e., canopy closure, basal area, stem distribution, or seedlings/ha, etc.

Standard Operating Procedures: a set of written instructions that document a routine or repetitive activity followed by an organization.

Stand Level: The level of forest management at which a relatively homogeneous land unit can be managed under a single prescription, or set of treatments, to meet well-defined objectives.

Stand structure: The distribution of trees in a stand, which can be described by species, vertical or horizontal spatial patterns, size of trees or tree parts, age, or a combination of these.

Stocking: A measure of the area occupied by trees, usually measured in terms of well-spaced trees per hectare or basal area per hectare, relative to an optimum or desired level.

Stub Tree: An artificially created wildlife tree, mechanically cut from a class 1, 2 or 3 tree.

Succession: The gradual supplanting of one community of plants by another.

Suitability: Ability of the habitat in its current condition to provide life requisites of an animal.

Sustainability (forest and ecosystem): A state or process that can be maintained indefinitely. The principles of sustainability integrate three closely interlined elements—the environment, the economy and the social system—into a system that can be maintained in a healthy state indefinitely.

Tenure: How land is held or owned, particularly as to manner or term (i.e., period of time). Land tenure may be broadly categorized into private lands, municipal lands, federal lands, and provincial Crown lands.

Terrestrial Ecosystem Mapping: Ecosystem mapping is the stratification of a landscape into map units, according to a combination of ecological features, primarily climate, physiography, surface material, bedrock geology, soil, and vegetation.

Thinning: A silviculture treatment that removes or cuts stems in an immature forest primarily to accelerate diameter increment but also, by suitable selection, to improve the average form of the trees that remain.

Threatened: A species likely to become endangered if limiting factors are not reversed.

Treatment Area: Land designated in a prescription for a specific silviculture activity or series of treatments.

Understory: Any plants growing under the main tree canopy, particularly those found in the herbaceous and shrub layers.

Urban interface: See Wildland Urban Interface (WUI)

Veteran Tree (Vet): A tree that is significantly older (usually >150 years of age) than the trees of the main forest canopy. Veteran trees may have survived one or more fires as evidenced by fire scars, and are usually isolated in distribution and often extend well above the main tree canopy. Because of their large size, they usually provide valuable wildlife tree habitat for many decades.

VRI data: The BC Vegetation Resources Inventory (VRI) provides an account of British Columbia's trees and other vegetation resources. It replaces the previous forest inventory, which was primarily focused on timber. The VRI is broader in scope and more reliable than past forest inventories because it uses statistically accurate procedures and detailed ground sampling to augment photo-interpreted estimates. The VRI covers all lands and forests in the province, including timber supply areas, tree farm licenses, private land and parks.

Weed: Any plant growing where it is not wanted.

Wetland: Land that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs, fens, vernal pools and estuaries.

Wildland Urban Interface (WUI): A term used to describe an area where various structures (most notably private homes) and other human developments meet or are intermingled with forest and other vegetative fuel types.

Wildlife/Danger Tree Assessor's Course: A course provided through the Wildlife Tree Committee (WTC), a multi-agency committee, to provide a wildlife/danger tree assessment procedure and appropriate training opportunities that will provide a high standard of worker safety. Assessors learn how to recognize important wildlife trees and assess risk of tree failure in order to maintain or incorporate wildlife trees safely within the operational setting.

Wildlife tree: A standing live or dead tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife. Characteristics include large diameter and height for the site, current use by wildlife, declining or dead condition, value as a species, valuable location and relative scarcity.

Windthrow: A tree or trees uprooted or broken off by the wind. Also known as blowdown.

Xeriscaping: A landscaping approach using plant species that are tolerant of drought conditions.

Yellow List: A list of ecological communities and indigenous species that are not at risk in British Columbia.

Young Forest: A loose term applied to all stages of forest after it is established and before it becomes mature.

8.0 References

Agee, J.K. 1996. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press; 493pp.

Allen, E.; D. Morrison; G. Wallis. 1996. Common Tree Diseases of British Columbia. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, B.C. 178 pp.

Allen, C.D.; Breshears, D.D. 1998. Drought-induced shift of a forest-woodland ecotone: rapid landscape response to climate variation. Proceedings of the National Academy of Sciences of the United States of America, Vol. 95, No. 25: 14839-14842.

Amman, G.D.; W.E. Cole. 1983. Mountain pine beetle dynamics in lodgepole pine forests part II: population dynamics. USDA Forest Service, Gen. Tech. Rep. INT-145. Intermountain Research Station, Ogden, UT: 59p.

Amman, G.D.; M.D. McGregor; D.B. Cahill; W.H. Klein. 1977. Guidelines for reducing the losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. USDA, Forest Service GTR-INT-36. Intermountain Forest and Range Experiment Station, Ogden, UT.

Arno, S.F.; D.J. Parsons; R.E. Keane. 2000. Mixed severity fire regimes in the Northern Rocky Mountains: consequences of fire exclusion and options for the future *in* Cole, D.N.; McCool, S.F.; Borrie, W.T; J. O'Loughlin, comps. Wilderness science in a time of change conference – Volume 5: Wilderness ecosystems, threats, and management; 1999 May 23-27; Missoula, MT. Proceedings RMRS-P-15-VP:-5. USDA Forest Service, Rocky Mountain Research Station, Ogden UT: 225-232.

Ayres, M.P.; M.J. Lombardero. 2000. Assessing the consequences of global change for forest. The Science of the Total Environment 262(2000): 263-286.

Bale, J.S.; G.J. Masters; I.D. Hodkinson; C. Awmack; M. Bezemer; V.K. Brown; J. Butterfield; A. Buse; J.C. Coulson.; J. Farrar; J.E.G. Good; R. Harrington; S. Hartley; T.H. Jones; R.L. Lindroth; M.C. Press; I. Symrnioudis; A.D. Watt; J.B. Whittaker. 2002. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. Global Change Biology (2002) 8: 1-16.

Beaubian, E.G.; H.J. Freeland. 2000. Spring phenology trends in Alberta, Canada: links to ocean temperature. International Journal of Biometeorology 44: 53–59.

Bentz, B.J.; J.A. Powell; J.A. Logan. 1996. Localized spatial and temporal attack dynamics of the mountain pine beetle in lodgepole pine. USDA, Forest Service INT-RP-494. Intermountain Research Station, Ogden, UT.

Bethlahmy, N. 1975. A Colorado episode: beetle epidemic, ghost forests, more streamflow. Northwest Science 49(2):95–105.

B.A. Blackwell & Associates Ltd.; R.W. Gray Consulting Ltd.; Compass Resource Management Ltd.; Forest Ecosystem Solutions Ltd. 2003. Developing a coarse scale approach to the assessment of forest fuel conditions in Southern British Columbia. http://www.for.gov.bc.ca/hfd/library/FIA/2003/FIA2003MR125.pdf

Blackwell, B.A.; F. Steele; R.W. Gray; K. Iverson; K. MacKenzie. 2001. Fire management plan Churn Creek Protected Area. Report to BC Parks, Cariboo District.

Blackwell, B.A.; R.W. Gray; R.N. Green; F.F. Figel; T.M. Berry; D.W. Ohlson; B. Hawkes. 2003. Development and Implementation of a Regional Scale Assessment of Fuel Conditions in Southern British Columbia. Contract report 2003.

British Columbia Ministry of Forests (BCMoF). 1995. Bark Beetle Management Guidebook. Forest Practices Code. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/beetle/betletoc.htm

British Columbia Ministry of Forests (BCMoF). 1995. Dwarf Mistletoe Management Guidebook. Forest Practices Code. URL: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/dwarf/dwarftoc.htm

British Columbia Ministry of Forests (BCMoF). 1995. Defoliator Management Guidebook, Forest Practices Code. URL: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/defoliat/defoltoc.htm

British Columbia Ministry of Forests (BCMoF). 2003. Forest Health, Okanagan Shuswap Forest District, Defoliators. URL: http://www.for.gov.bc.ca/dos/Programs/Forest_Health/Defoliators.htm

British Columbia Ministry of Forests and Range. 2004.. The State of British Columbia's Forests. URL: http://www.for.gov.bc.ca/hfp/sof/sof.htm

British Columbia Ministry of Forests (BCMoF) 2005. 2005 Overview of Forest Health in the Southern Interior Forest Region URL: http://www.for.gov.bc.ca/rsi/ForestHealth/PDF/2005Overviewpublication.pdf

Brown, P.M.; W.D. Shepperd; S.A. Mata; D.L. McClain. 1998. Longevity of windthrown logs in a subalpine forest of central Colorado. Canadian Journal of Forest Research 28(6): 932-936.

Canadian Forest Service. 2006 . Conifer Defoliating Insects of British Columbia: Dougla-fir Tussock Moth *Orgyia pseudotsugata* (McDunnough). URL: http://www.pfc.cfs.nrcan.gc.ca/entomology/defoliators/tussock_moths/douglas_fir_e .html

Cannings, R.A.; R.J. Cannings; S.G. Cannings. 1987. Birds of the Okanagan Valley, British Columbia. Royal British Columbia Museum.

Carroll, A.L.; L. Safranyik. 2003. The bionomics of the mountain pine beetle in lodgepole pine forests: establishing a context *in* Mountain Pine Beetle Symposium: Challenges and Solutions. October 30-31, 2003, Kelowna, British Columbia. *Edited by* T.L. Shore; J.E. Brooks; J.E. Stone, Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Information Report BC-X-399, Victoria, BC. 298pp

Carroll, A.L.; S.W. Taylor; J. Régnière; L. Safranyik. 2003. Effects of climate change on range expansion by the mountain pine beetle in British Columbia *in* Mountain Pine Beetle Symposium: Challenges and Solutions. October 30-31, 2003, Kelowna, British Columbia: pp. 223-232. *Edited by* T.L. Shore, J.E. Brooks, and J.E. Stone, Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Information Report BC-X-399, Victoria, BC. 298pp.

Cheng, J.D; B.G. Bondar. 1984. Impact of a severe forest fire on streamflow regime and sediment productions *in* Proceedings of the Canadian Hydrology Symposium No.15–1984: Water Quality Evolution within the Hydrological Cycle of Watersheds. Université Laval, Quebec City, Quebec. National Research Council of Canada, Ottawa, Ontario. Volume II:843–859.

Christensen, N. L.; A.M. Bartuska; J.H. Brown; S. Carpenter; C. D'Antonio; R. Francis; J.F. Franklin; J.A. MacMohon; R.F. Noss; D.J. Parsons; C.H. Peterson; M.G. Turner; R.G. Woodmansee. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. Ecological Applications 6(3): 665-691.

Clark, D. F.; D.D. Kneeshaw; P.J. Burton; J.A. Antos. 1998. Coarse woody debris in sub-boreal spruce forests of westcentral British Columbia. Canadian Journal of Forest Research 28: 284-290.

Cole, W.E.; G.D. Amman. 1969. Mountain pine beetle infestations in relation to lodgepole pine diameters. USDA Forest Service Research Note INT-95: 7p.

Cruickshank, M.G.; D.J. Morrison; Z.K. Punja. 1997. Incidence of *Armillaria* species in precommercial thinning stumps and spread of *Armillaria ostoyae* to adjacent Douglas-fir trees. Canadian Journal of Forest Research: 27, 481-490.

Dale, V.H.; L.A. Joyce; S. McNulty; R.P. Neilson. 2000. The interplay between climate change, forests, and disturbances. The Science of the Total Environment 262 (2000): 201-204.

Daniels, L.D.; E. Watson. 2003. Climate-fire-vegetation interactions in the Cariboo Forests: A dendrochronological analysis. Forest Innovation and Investment Forest Research Program. Final report.

Dekker-Robertson, D.; P. Griessmann; D. Baumgartner; D. Hanley. 2005. Forest Health Notes: A Series for the Non-Industrial Private Forest Landowner. Elytroderma Needle Cast. Washington State University, Cooperative Extension – Department of Natural Resource Sciences Extension. http://ext.nrs.wsu.edu/forestryext/foresthealth/notes/elytrodermacast.htm

DeMars, C.J.; B.H. Roettgering. 1982. Western Pine Beetle. Forest Insect and Disease Leaflet 1. U.S. Dept. of Agriculture Forest Service.

Dukes, J.S.; H.A. Mooney. 1999. Does global change increase the success of biological invaders? Tree 14(4):135-139.

Elkin, C. 2001. Does habitat choice by mountain pine beetles vary with population density? Research Links; A forum for natural, cultural and social studies. Volume 9(2): 8-11.

