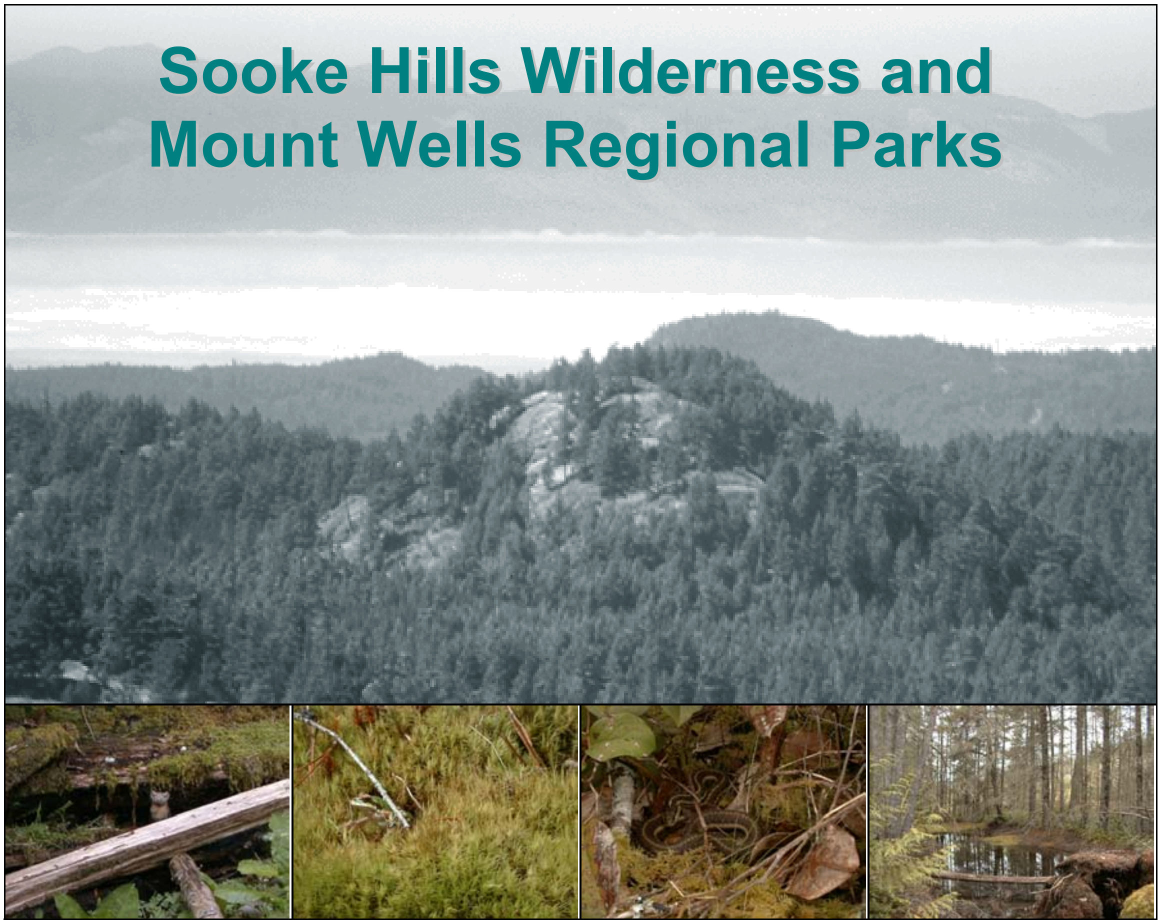
Sooke Hills Wilderness and Mount Wells Regional Parks



Terrestrial Ecosystem Mapping

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Prepared for:

CRD Parks

By:

The Ministry of Environment, Lands and Parks
Resources Inventory Branch

BRITISH COLUMBIA

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Barbara von Sacken and Sal Rasheed provided project co-ordination for the Terrestrial Ecosystem Mapping of Sooke Hills Wilderness and Mount Wells Regional Parks. Corey Erwin and Jo-Anne Stacey completed the ecosystem mapping; Jo-Anne Stacey, Barbara von Sacken, Sal Rasheed, Robert Maxwell and Corey Erwin produced the final report. Debbie Webb developed the format for the expanded legend and created the landscape profile diagrams. Bon Lee of Baseline Geomatics completed the GIS mapping. The field crews consisted of Lynne Bonner, Carmen Cadrin, Corey Erwin, Ted Lea, Robert Maxwell, Sal Rasheed, Christina Sinnemann, Jo-Anne Stacey, Calvin Tolkamp, and Barbara von Sacken.

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Jenifer Penny, assistant CDC botanist, Tracy Fleming, CRD Parks, ecologist and Andrea Leggett, CRD Parks volunteer, conducted the rare plant survey in conjunction with the TEM fieldwork.

Executive Summary

Overview

This document presents the results of Terrestrial Ecosystem Mapping of Sooke Hills Wilderness and Mount Wells Regional Parks. Wildlife Capability and Suitability interpretations for selected wildlife species are also presented.

Sooke Hills Wilderness and Mount Wells Regional Parks (the study area), part of the Capital Regional (CRD) Parks system are located on southern Vancouver Island, south-west of Finlayson Arm in the Saanich Inlet and north of Sooke Basin. The study area encompasses approximately 4,200 hectares of forests, wetlands, upland herb meadows and rocky outcrops all within a few kilometres of the large urban centre of Victoria, to the east.

Sooke Hills Wilderness and Mount Wells Regional Parks are located in what is known as the Nanaimo Lowland Ecosection. This area of coastal plain is situated along the southeastern margin of Vancouver Island and is characterized by a mild climate. Two biogeoclimatic units are recognized within the parks. Just over 97% of the study area is situated within the eastern variant of the Coastal Western Hemlock very dry maritime (CWHxm1) biogeoclimatic (BGC) subzone. The remainder is located in the Coastal Douglas-fir moist maritime (CDFmm) subzone. The CDFmm is one of the least extensive forested subzones in the province. The CDFmm occurs from sea level to approximately 150 m in elevation; the CWHxm1 is found from sea level, or above the CDFmm, where present, to 700 m in elevation.

Purpose

The primary purpose of this study was to provide CRD Parks with baseline ecological inventory and mapping. Other objectives included naturalness assessment of four catchment areas in the parks and wildlife habitat capability and suitability interpretations for Columbian black-tailed deer, black bear, Pileated Woodpecker and Marbled Murrelet. This baseline information will be used for park planning and management purposes.

Methodology

The Standard for Terrestrial Ecosystem Mapping in British Columbia, 1998 was the method selected to inventory and map the natural resources of Sooke Hills Wilderness and Mount Wells Regional Parks. Level-four survey intensity was used with 25 % polygon visitation. Mapping was completed at a scale of 1:20,000.

The Terrestrial Ecosystem Mapping (TEM) methodology stratifies the landscape into map units based on biotic and abiotic features such as climate, physiography, surficial material, soil and vegetation. Using a combination of air photo interpretation and field sampling, ecosystems are mapped using a hierarchy of ecological classifications. Wildlife interpretations follow the British Columbia Wildlife Habitat Rating Standards, Version 2 (1999). Both of these methodologies are Resources Inventory Committee (RIC) standards, which ensure the data can be added to the provincial data warehouse and that CRD parks can benefit from provincial designations for conservation significance and resource management guidelines.

Results

For mapping and analysis purposes, the study area was divided into four catchment areas, the Humpback, the Veitch, the Waugh and the Niagara. Each of these has a distinct set of terrain, ecosystem and wildlife features.

In total, six hundred and two polygons were mapped; 582 in the CWHxm1; 20 in the CDFmm. Eighty-three polygons were mapped as pure units (i.e. only one ecosystem unit) while the rest were mapped as complexes of two or three ecosystem units. Within the CWHxm1, ten forested and five non-forested ecosystems were mapped. In the CDFmm, five forested and one non-forested ecosystems were mapped. A combination of eight anthropogenic and non-vegetated units were mapped within both biogeoclimatic units.

Geologically the Sooke Hills Wilderness and Mount Wells Regional Parks are unique. The relatively small area encompasses three major terranes[1]. The Wrangellia, Pacific Rim and Crescent terranes are bounded by two very large and deep faults, the Survey Mountain Fault and Leech River Fault. This gives rise to very distinct groups of ecosystem, terrain and geological features which closely approximate the four catchment areas. (Figure 2)

Six distinct soil parent materials occur in the study area. Organics are rare and occur mainly as bogs and fens in the Niagara area. Fluvial materials are generally limited to narrow valley floors along streams. Some are found at wider sections of Waugh Creek. Glaciofluvial materials, deposited by glacial meltwater, are not common but where found they occur mainly as veneers (< 1m depth) on valley floors and lower slopes. Morainal deposits or glacial tills, which are formed under glacial ice, are variable with respect to depth, moisture availability and surface texture making ecosystem mapping complex on these materials. Morainal deposits give way to colluvial processes – downslope movement of materials – where slopes are greater than 40 %. Bedrock exposures are small but widespread through out the parks. The Niagara, Humpback, Veitch and lower Waugh consist of metamorphosed volcanic and gnessic rock. Both rock types are very hard and exhibit extensive fracturing. The upper Waugh consists of a softer rock (an argillite – metagreywacke unit).

Rocky upland areas dominated by Mount Wells characterize the Humpback. It includes the Humpback Reservoir and the eastern slope of Mount McDonald. The Humpback is the smallest of the four catchments, at 307 ha. The presence of both biogeoclimatic subzones is unique to the Humpback. The CDFmm is found at lower elevations from 0 – 150 m; the CWHxm1 is found above 150 m. In the Humpback, six ecosystem types were mapped in the CDFmm and eight ecosystem types were mapped in the CWHxm1.

The relatively flat, gently rolling terrain of the Waugh (1050 ha) is characterized by a mosaic of moist to mesic forest ecosystems, roads, reservoirs and dams. Evidence of damming activities is most apparent in this catchment. The Waugh does not have the same number and distribution of forested ecosystems at the wet and dry ends of the spectrum, as do the other catchments. However some moist to wet forests and wetlands are prevalent. Thirteen distinct ecosystem types are mapped in the Waugh.

The Niagara (1258 ha), the northern - most catchment of the study area, is characterized by gently rolling terrain, which becomes very steep to the east. The Niagara has a unique complex of wetland communities associated with small pocket depressions and riparian areas that have

[1]Terranes are areas of the earth's crust distinguished by a certain assemblage of rock types (Dunster and Dunster 1996)

formed within the undulating, shallow to bedrock terrain. Recent logging is evident in many of the forested ecosystems. However, significant areas of old forests remain in the steep terrain in the southeastern portion of the catchment. Thirteen distinct ecosystem types are mapped in the Niagara.

The Veitch (1496 ha), located in the south-western portion of the study area, is characterized by steep 'V' shaped valleys and rock outcrops. It has the greatest diversity of ecosystems of any of the catchment areas with fifteen distinct ecosystem types mapped. The diversity of ecosystems, their relative abundance, the large area, and few anthropogenic influences such as dams and roads, contribute to significant conservation values in this catchment.

Rare Plants and Ecosystems

Two types of rarity were identified within the scope of the project: rarity of ecosystems and rarity of plant species.

Mature and old forested ecosystems that are considered rare or endangered, by the Conservation Data Centre (CDC), comprise approximately 812 ha or 20 % of the study area. Endangered (red-listed) ecosystems cover only small areas within the study area and within each catchment, averaging less than 1% total cover. Rare (blue-listed) ecosystems tend to be more common and widespread, covering just over 18% of the study area.

A rare plant survey focusing on Mount Braden was conducted by CDC botanists on June 17 and June 28, 1999. Three vascular plant taxa were found during the course of this survey. One blue-listed species, *Agrostis pallens*, and two red-listed, *Githopsis speculariodes* and *Madia minima*, were collected.

Disturbance History

A long history of road building and forest management in the study area is evident by the limited distribution of old growth forests and the extensive network of roads and skid trails. In the CWHxm1, the majority of forested ecosystems are young, structural stage 5 with limited representation at both the younger and older stages of forest succession. The trend in the CDFmm forested ecosystems is similar with young forests dominating the landscape.

Although the Niagara has been the most heavily disturbed by forest harvesting and associated road building, it also has the highest overall percentage of old and mature forests of all the catchments. Conversely, the Niagara also has the greatest percentage of younger forest structural stages reflecting recent logging activity. An area-based analysis of structural stage distribution indicates that older forests in the Niagara occur as small patches rather than the larger patches found in the other catchment areas.

It appears that forest management and watercourse diversion have had a significant impact on many of the wet forest ecosystems, particularly in the Waugh. Very few mature or old Western redcedar - Sitka Spruce - skunk cabbage (RC) ecosystems or Western redcedar - slough sedge (CS) ecosystems were mapped in the study area. These ecosystems appear to have been altered by changes in water flow and repeated logging, and are now dominated by young, red alder stands.

Many upland areas within the parks have well-established hiking trails, particularly Mount Wells, Mount Braden, and Mount McDonald. Mount Wells is the most heavily used of these with numerous trails leading up the rocky slopes and to the base of steep rock walls used for rock climbing. Mount Braden has the least evidence of disturbance, probably due to the more remote location and limited access. Most of the sensitive, upland meadow ecosystems on Mount Braden and Mount McDonald remain in good to excellent condition.

Non-native species were observed in most ecosystems throughout Sooke Hills Wilderness and Mount Wells Regional Parks. Scotch broom is the most widespread. Scotch broom is scattered throughout the drier ecosystems in the study area and occurs commonly on disturbed sites. Most of the roads and ditches as well as the adjacent ecosystems have a component of broom associated with them. Powerlines, which bisect the Humpback and Veitch catchments, encourage the establishment of this invasive species. Non-native species observed in non-forested ecosystems were sweet vernal grass, foxglove, soft brome and oxeye daisy. Non-native species frequently observed in forested ecosystems include English holly and wall lettuce.

Naturalness

Naturalness assessments were completed for the four catchments in the study area, based on the structural and ecosystem diversity and the degree of disturbance. The Veitch, Niagara, Humpback and Waugh catchments were evaluated for naturalness relative to each other rather than to areas outside the project boundaries.

Naturalness was ranked highest in the Veitch. This catchment has the greatest diversity of forested ecosystems with few roads or trails and the greatest variety and area of upland ecosystems - many of which are still in good condition. The Veitch has had less recent forest harvesting or other disturbances. There is little sign of damming or altering of watercourses. As a result, riparian and wetland ecosystems along Veitch Creek are in good condition. The southwestern end of the catchment, along Shepherd Creek supports a large expanse of mature moist to wet forest. There is evidence of recreational trails, particularly to the summits of Mount McDonald and Mount Braden. Introduced species, such as Scotch broom, are well established on Mount McDonald and along the powerline right-of-way.

Naturalness in the Niagara was ranked second. The Niagara has the greatest diversity of structural stages represented in forested ecosystems and the largest amount of old forests. The wetland complex in the northwest portion of this catchment is important for a variety of animal species. Recent disturbances due to forest harvesting and the associated road network have resulted in large areas of young forests. These disturbances have also resulted in influxes of invasive species, in particular Scotch broom, along roads and in recently cut areas.

Naturalness in the Humpback was ranked third highest. Recreation use at Mount Wells and the Humpback Reservoir is high and the number of roads and dams in the area is significant. However, biodiversity values in this area are significant due to the presence of both the CDFmm and CWHxm biogeoclimatic units. The units have been highly developed throughout the province. The area to the west of Humpback reservoir has patches of old forest in good condition and of significant size with limited existing use.

Naturalness in the Waugh was ranked lowest. This area has many anthropogenic features including dams, reservoirs, exposed soils, and roads. Changes to watercourses and natural water flow have affected the distribution and function of ecosystems in this catchment. Forest harvesting and recent thinning is apparent throughout much of the catchment, particularly in the common circumesic ecosystems.

Wildlife

The objective of wildlife interpretations for the Sooke Hills Wilderness and Mount Wells Regional Parks was to estimate the potential value of the area's ecosystems to support selected animal species. This was accomplished by applying habitat ratings to ecosystem maps to produce capability and suitability maps. Four vertebrate species were chosen for this study: Columbian black-tailed deer (*Odocoileus hemionus columbianus*), black bear (*Ursus americanus*), Pileated Woodpecker (*Dryocopus pileatus*), and Marbled Murrelet (*Brachyramphus marmoratus*).

Habitat ratings indicate the value of a habitat to support a particular wildlife species for a specified habitat use compared to the best habitat in the province (i.e. the provincial benchmark) (RIC 1999). Capability is the ability of the habitat, under optimal natural conditions, to support a particular species irrespective of the current condition of the habitat. Suitability is the ability of the habitat to support a particular species in its current condition.

Sooke Hills and Mount Wells Regional Parks represent valuable wildlife habitat. The parks are the largest contiguous area of protected habitat for many wildlife species on southeast Vancouver Island. Within the study area, over 25% of the habitat corresponds to high value wildlife habitat regardless of the project species, life requisite or season under consideration. In particular, the older forests in the Niagara area, east of Niagara Main, were identified as having high suitability for several project species. Some ecosystem units and polygons in the Veitch area were also rated as high value habitat.

Summary

Sooke Hills Wilderness and Mount Wells Regional Parks remain relatively undeveloped and together are large enough to maintain a diversity of ecosystems and wildlife habitats. The area can support a variety of species from very small to large predator-prey relationships. As well, the study area provides breeding habitats for numerous species of invertebrates, birds, and small mammals. The parks likely represent the nearest habitat refuge for many wildlife species, which is especially important given its proximity to nearby urban centres.

However, various disturbances have altered the natural distribution, abundance and structure of the ecosystems found here. Forestry, including road building, fire, often a result of human activity, stream course diversions and damming, introductions of non-native and invasive vegetation species and recreational activities have all impacted the natural condition of the study area. The type and degree of influence varies in each catchment.

The parks contain components of mature and older forest that are considered provincially rare and endangered. Many of these ecosystems have little regional or provincial representation in protected areas, making the study area a significant contributor to their overall representation in parks. A number of red- and blue-listed plant species occur within the parks.

There is an abundance of young, even-aged forests found throughout the study area and within both BGC units. Young, even-aged forests have low structural diversity and as such have limited value to wildlife. Older forest types with greater structural complexity typically are more important wildlife habitat, in coastal ecosystems. Old forests, pole sapling and shrub stage forests are not well represented in the study area indicating a need to manage for greater structural variety. This will ensure not only the health and diversity of ecosystems, but will also support the greatest variety of wildlife species.

Upland meadow ecosystem complexes are common, particularly in the Veitch and Humpback. These are focal points for a variety of recreational uses (e.g. hiking, rock climbing, and mountain biking). The shallow soils and thick moss and lichen layers of these ecosystems make them very susceptible to trampling damage.

Wetlands are important ecosystems particularly from a wildlife perspective. The Niagara has a system of wetlands that remain in good natural condition. In the Waugh, the influence of past disturbances, especially the modification of natural water flow and volume, has impacted ecosystem function.

The physical characteristics of surficial materials such as texture, structure, cohesion and compactness, coupled with soil drainage characteristics can influence the engineering properties of surficial materials. For example, surficial material erodability and stability on slopes would directly affect the location of trails and parking areas in park designs. Park development will furthermore be limited by terrain features that can affect public safety (i.e. very steep colluvial and talus slopes may be unsuitable for recreation activities).

Sooke Hills Wilderness and Mount Wells Regional Parks represent an area of relative wilderness, large enough to support a diversity of ecosystems, wildlife habitats and animal species. However, given the increasing recreational demands of a growing population, urban development pressures and resource extraction on adjacent lands, maintaining the wilderness features of the parks will no doubt present an ongoing challenge to land managers.

Key Management Recommendations

Sensitive Ecosystems

Sensitive ecosystems should merit special attention and consideration in management plans. Establishment of trails is these areas should be kept to a minimum in order to minimize impacts on rare plants and fragile ecosystems. Red- and blue-listed ecosystems should have little or no development. More detailed inventory work is required to better determine the number and distribution of rare plant species in the study area.

Wetlands

Care should be taken to not cause further disturbance to wetland ecosystems. The influence of surrounding trails, roads or alterations in water flow can have significant impacts on wetland conditions, and therefore these activities should be avoided. Wetland ecosystems of limited extent, may require a buffer zone and protection of water input sources may be needed to ensure their long-term function.

Forests

Forested ecosystems should be managed to encourage the full spectrum of structural stages from young shrub stages to old forests. Methods of encouraging structural diversity, such as controlled burns or thinning, will need to be examined.

Roads and Access Routes

Management planning should consider decommissioning roads where possible. The use of existing roads for future public access routes, rather than establishing new trails and roads, should be encouraged. Public education regarding the fragile nature of sensitive ecosystems should be encouraged along all current and new access routes. For example interpretive signs along access routes can be posted, to increase user awareness of the potential impacts to ecosystems.

Management Considerations by Watershed

Humpback

Access is already well established to Mt. Wells. As a result, authorized trails should be developed with the aim to mitigate the impacts of foot traffic and rock climbing to the upland meadow communities.

Older forest ecosystems in the northwest portion of the catchment represent areas of high wildlife and ecosystem diversity. Access to these areas should be minimized

Veitch

Mt. Braden and Mt. McDonald will continue to attract a variety of user groups, therefore existing trails should be maintained or where possible improved, to minimize disturbance to the surrounding sensitive ecosystems. Efforts should be made to increase public awareness regarding the sensitive nature of the upland meadow area and the importance of staying on the trails.

It is not recommended that new trails be established on either Mt. Braden or Mt. McDonald.

Waugh

The existing level of disturbance, lack of critical wildlife habitat and fragile ecosystems combined with the gently undulating terrain make this catchment an excellent location for recreational development. Opportunities exist for hiking, cycling, rock climbing and horseback riding.

Niagara

Protection and limited access to the wetland complexes in the Niagara is recommended, as is protection and limited access to the old forest ecosystems. If access routes are needed they should be restricted to a single trail or access point.

Terrain Considerations

Terrain features such as surficial materials have development implications. Detailed guidelines are provided in the report for each type of surficial material.

Generally organic soils should be classed as very sensitive to use. Fluvial materials are usually located along the valley floors in association with steams. As such they may support riparian or wet loving vegetation, have poor drainage, and may be subject to compaction and erosion with moderate to heavy use. Glaciofluvial materials and morainal materials should be evaluated on a site by site basis. These deposits may be appropriate for some types of development, such as trails but not for others such as pit toilets. Because colluvial material is mostly found on steeper slopes it is likely not suitable for many applications. This terrain may show some instability as shallow to bedrock rubble (Cvx Rhm) could move under foot or possibly roll down-slope, particularly when on the steeper bedrock hills. Bedrock outcrops tend to support sensitive ecosystems and should be carefully considered before development occurs in these areas.

Management Considerations for Wildlife

Wildlife habitat management in the Sooke Hills Wilderness and Mount Wells Regional Parks should take four broad approaches.

1. Old-growth forests provide important habitat for all the project species and should be protected from disturbance.

2. Forest stands in young, structural stage (i.e., 2 and 3) offer abundant food value for Columbian black-tailed deer and black bear. Habitat that provides food for wildlife species should be protected and created. In general, recreational use and facilities in these areas should be careful scrutinized in order to maintain food values.

3. Natural disturbance regimes in coastal ecosystem should be identified and approximated with management techniques.

4. Existing wildlife tree and CWD volumes should be maintained. Moreover, initiatives should be implemented that recruit some live trees into the wildlife-tree population.

Considerations by Species

Columbian Black-tailed Deer – Winter Habitat

Activities, such as controlled burns, may be considered to improve deer growing season habitat. Recreational activities, particularly in winter, should be restricted in areas rated as high deer habitat. Year-round features (trails, viewing areas, boardwalks, and parking areas) should not be developed in high value winter habitat.

Black Bear – Spring Habitat

Protect all sites identified as Class 1 or 2 spring habitat (i.e., typically moist sites with a rich nutrient regime or wet meadows) from any year-round recreational activities or human disturbance regimes. Prevent encroachment by trees and possible elimination of available early spring forage in areas currently identified as early spring habitat.

Black Bear – Growing Habitat

Maintain the current volumes of Coarse Woody Debris (CWD) by restricting any activities that remove CWD from the landscape. Protect ecosystem units containing diverse berry producing shrub components and identify and protect fish habitat in any salmon bearing streams.

Black Bear - Hibernating Habitat

As black bear hibernating habitat shares many stand structure characteristics similar to deer winter range and Marbled Murrelet nesting habitat, protection of hibernating habitat can be accomplished in concert with protecting habitat values for other project species.

Pileated Woodpecker– Nesting Habitat

Maintain existing volumes of CWD to ensure adequate prey base – insects in CWD.

Marbled Murrelet – Nesting Habitat

Restrict any disturbance during the nesting period (mid April to late September) and any activities that may compromise the structural integrity of nesting habitat throughout the year. For murrelets and other wildlife species, the Niagara area is an area of high habitat value, and so should receive special consideration. Carefully evaluate recreational use in the Niagara area. Given the high importance of the Niagara area to several project wildlife species, limit recreational activities and permanent recreational facilities in the Niagara area.

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1.0 Introduction

1.1 Location

Sooke Hills Wilderness and Mount Wells Regional Parks are located on southern Vancouver Island, southwest of Finlayson Arm in the Saanich Inlet and north of Sooke Basin in the Strait of Juan de Fuca (Figure 1). The study area is located primarily within the Langford Electoral district with smaller portions in the Sooke and the District of Metchosin electoral areas.

Sooke Hills Wilderness Regional Park comprises two large areas of former non-catchment lands of the Greater Victoria Water District (GVWD), now Capital Regional District (CRD) Water. The park is located to the northeast and southwest of the current Goldstream water supply catchment and encompasses approximately 4,100 hectares of rocky hilltops, upland meadows, forests, wetlands and streams. Sooke Hills Wilderness Regional Park encompasses three catchments, from north to south, the Niagara, the Waugh, and the Veitch. A portion of the Humpback catchment is also included in this park. Mount Braden (471 m) and Mount McDonald (437 m), are the highest peaks within Sooke Hills Wilderness Regional Park.

The Mount Wells Regional Park portion is approximately 85 hectares in size and includes upland meadows, rock outcrops and forests rising to the summit of Mount Wells (370 m) and a smaller hill to the east. Mt. Wells Regional Park is considered part of the Humpback catchment. To the west this park connects to the Mount McDonald and Humpback Reservoir portions of Sooke Hills Wilderness Regional Park.

In this document Sooke Hills Wilderness and Mount Wells Regional Parks will be collectively referred to as the study area.

1.2 Background

Based on recommendations of the Perry Commission, the Sooke Hills Wilderness Regional Park was created by the *Capital Region Water Supply and Sooke Hills Protection Act (Bill 17-1997)* in May 1997 and designated a Regional Park Reserve by CRD Parks. The park is classified as a Regional Wilderness Area with management priorities to include the protection of the adjacent water supply and the protection of the natural environment (CRD 1999a). Public access and recreational uses are to be carefully managed to protect the water supply and sensitive environmental features. To this end, there is a currently no unauthorised public access to the lands making up the park (CRD 2000b) until a management plan for the park is complete and adequate facilities are in place.

Mount Wells Regional Park was established as part of a provincial government, land transfer resulting from the CRD contribution towards the purchase of the Gowlland-Tod Provincial Park. Mount Wells is classified as a Regional Conservation Area. This classification is given to areas that have significant natural or scientific importance and are of sufficient size to ensure natural features can be protected (CRD 1999a).

Public land acquisition, timber harvesting and damming activities in what is now Sooke Hills Wilderness Park began in the late 1800's. The Greater Victoria Water District (GVWD) was established in 1948 to supply water to several local municipalities. Large parcels of land were then transferred from the city of Victoria to the GVWD. Between 1949 and 1992 significant

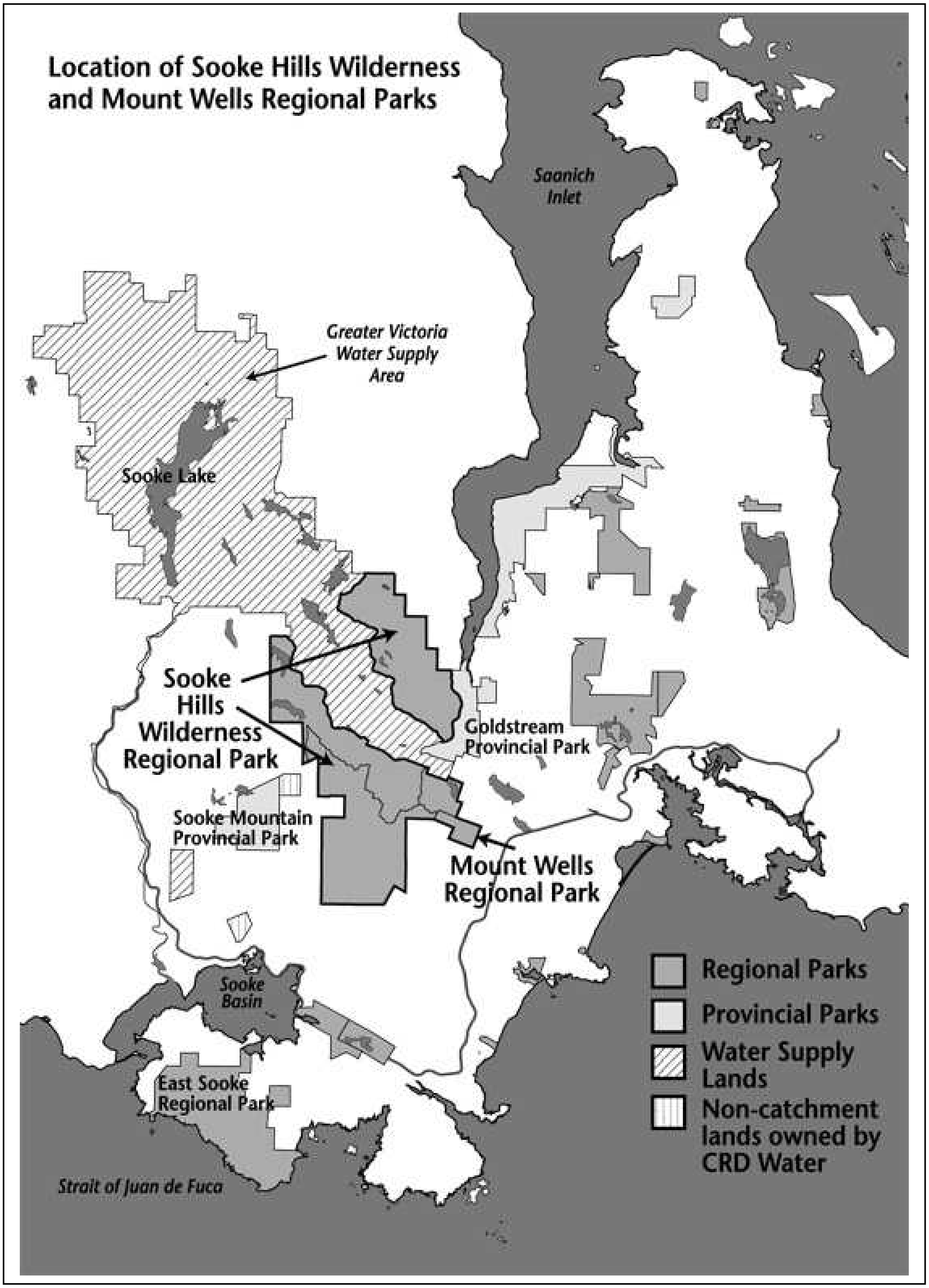

Figure 1: Sooke Hills study area.

portions of the GVWD lands were logged under a sustained yield strategy; as well, other areas in the GVWD were cleared to allow for increased reservoir capacities. Additional land management during this time included reforestation, fire suppression and timber salvage to maintain forest health and generate revenue for water supply infrastructure development. To accommodate these activities a network of roads was constructed and several rock quarries established (CRD Parks, 1995). In 1993 commercial logging ceased but harvesting for water supply and watershed management continued. (CRD 1999b). In the early 1990's the non-catchment lands began to be considered surplus and in 1995 CRD parks began to explore the area's value as a regional park (CRD 2000b).

The CRD Parks Master Plan (2000a) and regulatory bylaws govern current management for Sooke Hill Wilderness and Mount Wells Regional Parks. Potential management strategies for the parks are undergoing a public consultation process. In recent years it has been proposed that the park be incorporated into the CRD "S*ea to Sea Greenbelt*". This sea to sea initiative is intended to create a natural barrier to urban sprawl and to protect a largely uninterrupted zone of green space from Sooke Basin to Tod Inlet. (CRD, 1995). The Niagara catchment of Sooke Hills Wilderness Regional Park will likely provide a route for the Trans Canada Trail, a non-motorized-use recreation trail extending across the country.

CRD Parks are increasing the sophistication of ecological inventories within regional parks. Consequently, Terrestrial Ecosystem Mapping (TEM) with wildlife interpretations was selected to inventory the natural resources of Sooke Hills Wilderness and Mount Wells Regional Parks. Resource Inventory Committee (RIC) standards for TEM will ensure the data can be added to the provincial data warehouse and CRD parks can benefit from provincial designations for conservation significance and resource management guidelines.

2.0 Biophysical Setting

2.1 Ecoregion Classification

Sooke Hills Wilderness and Mount Wells Regional Parks are located in the Nanaimo Lowland Ecosection within the Georgia Depression Ecoprovince. The ecoprovince lies between the Vancouver Island Mountains and the Southern Coast Mountains. The Nanaimo Lowland Ecosection is a coastal plain situated on the southeastern margin of Vancouver Island.

The movement of coastal air masses influence the climate of the Nanaimo Lowlands ecosection. As these masses move eastward over the Vancouver Island Mountains, they subside and create clearer and drier conditions than in the areas adjacent to the ocean. The CWHxm and CDFmm have warm dry summers with a long growing season. Water deficits are common on zonal sites during the summer in both subzones. The winters are mild and moist to wet with relatively little precipitation falling as snow. (Green and Klinka 1994).

2.2 Biogeoclimatic Classification

Most of the study area is situated within the eastern variant of the Coastal Western Hemlock very dry maritime (CWHxm1) biogeoclimatic (BGC) subzone. A small portion of Mount Wells Regional Park located in the Coastal Douglas-fir moist maritime (CDFmm) subzone.

The CDFmm is one of the smallest forested subzones in the BGC system. It is the mildest subzone in British Columbia. The CDFmm is found only within the Georgia Depression Ecoprovince from sea level to approximately 150 m. This subzone is restricted to a small part of Vancouver Island, some of the Gulf Islands and a narrow band along the mainland coast. Coastal Douglas-fir, the dominant tree in the upland forests, is commonly found along with western redcedar, grand fir, arbutus, Garry oak and red alder, depending on the site conditions. Dominant understory species include salal, dull Oregon-grape, ocean spray and the moss, *Kindbergia oregana.* Many lily species are found in the drier ecosystems*.* The drier ecosystems on shallow soils are often associated with Garry oak and arbutus ecosystems. These sensitive ecosystems are becoming increasingly rare regionally, and are therefor considered to be of particular significance. Urbanisation and agricultural pressures have resulted in the loss of many natural ecosystems in this subzone. All mature and old forest ecosystems in the CDFmm are considered provincially rare and/or endangered by the Conservation Data Centre

The CWHxm1 is a wetter and cooler unit, occurring from sea level, or above the CDFmm, where present, to 700 m. The CWHxm1 is found on the east side of Vancouver Island and inland along major river valleys, on the islands of the southern Johnston Strait, south of the Fraser River on the mainland, and along the Sunshine Coast. Zonal sites are predominately composed of Douglas-fir and western hemlock with lesser amounts of western redcedar. Salal, dull Oregon-grape, and red huckleberry are common shrubs with *Kindbergia oregana* and *Hylocomium splendens* commonly occurring in the moss layer. The Conservation Data Centre currently lists nine of the forested ecosystems of the CWHxm1 as provincially rare or endangered.

2.3 Geology and Glacial History

The relatively small study area is geologically unique and quite remarkable in that it encompasses three major terranes[1], which are bounded by two very large and very deep faults. These faults are the Survey Mountain Fault separating the Wrangellia from the Pacific Rim Terrane, and the Leech River Fault separating the Pacific Rim Terrane from the Crescent Terrane (Yorath and Nasmith, 1995) (Figure 2). A significant fault, known as the Malahat Fault, also occurs along Niagara Creek, and another, known as the Goldstream Fault, occurs along the Goldstream River. Numerous smaller faults lie perpendicular to the major west to east faults. This extensive faulting provided ‘softer’ zones for glaciers to work and form the Sooke Hills.

2.3.1 Geology

The geological origin of the west coast of British Columbia is a terrane known as Wrangellia. It is hypothesized that a series of exotic terranes which originated in distant latitudes in an ancient Pacific Ocean were accreted to the edge of north America throughout the past 170 million years (Yorath and Nasmith, 1995). As a part of this process, the area now within the park, was an ancient volcanic island arc that consisted of deep oceanic lava plains and sedimentary rocks. These rocks, ranging in age from the Devonian to the Tertiary period (370 to 20 million years ago) became metamorphosed, complexed, and fractured as they moved from the south and were subjected to folding, faulting and uplift.

[1] [1]Terranes are areas of the earth’s crust distinguished by a certain assemblage of rock types (Dunster and Dunster 1996)

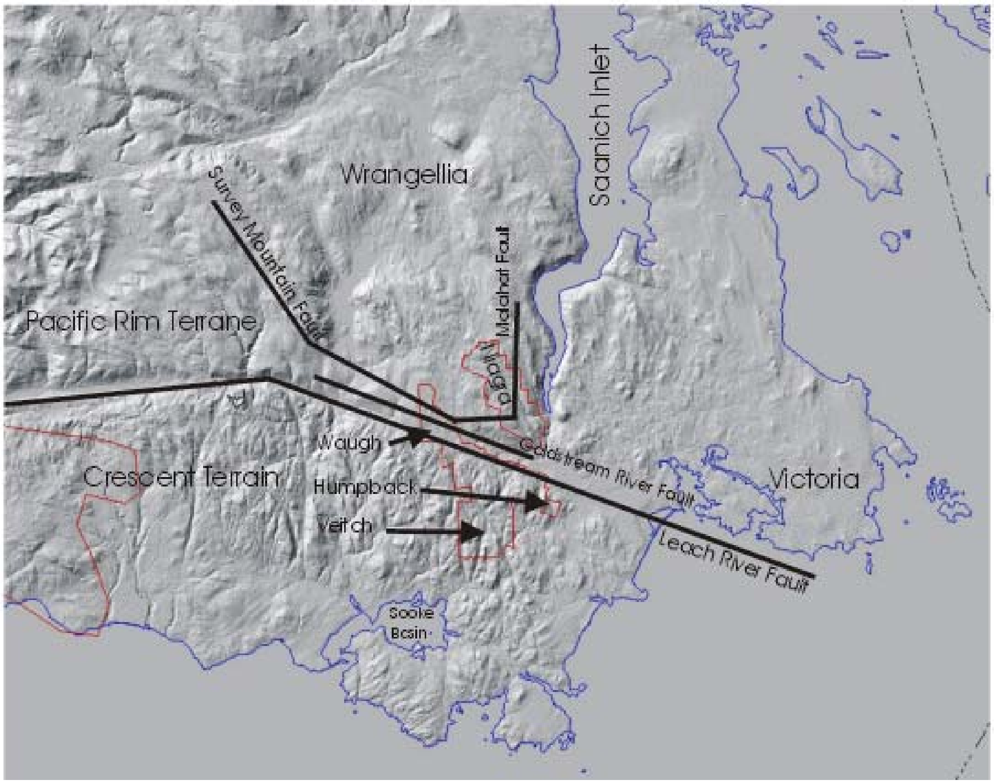

Figure 2: "Hill Shade" diagram illustrating the relationship of faults to catchment areas

Seismic studies conducted on the Survey Mountain Fault show it to be over 10 kilometers deep (Massey pers.com.). Most of these older major fault lines are now covered with a succession of sedimentary strata called the Sooke Formation consisting of sandstone and conglomerate rocks. T.J. Drown (1991) provides a good summary of the fault and bedrock information in a seven page Geological Report and map on the Greater Victoria Watershed.