Eng, M.; A. Fall; J. Hughes; T. Shore; B. Riel; A. Walton; P. Hall. 2006. Provincial-level projection of the current mountain pine beetle outbreak: update of the infestation projection based on the 2005 provincial aerial overview of forest health and revisions to "the model" (BCMPB.v3). www.for.gov.bc.ca/hre/bcmpb/BCMPB.v3.BeetleProjection.Update.pdf

Environment Canada. 1994. Alien Species Focus Group *in* Mosquin, T. 1997. Management guidelines for invasive exotic species in Canada's national parks. Parks Canada, Ottowa: http://www.ecospherics.net/AlienSpecnew.htm

Fellin, D.G. 1979. A review of some interactions between harvesting, residue management, fire and forest insect and diseases. USDA For. Ser. Gen. Tech. Rep. INT-90. pp. 335-414.

Filip, G.M.; L. Yang-Erve. 1997. Effects of prescribed burning on the viability of Armillaria ostoyae in mixed-conifer forest soils in the Blue Mountains of Oregon. Northwest Science: Vol. 71 (2), 137-144.

Finck, K. E.; P. Humphreys; G. Hawkins. 1989. Field Guide to Pests of Managed Forests in British Columbia. Joint Publication No. 16. Forestry Canada, Pacific forestry Centre, British Columbia Ministry of Forests, Forest Pest Review Committee of British Columbia, Victoria, BC.

Fleming, R.A.; Candau, J-N. 1998. Influences of climatic change on some ecological processes of an insect outbreak system in Canada's boreal forests and the implications for biodiversity. Environmental Monitoring and Assessment 49: 235-249.

Fleming, R.A.; W.J.A. Volney. 1995. Effects of climate change on insect defoliator population processes in canada's boreal forest: some plausible scenarios. Water, Air and Soil Pollution 82: 445-454.

Flowers, R. 1999. Douglas-fir tussock moth (*Orgyia pseudotsugata*). Forest Health Note, Oregon Dept. of Forestry. Forest Health Program. 3pp. http://www.oregon.gov/ODF/PRIVATE_FORESTS/docs/fh/tuskmoth.pdf

Forest Practices Board. 2004. Evaluating mountain pine beetle management in British Columbia. Forest Practices Board, Special Report, FPB/SR/20: 64p.

Foster, D. R.; D.H. Knight; J.F. Franklin. 1998. Landscape patterns and legacies resulting from large, infrequent forest disturbances. Ecosystems 1: 497-510.

Fuchs, M. 1999. The ecological role of the mountain pine beetle (Dendroctonus ponderosae): a description of research from the literature. Prepared by Foxtree Ecological Consulting for British Columbia Parks Service, Victoria, BC.

Gara, R.I.; W.R. Littke; J.K. Agee; D.R. Geiszler; J.D. Stuart; C.H. Driver. 1985. Influence of fires, fungi, and mountain pine beetles on development of a lodgepole pine forest in south-central Oregon in D. Baumgartner; R. Krebill; J. Arnott; G. Weetman, editors, Lodgepole pine, the species and its management. Pullman: Washington State University Office of Conferences and Institutes: 153-162.

Gray, R.W., E.H. Riccius, and C. Wong. 1998. Comparison of current and historic stand structure in two IDFdm2 sites in the Rocky Mountain Trench. R.W. Gray Consulting, Ltd., Chilliwack, B.C.

Harr, R.D.; R.L. Fredriksen. 1988. Water quality after logging small watersheds within the Bull Run watershed, Oregon. Water Resources Bulletin 24(5):1103–1111.

Hebda, R.J., 1997, Impact of climate change on biogeoclimatic zones of British Columbia and Yukon, *in* Responding to Global Climate Change in British Columbia and Yukon, *Edited by* E. Taylor and B. Taylor; Environment Canada and British Columbia Ministry of Environment, Lands and Parks, p. 13-1-13-15.

Henigman, J.; Ebata, T.; Allen, E.; Westfall, J.; Pollard, A. 2001. Field Guide to Forest Damage in British Columbia. 2nd Ed. Joint publn. No. 17. Co-published by BC Ministry of Forests and Canadian Forest Service, Victoria, B.C.

Humble, L.M.; E.A. Allen. 2004. Alien invaders: non-indigenous species in urban forests in Sixth Canadian Urban Forest Conference, October 19-23, 2004, Kelowna, B.C. pp. 6-1-6-17.

Hynum, B.G.; A.A. Berryman. 1980. Dendroctonus ponderosae: Pre-aggregation landing and gallery initiation on lodgepole pine. Canadian Entomologist: 10, 842-846.

Intergovernmental Panel on Climate Change (IPCC). 2001. Climate Change 2001: Synthesis Report. A contribution of working groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. *Edited by* Watson, R.T. and the Core Writing Teams. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 pp.

Iverson, K.; C. Cadrin. 2003. Sensitive ecosystem inventory – Central Okanagan 2000-2001. Volume 1: Methodology, ecological descriptions, results and conservation tools. Canadian Wildlife Service, Environmental Conservation Branch, Pacific and Yukon Region.

Iverson, K.E.; R.W. Gray; B.A. Blackwell; C.M. Wong; K.L. MacKenzie. 2002. Past fire regimes in the interior Douglas-fir, Dry Cool Subzone, Fraser Variant (IDFdk3). Report to Lignum Ltd.

Jackson, P.; G. Spomer. 1979. Biophysical adaptations of four western conifers to habitat water conditions. Botanical Gazette, Vol. 140, No. 4, pp. 428-432.

Johnston, M. 2001. Sensitivity of Boreal Forest Landscapes to Climate Change. Prepared for the Government of Canada's Climate Change Action Fund. Saskatchewan Research Council, Saskatoon, SK. SRC Publication No. 11341-7E01.

Johnston, M. 2004. Impacts and adaptation for climate change in urban forests *in* 6th Canadian Urban Forest Conference. October 19-23, 2004. Kelowna, B.C. pp. 3-1 – 3-14.

Koch, P. 1996. Lodgepole pine commercial forests: an essay comparing the natural cycle of insect kill and subsequent wildfire with management for utilization and wildlife. USDA For. Ser. Gen. Tech. Rep. INT-342: 24p.

Lloyd, D.; K. Angove; G. Hope; C. Thompson. 1990. A Guide to Site Identification and interpretation for the Kamloops Region. Part 1. British Columbia Ministry of Forests.

Lundquist, J.E.; J.F. Negron. 2000. Endemic forest disturbances and stand structure of ponderosa pine (Pinus ponderosa) in the Upper Pine Creek Research Natural Area, South Dakota, USA. Nat. Areas J. 20:126–132.

Machmer, M.M.; C. Steeger. 1995. The ecological roles of wildlife tree users in forest ecosystems. Land Management Handbook 35. British Columbia Ministry of Forests, Victoria, BC. 54pp.

Mallet, K.I. 1990. Host range and geographic distribution of Armillaria root rot pathogens in the Canadian prairie provinces. Canadian Journal of Forest Research: 20, 1859-1863.

Manning, T.; P. Bradford; C. White; D. Rowe; N. Densmore; S. Guy. 2002. British Columbia's dangerous tree assessment process. USDA Forest Service Gen. Tech. Rep. PSW-GTR-181, pp 863-868.

Manning, T. 2001. Dangerous tree report: destructive sampling field project. Report prepared for I.W.A. Canada-Forest Industry SAFER Council, Weyerhaeuser – B.C. Coastal Group, Ministry of Forests. www.safer.ca/Dangerous%20Tree%20Report.pdf

Mattson, W.J.; R.A. Haack. 1987. The role of drought in outbreaks of plant-eating insects. BioScience 37(2): 110-118.

McLauchlan, L. pers. comm., October 5th, 2006. Beetle taskforce meeting. City of Kelowna.

McMullen, L.H. 1984. Douglas-fir beetle in British Columbia. Can. For. Serv., Pac. For. Res. Cent., For. Pest Leafl. 14. 6 p

Mitchell, R.G.; R.E. Martin. 1980. Fire and insects in pine culture of the Pacific Northwest *in* Proceedings of the sixth conference on fire and forest meteorology. Seattle, Washington, 1980 Apr 22. Society of American Foresters, Washington, D.C: 182-190

Morrison, D. 2000. Armillaria root disease: A major impediment to sustainable management of southern Interior ecosystems *in* Proceedings, From science to management and back: a science forum for southern interior ecosystems in British Columbia. C. Hollstedt, K. Sutherland, and T. Innes, editors. Southern Interior Forest Extension and Research Partnership, Kamloops, BC: pp. 23-26.

Morrison, D.; K. Mallet. 1996. Silvicultural management of armillaria root disease in western Canadian forests. Can. J. Plant Pathol. 18: 194-199.

Morrison, M. L.; M.G. Raphael. 1993. Modeling the dynamics of snags. Ecological Applications 3(2): 322-330.

Ono, H. 2003. The mountain pine beetle: scope of the problem and key issues in Alberta *in* Mountain Pine Beetle Symposium: Challenges and Solutions. October 30-31, 2003, Kelowna, British Columbia. Pp. 62-66. *Edited by* T.L. Shore, J.E. Brooks, and J.E. Stone , Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Information Report BC-X-399, Victoria, BC. 298pp.

Perry, D.A. 1994. Forest ecosystems. The John Hopkins University Press, Baltimore, MA.

Pherotech. 2001. Forest health survey of RDCO Parks. RDCO, consultant report.

Potts, D.F. 1984. Hydrologic impacts of a large-scale mountain pine beetle Dendroctonus Ponderosae Hokins) epidemic. Water Resources Bulletin 20(3): 373–377.

Price, M.F. 1991. An assessment of patterns of use and management of mountain forests in Colorado, USA: implications for future policies. Transformations of mountain environments, 11(1): 57-64.

Province of British Columbia. 1972. Okanagan Basin Agreement Annual Report.

Pyne, S.J., P.L. Andrews, and R.D. Laven. 1996. Introduction to Wildland Fire, 2nd Edition. New York: John Wiley & Sons, Inc.

Regional District of Central Okanagan (RDCO). 2002 Regional Growth Strategy - Environmental Protection Discussion Paper. http://www.regionaldistrict.com/docs/planning/pl_en_dis.pdf

Riccius, E.H. 1998. Scale issues in the fire history of a fine grained landscape. MRM thesis. Simon Fraser Univ., Burnaby, B.C.

Robinson, R.M.; D.J. Morrison. 2001. Lesion formation and host response to infection by Armillaria ostoyae in the roots of western larch and Douglas-fir Forest Pathology 31 (6), 371–385.

Roed, M.A. 1995. Geology of the Kelowna area and origin of the Okanagan valley, British Columbia. Kelowna Geology Committee, Kelowna, BC.

Rodriguez, D. J.; L. Torres-Sorando. 2001. Models of infectious diseases in spatially heterogeneous environments. Bulletin of Mathematical Biology 63: 547-571.

Rogers, P. 1996. Disturbance ecology and forest management: a review of the literature. General Technical Report INT-GTR- 336. Intermountain Research Station, Forest Service, USDA, Ogden, UT.

Roy, J.; B. Saugier; H. Mooney. [eds.]. 2001. Terrestrial Global Productivity Academic Press, San Diego, USA.

Safranyik, L. 1978. Effects of climate and weather on mountain pine beetle populations. pp 77084. In A. Berryman, G.D. Amman, R.W Stark [eds.], Proceedings, Symposium: Theory and Practice of Mountain Pine Beetle Management in Lodgepole Pine Forests, 25-27 April 197, Moscow, ID. University of Idaho Forest, Wildlife and Range Experiment Station, Moscow.

Safranyik, L. 1989. Mountain pine beetle: biology overview *in* Amman, G.D. [ed.], Proceedings, Symposium on the management of lodgepole pine to minimize losses to the mountain pine beetle, USDA For. Ser. Gen. Tech. Rep. INT-262: 9-13.

Samman, S.; J. Logan. 2000. Assessment and Response to Bark Beetle Outbreaks in the Rocky Mountain Area. Report to Congress from Forest Health Protection. 46 p.

Scherer, R.; R.G. Pike. 2003. Effect of forest management activities on streaflow in the Okanagan Basin: Outcomes of a literature review and a workshop. Forrex Series 9.

Schowalter, T.D.; R.N. Coulson; D.A. Crossley. 1981. Role of the southern pine beetle and fire in maintenance of structure and function of the southeastern coniferous forest. Environmental Entomology, 10(6): 821-825.