The bedrock in the northeast part of the study area, the Niagara catchment, is part of Wrangellia and contains the oldest rock dated from the Devonian period 370 million years ago. The rock is mainly metamorphosed sedimentary and igneous types known as the dark - and light - coloured Colquitz Gneiss and the dark - and light - gray coloured Wark Gneiss. Both rock types are very hard and extensively fractured. Glaciated materials (till) derived from these rocks form mainly coarse textured soils having gravelly sandy loam and loamy sand textures. The thin colluvium originating from these rock types has similar textures but typically includes more rubble.

The Waugh catchment running through the centre of the study area is largely filled with sediment of the Vashon Drift deposited 20,000 to 15,000 years ago. This rolling terrain is roughly bounded by the Goldstream fault on its northern boundary and the Leech River fault on the southern boundary. Between these two faults lies the Pacific Rim Terrane, where it narrows distinctly to about 1,000 m. across. The rocks of this narrow terrane are derived mainly from the Leech River Formation (63 – 230 million years) and consist of the relatively softer metagreywacke, sandstone and siltstone. The glaciers have eroded this softer rock more extensively than in the harder rock found in the Niagara and Veitch areas, and consequently deposited deeper layers of drift[2] in the Waugh catchment.

The Veitch catchment contains distinct 'hill' formations commonly known as the Sooke Hills. These hills are formed in the Crescent Terrane, which arrived on the coast about forty-two million years ago. The bedrock in this terrane originates from an ancient sea floor formed about fifty-four million years ago (Yorath and Nasmith, 1995). The rocks here are of the Metchosin Igneous Complex and consist of marine and non-marine lavas and gabbro. The Crescent Terrane was emplaced below the Pacific Rim Terrane and subsequent uplifting has added to the extensive major cracks and joints, as well as to the many faults running perpendicular to each other. These geological processes have helped to create the hatched hill-like patterns, which over the millions of years of weathering and glaciations have enhanced and sculptured the rock into unique hill formations.

The Humpback catchment is the smallest in the study area and lies at the eastern extent. It holds the Humpback reservoir. Kapoor Main Road, running east to west, and Humpback Road, running north to south access the catchment. The area is characterized by two main hills separated by the Leech River Fault. On the north side is the Pacific Rim Terrane, which consists of Argillite – Metagreywache bedrock. On the southern and larger portion is the Crescent Terrane, which consists of basaltic lava of the tertiary Metchosin Volcanics. The hills rise from the Humpback reservoir, at about 100 metres, to the hilltops cresting at about 400 metres. These steep rises which consist of relatively hard bedrock have many rock exposures and steep rock faces – particularly in the southern portion. The surficial materials consist mainly of thin colluvium and till which rest on the more gentle slopes and in the valley bottoms. Deeper pockets of sediments occur in the 'Humpback basin' where the influences of water processes have resulted in the deposits of fluvial and organic materials.

2.3.2 Glaciation

About 20,000 years ago the Sooke Hills area was covered by glacial ice with depths ranging from 500 to 1000 m (D. Huntley et. al., in press, 2000). The climate then warmed significantly and at about 15 thousand years ago (ka) ice sheets began to melt (Heusser, 1973; Alley and Chatwin, 1979; Clague, 1981). Ice lobes became isolated in the valleys by about 14ka. By 12ka most of the ice had melted leaving the lakes, basins and watercourses that exist today (Alley and Chatwin, 1979).

The soils in this area began to form about 14ka to 12ka, along with the establishment of vegetation. Huntley et al. (2000) describe the early vegetation of the region as follows: "Floral macrofossils in early postglacial lake sediments indicate that vegetation was dominated by lodgepole pine stands and grassland". This vegetation assemblage is indicative of relatively dry, cool conditions (Hebda, 1995).

3.0 Terrestrial Ecosystem Mapping

Terrestrial Ecosystem Mapping (TEM) stratifies the landscape into map units according to a combination of ecological features, primarily climate, physiography, surficial material, bedrock geology, soil and vegetation. The mapping combines aspects of two ecological classification

[2] Drift: a general term for sediments or rock materials deposited by glacial ice or glacial meltwater, usually in areas no longer glaciated (Dunster and Dunster 1996)

systems, Biogeoclimatic Ecosystem Classification (BEC) and Ecoregion classification. Ecosystem units are mapped using a bioterrain approach, a procedure that focuses on observable site and biological features assumed to determine the function and distribution of plant communities on the landscape. Four classes are mapped: ecoregion (ecoregion units), zonal (biogeoclimatic units), site (site series), and vegetational development (structural stages and seral community types). Map units are delineated using a combination of aerial photograph interpretation and field sampling to verify ecosystem boundaries and types. Maps produced using the TEM methodology are incorporated into Geographic Information Systems (GIS) (RIC 1998).

3.1 Objectives

The primary purpose of the project was to complete terrestrial ecosystem mapping for Sooke Hills Wilderness and Mount Wells Regional Parks in order to provide baseline information for CRD park management purposes. In addition to the core suite of data collected for TEM mapping, CRD parks requested the inclusion of the following attributes to support interpretations.

Attributes collected in the field were:

- occurrences of invasive species, wildflower sites, anthropogenic sites and recreation sites, where observed
- threatened and endangered plant species (CDC botanical survey)

Mapped attributes included:

- stand composition modifiers (e.g. coniferous, mixed or broadleaf stand)
- percent canopy closure
- microsites (small but important ecosystem types comprising less than 10% of a polygon)

Data interpretation included:

- assessing habitat for black bear, Columbian black-tailed deer, Marbled Murrelet, and Pileated Woodpecker
- naturalness assessment of the four watersheds

3.2 Methodology

Mapping was completed according to the methodology outlined in Standard for Terrestrial Ecosystem Mapping *in British Columbia* (RIC, 1998*)*. Mapping was completed at a scale of 1:20,000 using Resource Inventory Committee (RIC 1998) survey intensity level four.

3.2.1 Terrain Mapping

Terrain units were delineated, prior to the beginning of field work, onto 1:15,000 scale black and white 1998 aerial photographs, following the standards outlined in the Terrain Classification System for British Columbia (Howes and Kenk 1997) and the Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC 1998). The first step in the mapping process was the delineation of polygons based on a variety of ecological parameters including surficial geology, topography, soil drainage, aspect and vegetation. Terrain symbols, geomorphic processes, and soil drainage classes were assigned to each polygon. Appendix 1 contains information regarding terrain mapping and the terrain symbology.

Following fieldwork, the pre-typed polygon lines, terrain symbols, and soil drainage classes were revised based on field data.

3.2.2 Ecosystem Mapping

Development of a Working Legend

A working legend describes the relationship between physical attributes of a site to ecological units. The sampling plan is based on the working legend and ensures that all of the variability present in the study area is sampled. Using the terrain pretyping as baseline information, ecosystem units expected to occur in the study area are correlated to the physical conditions most likely to support their development, and these assumptions are then verified or corrected during field sampling.

3.2.2.1 Field Sampling

Fieldwork was completed between May and August of 1999. There were 4 sampling sessions, May 17 – 18, June 15 – 24, July 20 – 22, and August 17 – 24. These sampling phases allowed for the sampling and identification of a range of spring and summer vegetation. Field crews consisted of three members, a plant ecologist, a terrain/soil specialist and a wildlife biologist. Carmen Cadrin, Jo-Anne Stacey and Corey Erwin, Tracy Fleming, Samantha Flynn and Barb von Sacken collected vegetation data; Bob Maxwell, Christina Sinnemann, and Corey Erwin collected soils data; Sal Rasheed, Calvin Tolkamp and Lynne Bonner collected wildlife data.

Polygons were sampled using three types of plot inspections;

1. full ecological plots with detailed site, soil, vegetation and wildlife descriptions (FS882 forms),
2. ground inspection plots (GIF) with abbreviated site, soil and vegetation descriptions,
3. and visual inspections to confirm mapping details.

Conservation evaluation forms were completed at each sample site.

The Field Manual for Describing Terrestrial Ecosystems, DTEIF (Province of BC 1998) provides a detailed methodology for data collection at full and ground inspection plots while The S*tandard for Terrestrial Ecosystem Mapping in British Columbia* (RIC, 1998) provides guidelines for data collection at visual sites. Photos were taken at each of the detailed and ground inspection plots, as well as many of the visual plots.

Colour photocopies of the original pre-typed black and white 1:15,000 air photos were laminated and used in the field. The location of all detailed plots, ground inspections, and visuals were placed on these photocopies with the corresponding plot number written on the back of the photo. The plot locations and numbers were then transferred to the original photos and basemap after each field session.

3.2.2.2 Plant Identification

Plants that were difficult to identify in the field were collected and keyed out using botanical keys (Douglas et. al., 1999, Hitchcock and Cronquist, 1973). Where identification could not be made with confidence, voucher specimens were submitted to Jennifer Penny at the CDC for expert identification. A list of plant species observed during the field surveys is found in Appendix 2.

3.2.2.3 Data Analysis

Upon completion of the fieldwork, the appropriate soils, vegetation and wildlife personnel reviewed the field forms. Data from the field plots were recorded in digital format using RIC standard software (Ministry of Forests 1997). The databases were used to sort the plots into groups with similar physical and vegetation attributes and then used to refine ecosystem classifications. The range of environmental conditions, terrain units, and vegetation communities over which site series were distributed is described in the expanded legend (Appendix 3).

3.2.2.4 Expanded Legend Development

Forested ecosystems were identified using existing site series described in *A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region* (Green and Klinka, 1994). Non-forested units such as wetlands and rock outcrops were described based on the field data. Plot data was used to describe all of the ecosystem units found in the parks during the development of the expanded legend. The structural stages that were not sampled were extrapolated from known seral community types and plot information from other studies in similar areas. Based on plot data, introduced species lists were created for each ecosystem type.

The range of elevation for units described in the expanded legend are specific to this project area only. For example, the CDFmm has a maximum range of 70m in the study area. Typical ecosystem descriptions are based on project specific characteristics along with provincial distribution of the units. The CDFmm occurs only as two very narrow bands in the Humpback Road and Mt. Wells area. The southern portion of the study area along Veitch Creek and Shepherd Creek show transitional characteristics to CDFmm, but are mapped as the CWHxm1.

3.2.2.5 Final Mapping

Ecosystem units were mapped according to the *Standard for Terrestrial Ecosystem Mapping in British Columbia* (RIC, 1998). Each forested ecosystem is assigned an uppercase two-letter code that is equivalent to a recognized biogeoclimatic ecosystem classification (BEC) site series. Site series have been identified according to Green and Klinka (1994). Labelling for all forested ecosystems follows the updated site series coding master list available on the Ministry of Environment, Lands, and Parks website (http://www.elp.gov.bc.ca/rib/wis/tem/provincial.htm). Where an ecosystem was not recognized as an official site series (eg. wetlands or herbaceous meadows), new ecosystem units were proposed and two letter codes applied similarly. Sparsely vegetated, non-vegetated and anthropogenic units follow the symbols outlined in Table 3.1 of the TEM standards (RIC, 1998). Figure 3 shows an example map label

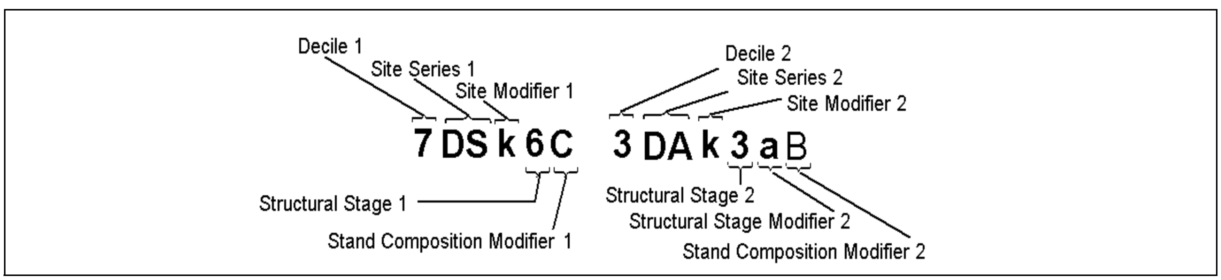

Figure 3. Example ecosystem map label.

Site modifiers were used where applicable, to more accurately describe the ecosystem (Table 1 and Figure 4). Up to two site modifiers may be present (in lower case letters) with each ecosystem unit. Site modifiers represent different site conditions than those of the typical environmental condition (typical situation), as defined by MELP, for each site series. Each site series has a set of assumed site modifiers under the typical situation. Hence, when a site series is mapped in its typical situation, site modifiers are not included in the map label. The site series code and/or site modifier(s) are followed by a numerical structural stage designation, 1 through 7 (Table 2). A structural stage modifier (a single lower case letter) further subdivides the structural stage designation where appropriate. Stand composition modifiers, (Table 3) a single uppercase letter indicating the dominant stand composition and crown closure were also mapped for each ecosystem unit.

Up to three ecosystems units were noted for each polygon. The percentage of each ecosystem unit present is indicated by deciles ranging from 1 to 10 (1=10%; 10=100%). Note that 10 (100%) is not displayed in the map label, but does appear in the database.

3.2.2.6 Site Modifiers

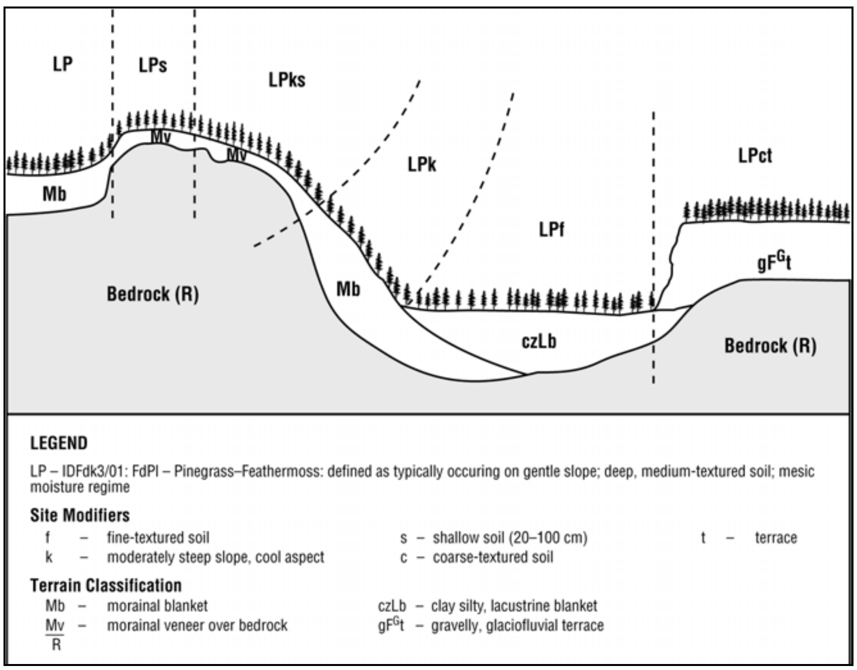

Figure 4: Use of site modifiers in mapping site series

The following is a list of TEM codes for site modifiers applied to the study (*Standard for Terrestrial Ecosystem Mapping in British Columbia* (RIC 1998)).

Table 1: Site modifiers for atypical conditions.

Code	Criteria
Topography	
a	active floodplain[1] – the site series occurs on an active fluvial floodplain (level or very gently sloping surface bordering a river that has been formed by river erosion and deposition), where evidence of active sedimentation and deposition is present.
g	gullying[1] occurring – the site series occurs within a gully, indicating a certain amount of variation from the typical, or the site series has gullying throughout the area being delineated.

Code	Criteria
h	hummocky[1] terrain (optional modifier) – the site series occurs on hummocky terrain, suggesting a certain amount of variability. Commonly, hummocky conditions are indicated by the terrain surface expression but occasionally they occur in a situation not described by terrain features.
j	gentle slope – the site series occurs on gently sloping topography (less than 35% in the CWH, CDF, and MH zones).
k	cool aspect – the site series occurs on cool, northerly or easterly aspects (285°–135°), on moderately steep slopes (35%–100% slope in the CWH, CDF and MH zones).
n	fan[1] – the site series occurs on a fluvial fan (most common), or on a colluvial fan or cone.
q	very steep cool aspect – the site series occurs on very steep slopes (greater than 100% slope) with cool, northerly or easterly aspects (285°–135°).
r	ridge[1](optional modifier) – the site series occurs throughout an area of ridged terrain, or on a ridge crest.
w	warm aspect – the site series occurs on warm, southerly or westerly aspects (135°–285°), on moderately steep slopes (35%–100% slope in the CWH, CDF and MH zones).
z	very steep warm aspect – the site series occurs on very steep slopes (greater than 100%) on warm, southerly or westerly aspects (135°–285°).
Soil	
c	coarse-textured soils[2] – the site series occurs on soils with a coarse texture, including sand and loamy sand; and also sandy loam, loam, and sandy clay loam with greater than 70% coarse fragment volume.
d	deep soil – the site series occurs on soils greater than 100 cm to bedrock.
f	fine-textured soils[2] – the site series occurs on soils with a fine texture including silt and silt loam with less than 20% coarse fragment volume; and clay, silty clay, silty clay loam, clay loam, sandy clay and heavy clay with less than 35% coarse fragment volume.
m	medium-textured soils – the site series occurs on soils with a medium texture, including sandy loam, loam and sandy clay loam with less than 70% coarse fragment volume; silt loam and silt with more than 20% coarse fragment volume; and clay, silty clay, silty clay loam, clay loam, sandy clay and heavy clay with more than 35% coarse fragment volume.
p	peaty material – the site series occurs on deep organics or a peaty surface (15–60 cm)[3] over mineral materials (e.g., on organic materials of sedge, sphagnum, or decomposed wood).
s	shallow soils – the site series occurs where soils are considered to be shallow to bedrock (20–100 cm).
v	very shallow soils – the site series occurs where soils are considered to be very shallow to bedrock (less than 20 cm).

[1] Howes and Kenk 1997
[2] Soil textures have been grouped specifically for the purposes of ecosystem mapping.
3 Canada Soils Survey Committee, 1987

3.2.2.7 Structural Stages

The following is a list of TEM codes for structural stages taken directly from *Standard for Terrestrial Ecosystem Mapping in British Columbia* (RIC 1998).

Table 2: Structural stages and codes[1]

Structural Stage	Description
Post-disturbance stages or environmentally induced structural development	
1 Sparse/bryoid[2]	Initial stages of primary and secondary succession; bryophytes and lichens often dominant, can be up to 100%; time since disturbance less than 20 years for normal forest succession, may be prolonged (50–100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover less than 20%; total tree layer cover less than 10%.
Substages	
1a Sparse[2]	Less than 10% vegetation cover;
1b Bryoid[2]	Bryophyte- and lichen-dominated communities (greater than 1/2 of total vegetation cover).
Stand initiation stages or environmentally induced structural development	
2 Herb[2]	Early successional stage or herbaceous communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree layer cover less than 10%, shrub layer cover less than or equal to 20% or less than 1/3 of total cover, herb-layer cover greater than 20%, or greater than or equal to 1/3 of total cover; time since disturbance less than 20 years for normal forest succession; many herbaceous communities are perpetually maintained in this stage.
Substages	
2a Forb-dominated[2]	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by non-graminoid herbs, including ferns.
2b Graminoid-dominated[2]	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by grasses, sedges, reeds, and rushes.
2c Aquatic[2]	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by floating or submerged aquatic plants; does not include sedges growing in marshes with standing water (which are classed as 2b).
2d Dwarf shrub[2]	Communities dominated (greater than 1/2 of the total herb cover) by dwarf woody species such as *Phyllodoce empetriformis, Cassiope mertensiana, Cassiope tetragona, Arctostaphylos arctica, Salix reticulata,* and *Rhododendron lapponicum*. (See list of dwarf shrubs assigned to the herb layer in the *Field Manual for Describing Terrestrial Ecosystems)*.
3 Shrub/Herb[3]	Early successional stage or shrub communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree layer cover less than 10%, shrub layer cover greater than 20% or greater than or equal to 1/3 of total cover.
Substages	
3a Low shrub[3]	Communities dominated by shrub layer vegetation less than 2 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 20 years for normal forest succession.
3b Tall shrub[3]	Communities dominated by shrub layer vegetation that are 2–10 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 40 years for normal forest succession.
Stem exclusion stages	
4 Pole/Sapling[4]	Trees greater than 10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually greater than 10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy – this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance is usually less than 40 years for normal forest succession; up to 100+ years for dense (5000–15 000+ stems per hectare) stagnant stands.

Structural Stage	Description
5 Young Forest[4]	Self-thinning has become evident and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions.
Understory reinitiation stage	
6 Mature Forest[4]	Trees established after the last disturbance have matured; a second cycle of shade tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance is generally 80–140 years for biogeoclimatic group A[5] and 80–250 years for group B.[6]
Old-growth stage	
7 Old Forest[4]	Old, structurally complex stands composed mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition typical, as are patchy understories; understories may include tree species uncommon in the canopy, due to inherent limitations of these species under the given conditions; time since disturbance generally greater than 140 years for biogeoclimatic group A[5] and greater than 250 years for group B.[6]

1 In the assessment of structural stage, structural features and age criteria should be considered together. Broadleaf stands will generally be younger than coniferous stands belonging to the same structural stage.
2 Substages 1a, 1b and 2a–d should be used if photo interpretation is possible, otherwise, stage 1 and 2 should be used.
3 Substages 3a and 3b may, for example, include very old krummholz less than 2 m tall and very old, low productivity stands (e.g., bog woodlands) less than 10 m tall, respectively. Stage 3, without additional substages, should be used for regenerating forest communities that are herb or shrub dominated, including shrub layers consisting of only 10–20% tree species, and undergoing normal succession toward climax forest (e.g., recent cut-over areas or burned areas).
4 Structural stages 4–7 will typically be estimated from a combination of attributes based on forest inventory maps and aerial photography. In addition to structural stage designation, actual age for forested units can be estimated and included as an attribute in the database, if required.
5 Biogeoclimatic Group A includes BWBSdk, BWBSmw, BWBSwk, BWBSvk, ESSFdc, ESSFdk, ESSFdv, ESSFxc, ICHdk, ICHdw, ICHmk1, ICHmk2, ICHmw3, MS (all subzones), SBPS (all subzones), SBSdh, SBSdk, SBSdw, SBSmc, SBSmh, SBSmk, SBSmm, SBSmw, SBSwk1 (on plateau), and SBSwk3.
6 Biogeoclimatic Group B includes all other biogeoclimatic units.

3.2.2.8 Stand Composition Modifiers

The following is a list of the TEM codes for stand composition modifiers taken directly from *Standard for Terrestrial Ecosystem Mapping in British Columbia* (RIC 1998).

Table 3: Stand composition modifiers, [1] and codes

Modifier	Description
C coniferous	Greater than 3/4 of total tree layer cover[2] is coniferous
B broadleaf	Greater than 3/4 of total tree layer cover[2] is broadleaf
M mixed	Neither coniferous or broadleaf account for greater than 3/4 of total tree layer cover[2]

1 Stand composition modifiers should be used as in the following examples: 6C for mature forest of coniferous composition, 7mM for old forest with multistoried structure and mixed composition, 3bC for tall shrub community dominated by coniferous saplings.
2 Stand composition modifiers emphasize overstory and intermediate tree layers, since these are the most visible on aerial photographs.

3.2.3 Discussion of Map Reliability

3.2.3.1 Survey Intensity

All CWHxm1 sites described were sampled in the field. Due to time and sampling constraints some CDFmm units were not sampled but were observed in the field, air photo interpreted and described based on other studies e.g. Jedediah Island TEM mapping. Some sparsely vegetated and anthropogenic units, for example, rock outcrops (RO) were observed in the field and on the air photos but no plot data were collected. Small pocket ecosystems, particularly in the upland meadows and rare ecosystems would benefit from further inventory and more detailed mapping to better describe their occurrence and distribution in the Sooke Hills.

The study area was well roaded and trailed, so access was rarely a limitation, except in the case of some rock outcrops in the Veitch and in the southeastern portion of Mt. Wells. A total of 602 polygons were delineated. Eight detailed plots, 24 ground inspection plots, and 126 visual inspections were completed. Plot locations are indicated on the TEM map (Appendix 4). One hundred and fifty-eight polygons (26%) were visited, equivalent to a level 4 survey intensity under the RIC standards. All other areas were photo interpreted. Extensive existing data sources such as forest cover maps, bedrock geology maps, soils maps, etc. provided useful additional information.

3.2.3.2 Air Photographs

Black and white aerial photographs taken in 1998, at a scale of 1:15,000, were used for mapping the study area. As well, an orthophoto was used as an overview map. With black and white photographs it was at times difficult to distinguish between bare rock and some herbaceous outcrop communities that occurred in similar situations. Laminated colour laser copies of the air photos proved to be very helpful for orientation during field sampling.

3.2.3.3 Ecosystem Identification

Although the scale of the airphotos did allow for significant detail to be captured, many small ‘pocket’ ecosystem types were too small to be delineated or even complexed with other units. Examples of these include areas where water collected in bedrock basins often smaller than 2 metres square, small seepage pools, and the complex of upland meadow and lichen communities that occurred on the rock outcrops. Where possible, small inclusions of ecosystems were noted in the comments and in the microsite fields of the database (see microsites section for further details).

3.3 Results and Discussion

3.3.1 Surficial (Genetic) Materials

There are six distinct soil parent materials or surficial genetic materials in the study area, each lying at different slope positions and containing different soil drainage and texture characteristics. These differences contribute to the array of ecosystem types in the study area.

3.3.1.1 Organic Deposits

Organic **(O)** deposits are mainly support bogs and fens in this area. They are located in water collecting hollows in many catchments, particularly the northeast Niagara. Glacial ice was likely responsible for ‘gouging’ the hollows along the drainage routes. It is in these locations that the last remnants of ice melted away about 13,000 years ago, leaving small lakes and ponds. Stream flow and some ground water flow have likely always fed these water bodies. As such, the relatively shallow cold waters were prime sites for the start of hydrophytic plant growth and subsequent bog succession. In many locations it appears bog succession has matured to a steady state, where peat has infilled the hollows and the vegetative cover now responds to the annual rise and fall of the water table.

Organic deposits associated with lakes and ponds, in the form of muck bottoms consisting of organic sediments from plants and aquatic animals and often fallen trees, branches and stumps were not mapped, but often contain significant flora and fauna. The bogs and wetlands which were sampled during the fieldwork included 'strips' located in narrow drainages (10 to 25m across), small, circular bogs (greater than .5ha) located in bedrock hollows and larger, shrubby bogs (5 to >10ha) in wider valley positions.

In most of the bogs the depth of peat is greater than 140cm placing these organic soils in the Typic Mesisol Organic Soil Classification. The organic soil profile is usually capped by about 30cm of fibric peat derived from sedges. Below the surface tier are layers of mostly humic peat with substantial layers of mesic and occasionally fibric horizons. Tree branches and occasionally logs were found with a probe indicating that some bogs may have gone through slightly forested stages of succession. The general chemical and physical status of these bogs, known as the Metchosin soil series is as follows:

- Bulk Density: 0.25 to 0.55.
- Von Post Scale: 7 – 10.
- pH H2O: 4.0 to 5.7.
- Exchangeable cations (meq/100g): Ca 50.0, Mg 5.3, Na 0.48, K 0.41
- Available P (ppm): 13 %
- Organic Carbon: 40%.
- Moderately pervious.

The ecosystem units typically associated with the organic deposits are the Sedge wetlands (SW), Hardhack – Labrador tea (HL), and Lodgepole pine – sphagnum (LS) wetland units.

Figure 5: Soil profile from western end of Mavis Reservoir.

Once a large floating pad of peat, from the flooding of the reservoir, this grounded section of humic organic (Figure 5), shows how deep and well humified the peat in has become in some bog filled basins.

Figure 6: A peat (organic) filled drainage.

Peat holds a large amount of water relative to its weight. It acts as a natural storage reservoir and purifies the water for streams and ponds (Figure 6).

3.3.1.2 Fluvial Deposits

Fluvial **(F)** sediments in the study area, consisting mainly of sorted sands and gravels, are limited to the narrow valley floors along stream channels and to some wider stream sections of the Waugh catchment. Fluvial sediments can be grouped into 'non-active' and 'active' deposits.

The 'non active' fluvial deposits include the well-drained terraces, some fluvial fans, blankets and veneers draped over tills. Except for the veneers, these deposits are usually 1 m deep and can consist of layers or strata of sand, fine sand, gravels, and sandy gravels. As such, the soils on benches such as terraces, are well-aerated, well-drained and likely experience significant moisture deficiencies during late summer. In some cases, a summer water table at a depth of 3 to 4m may be present, which provides moisture to larger cedar and fir trees throughout the year. Non active fluvial deposits are recorded in the terrestrial ecosystem database as **sFt, or sgFt, b, v or sFp or grFf.**

The 'active' fluvial deposits (Figure 7) are those associated with running water and overbank flooding which occurs today. Active sediments are recorded as **szFAp or sFAt**. These materials are also sorted sands and gravels but have very little to no soil development and their proximity to water creates imperfectly and poorly drained conditions. The active fluvial deposits have variable textures, often with well-sorted moist sands on the small floodplains or with gravelly bouldery deposits (Figure 8) adjacent to streams with steeper gradients. Some of the fluvial deposits in the steeper gullies associated with the larger streams are quite gravelly and stony, while the flatter sections of streams are mainly sands and some gravels.

Some lower benches, such as those found along Veitch Creek, have fluctuating water tables as well as groundwater influences from the lower slopes. These areas are among the most productive sites in the study area. They are recorded in the database as **FAt** (imperfectly drained). Narrow fluvial units, often only 3 to 10m in width, frequently occur along the margins of most streams. These are too small to be mapped and are not identified in the database. However, these areas are very important for many wildlife species, particularly those, which require riparian habitat and/or watercourses for their travel, food and cover.

The ecosystem units typically associated with fluvial materials are the Western redcedar - foamflower (RF), Western redcedar – Sitka spruce - skunk cabbage (RC) and the Western redcedar – slough sedge (CS).

Figure 7: Gravelly, pebbly active fluvial plain.

This is a small floodplain with gravelly sediments Silty sands likely occur along the less active parts of the stream banks.

Figure 8: Bouldery, cobbly active fluvial floodplain.

This material may be reworked glaciofluvial sediment.

3.3.1.3 Glaciofluvial Deposits

Glaciofluvial (**FG)** materials were not common in the study area. The area is generally too steep, consisting of hilly rock structures and narrow valleys. There are no large flat outwash plains or deltas where these deposits are usually extensive.

Where they were found, glaciofluvial materials occur mainly as veneers (<1m) and occasionally as blankets (likely over tills). They exist mainly along the valley floors, and lower slopes, particularly where the last lobes of ice melted away. At some locations pockets of deeper stratified deposits of gravels and sands occur (usually at the junctions of drainages).

Spot locations of glaciofluvial sediments occur as variable depths of sands and gravels at stream margins that once transported large volumes of glacial meltwater, such as Goldstream and Veitch creeks. These deposits are sorted where deeper sediments are found and non-sorted where thin deposits occur over gently sloping morainal surfaces. The latter has been seen to occur as a 'wash' or 'lag' where meltwaters have reworked the surface slightly and removed much of the fine sands and silts.

The textures are usually gravels and sands, and gravelly loamy sand, and the materials are mainly well-drained **(w)** with some moderately well (**m)** drained sites and imperfectly (**i**) drained sites.

The main ecosystem unit mapped on glaciofluvial materials is the Western hemlock – Douglas-fir – Kindbergia (HK).

Figure 9: Basin of Jack Reservoir

Glaciofluvial materials are often found in pockets and as thin veneers over tills in these landscapes.

3.3.1.4 Morainal Deposits or Glacial Till

Morainal **(M)** deposits or glacial tills (Figure 10) consist of a mixture of gravels, sands and silts deposited beneath glacial ice. The tills of the Sooke Hills are known as the 'Shawnigan' soils, which are common to the east coast of Vancouver Island in the CDFmm. These deposits were laid down about 15 000 years ago during the Vashon Ice advance. The Veitch, Humpback, Niagara and lower Waugh areas are hilly and consist of hard metamorphosed volcanic and gneissic bedrock. The till did not accumulate to any significant depths in most areas, as the glacial ice had to work with the hard rock and steeper slopes. Therefore the till surfaces here are classified mainly as veneers (<1m) with the deeper till blankets occurring in the hollows and on the flatter areas. In the upper Waugh catchment, the bedrock is softer (an 'argillite-metagreywacke' unit) and the terrain is gently rolling. Deeper tills are more common here. At the southern or lower end of the major streams in the Veitch catchment, deep deposits (>5m) of compact grey basal till are often found and are visible at some of the road cuts. Virtually no till is found on steep (>60%) hillsides and only rarely in the hollows on the hilltops.

Most of the soil textures are silty gravelly sand or gravelly loamy sand. The soils are generally loose and porous to a depth of about 60 cm, are very strongly acidic (4.6 to 4.8) in the solum, and have a medium nutrient status. The soils are moderately well and well drained, and usually have a duric or cemented pan at a depth of about 60 to 90cm. This pan, when it occurs, usually restricts root penetration and in some locations, such as in hollows, will restrict drainage and perch water. On longer slopes, soil water will flow laterally over the pan, increasing soil moisture status. During the late summer on the well and moderately well drained soils, drought conditions are common.

Given the variable nature of the tills, particularly with respect to depth, moisture availability and the generally unpredictable surface texture, the mapping of ecosystem units is complex. The dominant soil conditions are drier when on medium to coarse-textured, variable depth (50 to > 200cm) material. Well to moderately well drained soils occur on gentle to moderate slopes. Moister sites occur in hollows and on lower slope positions, which are also slightly richer in nutrients. The general physical and chemical properties of the rooting zone (80cm) of mineral soil, in a Shawnigan till are as follows:

- Bulk Density: 1.7
- pH CaCl2: 4.6 to 5.8.
- Exchangeable Cations (meq/100g): Ca 1.5, Mg 0.3, Na 0.1, K 0.1
- Available P (ppm): 19 %
- Organic Carbon: 1.1%
- Sulphur (ppm): 3.5
- Slowly pervious

Figure 10: A deep section of compact basal till in the lower Waugh Catchment

The ecosystem unit typically associated with morainal blankets in the CWHxm1 is the Western hemlock – Douglas-fir – Kindbergia (HK), while the Douglas-fir – Western hemlock – Salal (DS) is typically mapped on a morainal veneer, and less frequently on a morainal blanket. In the CDFmm1, the Douglas-fir - Salal (DS) unit is associated with till or morainal materials.

3.3.1.5 Colluvial Deposits

Morainal or till deposits give way to colluvial processes (downslope movement of materials) when slopes become steeper than 40%. Bedrock exposures, such as knolls and ridges, are very common throughout the study area and have mixtures of thin till and colluvium on their margins. Colluvium **(C)** is the most extensive material in the study area due to the hilly bedrock terrain. Colluvium takes on many forms (Figure 11 & 12). On the upper, mid and lower slopes with 40 to 70% gradients, thin rubbly colluvium occurs on rock shelves and hollows. This is usually in the form of very thin veneers, **x**, (only 4 to 25cm thick) but deeper colluvial veneers, **v,** (25 to 100cm thick) also occur on lower slopes and valley floors.

Colluvium is mixed with the till and usually derived from it. This results in a gravelly loamy sand soil texture and when broken bedrock is mixed in, rubbly silty sand textures occur. At the base of steep slopes, rubbly blocky soil textures, somewhat similar to talus, are common. Colluvium is porous and extremely droughty on the very thin materials over bedrock. Some colluvium at the base of slopes has more water available due to seepage and large trees are often found on these sites.

Figure 11: Rubbly silty sandy Colluvium over metamorphic rock.

Nutrient status is variable over the range of colluvial deposits. The thin black soils associated with the Fescue – Common camas (FC), Arbutus – Hairy manzanita (AM) and Selaginella – cladina (SC) ecosystem units likely have a high nutrient status, but low volume of nutrients due to the extremely thin soil which contributes to the site sensitivity. The other deeper sites (50 – 100cm) likely have a nutrient status similar to the morainal deposits. The seepage areas at the base of slopes have a higher nutrient status.

The ecosystem types typically associated with colluvial materials are Douglas-fir –Lodgepole pine – Cladina (DC), Douglas-fir – Western hemlock – Salal (DS) and Western hemlock – Douglas-fir – Kindbergia (HK)

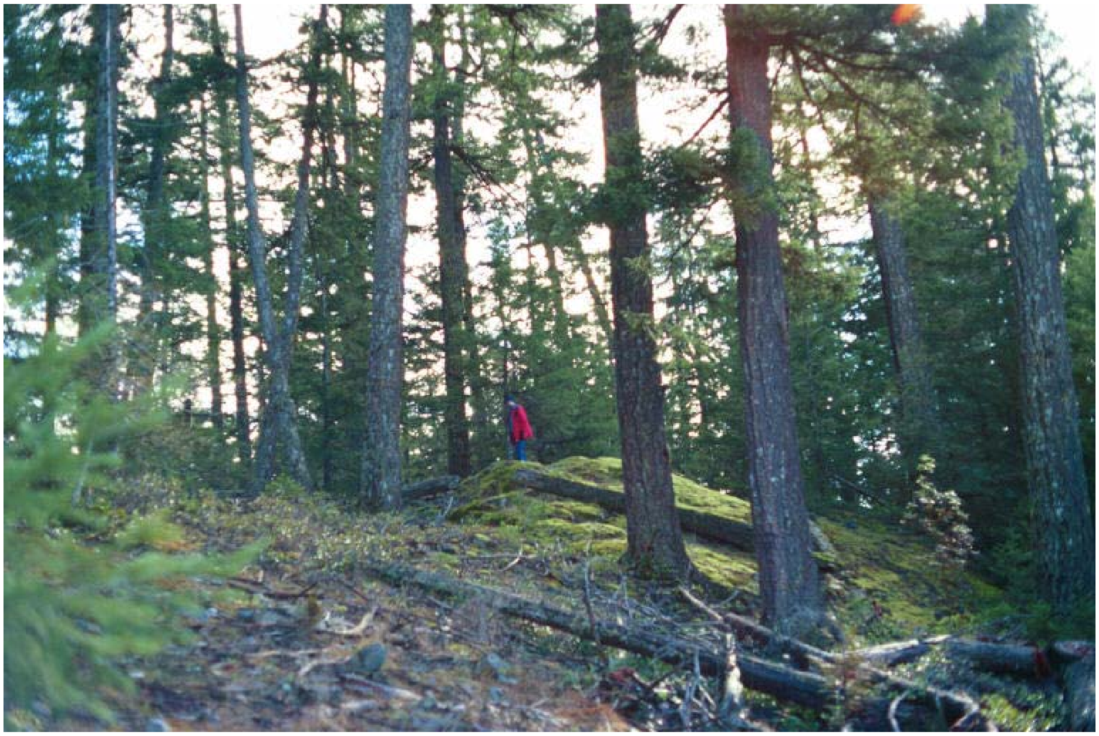

Figure 12: Typical thin colluvial and bedrock landscape in the Niagara Catchment.