Shaw, C.G.; G. A. Kile. (Eds.). 1991. Armillaria root disease. Agriculture Handbook No. 691. USDA, Forest Service, Washington, DC: 233p.

Smith, R. H. 1971. Red Turpentine Beetle. Forest and Range Experiment Station, USDA. Forest Service. Forest Pest Leaflet 55. US Department of Agriulture. Forest Service. Revised May 1971. www.fs.fed.us/r6/nr/fid/fidls/redturp.pdf

Stadt, J. 2001. The ecological role of beetle-killed trees: a review of salvage impacts. British Columbia Ministry of Water, Land and Air Protection, Habitat Protection, Skeena Region, Burns Lake, BC.

Steeger, C.; M.M. Machmer; B. Gowans. 1998. Impact of insectivorous birds on bark beetles: a literature review. Pandion Ecological Research, Ymir, BC.

Stock, A.; M. Duthie-Holt.; S. Walsh; J. Turner; K. Swift. 2005. Southern Interior Forest Region: Forest Health Stand Establishment Decision Aids. BC Journal of Ecosystems and Management 6(1):55-73. URL: www.forrex.org/jem/2005/vol6/no1/vol6_no1_art6.pdf

Turner, M. G.; R.H. Gardner; V.H. Dale; R.V. O'Neill. 1989. Predicting the spread of disturbance across heterogeneous landscapes. Oikos 55: 121-129.

Turner, M. G.; W.H. Romme. 1994. Landscape dynamics in crown fire ecosystems. Landscape Ecology 9(1): 59-77.

Unger, L. 1992. Dwarf Mistletoes. Forest Insect and Disease Survey, Forest Pest Leaflet No. 44, 7p. Forestry Canada

Unger, L. 1993. Mountain Pine Beetle. Pacific Forestry Centre, Forest Pest Leaflet. Cat.No. Fo 29-6/76-1993E: 7p.

Unger, L. 1995. Spruce budworms. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Forest Pest Leaflet 31, Copublished by the BC Ministry of Forests.

Volney, W.J.A.; R.A. Fleming. 2000. Climate change and impacts of boreal forest insects. Agriculture, Ecosystems and Environment 82 (2000): 283-294.

WeedsBC. 2002. Seven Steps to Managing your Weeds, A Manual for Integrated Weed Management in British Columbia. Open Learning Agency in cooperation with the British Columbia Ministry of Agriculture, Food and Fisheries. 58pp. URL: http://www.weedsbc.ca/resources.html.

Whitehead, R.J.; P. Martin; A. Powelson. 2001. Reducing stand and landscape susceptibility to mountain pine beetle. British Columbia Ministry of Forests, Victoria, BC.

Wickman, B. E.; R.M. Richard; G.C. Trostle. 1981. Douglas-fir Tussock Moth. Forest Insect and Disease Leaflet 86, UDA Forest Service.

Williams, D.W.; A.M. Liebhold. 2002. Climate change and the outbreak ranges of two North American bark beetles. Agricultural and Forest Entomology 4: 87-100.

Wong, C. 2001. Towards a taxonomy of natural disturbances in British Columbia. Prepared for B.C. Min. For., Res. Br., Victoria, B.C.

Wong, C.; B. Dorner; H. Sandmann. 2003. Estimating historical variability of natural disturbances in British Columbia. B.C. Min. For., Res. Br., B.C. Min. Sustain. Resource. Manage., Resource Plan. Br., Victoria, B.C. Land Manage. Handbook No. 53.

Zhang, Q.; F. Schlyter. 2003. Redundancy, synergism, and active inhibitory range of non-host volatiles in reducing pheromone attraction in European spruce bark beetle Ips typographus. Oikos 101: 299-310.

Zhang, J.W.; Z. Feng; B. Cregg; C. Schumann. 1997 Carbon isotopic composition, gas exchange and growth of three populations of ponderosa pine differing in drought tolerance. Tree physiol. 17(7):461-6.

Zhou,L.; C.J. Tucker; R.K. Kaufmann; D. Slayback; N.V. Shabanov; I.A. Fung; R.B. Myneni. 2001. Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999. Journal of Geophysical Research – Atmoshperes 106: 20,069-20,083.

Appendix 1 – Mission Creek Regional Park Restoration Pilot Project

RDCO
Urban Forest Health Strategy and Management Plan
Mission Creek Regional Park Restoration Pilot Project

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September, 2006

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REGIONAL DISTRICT OF CENTRAL OKANAGAN

URBAN FOREST HEALTH STRATEGY AND MANAGEMENT PLAN

Mission Creek Regional Park Restoration Pilot Project

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1.0 Objectives

Natural disturbance agents such as forest insects and pathogens, and wildfire play a major role in British Columbia's dry interior ecosystems. The Central Okanagan's regional park system has incurred a substantial number of tree mortality recently, primarily as a result of the Western Pine Beetle (*Dendroctonus brevicomis* LeConte) and the Okanagan Mountain Provincial Park fire. Two additional factors indicate that tree mortality, particularly in ponderosa pine, will continue to be a major management concern for the Regional District of Central Okanagan (RDCO) parks system. These are:

- The Mountain Pine Beetle, which is projected to impact the central Okanagan in the next several years and is likely to cause a high level of pine mortality; and
- Summer drought stress, which may become more common due to regional climate changes, can directly cause tree mortality or result in a greater number of trees being susceptible to attack from pests and pathogens.

This pilot project plan is designed to restore a small area, hereafter referred to as the 'site', of Mission Creek Regional Park. The site is located in the southwest corner of Mission Creek Regional Park (Figure 1). Western Pine Beetle has caused a high level of tree mortality and, subsequently, tree removals have occurred on the site. Weed species have also invaded the site and the numbers of natural regeneration are not considered sufficient to establish a new forest. The primary objectives of this plan are:

1. To reforest and restore an area in Mission Creek Regional Park impacted by tree removal associated with the current Western Pine Beetle outbreak.
2. To create a vigorous and healthy native forest cover that is ecologically appropriate and resilient to future outbreaks of pest and diseases.
3. To create a forest with low susceptibility to future insect outbreaks.
4. To create forest conditions with low fire behavior potential and associated interface fire hazard.

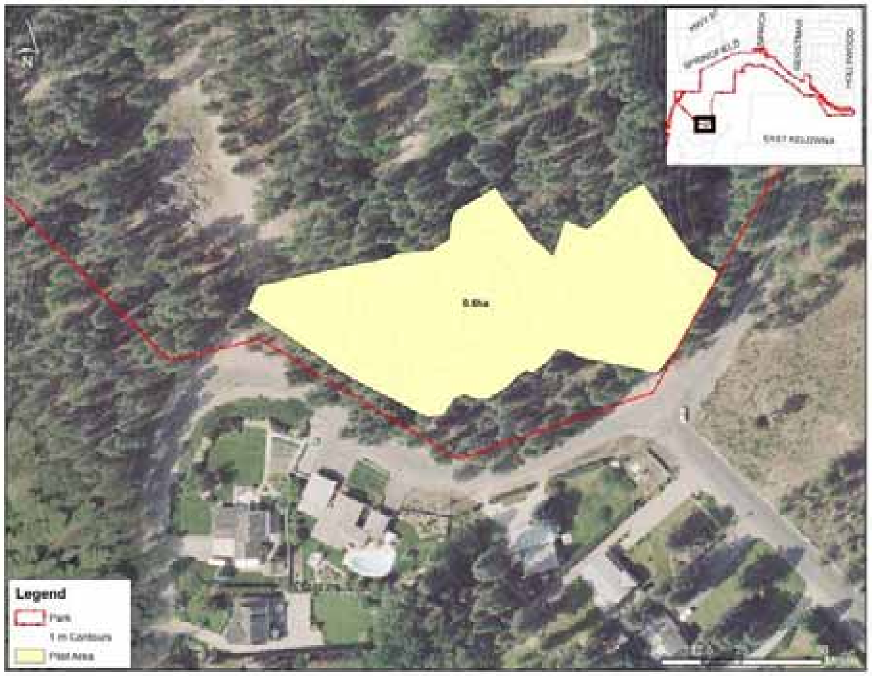

Figure 1. Map of Mission Creek Regional Park Pilot Area Site

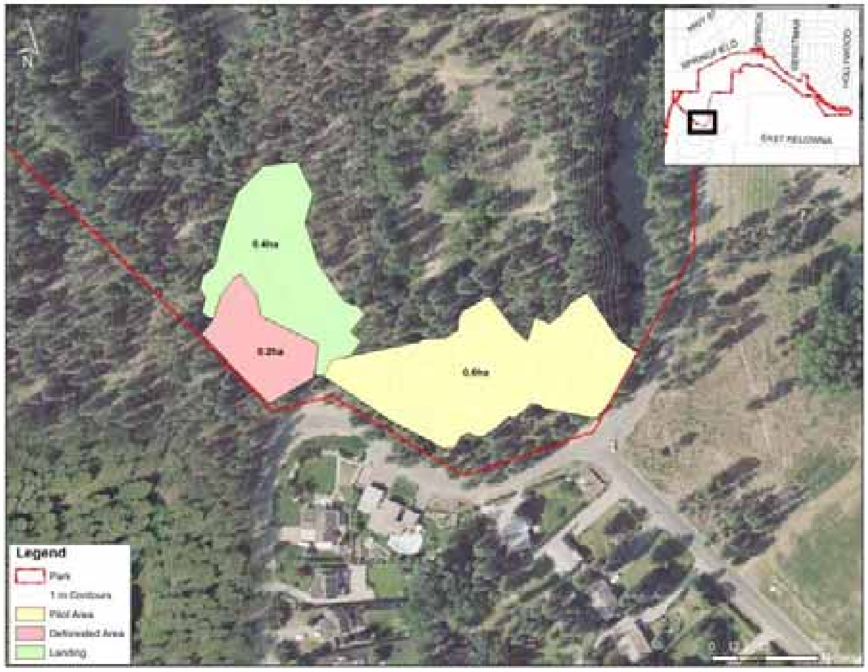

Figure 2. Map of Mission Creek Regional Park Pilot Area Site and Adjacent Degraded Areas

2.0 Ecological Site Description

The site is located within the Okanagan very dry hot ponderosa pine variant (PPxh1) on a mid-slope position. The PPxh1 variant occurs, in elevation, above the BGxh1 and below the IDFxh1, and is the driest forested subzone in British Columbia. The site is flat to gently rolling and is located within the mesic phase of the Py – Bluebunch wheatgrass – Rough fescue site series (PPxh1/05). The overstory is dominated by ponderosa pine (*Pinus ponderosa* Douglas ex Lawson) with a minor component of Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco var. *glauca* [Beissn] Franco). Tables 1 – 3 summarize the ecological attributes, soil characteristics and understory species recorded at the site.

Table 1. Ecological Site Description Attributes

Biogeoclimatic and ecological classification	Soil moisture/ nutrient regime	Dominant (subdominant) tree species	Latitude/ Longitude	Elevation	Slope (%) and aspect	Terrain Class
PPxh1/05	4/C	Py(Fd)	49°52'14.51/ 119°26'4.79	365 m	Flat	Morainal

Table 2. Site Soil Characteristics

Soil Texture	Geology	Coarse Fragments	Humus Form	Forest Floor Depth	Drainage
Fine Sand	Granitic	25%	Mor	<1 cm	Well-rapid

Table 3. Understory Species Recorded at the Site (not exhaustive)

Rosa nutkana	Nootka rose
Amelanchier alnifolia	saskatoon
Symphoricarpos albus	common snowberry
Achillea millefolium	yarrow
Agropyron spicatum	bluebunch wheatgrass
Calamagrostis rubescens	pinegrass

3.0 Restoration Plan

Given the low numbers of natural regeneration associated with the tree removal area it is necessary to develop a restoration plan that includes artificial regeneration. The plan needs to consider the preferred and acceptable species considering a number of factors including:

- Changes in regional climate;
- Resistance to future insect and disease outbreaks; and
- Fire behavior potential and associated interface fire hazards.

Prior to human settlement frequent low severity fires resulted in an uneven aged forest that was maintained in equilibrium. Stocking levels remained fairly constant with few disturbance events that resulted in wide spread stand replacement. The goal of the stocking requirements and planting plan is to develop forest structure that is closer to historic conditions and that will result in a stable and sustainable forest ecosystem. The following restoration plan has four key elements that include stocking standards, planting quality, additional requirements and invasive species management.