3.3.1.6 Bedrock

The bedrock **(R)** in the Niagara catchment is mainly metamorphosed sedimentary and igneous types known as the dark - and light - coloured Colquitz Gneiss and the dark - and light - grey coloured Wark. Both rock types are very hard and extensively fractured. These fractures allow water to penetrate into the groundwater system. Some of this groundwater likely emerges at lower slope positions providing moisture to the wetter ecosystems.

Like the Niagara, the Veitch, Humpback, and lower Waugh areas are hilly and consist of hard, metamorphosed volcanic and gneissic bedrock(Figure 13). The bedrock of the Veitch catchment often shows exposed pillow basalts that have interesting geological characteristics. These rocks are also cracked and jointed allowing water to penetrate and re-emerge at the base of some slopes.

In the upper Waugh catchment, the bedrock is softer (an 'argillite-metagreywacke' unit) and the terrain is gently rolling. The rocks in this area may contain more nutrients than in the neighboring catchments. This could be reflected in the high percentage of rich ecosystems (i.e. Western redcedar - Sitka Spruce - skunk cabbage (RC) and Western redcedar - foamflower (RF) units found on the lower slopes in this area. These units, in all probability, benefit from the downhill nutrient flow. Joints and cracks in this the bedrock allow water to move into groundwater systems.

The ecosystem types associated with bedrock are Douglas-fir –Lodgepole pine – Cladina (DC), Fescue – Common camas (FC), Arbutus – Hairy manzanita (AM) and Selaginella – Cladina (SC).

Figure 13: Bedrock hills and Cliff typical of the Veitch catchment - Basalt of the Metchosin Igneous Complex

3.3.2 Site Series and Ecosystem Units

The majority of Sooke Hills wilderness area occurs within the eastern, very dry maritime Coastal Western Hemlock (CWHxm1) biogeoclimatic subzone (4019 ha). Only a small portion of the study area lies within the moist maritime Coastal Douglas-fir (CDFmm) subzone (94 ha). Within the project area six hundred and two polygons were mapped, 582 were mapped in the CWHxm1 while only 20 were mapped in the CDFmm. Map polygons consist of either pure map units e.g. only one ecosystem unit mapped in the polygon, or complex map units with two or three ecosystem units mapped within a polygon. Of the total polygons only eighty-three were mapped as pure units, the rest were mapped as complexes. There were 1403 ecosystem units mapped.

Twenty-three distinct ecosystem units were mapped in the CWHxm1; ten were mapped in the CDFmm. Within the CWHxm1 ten forested and five non-forested ecosystems were mapped. Five forested and one non-forested ecosystems were mapped in the CDFmm. Both biogeoclimatic units had a combination of eight anthropogenic and sparsely or non-vegetated units mapped.

Detailed accounts for each ecosystem unit are provided in the expanded legend (Appendix 3). Each unit is described over two pages. The first provides a description of the ecosystem including its typical topographical position, site, soil and terrain characteristics, as well as a photo of the community and/or an illustration of common plant species. A small distribution map, indicating all polygons where the unit was mapped in at least one of the three deciles regardless of the relative proportion, is included. The second page provides a summary of the dominant and associate plant species at each developmental stage and lists all of the relevant plot numbers. Also included is a brief discussion of the wildflowers and the introduced species commonly associated with that unit.

Dominant species are defined as those having 5% or higher cover and occurring in the unit with at least 75% frequency. Associates are considered those species that have 40% to 75% frequencies in a unit regardless of cover.

Six potential structural stages are listed for the forested ecosystem units. Structural stages that were not sampled were extrapolated from other developmental stages, known seral community types, plot information from other studies in similar areas, and the Ministry of Forests environment and vegetation tables for the CWHxm1 and CDFmm (Inselberg, 1991). For the edaphic units, such as the wetland and rock outcrop communities, only the herb or shrub stages are described. Notes to further describe the unit or explain how the findings in Sooke Hills may differ from sites found in other areas of the CWHxm1 and CDFmm are provided at the bottom of each table.

Ten forested ecosystems occur in the CWHxm1 from upper to lower slopes, in moist to very dry conditions. Figures 14, 15, 16 and 17 provide generalized diagrams of how the ecosystems occur across areas in the CWHxm1.

The upland sites include, from driest and poorest to mesic: the FdPl[3] – Cladina unit (DC/02), the Fd[3] – Salal unit (DS/03) and the HwFd[3] – Kindbergia unit (HK/01). The three remaining upland communities were nutrient rich ecosystems with the driest unit being the Fd[3] – Oregon-grape (DG/04), followed by the CwFd[3] – Sword fern (RS/05), and finally the Cw[3] – Foamflower (RF/07). Three other forested communities, wetter and richer sites, with a considerably high water table for a significant portion of the year were mapped. These include the Western redcedar - Sitka Spruce - skunk cabbage forested swamp (RC/12); the Cw[3] – Slough sedge fluctuating water table unit (CS/15); and a high bench floodplain, the Act – Red-osier dogwood unit (CD/09). The Pl – Sphagnum bog (LS/11) unit was a wet, poor forested site.

Five previously undescribed non-forested ecosystems were also mapped in the CWHxm1. These include two wetland communities; the Sedge – wetland (SW), a sedge-dominated fen and the Hardhack – Labrador-tea (HL) unit, a shrub-dominated fen. Three upland units were mapped as well, the Arbutus – Hairy manzanita (AM) shrub type unit, the Fescue – Common camas (FC) meadow, and the Selaginella – Cladina (SC) unit, a bryophyte dominated rock outcrop ecosystem.

Eight sparsely vegetated, non-vegetated, and/or anthropogenic units, such as shallow open water, rock, lakes, roads, dams, and reservoirs were also mapped.

[3] Tree codes follow MoF codes: Fd – Douglas-fir, Cw – western redcedar. Pl – lodgepole pine, Bg – grand fir, Hw - western hemlock, Act – black cottonwood

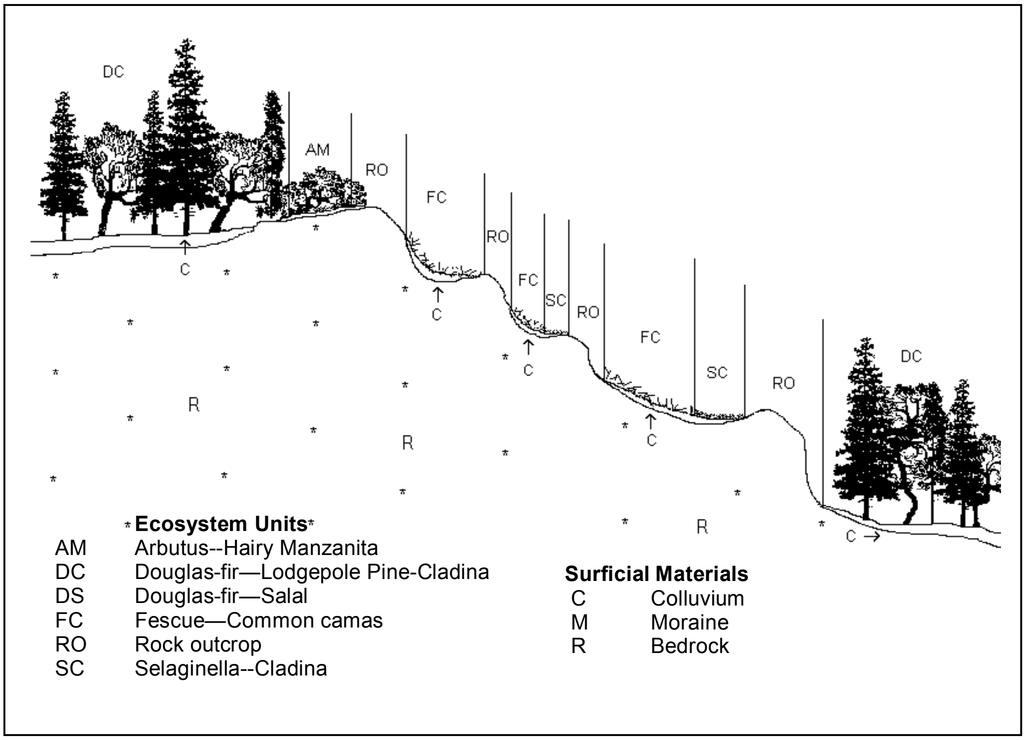

Figure 14: Landscape Profile Diagram for the Crest and Upper Slope Positions on Mt. Braden and Mt. McDonald (warm aspects)

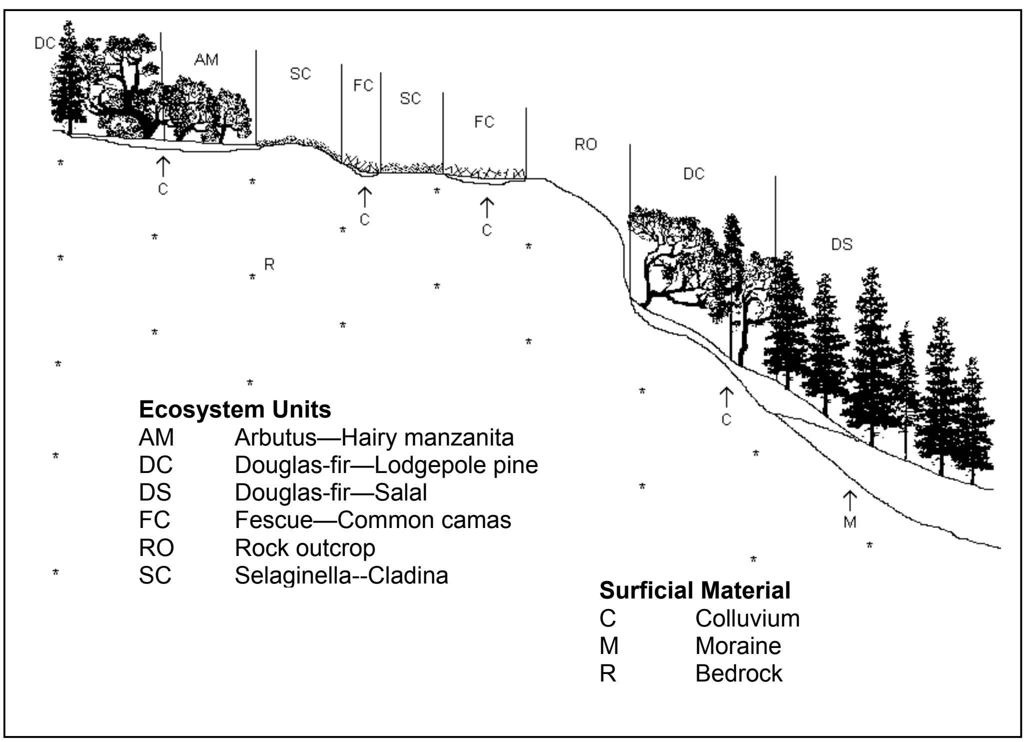

Figure 15: Landscape Profile Diagram for the Mid to Upper Slope Positions on Mt. Braden and Mt. McDonald (warm aspects)

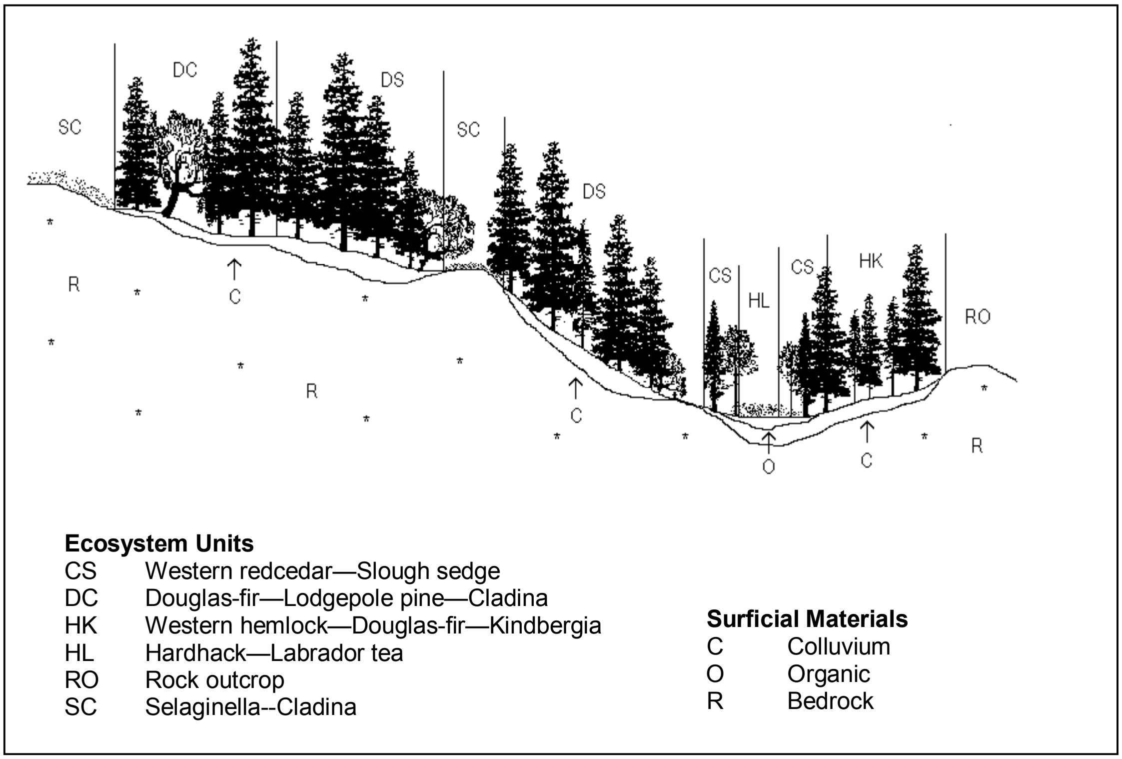

Figure 16: Landscape Profile Diagram for the Upper Niagara Catchment

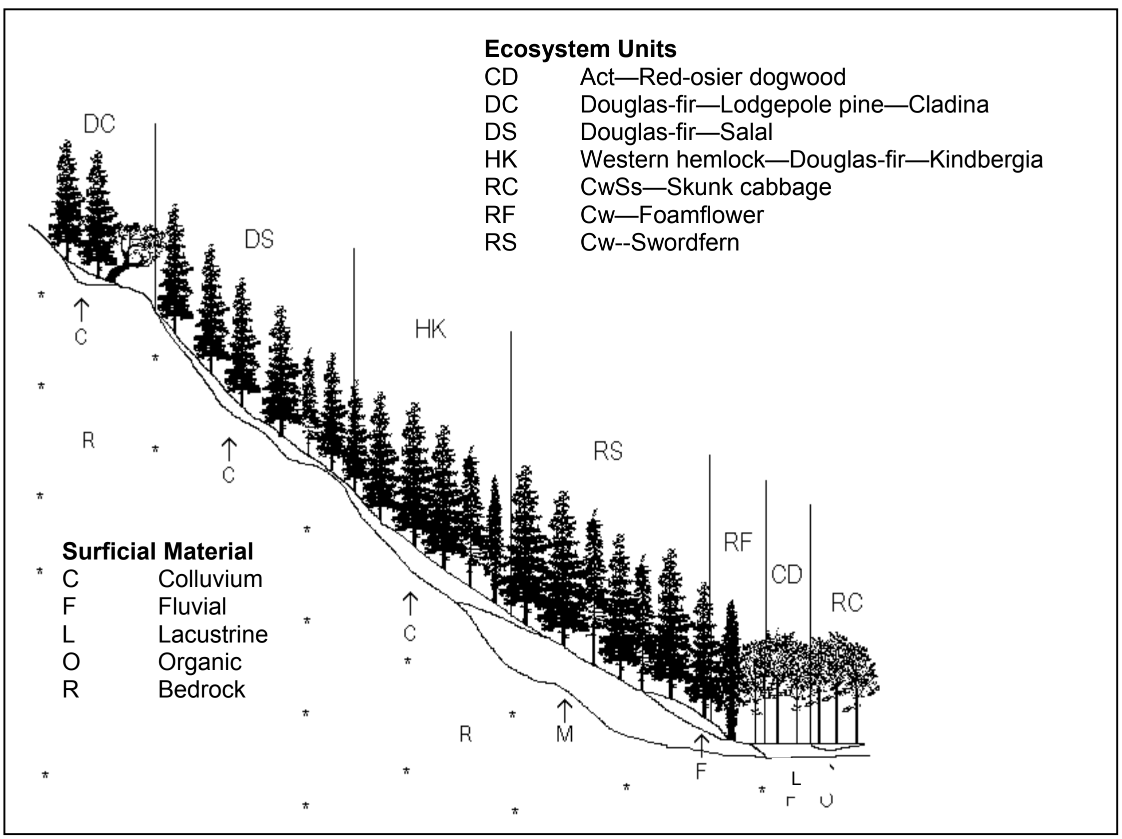

Figure 17: Landscape Profile Diagram for the Veitch

Five forested ecosystems occur in the CDFmm1 from mid to lower slopes, at elevations below the CWHxm1. Figure 18 shows a generalized diagram of how ecosystems occur in the CDFmm. Ecosystem occurrence, from driest and poorest to richest and wettest, is as follows; FdPl[3] – Arbutus (DA/02), Fd[3] – Salal (DS/01), CwFd[3] – Kindbergia (RK/05), CwBg[3] – Foamflower (RF/06), and the Cw[3] – Skunk cabbage (RC/11).

One non-forested wetland, the Hardhack – Labrador tea unit (HL), a shrub-dominated fen, was mapped along the valley bottom. Four sparsely vegetated, non-vegetated, and anthropogenic units were also mapped in the CDFmm.

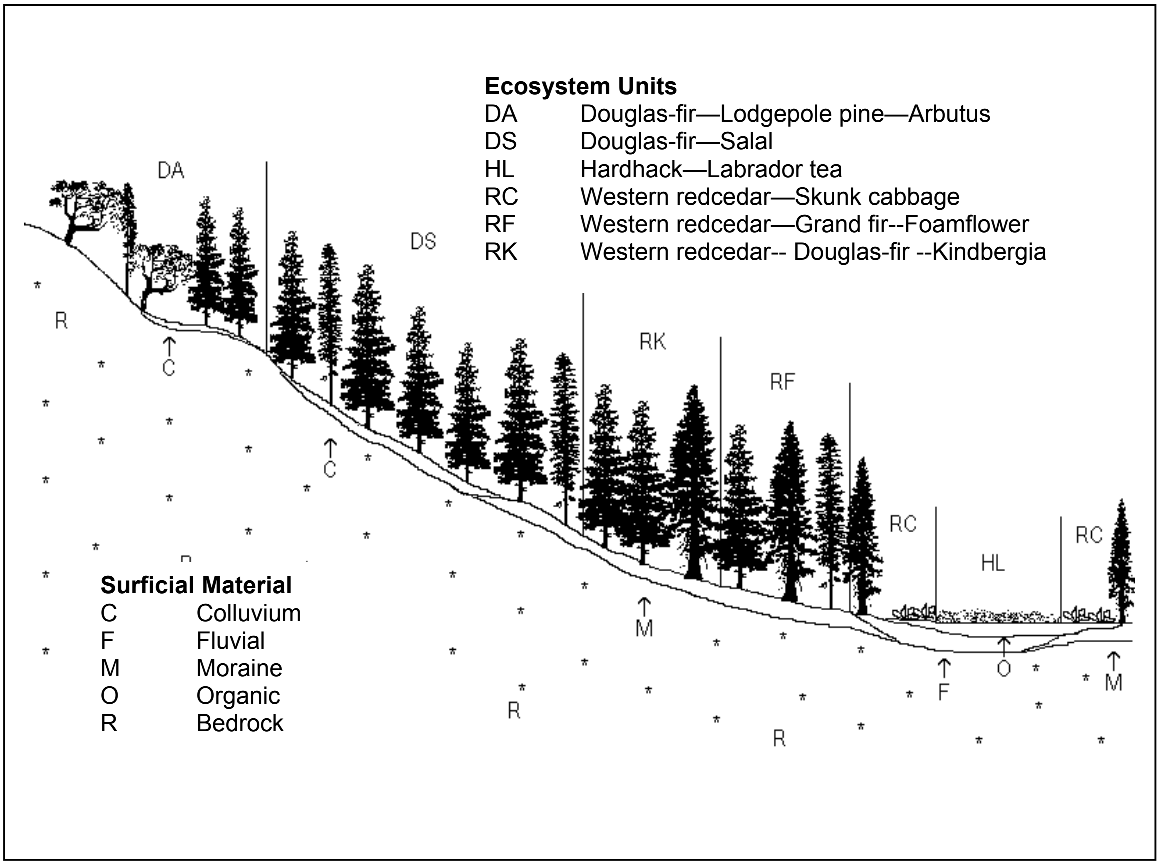

Figure 18: Landscape profile diagram for the CDFmm

Forested and non-forested ecosystem units that were mapped are shown for the CWHxm1 and CDFmm in Tables 4 and 6 respectively. Tables 5 and 7 indicate the sparsely and non-vegetated and anthropogenic units by subzone. These tables include the area mapped for each unit and the percentage of the total study area represented by each unit. These tables also show the number of times each ecosystem unit was mapped and the relative proportion of units mapped within each subzone. The number of times each unit was mapped as a microsites is also included.

Table 4: Forested and non-forested ecosystem units mapped for the CDFmm from highest to lowest total area (ha)

BGC Unit	Ecosystem Unit Code/Number	Ecosystem Unit Name[3]	Total Area (ha)	% of total study area	Total # of times ecosystem unit is mapped	% of the total units mapped	# of times mapped as microsite
CDFmm	DS/01	Fd – Salal	29.793	0.72	11	0.78	0
CDFmm	RF/06	CwBg - Foamflower	18.658	0.45	4	0.29	0
CDFmm	RK/05	CwFd – Kindbergia	15.318	0.37	12	0.86	0
CDFmm	DA/02	FdPl - Arbutus	9.689	0.24	4	0.29	0
CDFmm	RC/11	Cw – Skunk cabbage	2.697	0.07	4	0.29	0
CDFmm	HL/00	Hardhack – Labrador-tea	1.116	0.03	3	0.21	0
CDFmm Forested and Non-forested Subtotal			77.271	1.88	38	2.72	0

Table 5: Sparsely, Non-vegetated and Anthropogenic units mapped for the CDFmm in Sooke Hills from highest to lowest total area (ha)

BGC Unit	Ecosystem Unit Code/Number	Ecosystem Unit Name	Ha[1]	% of total study area	Total # of times ecosystem unit is mapped	% of the total units mapped	# of times mapped as microsite
CDFmm	RE/00	Reservoir	9.314	0.23	1	0.07	0
CDFmm	RZ/00	Road Surface	5.193	0.13	6	0.43	4
CDFmm	RR/00	Rural	1.614	0.04	1	0.07	0
CDFmm	OW/00	Shallow open water	0.185	0.00	1	0.07	0
CDFmm Anthropogenic/ Non-vegetated Subtotal			16.306	0.4	9	0.64	4
CDFmm TOTAL			**93.577**	**2.28**	**47**	**3.36**	**4**

[1] Note that each polygon can include up to a maximum of five microsites and up to three map units.

Table 6: Forested and Non-forested ecosystem units mapped for the CWHxm1 from highest to lowest area (ha)

BGC Unit	Ecosystem Unit Code/Number	Ecosystem Unit Name	Ha[1]	% of total study area	Total # of times ecosystem unit is mapped	% of the total units mapped	# of times mapped as microsite
CWHxm1	DS/03	FdHw – Salal	1082.905	26.33	305	21.74	3
CWHxm1	HK/01	HwFd – Kindbergia	1025.359	24.93	224	15.97	2
CWHxm1	DC/02	FdPl – Cladina	732.184	17.81	273	19.46	11
CWHxm1	RS/05	Cw – Sword fern	462.914	11.26	114	8.13	0
CWHxm1	RF/07	Cw – Foamflower	146.946	3.57	50	3.56	0
CWHxm1	FC/00	Fescue – Common camas	117.831	2.87	63	4.49	66
CWHxm1	SC/00	Selaginella - Cladina	87.838	2.14	70	4.99	147
CWHxm1	DF/04	Fd – Sword fern	61.778	1.50	14	1.00	0
CWHxm1	RC/12	CwSs – Skunk cabbage	40.154	0.98	31	2.21	10
CWHxm1	SW/00	Sedge wetland	30.399	0.74	37	2.64	28
CWHxm1	AM/00	Arbutus – Hairy manzanita	27.866	0.68	24	1.71	24
CWHxm1	HL/00	Hardhack – Labrador-tea	27.171	0.66	26	1.85	10
CWHxm1	CS/15	Cw - Slough sedge	24.414	0.59	26	1.85	11
CWHxm1	LS/11	Pl – Sphagnum	12.417	0.30	11	0.78	4
CWHxm1	CD/09	Act – Red-osier dogwood	3.789	0.09	1	0.07	0
CWHxm1 Forested and Non-forested Subtotal			**3883.965**	**94.45**	**1269**	**90.45**	**316**

3.3.3 Trends in Data

Analysis of the data indicates there were definite trends in the distribution and occurrence of various ecosystems throughout the study area, and within each catchment. In the CDFmm, two ecosystem units covered most of the area. These are the mesic Douglas-fir – Salal (DS) covering 30 ha, followed by the moister, richer Western redcedar – Grand fir - foamflower (RF) covering 19 ha. In the CWHxm1 the sub-xeric to xeric FdHw – Salal (DS) unit covered the greatest area (1083 ha), followed by the mesic Western hemlock – Douglas-fir – Kindbergia (HK) unit covering 1025 ha. Appendix 5 provides a summary of the area and percentage of each ecosystem by catchment.

Table 7: Sparsely, Non-vegetated and Anthropogenic units mapped for the CWHxm1 from highest to lowest total area (ha)

BGC Unit	Ecosystem Unit Code/Number	Ecosystem Unit Name	Ha[1]	% of total study area	Total # of times ecosystem unit is mapped	% of the total units mapped	# of times mapped as microsite
CWHxm1	RZ/00	Road surface	43.270	1.05	47	3.35	81
CWHxm1	RE/00	Reservoir	34.833	0.85	4	0.29	0
CWHxm1	RO/00	Rock outcrop	27.441	0.67	22	1.57	14
CWHxm1	ES/00	Exposed soil	16.141	0.39	5	0.36	0
CWHxm1	LA/00	Lake	6.254	0.15	3	0.21	0
CWHxm1	OW/00	Shallow Open Water	2.971	0.07	1	0.07	1
CWHxm1	RR/00	Rural	2.588	0.06	2	0.14	1
CWHxm1	DM/00	Dam	1.190	0.03	3	0.21	0
CWHxm1 Anthropogenic/ Non-vegetated Subtotal			134.688	3.27	87	6.2	97
CWHxm1 Totals			**4018.653**	**97.72**	**1356**	**96.64**	**413**
Combined CWHxm1 and CDFmm TOTALS			**4112.230**	**100**	**1403**	**100**	**417**

[1] Note that each polygon can include up to a maximum of five microsites and up to three map units.

The Humpback catchment is the smallest sub-area in the study covering only 307 ha or 7% of the total study area. This catchment has a total of fourteen forested and non-forested ecosystem units mapped, six in the CDFmm and eight in the CWHxm1.

The Waugh covers 1050 ha or approximately 26% of the total study area. This catchment has thirteen forested and non-forested ecosystem units mapped.

The Niagara is second largest at 1258 ha or 31% of the study area. Thirteen forested and non-forested ecosystem units are mapped in this catchment.

The Veitch covers 1497 ha, equivalent to 36% of the total study area. This catchment represents the greatest diversity of ecosystem units with fifteen forested and non-forested units mapped.

3.3.3.1 Dry Ecosystems

Dry upland ecosystems such as the Fescue – Common camas (FC), Selaginella – Cladina (SC), and Arbutus – Hairy manzanita (AM) characteristically occur in the landscape as small pockets within complexes of rock outcrops and dry forests. These ecosystems are not widespread regionally or provincially (A. Ceska pers.com). However, in the study area the distribution of these ecosystems is noteworthy. There are 28 ha of the Arbutus – Hairy manzanita (AM) unit, 118 ha of the Fescue – Common Camas (FC) unit and 88 ha of the Selaginella – Cladina (SC) unit mapped. These occur primarily in the uplands of the Veitch and Humpback. The extent of these ecosystems is quite significant considering that at 1:20 000 scale, these ecosystems are often too small to comprise 10% of most polygons and are thus included as microsites (point locations). The concept of microsites will be further discussed in section 3.3.3.4 Microsites.

3.3.3.2 Wetland Ecosystems

Three wetland ecosystems comprise less overall area than dry ecosystems: The Hardhack – Labrador tea (HL) unit covers 28 ha, the Sedge – wetland (SW) covers 30 ha, and the Pl – Shagnum (LS) unit covers 12 ha. Unlike the dry ecosystems described above, the wetland ecosystems tended to be less common in occurrence, rather than being too small to map at 1:20 000 scale. The steep 'V' shaped valleys such as those found in the Humpback and Veitch do not support the development of wetland ecosystems. However the gently rolling terrain of the Waugh and some areas of the Niagara better support the development of wetland communities.

3.3.3.3 Forested Ecosystems

The majority of forested ecosystems are either young, structural stage 5, or mature, structural stage 6, forests. Table 8 provides a summary of structural stage frequency of forested ecosystems by subzone and catchment area. This trend in structural stage reflects the past disturbance history of harvesting and a frequent fire regime.

In the CWHxm1 the majority of forested ecosystems are young forest (2033 ha), with the Waugh having the highest percentage at 74% of the area. The Niagara has the highest percentage of mature forests at 43%. Shrub, pole/sapling and old forest stages are much less common throughout the CWHxm1. In particular old forests or structural stage 7 are quite rare in the study area with only five locations mapped within the CWHxm1. Old forests total approximately 25 ha or just over 0.7% of the study area. Old forest units were mapped only five times, one Western redcedar – Sword fern (RS) ecosystem in the Humpback, one Western hemlock – Douglas-fir – Kindbergia (HK) ecosystem in the Veitch, and the remaining three, Western hemlock – Douglas-fir – Kindbergia (HK), Western redcedar - foamflower (RF), and Western redcedar - foamflower (RS) in the Niagara catchment.

The Niagara has approximately 20 ha (80%) of old forests. Many pockets of old forests and veteran trees, too small to map, were also noted throughout the study area, in particular in the southeastern portion of the Niagara catchment. The Niagara also has the highest overall percentage of shrub or structural stage 3, and pole sapling or structural stage 4, (approximately 4 ha and 14 ha respectively) forested ecosystems. Stand origin of these young forests is the recent harvesting in this area.

In the CDFmm, forested ecosystems were mapped primarily as young and mature forests. Over 61 ha of forested ecosystems in the CDFmm were mapped at structural stage 5. Few forested ecosystems were mapped in the pole sapling structural stage or younger. Only two locations of structural stage 3 were mapped, one in an Western redcedar – Douglas-fir – Kindbergia (RK) and one in a Fd – Salal (DS) ecosystem unit. No old forests were mapped in this subzone. This seeming trend in CDFmm forested ecosystems needs to be considered in relation to the small area, 76 ha, of CDFmm mapped.

Table 8: Area of Forested* Ecosystems by Structural Stage by catchment and subzone

	Herb Structural Stage 2	Shrub Herb Structural Stage 3	Pole Sapling Structural Stage 4	Young Forest Structural Stage 5	Mature Forest Structural Stage 6	Old Forest Structural Stage 7	
CWHxm1							
Catchment	**Area (ha)**						**Total (ha)**
Humpback	0.0000	4.2401	10.0845	95.4805	55.6035	1.7831	167.1917
Veitch	0.0000	30.9281	176.4284	793.0719	264.4868	3.8760	1268.7912
Waugh	2.6893	33.0793	62.0055	699.7978	151.7213	0.0000	949.2932
Niagara	0.0000	45.9165	170.6168	444.8955	520.3832	19.7339	1201.5459
Total CWHxm1	2.6893	114.1640	419.1352	2033.2457	992.1948	25.3930	3586.8220
CDFmm							
Catchment	**Area (ha)**						**Total (ha)**
Humpback	0.000	0.9779	0.000	61.2311	13.9463	0.000	76.1553
Total CDFmm	0.000	0.9779	0.000	61.2311	13.9463	0.000	76.1553

- Forested ecosystems include the DA, DS, RC, RF, and RK in the CDFmm and the CD, CS, DC, DF, DS, HK, LS, RC, RF, and RS in the CWHxm1.

3.3.3.4 Microsites

Microsites are ecosystems, which are too small to map as 10% of a polygon. These small occurrences were mapped where they could be seen on the air photos or where they were observed in the field. As microsites were noted in the database in terms of presence only, area calculations could not be determined. Microsite data significantly increased the overall frequency of occurrences of certain ecosystems mapped in the study area (see Tables 4 through 7). Microsites were included to provide as much detail as possible about ecosystem presence and distribution for CRD Parks planning purposes.

Table 9: Percent of Forested* Ecosystems represented by Structural stage by catchment and subzone

CWHxm1

Catchment	Herb Structural Stage 2	Shrub Herb Structural Stage 3	Pole Sapling Structural Stage 4	Young Forest Structural Stage 5	Mature Forest Structural Stage 6	Old Forest Structural Stage 7	Total (%)
	% of Forested area represented by each structural stage						
Humpback	0.0000	2.5360	6.0317	57.1084	33.2574	1.0665	100.0000
Veitch	0.0000	2.4376	13.9052	62.5061	20.8456	0.3055	100.0000
Waugh	0.2833	3.4846	6.5318	73.7178	15.9826	0.0000	100.0000
Niagara	0.0000	3.8215	14.1998	37.0269	43.3095	1.6424	100.0000
Total CWHxm1	0.0750	3.1829	11.6854	56.6866	27.6622	0.7080	100.0000

CDFmm1

Catchment	Herb Structural Stage 2	Shrub Herb Structural Stage 3	Pole Sapling Structural Stage 4	Young Forest Structural Stage 5	Mature Forest Structural Stage 6	Old Forest Structural Stage 7	Total (%)
	% of Forested area represented by each structural stage						
Humpback	0.0000	1.2840	0.0000	80.4029	18.3130	0.0000	100.0000
Total CDFmm1	0.0000	1.2840	0.0000	80.4029	18.3130	0.0000	100.0000

* Forested ecosystems include the DA, DS, RC, RF, and RK in the CDFmm and the CD, CS, DC, DF, DS, HK, LS, RC, RF, and RS in the CWHxm1.

In the CWHxm1 ecosystems that exist within the complex system of upper slope, dry forests, meadows and rock outcrops were most often recognized as microsites. For example, 24 Arbutus – Hairy manzanita (AM), 66 Fescue – Common camas (FC), and 147 Selaginella – Cladina (SC) microsites were noted. The dry, upland meadow ecosystems showed a significant increase in their overall representation in the CWHxm1 when included as microsites. Forested ecosystems and wetlands were not as frequently mapped as microsites. The forested ecosystems most frequently mapped as a microsites were the Western redcedar - slough sedge (CS) and Douglas-fir –Lodgepole pine – Cladina (DC), which were both mapped as microsites eleven times. The wetland most frequently mapped as a microsite was the Sedge wetland (SW) ecosystem.

In the CDFmm, there was no significant difference between the frequency of the ecosystems mapped as components and those mapped as microsites. This may be due to the small overall area of CDFmm represented in the study area.

3.3.3.5 Roads

Overall, roads (RZ) cover 48 ha of the study area or just over 1%. Because of their thin and linear nature, roads often represent less than 10% of a polygon. As a result, roads were often mapped as microsites rather than components of a polygon. The road surface (RZ) microsite was mapped 81 times in the CWHxm1. As a mapped unit, the RZ unit was mapped most frequently in the Waugh at 23 ha or 2% of the catchment, followed by the Niagara at 17 ha or approximately 1% of the catchment. Roads were least frequently mapped in the Veitch where the RZ unit comprises only 2 ha or .1% of the catchment.

In the CDFmm the road surface (RZ) unit covered five ha or 5% of the total catchment. The frequency of the RZ unit changed only minimally when roads mapped as microsites, were considered.

The frequencies of the road surface (RZ) unit in each of the catchments was largely attributed to the level of site disturbance found there. This is discussed further in the disturbance history section.

3.3.3.6 Trends by Catchment

There were interesting trends in the distribution of ecosystem units found in the four separate catchment areas.

Humpback

The Humpback is characterized by rocky uplands and dominated by Mt. Wells. The Humpback is unique in that it represents the only area where the CDFmm subzone was mapped. The CDFmm subzone is warmer and drier than the CWHxm1. The growing season is long and water deficits are typical on zonal and drier sites. The CWHxm1 in the Humpback had different characteristics than in the other catchments reflecting a transition to the CDFmm, which is found at the lower elevations (below 150 m) and at toe slope positions. Transitional characteristics include plant species, such as the presence of Garry oak at lower elevations in the CWHxm1 ecosystems.

The most common ecosystems in the CWHxm1 were the very dry Douglas-fir –Lodgepole pine – Cladina (DC) forested unit, followed by the dry FdHw – Salal (DS) unit. None of the moister CWHxm1 ecosystem types were mapped in the Humpback, reflecting the transition to the CDFmm. The highest overall incidence of the rock outcrop (RO) unit was mapped in the CWHxm1 portion of this catchment.

In the CDFmm portion of the Humpback, the mesic Fd – Salal (DS), followed by the moister Western redcedar – Grand fir - foamflower (RF), were the most commonly mapped ecosystems. This was expected, as the CDFmm occurs from mid to lower slope positions in this area.

Waugh

The relatively flat, gently rolling terrain of the Waugh is characterized by a mosaic of young moist forests, roads, reservoirs, and dams. The most commonly mapped ecosystems in the Waugh were the zonal Western hemlock – Douglas-fir – Kindbergia (HK), followed by the drier FdHw – Salal (DS) unit. The variety of ecosystems was not as great as in other catchments. Many of the wet and dry units were either rarely mapped or missing all together. Two of the drier upland ecosystem types, the Selaginella – Cladina (SC) and Arbutus – Hairy manzanita (AM) units, had limited distribution. As well, the dry, rich Douglas-fir – Sword fern (DF) ecosystem was not mapped in this catchment.

In the moist to wetland range of ecosystems there were fewer Hardhack – Labrador tea (HL), Western redcedar - slough sedge (CS) and Lodgepole pine – sphagnum (LS) ecosystems mapped than expected. This is considering that other moist forest to wetland types, such as the Western redcedar - Sitka Spruce - skunk cabbage (RC), the Western redcedar- foamflower (RF) and the Western redcedar - foamflower (RS) were common and covered significant areas. For example, in other parts of the study the LS unit was commonly associated with small pockets of the RC unit. This was not commonly the case in the Waugh. These facts, combined with the numbers of dams and reservoirs seem to suggest that alteration of natural water flow and volume may have given rise to artificial landscape patterns in terms of wetland and moist forest ecosystems.

Niagara

The Niagara, characterized by gently rolling terrain that becomes steeper to the east, has a combination of ecosystems distinctive from those of the southern catchments. Like the Waugh, the submesic FdHw - Salal (DS) and mesic Western hemlock – Douglas-fir – Kindbergia (HK) ecosystems dominate the Niagara. The HK is typically found on long gently sloping terrain, as throughout the rest of study area. However, the DS ecosystem was most often found in different environmental conditions than in the other catchments. Here, the DS unit was associated with shallow soils on gently rolling upper slopes. In the other catchments, this ecosystem was typically found on steep, warm aspects with deeper soils, commonly adjacent to the Douglas-fir – Lodgepole pine – Cladina (DC)/ Arbutus – Hairy manzanita (AM)/ Fescue – Common camas (FC)/ Selaginella – Cladina (SC) complexes. This association of dry upland ecosystems was very rare in the Niagara. Few FC and SC, and no AM or rock outcrop (RO) units were mapped. The rock outcrop (RO) ecosystem was mapped as a microsite only four times.