3.1 Stocking standards

Tree Species		Spacing (sph)	
Primary Species	Secondary Species	Minimum	Target
Py (Ponderosa Pine)	Act (Black Cottonwood)	150	300
Other Requirements:			
Where stocking levels fall below 80% after year 1, 3, 5 or 10 as determined by a survey, consider fill planting. Where stocking levels fall below 50% after year 1, 3, 5 or 10 as determined by a survey, consider a replant. Where stocking levels exceed 300 sph as determined by a survey after year 1, 3, 5 or 10, consider thinning to target densities.			

<u>Rationale for Choice of Stocking Requirements</u>

These stocking standards developed for the pilot area in Mission Creek are lower than those prescribed by the Tree Species Selection and Free Growing Stocking Standard Guidelines for British Columbia (Target 400, Minimum 200) by the Ministry of Forests. This plan calls for fewer stems per hectare (sph) on the basis that this site historically experienced a frequent low severity fire regime that would have maintained a low density, open forest. An ocular stump survey indicated that the older, larger diameter ponderosa pine trees were stocked at less than 200 sph. The stump survey and adjacent forested area indicated that the total stems per hectare prior to the tree removal were in the range of 400 to 700 stems per hectare. This density was likely due to ingrowth resulting from effective fire suppression and limited disturbance over the past 60 years. The absence of frequent low severity fire enabled seedlings to establish in the understory and reach reproductive maturity resulting in a higher density forest structure than was historically present. This higher density forest structure is more susceptible to pathogens and disease due to increased moisture and nutrient competition and at the same time is more susceptible to high severity stand replacing fire. The stocking requirements in this plan aim to mimic historic stand structure and density. Figure 3 shows a schematic representation of how the site's structure is thought to have changed over time, and how it is proposed to change as a result of the implementation of this plan. A number of benefits are perceived from the prescribed stocking at lower densities. These include:

- reduced competition for moisture and nutrients resulting in a more vigorous overstory that is less susceptible to drought stress, insect attack and pathogens;
- reduced crown fire potential due to greater space between tree crowns; and
- reduced shading resulting in a more vigorous understory for improved biodiversity and habitat value.

The stocking requirements also call for a component of black cottonwood (*Populus balsamifera* ssp. *Trichocarpa* Torr. & Grat ex Hook.) to be planted with the ponderosa pine. Black cottonwood occurs naturally in forested areas adjacent to the site, which indicates that it is an appropriate species to plant in the wetter portions of the site (swales and moisture receiving zones). The benefits perceived from stocking black cottonwood are:

- greater biodiversity resulting in greater overall stand resilience to pest and pathogen attack;
- foliage is higher in foliar nutrients therefore leaf fall will improve nutrient cycling and forest floor development; and
- as a deciduous species cottonwood is a more resistant to fire ignition and reduces fire behaviour potential.

While there was some Douglas-fir (Fd) in the overstory stands immediately adjacent to the treatment area, and it is considered a minor natural stand component, a number of naturally regenerating seedlings were found in the tree removal area. It is expected that sufficient Douglas fir seedlings will survive to maturity and that this stocking will provide a component of fir in the stand. Therefore, no planting of Douglas-fir is prescribed in the restoration plan.

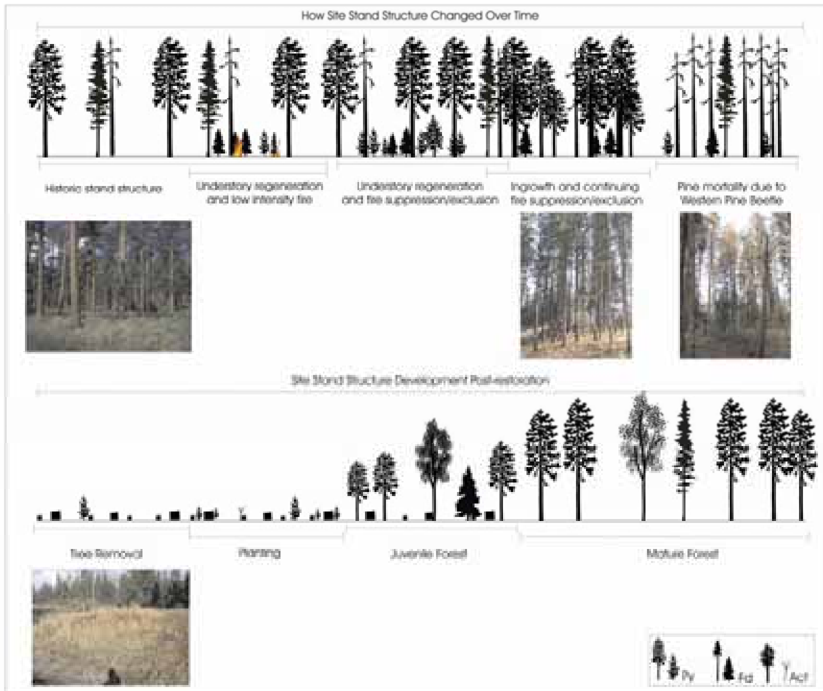

Figure 3. Schematic representation of the site's forest structure changing over time

3.2 Planting Guidelines

Plant ponderosa pine (Py) (80%) and cottonwood (Act)(20%) at a target density of 300 sph (minimum density of 150 sph). The site brush hazard is considered low; therefore brushing is not likely required. Retain naturals (*i.e.*, do not remove any existing seedlings of Py or Fd). Space planted stock a minimum of 1 m from any established naturals (>30 cm in height). Plant Act in moisture receiving sites (*i.e.*, in the swales and draws). Plant Py as variably spaced single stems and or clusters of two to three trees (minimum spacing 1.5 m) adjacent to larger stumps in order to mimic historic distribution and stocking (Figure 4). Completely excavate the planting cavity and backfill seedlings to top of plug.

Species	Stock			Height	Amount	Seedlot Number	Sow (HVST +/-)	Plant (HVST +)	Plant Season
	Age	Type	CTNR						
Ponderosa pine (Py)	1+1.5	PSB	412	30 cm	240		n/a	n/a	Fall 2006
Black cottonwood (Act)	1.5+0	PSB	412	30 cm	60	Locally Collected	n/a	n/a	Fall 2006

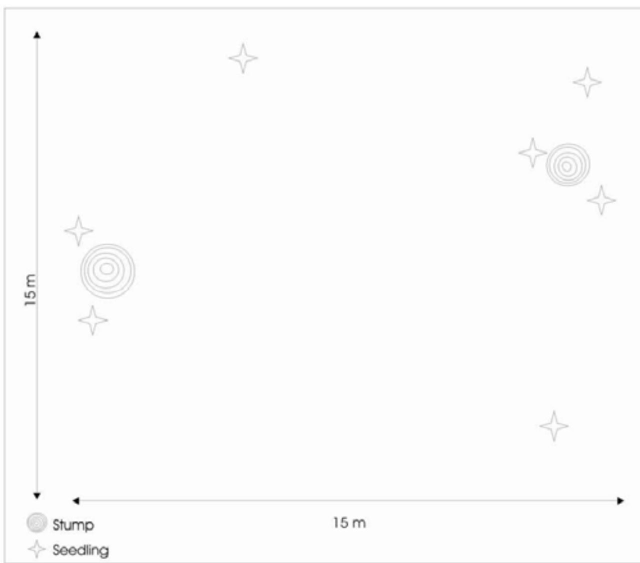

Figure 4. Diagrammatic example of proposed irregular spacing and density.

3.3 Additional Requirements

To increase the probability of seedling survival and early growth it is recommended that seedlings be fertilized by placing a package of slow release fertilizer (One T-bag/ seedling

18-9-9-9) in the soil near the seedling at the time of planting. The tea bag fertilization will improve the overall survival and growth performance of seedlings during the plantation and establishment phase. While tea bag fertilization may be desirable for planting projects both large and small, costs may prohibit their use on larger scale projects within the Regional Parks system.

3.3.1 Landing and Debris

Adjacent to the restoration site is a landing that has been used to store and accumulate trees and debris associated with tree removals throughout the park (Figure 5). This area has been degraded by compaction and has significant accumulations of chips, woody debris and soil that have impacted the site. It is recommended that the chips, woody debris and soil should be removed from the site. Given that future tree removals are expected, that landing should be maintained but debris management should be more carefully controlled in the future to avoid attracting beetles and other pest that could impact the adjacent forested areas of the park.

Figure 5. Landing and debris piles adjacent to the restoration site.

3.4 Invasive Species Management

If invasive species are observed at >20% cover, these should be hand pulled prior to planting or treated using alternative methods including herbicides, grazing, mechanical methods, prescribed burning and or forms of biocontrol that are species specific. Table 4 provides a list of invasive species that are found in the Okanagan. Not all of these species were observed on site, however, any of these species could potentially occur there. The Guide to Weeds in BC contains descriptions and illustrations for each weed listed in Table 4. It can be downloaded from http://www.weedsbc.ca/resources.html.

Table 4. A list of invasive species common to the Okanagan Region.

Invasive Species		
Annual Sow Thistle	Flixweed	Redroot Pigweed
Barnyard Grass	Green Foxtail	Rush Skeletonweed
Black Nightshade	Hairy Nightshade	Russian Knapweed
Blue Mustard	Hemp Nettle	Russian Thistle
Blueweed	Hoary Alyssum	Scentless Chamomile
Bull Thistle	Hoary Cress	Scotch Thistle

Invasive Species		
Canada Thistle	Hound's-tongue	Sheep Sorrel
Cheatgrass	Kochia	Shepherd's-purse
Chicory	Lady's-thumb	Spotted Knapweed
Cleavers	Lamb's-quarters	St. John's-wort
Common Bugloss	Leafy Spurge	Stork's-bill
Common Burdock	Meadow Knapweed	Sulphur Cinquefoil
Common Chickweed	Night-flowering catchfly	Tansy Ragwort
Common Groundsel	Nodding Thistle	Water Hemlock
Common Tansy	Orange Hawksweed	White Cockle
Corn Spurry	Oxeye Daisy	Wild Mustart
Curled Dock	Parasitic Dodder	Wild Oats
Dalmation Toadflax	Perennial Sow Thistle	Wild Proso Millet
Diffuse Knapweed	Poison Hemlock	Yellow Toadflax
Field Bindweed	Puncture vine	
Field Horsetail	Purple Loosestrife	
Field Scabious	Quackgrass	

4.0 Monitoring

A regeneration survey, to B.C. Ministry of Forests standards, should be conducted at 1, 3, 5 and 10 years following planting to monitor stocking densities, species composition, brush hazards and to ensure that prescribed stocking levels are maintained. In addition, the cause of any tree damage or mortality should be recorded. Weed surveys should be conducted simultaneously to monitor the number and species of weeds that occur and to determine whether weed removal treatments are required. The purpose of these surveys is to assess whether or not the restoration plan has been effective and whether changes are required in order to achieve the plan's objectives. The data will provide a valuable inventory of tree health and weed presence on the site that can be used to improve restoration strategies throughout the parks system.

Appendix 2 – Woodhaven Nature Conservancy

RDCO
Urban Forest Health Strategy and Management Plan
Woodhaven Nature Conservancy

Submitted By

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October, 2006

B.A. Blackwell
& Associates Ltd.

REGIONAL DISTRICT OF CENTRAL OKANAGAN

URBAN FOREST HEALTH STRATEGY AND MANAGEMENT PLAN

Woodhaven Nature Conservancy Restoration Plan

Submitted by:

B.A. Blackwell and Associates Ltd.
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Submitted to:

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October 2006

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1.0 Objectives

Natural disturbance agents such as forest insects, pathogens and wildfire play a major role in British Columbia's dry interior forest ecosystems. The Central Okanagan's regional park system has been impacted by significant tree mortality recently, primarily as a result of insect and disease pressures, historic fire suppression and regional drought.

The Woodhaven Nature Conservancy has a smaller percentage of ponderosa pine than is generally found within other RDCO parks. The park is dominated by Douglasfir, mixed Douglas-fir and cottonwood types, and western red cedar. Forest health of the area has been impacted by a combination of changes to the site hydrology, drought, Armillaria root disease (*Armillaria ostoyae* [Romangn.] Herink) and Douglas-fir beetles (*Dendroctonus pseudotsugae* [Hopkins]). All of these factors have been associated with endemic tree mortality within the park. In addition, large, senescent black cottonwood trees are at the end of their ecological rotation and, given the current level of rot and disease, are considered hazard trees. These trees pose a significant safety risk to park visitors and need to be topped and or removed if the park is to remain open to visitors. This restoration plan contains strategies to address both forest health and safety issues within the park.