The Niagara is unique for the wetland complexes located in the northern portion of the catchment area. Approximately 80% of the total area of Western redcedar - slough sedge (CS) units were mapped in the Niagara along with 40 % of the Sedge Wetlands (SW) and 49 % of the Hardhack – Labrador tea unit (HL). The highest proportions of CS and SW microsites were also noted in the Niagara. These wetland communities are found in small pocket depressions and riparian areas that have formed within the undulating, shallow to bedrock terrain. When precipitation is abundant, there is likely a rapid influx of water into these poorly drained depressional sites, creating a situation of fluctuating water tables from season to season.

Significant amounts of the submesic FdHw - Salal (DS) unit were found in either herb, shrub or young forest structural stages, reflecting the recent forest harvesting activities in the Niagara. This catchment also has the most mature and old forest units mapped particularly the Western hemlock – Douglas-fir – Kindbergia (HK) and DS ecosystems. Much of the older forest exists in small patches in the southern and eastern portions of the area, where access is limited.

Veitch

The steep ‘v’ shaped valleys and rock outcrops of ‘pillow basalts’ that characterize the Veitch catchment give rise to the greatest diversity of ecosystems seen in any of catchments in the study area. Ecosystems range from very dry to very wet and rich. This diversity combined with the relative abundance of ecosystems and few anthropogenic units, such as dams and roads contribute to the overall conservation significance of this area.

The most common ecosystems in the Veitch are the driest forest ecosystem, the Douglas-fir – Lodgepole pine – Cladina (DC), followed by the dry FdHw - Salal (DS). These dry forested ecosystems, along with the associated dry upland non-forested ecosystems (the Arbutus – Hairy manzanita (AM), Fescue – Common camas (FC), and Selaginella – Cladina (SC)) characterize much of the Veitch catchment. Approximately 91% of the total area of Arbutus – Hairy manzanita (AM) were mapped in the Veitch, along with 88% of the Fescue – Common camas (FC), and 65% of the SC. The AM, FC, and SC were also the most commonly mapped microsites in the Veitch. All of these units were typically found in association with one another, most notably occurring as a patchwork on the warm upper, south-facing, rocky slopes of Mt. Braden and Mt. McDonald. Anthropogenic ecosystems were absent or infrequent in the Veitch.

Moist and rich forest ecosystems were also common along the valley bottoms, as shown by the significant distribution (162 ha) of the Western redcedar - foamflower (RS) ecosystem. The occurrence of the Black cottonwood – Red-osier dogwood (CD) unit, a medium bench floodplain is particularly noteworthy, as the geology and drainage patterns of the study area do not generally support the development of floodplain type ecosystems.

3.3.4 Rarity Assessments

Rarity was assessed within the scope of the Sooke Hills study area for both rare ecosystems and rare vascular plant species.

3.3.4.1 Rare Plant Associations (Ecosystems)

The Conservation Data Centre (CDC) tracks rare and endangered plant associations throughout the province. Plant associations are units of vegetation with relatively uniform species composition and distribution. Plant associations tend to have characteristic environmental features such as bedrock geology, soil type, topographic position, climate, and energy, nutrient and water cycles. In this mapping project, the mapped ecosystem element was “site series” along with an indication of its developmental stage (structural stage) and specific features of the site (site modifiers). Site series is a member of a plant association, this relationship may be exclusive or there may be many site series within one plant association. Because the CDC tracks plant associations rather than site series, for the purposes of this report, each site series reflects the rarity rank of its parent plant association.

Many forested plant associations, which were once common at a climax stage over the landscape, have been significantly depleted by harvesting practices. The occurrence of mature climax forests has become increasingly rare, for these plant associations. For these reasons, many of the forested plant associations in the CDFmm and CWHxm1, have been red and blue-listed (The criteria for red, blue, and yellow-listed ecosystems are provided in Appendix 6). Plant association occurrences of interest for conservation planning are the related forested site series mapped at structural stages 6 and 7. Because so few of these remain in viable condition the importance of younger occurrences of these plant associations is of significant interest also. Table 10 indicates plant associations and their relationship to site series mapped in the study area. Provincial ranks and structural stages mapped in the study area are provided for each.

Several previously undescribed non-forested community types were also mapped in the Sooke Hills. As little is known of the distribution of these community types within the mapped subzones, it is not possible to assign them a rarity rank. The Fescue–Common camas (FC) ecosystem unit is likely related to the *Festuca idahoensi–Koelaria macrantha* plant association, a CDC red-listed ecosystem, but further classification work is required to determine the correlation.

Table 11 provides frequency, area and percent calculations for the red and blue-listed ecosystems mapped. Structural stages 6 and 7 were used to determine area and percent calculations for forested ecosystems. Approximately 812 ha or 20% of the total study was mapped as rare or endangered based on the CDC criteria described above.

Table 10: CDC Ratings of Plant Associations and relationship to Site Series mapped in Sooke Hills Wilderness and Mount Wells Regional Parks

Equivalent Site Series	Plant Association	Common Name	CDC Rank[1]	Prov. Listing	Mapped Structural Stage
CWHxm1/00 **FC**	*Festuca idahoensis–Koelaria macrantha*	Idaho fescue–Junegrass	S1S2	RED	2b
CWHxm1/01 **HK**	*Tsuga heterophylla–Pseudotsuga menziesii–Kindbergia oregana*	Western hemlock–Douglas-fir–Oregon beaked moss	S2S3	BLUE	3 – 7
CWHxm1/02 **DC**	*Pseudotsuga manziesii–Pinus contorta–Rhacomitrium canescens*	Douglas-fir–Lodgepole pine–Rhacomitrium	S3?	BLUE	3 – 6
CWHxm1/03 **DS**	*Pseudotsuga menziesii–Tsuga heterophylla–Gaultheria shallon*	Douglas-fir–Western hemlock–Salal	S2S3	BLUE	3 – 6
CWHxm1/04 **DF**	*Pseudotsuga menziesii–Polystichum munitum Very Dry Maritime*	Douglas-fir–Swordfern Very Dry Maritime	S2	RED	3, 5 – 6
CWHxm1/05 **RS**	*Thuja plicata–Polystichum munitum Very Dry Maritime*	Western redcedar–Swordfern Very Dry Maritime	S2S3	BLUE	3 – 7
CWHxm1/07 **RF**	*Thuja plicata–Tiarella trifoliata Very Dry Maritime*	Western redcedar–Three-leaved foamflower Very Dry Maritime	S2S3	BLUE	2, 4 –7
CWHxm1/09* **CD**	*Populus balsamifera spp. trichocarpa–Cornus stolonifera*	Black cottonwood–Red-osier dogwood	S3	BLUE	5
CWHxm1/11 **LS**	*Pinus contorta–Sphagnum spp. Very Dry Maritime*	Lodgepole pine–Sphagnum Very Dry Maritime	S3?	BLUE	3 – 5
CWxm1/15 **CS**	*Thuja plicata–Carex obnupta*	Western redcedar–Slough sedge	S2S3	BLUE	3 – 5
CDFmm/01 **DS**	*Pseudotsuga menziesii–Gaultheria shallon*	Douglas-fir–Salal	S1S2	RED	5 – 6
CDFmm/02 **DA**	*Pseudotsuga menziesii–Pinus contorta–Arbutus menziesii*	Douglas-fir–Lodgepole Pine–Arbutus	S2S3	BLUE	4
CDFmm/05 **RK**	*Thuja plicata–Pseudotsuga menziesii–Kindbergia oregana*	Western redcedar–Douglas-fir–Oregon beaked moss	S1S2	RED	3 – 6
CDFmm/06 **RF**	*Abies grandis–Tiarella trifoliata*	Grand fir–Three-leaved Foamflower	S1S2	RED	5 – 6
CDFmm/11 **RC**	*Alnus rubra–Lysichiton americanum*	Red Alder–Skunk cabbage	S2S3	BLUE	5

Red - listed ecosystems cover very small areas within the study area. The most widespread red - listed ecosystem in the CWHxm1 is the Douglas-fir – Sword fern (DF) unit, comprising 1% of the total study area. However, if the Fescue–Common camas (FC) unit does correlate to the *Festuca idahoensis – Koelaria macrantha* plant association, the FC unit will be considered the most widespread red-listed ecosystem covering 118 ha or 2.9% of the study area. Blue-listed ecosystems tend to be more common and widespread throughout the study area. The most extensive blue-listed ecosystem in the CWHxm1 is the FdHw - Salal (DS) unit covering over 300 ha or 8% of the total study area.

Table 11: Area and Percent calculations of red- and blue-listed ecosystems in the Sooke Hills**

BGC Unit	Ecosystem Unit Code/ Number	Ecosystem Unit Name	Ha²	% of total study area (4113 ha)	Total # of ecosystem units mapped	% of the total units mapped (1403)
Red-Listed Ecosystems						
CWHxm1	DF/04	Fd – Sword fern	44	1.0698	10	.7
CDFmm	DS/01	Fd – Salal	5	0.1216	2	.1
CDFmm	RF/06	CwBg – Foamflower	4	0.0973	2	.1
CDFmm	RK/05	CwFd – Kindbergia	5	0.1216	2	.1
		Subtotal – Red-Listed Ecosystems	**58**	**1.4103**	**16**	**1**
Blue-Listed Ecosystems						
CWHxm1	DC/02	FdPl – Cladina	97	2.3584	34	2
CWHxm1	DS/03	FdHw – Salal	317	7.7073	82	6
CWHxm1	HK/01	HwFd – Kindbergia	304	7.3912	74	5.2
CDFmm	RC/11	Cw- Skunk cabbage	2	0.0486	3	.2
CWHxm1	RF/07	Cw – Foamflower	34	0.8266	9	.6
		Subtotal – Blue-Listed Ecosystems	**754**	**18.3321**	**202**	**14**
		TOTAL	**812**	**19.7424**	**218**	**15**
CWHxm1	FC/00	Fescue – Common camas	118	2.8690	63	

**Only structural stages 6 and 7 were used to determine area and percent calculations for forested ecosystems.

3.3.4.2 Rare Plant Survey

A rare plant survey was conducted in conjunction with TEM fieldwork in the Sooke Hills. The survey focused on Mt. Braden, Mt. McDonald and other rocky hilltops in the Veitch catchment. These peaks have extensive seepage slopes that make up habitat for the rare species known to occur in the Sooke Hills. The locations of any rare plant species were documented. The site and occurrence were photographed and a voucher specimen submitted to the Conservation Data Centre botanist. Table 12 provides a summary of the rare plants observed. Appendix 7 provides a full report on this plant survey.

Table 12: Sooke Hills Wilderness Regional Park 1999 Rare Vascular Plant Summary

Taxon Name	MELP Ranking	Locality
Agrostis pallens	Blue-listed	*Mt Braden and Mt McDonald*
Githopsis specularioides	Red-listed	*Mt Braden*
Madia minima	Red-listed	*Mt Braden*

Mount Braden was surveyed on June 17th and June 28th 1999. Three rare vascular plant taxa were collected. *Githopsis specularioides* (common bluecup; red-listed) was found in three different seepage sites in small to moderate numbers. Plants were fruiting with only a few still flowering. Numbers of this annual species fluctuate from year to year depending on the conditions of a given year. Numbers observed this year were lower than what is normally observed for this species. Hans Roemer has also identified this species in other sites in previous years (Appendix 8).

Also rare and found in two sites on Mount Braden is the rhizomatous grass, *Agrostis pallens*. It is often found with *Arctostaphylos columbiana* in the Sooke Hills. *A.pallens* tracked by the CDC, will likely turn out to be a regionally important, but not rare species, once more inventory is done (Penny 1999).

Madia minima (small-headed tarweed),a red-listed species was found on Mount Braden. The CDC did not track this species at the time of sampling, but it has since been added to the tracking lists (CDC 1998). *M. minima* was found in a drier microsite, at the forest edge along the trail to the summit of Mount Braden. It grew with *Arctostaphylos columbiana* (manzanita), *Agrostis pallens* (dune bentgrass, blue-listed), *Cytisus scoparius* (scotch broom), *Polytrichum juniperinum* (moss), *Achillea millefolium* (yarrow) and *Aira caryophyllea* (hairgrass).

Another annual member of the Campanulaceae (Harebell family) was found on Mount Braden in similar habitat. *Heterocodon rariflorum* (heterocodon) is infrequent in the Sooke Hills, but is not found in other areas in the province. The CDC no longer tracks this species. In addition, *Allium amplectens* (slimleaf onion) was observed on Mount Braden, this species has only recently been removed from the CDC tracking list.

One red-listed plant that the CDC had hoped to relocate in 1999 was *Lupinus lepidus var lepidus* (prairie lupin) which was last observed in 1996 by Hans Roemer on the east peak of Mount Braden. This plant was last seen in BC at this site and has been destroyed in at least two other localities. Its persistence in the Sooke Hills should not be ruled out since it has a relatively long-lived seedbank and could appear again in the near future in the area.

Unfortunately, only a small amount of data was gathered during the July 5, 1999 survey on Mount McDonald. Areas surveyed on Mount McDonald appeared to be perfect habitat for *Githopsis specularioides*, but no plants were seen. Only one small population of *Heterocodon rariflorum* (recently de-listed) was found. In previous years, Hans Roemer had found numerous sites for these taxa. It may be that the survey date, was a bit late for them, but it also appears that neither species had made a good showing this year on either Mount Braden or McDonald. Only one rare species was collected on Mount McDonald this year, *Agrostis pallens.*

3.3.5 Disturbance History

3.3.5.1 Forest Harvesting

The majority of the Sooke Hills wilderness area has either been logged or has been directly affected by logging practices (e.g. road building). Historical logging seems to have been concentrated in the valley bottoms and along lower slopes of the Waugh, Veitch and Humpback catchments. This is evident by the number of springboard stumps and overgrown skid trails and landings found along most major creeks and streams. There is some evidence of historical logging in the Niagara area, but the true extent of this disturbance may be masked by the more recent activities that have taken place (e.g. clear-cut logging, thinning and spacing). The Niagara and Waugh are the most heavily disturbed catchments of the Sooke Hills.

Initial analysis of the structural stages mapped in each of the catchments indicates a slightly higher level of disturbance in the forested ecosystems of the Niagara. Approximately 18% of the forested units in the Niagara catchment were mapped at structural stage 4 or younger, compared to 17% in the Veitch, 10% in the Waugh, and 9% in the Humpback. However, because of extremely dry, poor site conditions reflecting edaphic conditions rather than recent disturbances the forested Douglas-fir –Lodgepole pine – Cladina (DC) units often appear to be young forests and hence are mapped as younger structural stages. Therefor if structural stages are analysed excluding the DC unit, the Niagara shows an even higher overall proportion of younger structural stages.

Alternately it is interesting to note that 45 % of the forested ecosystem units in the Niagara were mapped as structural stages 6 or 7, compared to 16% in the Waugh, 34% in the Humpback and 21% in the Veitch. An area-based analysis of structural stage distributions indicate that the older forests of the Niagara occur as small patches, often in the steep terrain, in contrast to the larger patches found in the other catchments.

Although the majority of the Veitch catchment has been impacted by historical logging, overall it is the least disturbed area in terms of recent forest management. Only 5% of the Veitch polygons include a road surface (RZ) component or microsite. This lower level of disturbance may be attributed to the steep valleys and terrain that are less conducive to road building and the large percentage of ecosystems in dry forests and upland meadows that would result in lower harvest yields.

Forest harvesting has had a significant impact on several of the wet forests found in the Sooke Hills. Very few mature or old Western redcedar - Sitka Spruce - skunk cabbage (RC) units or Western redcedar - slough sedge (CS) units were observed. Almost all have been logged and are now dominated by young red alder forests.

3.3.5.2 Fire

Small, low intensity ground or surface fires appear to have been a common event in the Sooke Hills as evidenced by the high number of trees displaying burn scars. This is also supported by the frequent occurrence of veteran, fire scarred Douglas-fir trees scattered throughout pole sapling and young forests.

Ministry of Forests estimation of wildfire frequency in the CDF shows an average fire interval of 100 – 300 years, with a minimum of 50 –100 years, and a maximum of 300 –400 years. This wildfire frequency is one of the more frequent fire regimes for forested BGC zones in the province. Average size of fires in the CDF is 5 –50 ha and 150 – 500 ha maximum size. Fires range from low intensity surface fires, to medium to high intensity surface – crown fires (Parminter 1992).

In the CWH wildfire frequency is longer with the average fire interval of 150 – 350 years, with a minimum of 100 – 150 years and a maximum of 350- 500 years. Fire size ranges from .1 – 5 hectares as a minimum, 50 – 500 as an average and >500 ha as the maximum (Parminter 1992).

The Strategic Plan for Watershed Management in the Sooke Hills has records dating back to 1920 which track the date, cause and size of fires in the area. Approximately 66 occurrences of fire ranging in size from .1 ha to >250 ha are shown to have occurred within the study area. Of these fires the majority occurred along the perimeter of the park, often in association with rail lines, roads or trails. For example the railway line along the southeastern edge of the Niagara catchment, Humpback road, and the access road to Mt. McDonald all have high incidence of fire occurrence. Recreation and human activities appear to be the primary causes of fires in and around the Sooke Hills.

3.3.5.3 Drainage Alterations

The damming and diversion of natural watercourses, particularly in the Waugh, has directly impacted the surrounding ecosystem dynamics. Some wet forests adjacent to reservoirs have been trenched to increase the flow of water into the reservoirs from these moist, upslope ecosystems. In other ecosystems the water tables appear to have been raised, for example many of the Western redcedar – slough sedge (CS) units. Changes to the rate and volume of water flowing into and out of ecosystems have undoubtedly altered the species composition on some sites. Changes in species composition observed in the study area include dead cedar trees on the fringe of some wetlands and the succession of dry site indicator plants into what were once much wetter forests.

Historical logging practices have also impacted the drainage of many sites. Almost all of the Western redcedar - slough sedge (CS) units have been logged, and in some cases the drainage may have been directly affected by the removal of the large cedar trees. Very little western redcedar or red alder regeneration was observed on these sites. Most sites appeared to be dominated by slough sedge and cedar stumps. The lack of forest regeneration may be linked to an increase in the water table, and the inability of the trees to become established due to poor growing conditions. The location of old roadbeds and skid trails has influenced soil drainage as well. Many of the small creeks and streams in the area have old road beds and/or skid trails situated immediately adjacent to them or sometimes running directly through the active watercourse. In most cases this appears to have slowed the flow of these streams and created a much wider stream channel than previous. The majority of these sites are dominated by stands of red alder and sword fern, with some skunk cabbage present in areas where slight depressions were created.

3.3.5.4 Other Human Disturbance

Trails, fire pits and structures occur throughout the study area. Numerous hiking trails are established, most notably on Mt. Wells, Mt. McDonald and Mt. Braden. These trails lead to the dry rock outcrop communities associated with the upper slopes of Veitch area, namely the Arbutus – Hairy manzanita unit (AM), Douglas-fir –Lodgepole pine – Cladina (DC) FdPl – Cladina unit (DC), Fescue – Common camas unit (FC), and the (SC) Selaginella – Cladina unit. These fragile communities are typically found on shallow soils and are very sensitive to foot traffic, in particular the FC and SC units. Mt. Wells appears to be the most heavily used. There are numerous trails that lead up the rocky slopes and to the base of steep rock walls utilized for rock climbing. Many of the rocky bluffs have been heavily disturbed. Bare rock is found in areas that would normally be dominated by the SC and FC units. In addition, old fire pits were found scattered over the summit.

Although Mt. McDonald does not have significant numbers of established trails, the proximity of Humpback Road and the existing gated road that leads to the summit make it accessible to hikers. As seen on Mt. Wells, significant areas of the upland meadow communities, near the summit, have been disturbed by human activity leaving bare rock. There were also a few old fire pits observed near the summit.