The primary objectives of this plan are:

1. To define a process for identification and removal of hazard trees throughout the park area;
2. To improve the resilience of the forest to drought and future outbreaks of pest and diseases; and,
3. To create forest conditions with reduced fire behavior potential and associated interface fire hazard.

Ecological Site Description

The site is located within the Okanagan very dry hot ponderosa pine variant (PPxh1) on a lower-slope position. The PPxh1 variant occurs, in elevation, above the BGxh1 and below the IDFxh1, and is the driest forested subzone in British Columbia. The site is flat and is located within the subhygric phase of the FdPy – Snowberry – Spirea site series (PPxh1/07). The overstory is dominated by Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco var. *glauca* [Beissn] Franco) with lesser components of black cottonwood (*Populus balsamifera* ssp. *trichocarpa* [Torr. & Gray ex Hook.] Brayshaw) western red cedar (*Thuja plicata* Donn ex D. Don.) and a minor component of ponderosa pine (*Pinus ponderosa* Doug. ex Laws.). Tables 1 – 3 summarize the ecological attributes, soil characteristics and understory species.

Table 1. Ecological Site Description Attributes

Biogeoclimatic and ecological classification	Soil moisture/ nutrient regime	Dominant (subdominant) tree species	Latitude/ Longitude	Elevation	Slope (%) and aspect	Terrain Class
PPxh1/07	5/C-D	FdAtCw(Py)	49°48'40" 119°28'7"	420 m	Flat	Fluvial

Table 2. Site Soil Characteristics

Soil Texture	Geology	Coarse Fragments	Humus Form	Forest Floor Depth	Drainage
Sandy Loam	Granitic	25%	Mor/Moder	<7 cm	Poor-Moderate

Table 3. Understory Species Recorded at the Site (not exhaustive)

Rosa nutkana	Nootka rose
Amelanchier alnifolia	saskatoon
Symphoricarpos albus	common snowberry
Mahonia aquifolium	tall Oregon-grape

2.0 Restoration Plan

2.1 Hazard Tree Removal

Woodhaven Nature Conservancy (Figure 4) is a natural area park and should be managed in a way that maintains ecological values through limited human intervention. However, the hazardous condition of many trees in the park necessitates intervention if Woodhaven Nature Conservancy is to remain open to park visitors.

Senescent (dying) black cottonwoods are a major hazard within Woodhaven Nature Conservancy (Forest Type 1 Figure 4). Black cottonwood trees have an average lifespan of approximately 100 years but are prone to losing their branches and tops as they get older. Maintenance or removal of black cottonwood trees within one tree length from walking trails should occur if they are assessed to be 'Dangerous Trees'.

Figure 1. Senescent black cottonwood trees in the park

The recorded forest health factors[1] causing tree mortality within the park include drought and Armillaria root disease. A change in hydrology appears to have compounded drought stress in parts of the park, although the precise cause of this change is not known, there appears to be a reduction in the water table associated with a combination of anthropogenic and drought impacts. During the 2006 field visit conducted for the development of this plan, evidence of Douglas-fir beetle attack was found in the drought stressed and dying Douglas-fir (Forest Type 2 Figure 4). Patches of dead and dying western red cedar were also evident in some sections of the park and this was also attributed to drought stress (Forest Type 3 Figure 4). Though there are few ponderosa pine trees in the park, increasing bark beetle pressure has (Figure 2) and is likely to result in pine mortality from western pine beetle and mountain pine beetle (*Dendroctonus ponderosae* [Hopkins]). From an ecological perspective, leaving the dead trees in the park is acceptable. However, dead trees within one tree length of the walking paths should be removed if they are assessed to be 'Dangerous Trees'.

[1] Pherotech Inc. 2001. Forest Health Incidence for Central Okanagan Regional Parks. Pherotech. Report submitted to Regional District of Central Okanagan.

Figure 2. Dead and dying Douglas-fir, ponderosa pine and western redcedar in the park

The British Columbia Dangerous Tree Assessment Process[2] and the Workers' Compensation Board Occupational Health and Safety Regulations[3] defines a 'Dangerous Tree' as:

Any tree that is hazardous to workers because of location or lean, physical damage, overhead hazards, deterioration of the limbs, stem or root system, or a combination of these.

An ISA certified arborist should be contracted by the Regional District to assess and inventory all trees within Woodhaven Nature Conservancy. Those trees that are within one tree length from any trail and that are identified as Danger Trees should be removed or topped to a height of less than 5 metres to create a wildlife tree (snag) (Figure 3). This assessment and removal should be repeated on an annual basis. The assessment should be conducted as per British Columbia's Dangerous Tree Assessment Process.

[2] Manning, T.; P. Bradford; C. White; D. Rowe; N. Densmore; S. Guy. 2002. British Columbia's Dangerous Tree Assessment Process. USDA Forest Service Gen. Tech. Rep. PSW-GTR-181.

[3] Workers' Compensation Board of British Columbia (WCB). 1998. Occupational Health & Safety Regulation, Industry/Activity Specific Requirements, parts 20-33. Richmond, BC: Workers' Compensation Board of British Columbia, April 1998; 151p.

Figure 3. Example of < 5 metre tall wildlife trees adjacent to the trail.

At the present time, no replanting is recommended. If openings greater than 0.5 ha develop, then a site specific reforestation plan that considers site series and ecological requirements for artificial regeneration of ponderosa pine, western red cedar or Douglas-fir should be established. Black cottonwood trees will re-sprout from the stump and roots and therefore will not require replanting. The debris associated with these dead and dying trees and tree removal should be removed and disposed of to limit accumulations of surface fuel and associated fire hazard. An acceptable level of coarse woody debris post danger tree removal can be described as follows:

- Minimum of 5-10 pieces of CWD, 12 cm diameter or greater and greater than 5 meters in length is considered an acceptable level of retention on a per hectare basis.

Figure 4. Woodhaven Nature Conservancy Area Map

2.2 Additional Requirements

2.2.1 *Debris cleanup*

Substantial debris has been left on site from past tree removals. This debris attracts and provides food for Douglas-fir beetles, which is likely to increase the beetle population in the park and the incidence of attack on Douglas-fir. The debris that has been left along the trails should be removed from the park and disposed of. Any debris created from future Danger Tree removals or treatments should also be removed from the park and disposed of. Within the drier areas of the park and in high traffic areas this material is considered a fire hazard.

Figure 5. Debris left along trails in the park

2.2.2 *Park Residence*

The Park Residence building (Type 4 Figure 4 and Figure 6) is constructed primarily of wood and is vulnerable to fire. Vegetation is too close to the structure and, if ignition occurs either in the house or the adjacent vegetation, radiant heat and flame contact could easily spread fire between the structure and the vegetation (Figure 7).

The understory vegetation immediately adjacent to the structure (within 10m) should be removed and the larger trees should have their crowns pruned up to 3 metres. The building's roof should be cleaned of needles and litter. The building site should be cleared of debris and combustible materials within a 10 m radius of the structure. Any wood piles or other flammable materials (e.g., gas tanks) should be stored away from the structure (at least 10 m).

Figure 6. Park residence structure imbedded in the forest

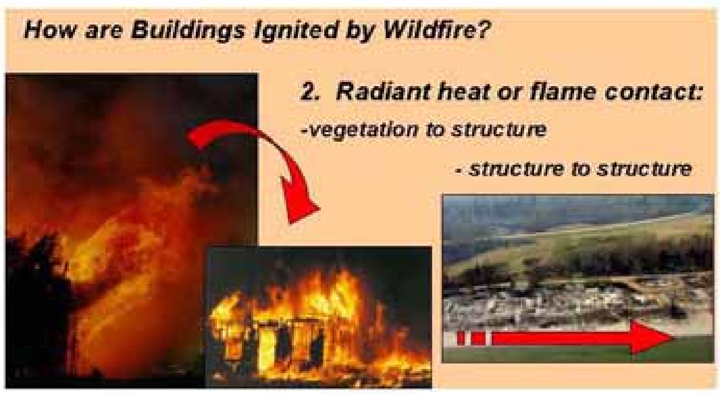

Figure 7. Radiant heat and flame contact allows fire to spread from vegetation to structure or from structure to structure.

2.2.3 *Proximity to homes and ignition risks*

The park is partially surrounded by homes. It would be beneficial to create a 10 m understory fuel free zone in the park where the fence abuts private land with dwellings. The intention of a fuel free zone would be to slow fire spread into or out of the park. This does not mean the large overstory trees should be removed but they should be pruned up to 3 metres. All surface fuel < 10 cm in diameter should be removed from this fuel free zone.

Figure 8. Continuity of forest from the park into private land.

Because of human activity, trails are often locations of human caused ignitions. Fire hazard reduction adjacent to trails would be beneficial to:

- Lower the risk of human ignition
- Lower fire behaviour potential
- Improve suppression capability within the park

Currently, many sections of the main trail are surrounded by dense vegetation, variable surface fuels and trees with low crown base heights (Figure 9). The main trail around the perimeter of the park should be widened to allow the setup of sprinklers and the movement of quads around the park. Overstory vegetation within 3 metres of the trail should be pruned to a height of 3 metres. All woody surface fuel < 10 cm within 3 metres of the trail should be removed. Understory vegetation should be living and healthy and any dead material should be removed from the park and disposed of. If tree density is greater than 100 sph within 3 m of the trail, then it should be reduced by thinning. Thinning should target removal of the smallest trees and retain the largest trees with the highest crown base heights.

Figure 9. Photo showing dense vegetation and low crown base heights adjacent to the main trail.

3.0 Monitoring

A yearly hazard tree survey and inventory by an ISA Certified Arborist is required to ensure that Danger Trees are identified and removed. This assessment should include a spatial component such that individual Danger Trees are mapped and any treatments are recorded (e.g., full removal or branch modification).

In addition, an annual forest health survey that documents any new disease outbreaks and/or identified mortality should be conducted in the park. The survey should consider common forest health factors – western pine beetle, mountain pine beetle, Douglas-fir bark beetle, Armillaria root disease and drought. Several permanent photo plots should be established (three in each of the identified forest cover types) to record changes over time and to provide a measure of forest succession.

These inventories will provide a valuable resource for tracking forest health, tree maintenance and improving the efficiency of future danger tree surveys.

Appendix 3 – Useful Information Sources

Legislation

For a full listing of provincial government legislation, see

http://www.qp.gov.bc.ca/statreg/list_statreg_l.htm

Fish Protection Act [SBC 1997]: http://www.qp.gov.bc.ca/statreg/stat/F/97021_01.htm

Forest Range and Practices Act [SBC 2002]:
http://www.for.gov.bc.ca/tasb/legsregs/frpa/frpa/frpatoc.htm

Growth Strategies Statutes Amendment Act [SBC 1995]:
http://www.leg.bc.ca/1995/3rd_read/gov11-3.htm

Local Government Act [RSBC 1996]: http://www.qp.gov.bc.ca/statreg/stat/L/96323_00.htm

Water Act [RSBC 1996]: http://www.qp.gov.bc.ca/statreg/stat/W/96483_01.htm

Weed Control Act [RSBC 1996]: http://www.qp.gov.bc.ca/statreg/stat/W/96487_01.htm

Wildfire Act [SBC 2004]:
http://www.for.gov.bc.ca/tasb/legsregs/wildfire/wildfireact/wildfire.htm

Wildlife Amendment Act, 2004: http://www.leg.bc.ca/37th5th/3rd_read/gov51-3.htm

Streamside Protection Regulations:
http://www.qp.gov.bc.ca/statreg/reg/F/FishProtect/10_2001.htm

For a full listing of federal government legislation, see: http://laws.justice.gc.ca/en/

Canada Fisheries Act: http://laws.justice.gc.ca/en/F-14/

Canada Migratory Birds Convention Act: http://laws.justice.gc.ca/en/M-7.01/

Canada Species at Risk Act: http://www.sararegistry.gc.ca/the_act/default_e.cfm

Canada Wildlife Act: http://laws.justice.gc.ca/en/W-9/

Inventory and Mapping

Conservation Data Centre http://srmwww.gov.bc.ca/cdc/index.html

Conservation Data Centre known occurrences: http://srmwww.gov.bc.ca/cdc/access.html

Conservation Data Centre data requests: http://srmwww.gov.bc.ca/cdc/request.html

Conservation Data Centre report of findings: http://srmwww.gov.bc.ca/cdc/contribute.html

Sensitive Ecosystems Inventories: http://srmwww.gov.bc.ca/sei/index.html

Sensitive Habitat Inventory and Mapping (part of the Community Mapping Network):

http://www.shim.bc.ca/maps2.html

Resource Information Standards Committee http://srmwww.gov.bc.ca/risc/standards.htm

Terrain stability mapping: http://srmwww.gov.bc.ca/terrain/inventory/stability/index.html

Floodplain mapping: http://srmwww.gov.bc.ca/aib/fpm/

Other

Stewardship Series: http://www.stewardshipcentre.bc.ca/sc_bc/stew_series/bc_stewseries.asp

Alien Species in British Columbia: http://wlapwww.gov.bc.ca/wld/aliensp/index.html

Invasive Plant Strategy for British Columbia: http://www.fraserbasin.bc.ca

FireSmart: http://www.partnersinprotection.ab.ca/downloads/

Links to Best Management Practices are provided as footnotes in the Best Management Practices section of the document.

Appendix 4 – 2007 Summary of Forested Parks

Alphabetical summary of forested parks based on VRI data and orthophoto interpretation.

Park Name	Total Area	Area with Pine	Area with>50% Pine	Park Class	Park Status	Park Group	Tenure 1	Tenure 2	Tenure 3	Tenure 4
Antlers Beach	11.4	4.0	0.0	Recreation / Waterfront	Regional	A	RDCO Titled	Licence of Occupation (Province)		
Aspen	0.3	Data Missing	Data Missing	Open Space	Westside	B	RDCO Titled			
Bertram Creek	25.7	8.5	8.5	Recreation / Waterfront	Regional	A	Aquatic Licence	RDCO Titled		
Black Canyon	1.5	Data Missing	Data Missing	Neighbourhood	Westside	A	RDCO Titled			
Bouleau Lake	4.5	0.5	0.2	Open Space	Westside	B	Licence of Occupation (Province)			
Bowen Creek Corridor	0.2	Data Missing	Data Missing	Open Space	Westside	B	RDCO Titled			
Broadview	0.2	0.0	0.0	Neighbourhood	Westside	A	RDCO Titled			
Casa Loma Beach	0.4			Waterfront	Westside	A	RDCO Titled	Road Permit	Aquatic Licence	
Casa Palmero	7.3	5.3	5.3	Open Space	Westside	B	RDCO Titled			
Cedar Mountain	210.4	120.6	24.6	Natural	Regional	B	Lease (COPWT)	Licence of Occupation (Province)	RDCO Titled	
Cinnabar Creek	0.3	0.3	0.3	Open Space	Westside	B	RDCO Titled			
Coldham	6.1	5.5	0.0	Natural	Regional	B	RDCO Titled			
Connemara	0.8	0.8	0.8	Neighbourhood	Westside	A	RDCO Titled			
Copper Ridge	0.1	0.1	0.1	Neighbourhood	Westside	A	RDCO Titled			
Daves Creek Corridor	2.3	1.0	0.4	Linear	Eastside	A	RDCO Titled	Statutory Right of Way		
Davidson Creek	3.2	3.2	1.9	Neighbourhood	Westside	A	RDCO Titled			
Deer Ridge	0.2	Data Missing	Data Missing	Neighbourhood	Westside	A	RDCO Titled			

Park Name	Total Area	Area with Pine	Area with>50% Pine	Park Class	Park Status	Park Group	Tenure 1	Tenure 2	Tenure 3	Tenure 4
Devon	0.1	Data Missing	Data Missing	Neighbourhood	Westside	A	RDCO Titled			
Eain Lamont	2.5	0.9	0.9	Neighbourhood	Westside	A	RDCO Titled			
Eleanor Reece	0.1			Neighbourhood	Westside	A	Road Permit			
Ellison Estates Trail	0.1	<0.1	0.0	Linear	Eastside	A	Statutory Right of Way			
Faulkner Creek	3.8	0.7	0.7	Open Space	Westside	B	RDCO Titled	Statutory Right of Way		
Fintry Access #1	0.6	0.2	0.0	Waterfront	Westside	A	Road Permit	Aquatic Licence		
Gellatly Heritage	3.0	2.7	0.0	Cultural	Regional	A	RDCO Titled			
Glen Canyon	72.0	58.9	29.4	Trails (Greenways)	Regional	A	Licence of Occupation (Province)	Easement	RDCO Titled	Statutory Right of Way
Glenrosa	0.6	Data Missing	Data Missing	Neighbourhood	Westside	A	RDCO Titled			
Glenrosa Cemetary	0.1			Neighbourhood	Westside	A	RDCO Titled			
Glenway	0.5			Neighbourhood	Westside	A	RDCO Titled			
Gregory Road Walkway	0.2	<0.1	<0.0	Linear	Westside	A	Easement			
Harold	0.3	Data Missing	Data Missing	Neighbourhood	Westside	A	RDCO Titled			
Horizon	1.4	0.9	0.9	Neighbourhood	Westside	A	RDCO Titled			
Issler	0.9			Athletic	Westside	A	RDCO Titled			
Johnson Bentley Aquatic Centre	0.9			Athletic	Westside	A	RDCO Titled			
Joe Rich Community Hall	1.0	0.9	0.9	Community	Eastside	A	RDCO Titled			
Jonagold	0.8	0.8	0.8	Neighbourhood	Westside	A	RDCO Titled			
Kalamoir	28.0	Data Missing	Data Missing	Natural	Regional	B	RDCO Titled	Crown Grant		

Park Name	Total Area	Area with Pine	Area with>50% Pine	Park Class	Park Status	Park Group	Tenure 1	Tenure 2	Tenure 3	Tenure 4
Killiney Beach	5.2	Data Missing	Data Missing	Waterfront	Westside	A	RDCO Titled	Road Permit	Aquatic Licence	
Killiney Community Hall	1.8	1.8	1.8	Community	Westside	A	RDCO Titled			
Kinsmen	10.8	0.1	0.1	Athletic	Westside	A	RDCO Titled	Licence of Occupation (Province)		
Lakeshore Road	0.1	0.1	0.1	Waterfront	Eastside	A	RDCO Titled			
Lakeview Cove Walkway	0.2			Linear	Westside	A	RDCO Titled			
Marjorie Pritchard Memorial	0.6			Neighbourhood	Westside	A	Road Permit			
McCulloch / Hydraulic Lake Forest Rec Site	27.7	24.0	24.0	Recreation	Regional	A	Management Contract (Province)			
McCulloch Station	2.5	2.0	2.0	Recreation / Cultural	Regional	A	RDCO Titled			
McDougal Creek	0.2			Linear	Westside	A	Statutory Right of Way			
McIver	0.3			Neighbourhood	Westside	A	RDCO Titled			
Mill Creek	14.9	9.3	0.0	Natural	Regional	B	RDCO Titled			
Mission Creek	81.1	50.6	49.9	Natural	Regional	A	Crown Grant	Crown Lease	RDCO Titled	
Mission Creek Greenway	43.0	19.5	4.3	Trails (Greenways)	Regional	A	Management Contract (Kelowna)	RDCO Titled	Lease (COPWT)	
Mission Ridge	1.7	Data Missing	Data Missing	Open Space	Westside	B	RDCO Titled			
Morningside	0.3	Data Missing	Data Missing	Open Space	Westside	B	RDCO Titled			
Mount Boucherie	36.4	36.3	30.0	Conservation	Regional	B	RDCO Titled			

Park Name	Total Area	Area with Pine	Area with>50% Pine	Park Class	Park Status	Park Group	Tenure 1	Tenure 2	Tenure 3	Tenure 4
Mount Boucherie Sports Fields	4.2	0.3	0.0	Athletic	Westside	A	RDCO Titled			
Okanagan Lake Forest Rec Site	103.7	61.7	33.0	Recreation / Waterfront	Regional	A	Management Contract (Province)			
Oriole	0.2	<0.1	<0.1	Neighbourhood	Westside	A	RDCO Titled			
Paula	0.6	<0.1	0.0	Neighbourhood	Westside	A	RDCO Titled			
Philpott Trail	4.9	0.5	0.5	Linear	Eastside	A	Statutory Right of Way			
Pine Point	0.2	0.0	0.0	Waterfront	Westside	A	RDCO Titled			
Raymer Bay	6.6	3.7	3.5	Recreation / Waterfront	Regional	A	RDCO Titled			
Rock Ridge	2.6	1.3	1.3	Open Space	Westside	B	RDCO Titled			
Rose Meadow Park	5.1	3.8	3.8	Open Space	Westside	B	RDCO Titled			
Rose Valley	216.7	173.4	132.5	Conservation	Regional	B	RDCO Titled	Licence of Occupation (Province)		
Rose Valley Community	0.9	0.1	0.1	Community	Westside	A	RDCO Titled			
Rose Valley Pond	0.5	0.1	0.1	Open Space	Westside	B	RDCO Titled			
Rosewood	0.5	0.1	0.1	Open Space	Westside	B	RDCO Titled			
Sandstone	2.2	2.1	2.1	Open Space	Westside	B	Licence of Occupation (Province)			
Scenic Canyon	125.2	77.7	50.8	Natural	Regional	B	Management Contract (Kelowna)	RDCO Titled	Crown Grant	
Scotty Creek	1.3			Neighbourhood	Eastside	A	RDCO Titled			
Shannon Highlands Park	2.5	2.3	0.0	Open Space	Westside	B	RDCO Titled			
Shannon Lake	3.9	1.9	1.9	Recreation / Waterfront	Regional	A	RDCO Titled	Verbal Agreement		
Shannon	1.4		Data	Linear	Westside	A	RDCO Titled			

Park Name	Total Area	Area with Pine	Area with>50% Pine	Park Class	Park Status	Park Group	Tenure 1	Tenure 2	Tenure 3	Tenure 4
Lake Trails			Missing							
Shannon View Walkway		0.1	0.0			A				
Shannon Way	2.8	2.5	2.5	Open Space	Westside	B	RDCO Titled			
Shelter	0.1			Neighbourhood	Westside	A	RDCO Titled			
Smith Creek	0.4	0.2	0.2	Neighbourhood	Westside	A	RDCO Titled			
Smith Creek Trail	0.7	0.4	0.4	Linear	Westside	A	RDCO Titled			
Smith Creek Walkway	0.3	<0.1	<0.1	Linear	Westside	A	RDCO Titled			
Springer	0.1			Neighbourhood	Westside	A	RDCO Titled			
Star	3.1	3.1	2.1	Open Space	Westside	B	RDCO Titled			
Stephens Coyote Ridge	110.9	13.9	13.9	Conservation	Regional	B	RDCO Titled	Crown Lease		
Stonegate	0.2			Open Space	Westside	B	RDCO Titled			
Sunnyside	0.3			Neighbourhood	Westside	A	RDCO Titled			
Sunset Ranch Park	2.6	0.2	0.2	Neighbourhood	Eastside	A	RDCO Titled			
Sunview	0.1			Neighbourhood	Westside	A	RDCO Titled			
Three Forks	5.4	0.0	0.0	Community	Eastside	A	RDCO Titled			
Timothy	0.2	0.1	0.1	Neighbourhood	Westside	A	RDCO Titled			
Traders Cove	13.6			Recreation/Water front	Regional	A	RDCO Titled	Aquatic Licence		
Vineyard	1.2	0.0	0.0	Neighbourhood	Westside	A	RDCO Titled			
Westbank Community	3.1			Community	Westside	A	RDCO Titled			
Westlake Community	3.5	0.2	0.2	Community	Westside	A	RDCO Titled			
Westridge	1.0	0.7	0.7	Open Space	Westside	B	RDCO Titled			
Westside Aquatic Marina	0.3			Waterfront	Westside	A	Crown Lease			
Westside Rotary Trails	0.7	Data Missing	Data Missing	Waterfront	Westside	A	RDCO Titled			

Park Name	Total Area	Area with Pine	Area with>50% Pine	Park Class	Park Status	Park Group	Tenure 1	Tenure 2	Tenure 3	Tenure 4
Westside Seniors Centre	0.2			Community	Westside	A	RDCO Titled			
Wild Rose	0.2	Data Missing	Data Missing	Open Space	Westside	B	RDCO Titled			
Wildhorse	0.5	0.2	0.2	Community	Westside	A	RDCO Titled			
Woodhaven Nature Conservancy	8.7	Data Missing	Data Missing	Conservation	Regional	B	Crown Grant			
Total	1262.1									

Appendix 5 – Fuel Management Standard for Parks and Green Spaces

Within Regional Parks and green spaces the goal of fuel management is to minimize fire behaviour potential and the risk of human ignition. Fire behaviour potential is of greatest concern in the vicinity of public buildings, areas of high public use, and adjacent to private homes and businesses. The risk of human ignition is associated with areas of high visitor use and or where recreational activities (*e.g.*, use of barbeques) elevate risk. These are the types of areas where fuel management is appropriate and should be considered within parks and green spaces.

To reduce fire behaviour potential the goal of fuel management is focused on a reduction in the vertical and horizontal continuity of surface and crown fuels. Significant accumulations of fine surface fuels (<1 cm) are considered hazards that contribute to the ease of ignition and the rate of fire spread. Accumulations of coarse surface fuels contribute to head fire intensity and flame height and enable fire to propagate into the crowns. A low crown base height (< 2 metres) allows fire to spread more easily into the crowns. High crown closure (related to high stem density) allows fire to spread more easily and rapidly between tree crowns. The species composition is also an important consideration as deciduous fuels are less vulnerable to fire in comparison to coniferous fuels. Based on these fundamental fire behaviour principals it is desirable to treat fuels in a manner that:

- Reduces surface fuel continuity (both fine and coarse fuels);
- Increases crown base height;
- Reduces the tree density and crown closure; and,
- Shift species composition from coniferous to mixed deciduous fuels.

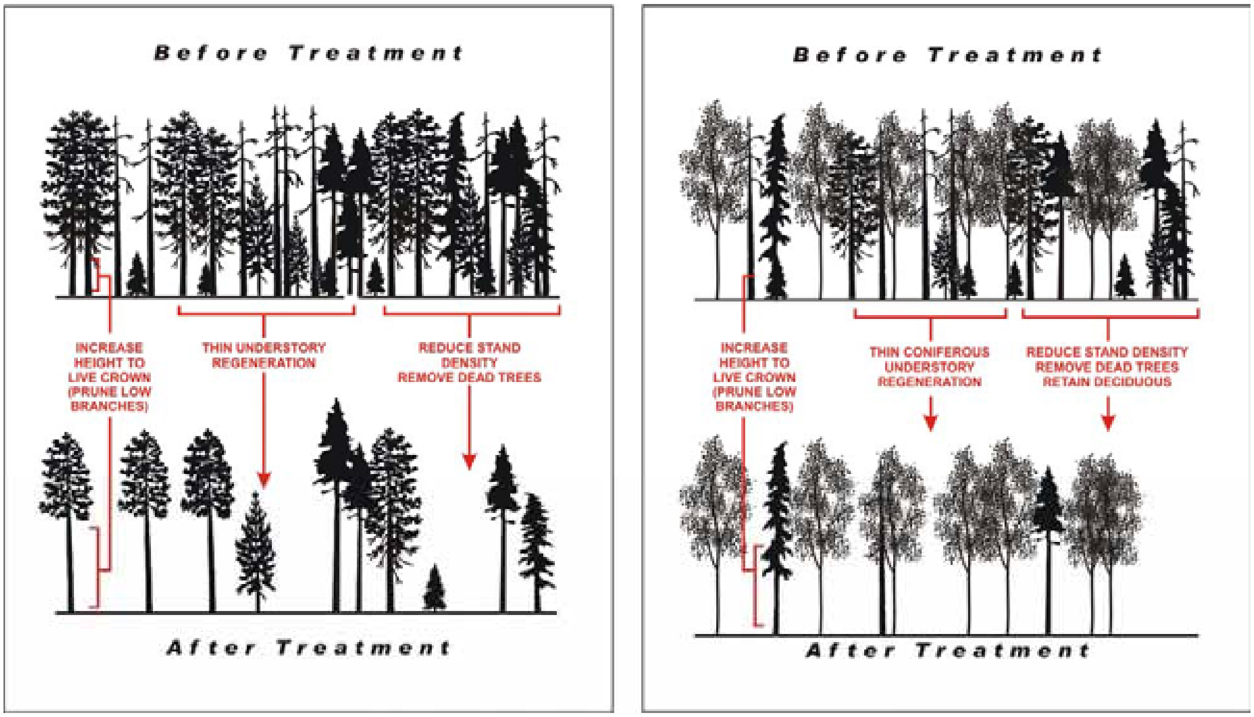

Figure 10. Conceptual examples of hazard coniferous and mixed deciduous fuel types treated to achieve a reduction fire behaviour potential.

To meet an acceptable level of fire behaviour potential and or lower the risk of ignition the following targets for specific stand attributes is recommended:

- Within mature forest types target crown closure is <35% where the distance between crowns is between 3 and 6 metres. This includes trees in all layers (1 through 4) and all tree species (coniferous and deciduous);
- Within mature forest types target crown base is an average greater than 2 metres;
- Within mature forest types target coarse woody debris retention is 5-10 pieces of CWD per hectare, 12 cm diameter or greater and greater than 5 meters in length; and,
- Within mature forest types the target deciduous component is 10 to 30%. Deciduous species composition that exceeds 30% is considered desirable.

Given that stand density varies greatly with tree age and size, no density target it provided. It is recognized that stands of a younger age may contain a greater number of stems when compared with older stands. Crown closure is probably a better measure of specific fire behaviour conditions.

From a fire perspective, the application of fuel treatments should be used to reduce hazardous understory development and provide shade to maintain higher relative humidity and a reduced temperature regime while maintaining an overstory with low crown fire potential. The focus of specific fuel treatment prescriptions should be a one time entry to remove a portion of smaller and larger diameter overstory stems, downed stems and fine fuels.

Given the forest health issues facing the RDCO and the increasing mortality associated with Mountain Pine Beetle and Western Pine Beetle, fuel treatments may not be appropriate until there is a recession in the beetle populations and associated mortality. Restoration treatments that remove the dead pine may facilitate the removal of hazardous fuel accumulations. Fuel treatments prior to the beetle outbreak may limit and or reduce tree retention options in parks and green spaces.

Appendix 6 – Sample Fuel Treatment Prescription

CITY OF PRINCE GEORGE	**DRAFT SITE PLAN FOR PRINCE GEORGE MUNICIPAL FUEL TREATMENT XX**

A. SITE PLAN OBJECTIVES

This site plan is consistent with the Prince George Community Forest - Forest Stewardship Plan and Community Wildfire Protection Plan

This site plan is consistent with Higher Level Plan objectives that include;

- **Protection of public safety both within and adjacent to the City of Prince George,**
- **Improvement of the ability of Prince George Fire Rescue to protect both life and property values at risk within the boundaries of the City of Prince George and the Community Forest,**
- **Removal of dead, dying and or susceptible lodgepole pine impacted by the current Mountain Pine Beetle outbreak.**
- **Enhancement of natural barriers that reduce the continuity of fuel loads and wildfire risk,**
- **Improvement in biodiversity of wildlife habitat through improved understory vegetation development and or the establishment of early seral forests,**

Specifically, within a five year period this site plan will address the following;

- **Removal of both understory and overstory trees to reduce identified fire risk to the City of Prince George,**
- **Determine the effectiveness of this treatment in the reduction of fuel and fire risk,**
- **Rehabilitation of forests impacted by the Mountain Pine Beetle,**
- **Minimize negative impacts on the aesthetic values, soil, non-targeted vegetation, water and air quality and wildlife,**
- **Meet or exceed the stand level planning and practice requirements of the Forest and Range Practices Act,**
- **Rehabilitation of disturbed areas upon project completion**

B. AREA SUMMARY AND NET AREA OF TREATMENT

Gross Area (Ha)	6.4		
Net Treatment Area (Ha)	4.6		

SU	Area Description	NAR (ha)	Treatment
1	SBS mk1-01 Mixed conifer/deciduous At/Pl	2.3	Dead Pl/Hazard Tree Removal
2	SBSmk1-01 Mixed conifer Pl, Sxw, Bl, (At, Ep)	2.3	Under/Overstory Tree Removal
	*Critical site conditions that affect the timing of operations: - **none identified in the block***		
	Comments specific to SU 1and 2:		

C. SOIL DISTURBANCE

SU	Hazard Ratings				Maximum Allowable Soil Disturbance (%)	Sensitive Soils (Y/N)	Maximum Allowable Soil Disturbance at Roadside (%)	Maximum Soil Disturbance Temp. Exceeded (%)	Maximum Permanent Access Structures	Texture	Coarse Fragments
	Soil Comp	Surface Soil Erosion	Soil Disp.	FF Disp.							
1,2					5.0	Y	5.0	n/a	n/a	CL	<10

Depth to Unfavourable Subsoil		Type of Unfavourable Subsoil	Sediment Delivery Risk (Community Watersheds)	Cwd (Kg/m^2)
Min (cm)	Max (cm)			
			n/a	n/a

Soil Conservation Comments: The soil protection objective is to minimize site disturbance and potential long term productivity losses. No permanent roads will be constructed. All removal operations are restricted to dry periods (to be determined by the contract monitor) and or winter conditions when the ground is frozen.

D. STOCKING REQUIREMENTS

SU	Other Performance Standards	Desired Outcome	CWD M³/HA
1,2	Formal stocking standards are not required. Stocking to be determined by overstory and understory residuals and natural regeneration. No free growing requirements. No requirement for well spaced trees. No MITD. Trees are to be free of diseases that could result in mortality. Trees with defects and diseases that will not result in mortality are acceptable. All deciduous and conifer tree species other than Pl are preferred species.	An assessment of regeneration performance and stocking will be conducted at 1, 3 and 5 years following tree removal to determine regeneration success and performance. If stocking levels do not meet the objectives set out in this prescription then consideration will be given to an alternative silviculture treatment (planting and or stocking control). The treatment will be considered a success if variable stocking ranging from 200 to 500 stems/ha is achieved. If regeneration densities exceed 1000 stems/ha over an extensive (50%) area a stocking control treatment will be considered.	Minimum of 5-10 pieces of CWD, 12 cm diameter or greater and greater than 5 meters in length will be retained.

1. ASSESSMENTS

VISUAL IMPACT ASSESSMENT			
Is the block in a known scenic area (yes/no)	Yes	Date of Assessment	
Pre-harvest visual condition	Current status: Retention – no significant disturbance		
Established Visual Quality Objectives	Post Treatment – Partial Retention		
Post Harvest Visual Condition	Will range from retention to partial retention		

Comments:	A visual quality assessment of this area has not been completed. It is expected that the treatment will have a minor impact on the visual quality as a significant portion of the overstory will be retained.

PEST INCIDENCE SURVEY								
SU	Pest Code	Incidence or Rating	SU	Pest Code	Incidence or Rating	SU	Pest Code	Incidence or Rating
1,2	MPB	Low	1	DMF	Low			
Comments	Mountain Pine Beetle mortality is present within the treatment units with scattered standing dead trees.							
Date of Survey	No survey has been conducted related to site plan work.							

ARCHAEOLOGICAL IMPACT ASSESSMENT		
Date	Consultant	Recommendations
		There is no archaeological assessment of City owned lands. At this time the City has indicated that there are no known archaeological values associated with this treatment unit.

RIPARIAN ASSESSMENTS						
SU	Riparian I.D. and Class.	RRZ Width (m)	RMZ Width (m)	Leave Tree Species and Spacing or BA Retained	Stems/ha	Comments (Indicate if in a community watershed)
1,2	S6					This ephemeral stream transects a significant portion of the block
Comments:						

TERRAIN STABILITY FIELD, FLAT OVER STEEP AND AVALANCHE ASSESSMENTS				
Date	Consultant	Polygon	Classification	Recommendations
				Portions of the block that exceed 60% or where there are identified terrain stability issues have been deleted from the treatment unit until such time as a terrain stability field assessment has been completed. If the terrain stability assessment indicates there are no hazards associated with treatment these areas will be treated during the winter of 2007/2008.

2. BACK UP DATA

HIGHER LEVEL PLAN CONSIDERATIONS:	Response	Comments
Forest Stewardship Plan		Prescription is consistent with the City of Prince George Community Forest Stewardship Plan.
Urban Forest Management Plan		Prescription is consistent with the City of Prince George Urban Forest Management Plan

Community Wildfire Protection Plan		Prescription is consistent with the City of Prince George Community Protection Plan
Wildlife/ Endangered Species		None identified
Sensitive Areas		None identified
Cultural Assessment		No known archaeological features exist within the treatment unit
Fisheries		None identified
Recreation		None identified
Other Resources		None identified

3. SILVICULTURAL/ TREE REMOVAL SYSTEMS

SILVICULTURAL SYSTEMS				TREE REMOVAL SYSTEM		
SU	SYSTEM	VARIANT	RESERVE TYPE	FALLING	YARDING	LANDING
1	Dead pine and hazard tree removal	Single tree removal		Hand	Full Tree Manual understory removal where required	Conventional
2	Understory/overstory tree removal	Opening < 0.2 ha in which trees are retained either uniformly or in small groups		Hand	Full tree Manual understory removal – hand pulling	Conventional
Silvicultural Constraints		Minimize scarring and marking on overstory leave trees				
Harvesting Constraints		Harvesting to occur during periods of dry conditions and or when the ground is frozen. Acceptable conditions to be determined by the contract monitor and City Environment staff.				

LEAVE TREE SPECIES AND FUNCTIONS				
SU	Species		Layer	Minimum Leave Tree Characteristics Including Form, Health And Vigour
1,2	Fd, Sxw, Bl	At, Act,Ep	1-4	Retain all deciduous tree species - cottonwood, aspen, and birch. Conifer retention preference Douglas-fir, hybrid white spruce, subalpine fir. Smaller diameter lodgepole pine (10 cm or less) can be retained. Low numbers of red attacked trees (<10 hectare) can be left for recruitment of wildlife trees and snags.
COMMENTS				

COARSE WOODY DEBRIS MANAGEMENT STRATEGIES
Comments: Current levels of surface coarse woody debris are low throughout the site plan area. Levels of coarse woody debris will be maintained by the residual overstory.
The following stems will be retained to maintain basic Coarse Woody Debris (CWD) levels: ▪ Firm wood reject, grade 4 and 5 which includes red attacked Pl

▪ A component of the residuals

SITE PREPARATION	
SU	TECHNIQUE (S) / LIMITING FACTORS
1,2	Excess slash must be pulled to trail or roadside and either chipped on site or removed. Accumulations of fine slash < 10 cm in diameter can not exceed 10kg/m2 in an area larger than 50 m2. Accumulations that exceed this level are considered a surface fuel hazard.
BRUSHING / STAND TENDING	
SU	TECHNIQUE (S) / LIMITING FACTORS
1,2	Ingress of brush species will enhance opportunities for wildlife and increase biodiversity. No brush treatments are required as this is a regional park. Natural succession will determine the brush cover within the treatment area.

Fuel Management Objectives

- Reduction of crown closure to a target of 35% cover in the overstory– this is expected to reduce the overall crown fire behaviour potential within the unit.
- Reduce overall stocking in both the overstory and understory to target 500 sph (minimum 200 sph)
- Where the combined overstory and understory tree density exceeds 500 sph target removal of understory conifers to increase the height to live crown above 6m.
- Removal of dead and dying lodgepole pine and all susceptible lodgepole pine inventory,
- Target retention of all deciduous species (Act, At, and Ep) provided they are healthy and vigorous,
- Target retention of alternate tree species (Fd, Sxw, and Bl) to facilitate maintenance of biodiversity,
- Allow for natural variation in retention patterns through the units,
- Minimize the creation of surface fuel by limiting slash accumulations to < 5 kg/m^2.

Tree Removal Objectives

- Minimize soil disturbance (<5%) and forest floor displacement,
- Minimize impacts on riparian areas (one identified),
- Minimize visual impact of harvest – stumps flush cut to the soil surface,
- Trees removed will be felled and skidded in a manner that protects the advanced regeneration.
- Skidding will be done only when soil conditions are frozen and covered by snow or conditions are dry.
- All timber will be felled and skidded away from wet areas and reserves.
- Tree removal be completed by March 31, 2007 and site clean-up and rehabilitation by June 30, 2007.

Rehabilitation Objectives

- Chip or remove debris on landings and within the unit,
- Rehabilitate and restore hiking trails that traverse SU 1. The pre-treatment condition of the trail should be established by photographic documentation and mapping at 1;5000 scale.
- If unacceptable levels of soil disturbance are identified, the City Environment Manager will develop an appropriate rehabilitation plan.

Future Fuel Maintenance

It is expected that this fuel treatment will significantly reduce wildland urban interface fire risk for a period of up to 20 years. After this time it is expected that ingress of understory conifers will create ladder fuels that are likely to increase the crown fire hazard. Maintenance at this time may include an understory thinning removal to maintain the effectiveness of the treatment and public safety. Given our limited understanding of the longevity of these types of treatments it is recommended that fixed reference photo points be established throughout the unit to track the success of treatments and required maintenance.

Registered Professional Foresters Signature and Seal	RPF PRINTED NAME
	DATE SIGNED
	I certify that I have reviewed this document and I have determined that this work has been done to standards acceptable of a Registered Professional Forester.

Appendix 7 – Plant List Template

Common Name	Latin Name	Life Expectancy	Tree Size (Large, Medium, Small)	Appropriate Park Types for Planting	Planting and Use Recommendations*
Black Cottonwood	*Populus trichocarpa*	50 – 100 years	Large	Natural Conservation	Planting: Plant in moisture receiving zones and riparian areas, do not plant along paths or in high use areas Benefits: Deciduous native hardwood, low fire hazard, nutrient cycling, fast growing, resprouts from stumps, wildlife habitat value, good soil/bank stabilization, aquatic habitat value, high flood tolerance Cautions: Deteriorate with age, prone to dropping branches and loosing tops, low drought tolerance, high potential for failure.
Douglas-fir	*Psuedotsuga menziesii*		Large		Planting: Benefits: Low potential for failure Cautions:
Subalpine fir	Abies lasiocarpa		Large		Planting: Benefits: Low potential for failure Cautions:
Amabilis fir	*Abies amabilis*		Large		Planting: Benefits: Cautions: High potential for failure
Ponderosa pine	*Pinus ponderosa*		Large		Planting: Benefits: Moderate potential for failure Cautions:
Lodgepole pine	*Pinus contorta*		Large		Planting: Benefits: moderate potential for failure Cautions:
Western white pine			Large		Planting: Benefits: Low- moderate potential for failure Cautions:
Sitka spruce			Large		Planting: Benefits: Low potential for failure Cautions:
Western hemlock			Large		Planting: Benefits: Low potential for failure Cautions:
Mountain hemlock			Large		Planting: Benefits:

					Cautions: High potential for failure
Western redcedar			Large		Planting: Benefits: Low potential for failure Cautions:
Yellow cedar			Large		Planting: Benefits: Low potential for failure Cautions:
Western larch			Large		Planting: Benefits: Cautions: Moderate to high potential for failure
Trembling Aspen			Medium		Planting: Benefits: Cautions: High potential for failure

Appendix 8 – RDCO Stocking Standards

Standards ID #	BGC Classification Zone/SZ	Series	Acceptable Species Conifers	Hardwoods	Stocking Target (well-spaced/ha)	MIN	Comments (Block Number)
	PPXh1	01	Py Fd		400	200	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	PPXh1	02	Py Fd		400	200	Avoid logging; manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	PPXh1	03	non-forested	non-forested			
	PPXh1	04	Py Fd		400	200	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	PPXh1	05	Py Fd		400	200	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	PPXh1	06	Fd Py	At Ep	600	400	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	PPXh1	07	Fd Py		800	500	
	PPXh1	08	Pl Sx Fd Py Cw	Act At Ep	800	500	Pl, Fd, Cw, Py on elevated microsites; Pl extended beyond normal range (spp should only be used on a trial basis until its success can be demonstated). Risk of frost damage to Py, Cw. Consider hardwood management for Act(if approved in management plans).
	IDFXh1	01	Fd Py Lw	At	800	500	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFXh1	02	Py Fd		400	200	Avoid logging; manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFXh1	03	Py Fd		600	400	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFXh1	04	Py Fd		600	400	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFXh1	05	Py Fd		600	400	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFXh1	06	Fd Py Lw	At	800	500	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFXh1	07	Fd Py Lw	At	800	500	
	IDFXh1	08	Fd Sx Pl Lw Py Cw	Act At Ep	1000	700	Pl, Fd, Lw, Py on elevated microsites. Risk of frost damage to Fd, Lw, Py. Consider hardwood management for Act (if approved in management plans).

Standards ID #	BGC Classification Zone/SZ	Series	Acceptable Species Conifers	Hardwoods	Stocking Target (well-spaced/ha)	MIN	Comments (Block Number)
	IDFXh1	09	non-forested	non-forested			
	IDFXh1a	91	non-forested	non-forested			
	IDFXh1a	92	non-forested	non-forested			
	IDFXh1a	93	non-forested	non-forested			
	IDFXh1a	94	non-forested	non-forested			
	IDFXh1a	95	non-forested	non-forested			
	IDFXh1a	96	non-forested	non-forested			
	IDFXh1a	97	non-forested	non-forested			
	IDFXh1a	98	Fd Py	At	1000	700	Risk of frost damage. Consider hardwood management (if approved in management plans).
	IDFmw1	01	Fd Lw Pl Py Bl Cw Sx	At Ep	1000	700	Py on south aspects (SSE to WSW). Bl, Cw, Sx on south aspects (NW to ENE). Bl, Cw, Sx in upper elevations of biogeoclimatic unit. Py in lower elevations of biogeoclimatic unit.
	IDFmw1	01-YC	Fd Lw Pl Py Bl Cw Sx	Act At Ep	1000	700	Py on south aspects (SSE to WSW). Bl, Cw, Sx on south aspects (NW to ENE). Bl, Cw, Sx in upper elevations of biogeoclimatic unit. Py in lower elevations of biogeoclimatic unit.
	IDFmw1	02	Fd Py Pl		600	400	Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFmw1	03	Fd Py Pl Lw	At Ep	600	400	Py on south aspects (SSE to WSW). Lw on south aspects (NW to ENE). Lw in upper elevations of biogeoclimatic unit. Py in lower elevations of biogeoclimatic unit. Manage stand to provide shade and protection (to allow for natural regeneration of Fd)
	IDFmw1	04	Fd Lw Pl Py Cw Sx	At Ep	800	500	Py on south aspects (SSE to WSW), in lower elevations, southern portions of biogeoclimatic unit. Cw, Sx on south aspects (NW to ENE) in upper elevations of biogeoclimatic zone.
	IDFmw1	05	Fd Lw Sx Pl Bl Cw	Act At Ep	1000	700	Risk of frost damage to Fd, Lw. Bl in upper elevations of biogeoclimatic unit. Consider hardwood management for Act (if approved in management plans).

Standards ID #	BGC Classification Zone/SZ	Series	Acceptable Species Conifers	Hardwoods	Stocking Target (well-spaced/ha)	MIN	Comments (Block Number)
	IDFmw1	06	Sx Fd Lw Bl Cw Pl	Act At Ep	1000	700	Fd, Lw on elevated microsites; risk of frost damage. Bl in upper elevations of biogeoclimatic unit. Consider hardwood management for Act (if approved in management plans).
	MSdm1	01	Pl Sx Bl Fd Lw	At	1000	700	Fd, Lw on south aspects (SSE to WSW), in lower elevation, risk of frost damage.
	MSdm1	02	Fd Pl Lw	At	600	400	
	MSdm1	03	Pl Fd Lw Bl Sx	At	800	500	Bl, Sx on south aspects (NW to ENE), in upper elevations of biogeoclimatic unit. Risk of frost damage to Fd, Lw.
	MSdm1	04	Fd, Lw, Pl, Bl, Sx	At	1000	700	Bl, Sx on south aspects (NW to ENE), in upper elevations of biogeoclimatic unit. Fd, Lw in lower elevations, risk of frost damage.
	MSdm1	05	Pl Fd Lw Sx Bl	At	1000	700	Fd, Lw on south aspects (SSE to WSW), in lower elevation, risk of frost damage.
	MSdm1	06	Pl Sx Bl Fd Lw	Act At	1000	700	Fd, Lw on south aspects (SSE to WSW), in lower elevation, risk of frost damage.
	MSdm1	07	Pl Sx Bl		800	500	On elevated microsites.
	MSdm1	08	non-forested	non-forested			

* *Developed from: "Guidelines for Tree Species Selection and Stocking Standards for British Columbia" and "Reference Guide for FDP Stocking Standards, Kamloops Forest Region".*