Mt. Braden has an established trail leading to the summit but it's more remote location and limited accessibility has resulted in much less disturbance. Most of the Selaginella – Cladina (SC) and Fescue – Common camas (FC) units found on Mt. Braden remain intact, along with the associated Arbutus – Hairy manzanita (AM) and Douglas-fir –Lodgepole pine – Cladina (DC) units. However there was some evidence of fire pits as seen on the other mountains. The sensitive ecosystems of the AM, DC, FC, and SC of the many other smaller hilltops in the Veitch south of Mt. Braden and Mt. McDonald appear to be in good to excellent condition which can be largely attributed to their limited accessibility,

Generally, the existing trails in the Niagara creek area lead to patches of old growth and/or small forested wetlands. For the most part very limited disturbance can be attributed to these trails, in particular those that extend into the study area from Goldstream Park.

Old abandoned cabins and huts were occasionally observed in remote parts of the study area.

3.3.5.5 Non-native and invasive species

Non-native species such as English holly, wall lettuce, sweet vernalgrass, foxglove, soft brome, barren fescue, scotch broom and oxeye daisy were observed in many ecosystems throughout the study area. Scotch broom, the most prevalent of these invasive species, is scattered throughout the study area most commonly occurring in areas where there has been some previous site disturbance. Most of the major roads and ditches, and ecosystems adjacent to them have some component of broom, especially where there has been recent soil disturbance. Many of the drier ecosystems contain Scotch broom, with the Selaginella – Cladina (SC) and Douglas-fir – Lodgepole pine – Cladina (DC) units being the most prominent, as well as, the FdHw - Salal (DS) and Western hemlock – Douglas-fir – Kindbergia (HK) units that have been recently logged or thinned.

In the Niagara, the hydro lines running through the northern portion of this catchment are dominated by Scotch broom. All rock outcrops and dry open forests located next to the hydro lines have Scotch broom in them or are at high risk of infestation in the near future. A deactivated road, 11N, is also dominated by Scotch broom.

In the Waugh, Scotch broom is commonly associated with the dams and exposed soils of Jack and Mavis reservoirs. The hydro lines that pass through the eastern portion of the catchment contain a significant amount of broom. Most of the ecosystems adjacent to this right-of-way, are dry units with shallow soils that are very susceptible to the invasive nature of Scotch broom.

In the Veitch, the largest concentration of broom is found along the hydro right-of-way that runs from north to south between Mt. McDonald and Mt. Braden. Minor amounts are also found scattered throughout the Arbutus – Hairy manzanita (AM), Douglas-fir –Lodgepole pine –

Cladina (DC), Fescue – Common camas (FC), and Selaginella – Cladina (SC) units on the south slopes of both mountains. Given the proximity of the hydro lines and the large amount of broom associated with them, the rocky slopes of Mt. Braden and Mt. McDonald, are very susceptible to a rapid influx of Scotch broom.

In the Humpback, there is a significant amount of broom associated with the cleared areas surrounding Humpback reservoir. It is also common in the dry non-forested units found on Mt. Wells (e.g. Fescue – Common camas (FC) and Selaginella – Cladina (SC)), and the open dry forests of the Douglas-fir –Lodgepole pine – Cladina (DC) in the CWHxm1 and FdPl – Arbutus (DA) in the CDFmm.

Introduced species commonly associated with the dry upland units include hairy cat's-ear, sweet vernal-grass, barren fescue, tall oatgrass, bluegrass, oxeye daisy, and soft brome. Introduced species associated with the mesic to wet forests include English holly and wall lettuce.

3.3.6 Naturalness Evaluation of Sooke Hills

For the purposes of this report, naturalness was considered a combination of ecosystem quality and condition in relation to human activity. Naturalness ratings provide an indication of the effects of human activity within each catchment as they were found during fieldwork in 1999 and airphoto interpretation of the 1998 photos.

Specifically naturalness was ranked as follows. The drainages were ranked from 1 to 4. Rank 1 was considered to be the most natural condition while rank 4 was considered to be the least natural condition. The following four criteria were used to determine overall naturalness rankings:

- diversity of structural stages in forested ecosystems. Greater diversity equated to a higher ranking.
- disturbances such as logging, road building, recreation activities, and damming. The more disturbances noted, the lower the ranking.
- the number of anthropogenic units mapped in the catchment. The greater the number of anthropogenic units the lower the ranking.
- the diversity of ecosystems present. The greater the diversity of ecosystems the higher the ranking.

The comparison of the four catchments will provide a useful planning tool in determining what and where to initiate various management activities within the park.

During the course of fieldwork, conservation evaluation forms, to determine naturalness were completed for Full and GIF plots. This amounted to 32 plots, which provided the baseline data for the naturalness ratings. This data was then built upon by the expert opinion of the field and mapping crew, and through analysis of mapped data. Results are listed in Table 13.

Table 13: Naturalness Rankings by catchment

Catchment	Structural Stage Diversity	Human Disturbances Noted	Percent (%) of area mapped as Anthropogenic Units	Diversity of Natural Ecosystems	TOTALS	**Overall Naturalness Rating**
Veitch	2	1	1	1	5	**1**
Niagara	1	3	2	3	9	**2**
Humpback	2	2	3	2	9	**3**
Waugh	3	3	4	3	13	**4**

3.3.6.1 Veitch

Naturalness of the Veitch was ranked highest of the four catchments.

- The diversity of forested structural stages was moderate; there was little representation of the youngest or oldest stages. Significant areas of the Veitch are steep, rocky, upland areas which give rise to non-forested meadow communities and dry, submesic, forest types. These dry forest types appear younger than the mesic forest types due to edaphic conditions. As a result the Veitch had a high representation in younger forest types. See Table 8 & 9.
- Fewer disturbances from recent forest harvesting were noted than in the other catchments. There was evidence of roads and recreation trails, however their impact on the entire catchment was localized to the southeastern area. One area of concern was the hydro right of way, a highly disturbed area with many introduced species, in particular Scotch broom. However there was also evidence of significant use by wildlife ranging from ungulates using the right of way for forage, to wolf and bear scat.
- There was little sign of damming or altering of watercourses apparent in riparian and wetland areas. As a result, Veitch Creek and the moist to wet forests along Shepherd Creek are examples of large areas of moist to wet ecosystems in excellent natural condition.
- Mapped anthropogenic units comprised approximately 4.5 ha or 0.3% of the total area of this catchment.
- All ecosystem types, ranging from the very dry upland meadow ecosystems to moist, rich forests and wetland ecosystems were well represented. The greatest variety and area of upland meadow ecosystems, most of which were in excellent condition, were mapped in the Veitch.

3.3.6.2 Niagara

Naturalness in the Niagara was ranked second of the four catchments.

- The Niagara had the greatest diversity of structural stages represented in forested ecosystems. The greatest amount of old forest was mapped in this catchment, and numerous pockets of older forest, particularly in the southeastern area were observed. There was adequate representation of the other structural stages. See Table 8 & 9.
- There was significant evidence of recent human disturbances particularly from forest harvesting and the associated road network. Recent forest harvesting in this catchment has resulted in large influxes of invasive species, particularly Scotch broom, along roads, in drier ecosystems and in recently cut areas. Other invasive species of note are English

holly and wall lettuce. There is little evidence of damming or its' associated effects on ecosystem distribution and function.

- Roads were the only anthropogenic units mapped and comprised approximately 17 ha or 1.3% of the total area of this catchment.
- The diversity of ecosystems represented was ranked medium for the Niagara. Areas of particular note are the extensive wetland complexes in the northwest section and the areas of old forest in the southeastern portion. Both of these areas are of particular significance for wildlife use.

3.3.6.3 Humpback

Naturalness of the Humpback was ranked third of the four catchments.

- The diversity of structural stages was moderate in the CWHxm1 portion of this catchment. The majority of forested ecosystems occurred as young forests. There was some representation in older and younger structural stages. Of particular note are forested areas to the west of Humpback reservoir, which had patches of old forest in good condition and of significant size with little evidence of historical use. See Table 8 & 9.
- There is evidence of a variety of human disturbances. Access routes from hikers and climbers to upland areas, such as Mt. Wells, are well developed. Trampling in upland ecosystems such as the Selaginella – Cladina (SC), and Fescue – Common camas (FC) is apparent, and the presence of introduced vegetation species such as English holly and Scotch broom has been noted. While there is little evidence of recent logging the influence of damming and drainage changes are significant e.g. Humpback reservoir comprises 3% of the total area of this catchment. Humpback Road cuts through the center of this catchment, which negatively influences moist to wet CDFmm ecosystems such as the Western redcedar - skunk cabbage (RC), Western redcedar – Grand fir - foamflower (RF), and Western redcedar – Douglas-fir – Kindbergia (RK).
- Because the catchment area is small, there is little to buffer the ecosystems of the CWHxm1 and CDFmm from potential negatives influences from surrounding disturbances such as urban development and high traffic roadways, such as Sooke Road.
- Surrounding disturbances to the south and east may act as a barrier to wildlife into and out of this catchment.
- Mapped anthropogenic units comprised approximately 17 ha, or 5% of the total area of this catchment area.
- The diversity of natural ecosystems was high, largely due to the presence of two subzones. In particular the southeastern portion of CDFmm shows evidence of mature Garry oak and Arbutus stands.
- Although the Humpback and the Niagara had the same naturalness totals, this catchment was ranked lower overall due to its' smaller size, and the potential impacts of adjacent disturbances, such as urbanization.

3.3.6.4 Waugh

Naturalness of the Waugh was ranked fourth of the four catchments.

- Structural stage diversity was the lowest of the four catchments. There were no old forests mapped, and very sparse representation of shrub or pole sapling structural stages.

Overwhelmingly forested ecosystems were mapped as young forest structural stage 5, much of which had been thinned giving rise to large expanses of salal dominated understory. See Table 8 & 9.

- There was evidence of forest harvesting and recent thinning throughout much of catchment, particularly in the large expanses of Western hemlock – Douglas-fir – Kindbergia (HK), FdHw - Salal (DS), Western redcedar - Foamflower (RS) ecosystems. Thinning particularly in FdHw - Salal (DS) ecosystems has given rise to large expanses of salal dominated understory. This lack of vegetation diversity in the understory makes these areas less appealing to foraging wildlife. Cavity nesters such as Pileated Woodpecker have little of their habitat requirements met by these modified ecosystem types. Human disturbances were apparent in around Jack and Mavis reservoirs in the form of dams, introduced species, and exposed soils. The alteration of natural water flow patterns has influenced ecosystem distribution and function of associated moist forests and wetlands.
- This was an area with significant anthropogenic units mapped including dams, reservoirs, exposed soils, and roads. Mapped anthropogenic units comprised approximately 75 ha or 7% of the total area of this catchment. The influences of dam construction, channelization of streams, and other disturbances need to be considered when assessing the size, distribution, and variety of wetlands in the Waugh.
- The Waugh had the least diversity of ecosystems of the four catchments.
- Drier units such as the Arbutus – Hairy manzanita (AM) and Selaginella – Cladina (SC) were not well represented in this catchment, due to the underlying topographical features. However richer, mesic forests such as the Western redcedar - Sitka Spruce - skunk cabbage (RC) were well represented.

3.4 Park Development Recommendations and Limitations

This project provides a general inventory and overview of the conditions of the Sooke Hills Wilderness and Mount Wells Regional parks. Based on this information general recommendations regarding the management can be made and further inventory needs and priorities can be established.

3.4.1 Upland Ecosystems

Upland ecosystem complexes of Arbutus – Hairy manzanita (AM), Fescue – Common camas (FC), Selaginella – Cladina (SC) and the dry Douglas-fir –Lodgepole pine – Cladina (DC) forests are well represented in the study area, particularly in the Veitch and Humpback. Regionally these complexes are often found in areas of urban growth where they are increasingly at risk from a variety of land-use pressures. These areas are focus locations for a variety of recreational uses (e.g. hiking, rock climbing, and mountain biking). The shallow soils with their thick moss and lichen layers of these ecosystems make them very susceptible to damage and degradation if subject to heavy use.

Recommendations:

1. These sensitive ecosystems should merit special attention and consideration in management plans.
2. Establishment of trails is these areas should be kept to a minimum in order to minimize impacts on rare plants and fragile ecosystems.

3. Where access routes are developed public education regarding the fragile nature of these ecosystems should be encouraged. For example place signs along access routes to increase user awareness of the potential impacts of their use on these ecosystems.

3.4.2 Wetlands and Wet Forested Ecosystems

Wetlands, such as the Hardhack – Labrador tea (HL) and Sedge wetland (SW) ecosystems adjacent to shallow, open water or lakes, and ecosystems occurring on organic soils are important particularly from a wildlife perspective and in maintaining a natural water table. The influence of past disturbances, especially the modification of natural water flow and volume on these ecosystems needs to be considered, principally in the Waugh catchment

Recommendations:

1. These sensitive ecosystems should merit special attention and consideration in management plans.
2. Wetlands and ecosystems occurring on organic soils need to be further inventoried for complete species lists and wildlife use.
3. Care should be taken to not cause further disturbance to wetland ecosystem types. The influence of surrounding trails, roads or alterations in water flow can have significant impacts on wetland conditions, and therefore these activities should be avoided.
4. Efforts could be made to re-establish natural water flow patterns where feasible to ensure the future viability of wetlands and wet forest types within the study area.
5. Wetland ecosystems are of limited extent and may require a minimum buffer zone. Protection of water input sources might be needed to ensure their long-term function.

3.4.3 Structural Diversity

Currently the majority of forested ecosystems, 57% of the area of CWHxm1 forests and 80% of CDFmm forests, are at the young forest structural stage. The lack of structural variety resulting in large areas of even aged stands can create potential risks in terms of fire hazards, loss of plant and animal species diversity and beetle infestation. The needs of the key wildlife species show an important consideration for old forest habitat. Managing to ensure long term structural diversity, which will in turn contribute to the overall health and diversity of ecosystems and will support the greatest diversity of wildlife species. However, this needs to be weighed against the fact that fire, one of the primary natural disturbance types for the ecosystems of the study area, will unlikely be a preferred management method because of issues of water supply and adjacency to urban setting.

Recommendations:

1. Forested ecosystems should be managed to encourage the full spectrum of structural stages from young shrub stages to old forests.
2. Methods of encouraging structural diversity, such as controlled burns or judicious thinning, will need to be examined.

3.4.4 Roads

Roads alter the composition and dynamics of ecosystems they exist within and next to. Roads can also provide travel corridors for wildlife and access for human disturbances and initiation sites for introduced species.

Recommendations:

1. The study area is heavily roaded and consideration should be given to the influence that these roads have on the ecosystems that they traverse.
2. Management planning should consider decommissioning roads where possible.
3. Use of existing roads for future public access routes rather than establishing new trails and routes should be encouraged.

3.4.5 Red - and Blue - Listed Ecosystems and Species

The red- and blue-listed ecosystems comprise approximately 20% of the total study area. All of the rare plant species found to date in the study area are located in upland meadow complexes.

Recommendations:

1. Red- and blue-listed ecosystems should be given special consideration in management planning. If possible these ecosystems should have little or no development.
2. More detailed inventory work is needed to fully determine the number and distribution of rare plant species in the study area.
3. Further detailed inventory work of these upland meadow ecosystems is needed to refine the classification of these ecosystems. Determine the correlation between the Fescue – Common camas (FC) ecosystem unit and the *Festuca idahoensis – Koelaria macrantha* plant association, which is red-listed by the CDC.
4. Some ecosystem may only be rare in the context of the study area but may be quite common in the surrounding areas, making them less of a protection concern. Others may be rare regionally as well as in the park, and therefore merit special protection consideration. Buffer zones may need to be established to ensure the long term health and integrity of rare ecosystems.

3.5 Watershed Management Considerations by Catchment Area

3.5.1 Humpback

Because this area is bounded on all sides by roads, trails, urban development and existing recreation activities, it will be difficult to limit access. However, this catchment has many sensitive features. Three provincially red-listed ecosystems are represented in the CDFmm. Garry oak and arbutus stands on east and south slopes of Mt. Wells are regionally significant. In the CWHxm1 important older forested ecosystems exist in the northwestern portion of this catchment. The upland meadow communities are fragile ecosystems, very susceptible to site disturbance. This catchment represent a transition zone between the CDFmm and CWHxm1 subzones, which is reflected in the higher plant and animal species diversity.

Recommendations:

1. As access is already well established to Mt. Wells, authorized trails should be developed which aim to mitigate the impacts of foot traffic and rock climbing to the upland meadow communities.
2. Efforts should be made to increase public awareness regarding the sensitivity and value of the upland meadow areas, and the rock bluffs.

3. Garry oak and arbutus stands on east and south slopes of Mt. Wells are regionally significant. Access in these areas should be discouraged until further detailed inventory work can be done to assess the condition of these sites.
4. Access to the older forest ecosystems in the northwest portion of the catchment should be minimized, as these represent important ecosystems in terms of wildlife and ecosystem diversity.
5. The Humpback reservoir, which has been dramatically altered from its natural state and exists close to public roads, would be an excellent candidate for a park recreation development area.

3.5.2 Veitch

This large area represents the greatest diversity of ecosystems in the best natural conditions in the study area. The diversity of ecosystems relates directly to diverse habitat opportunities for a great number of wildlife species. Few roads and less recent forest harvesting contribute to the overall health of ecosystems in this area. Roads such as Veitch Main, 3J and 3J5 currently act as access routes into this catchment. The hydro line running through this catchment has both beneficial and harmful aspects. The power line acts as an access and travel corridor for wildlife as noted by the high incidence of browse, scat and tracks along the right of way. Conversely, it also creates a travel route for humans and human disturbances, and provides a source and dispersal point for non-native vegetation species.

Mt. Braden and Mt. McDonald, the two largest upland areas of the Veitch, both have existing trails or travel routes to the summits. Access to Mt. Braden is currently limited to a rough foot trail while Mt. McDonald has a gated road allowing access to the communication tower at the summit.

Recommendations:

1. Future access in this catchment should be limited.
2. The Black cottonwood – Red-osier dogwood (CD) floodplain, which was mapped only once and comprises less then 4 ha., should be assessed for its long-term viability within the overall park plan.
3. Consideration should be given to decommissioning existing roads such as Veitch Main, 3J and 3J5 as these run through some of the most highly rated wildlife habitat in the Veitch.
4. Mt. Braden and Mt. McDonald will continue to attract a variety of user groups, therefore existing trails should be maintained or where possible improved, to minimize disturbance to the surrounding sensitive ecosystems. Efforts should be made to increase public awareness regarding the sensitive nature of the upland meadow area and the importance of staying on the trails.
5. It is not recommended that new trails be established on either Mt. Braden or Mt. McDonald.
6. The Humpback to the east, and the Waugh to the north, act as a natural buffers around this catchment. Land acquisition to the west, if available, would further protect this catchment and provide a contiguous habitat link for wildlife.

3.5.3 Waugh

The geomorphological history of this area has resulted in a gentle, rolling terrain that is reflected in large areas of FdHw - Salal (DS), Western hemlock – Douglas-fir – Kindbergia (HK) and Western redcedar - Foamflower (RS) ecosystem complexes. The upland meadow communities tend to be smaller in size and number than in other catchments. Alteration of natural watercourses through the establishment of Jack and Mavis reservoirs has significantly affected the wet forests and wetlands, altering ecosystem and species composition. Many areas surrounding the dams and reservoirs in the Waugh were mapped as ES – Exposed Soils. These are highly disturbed ecosystems not only in terms of vegetation composition, but the soils have been significantly altered. Rising and falling water levels have led to layers of lacustrine deposits over the original soil structure resulting in richer soil conditions. Wetland and wet forests seem to be significantly altered from their natural states. Roads have further affected natural watercourses.

Recommendations:

1. The influence of past disturbances, especially modification of natural water levels and changes to watercourses needs to be considered, particularly in the Waugh.
2. The existing level of disturbance, lack of critical wildlife habitat and fragile ecosystems combined with the gently undulating terrain would make this drainage an excellent location for recreation development opportunities, such as hiking, cycling, rock climbing and horseback riding.
3. There are potential freshwater recreational opportunities at Jack and Mavis reservoirs.
4. Disturbed areas mapped as exposed soil (ES) surrounding Jack and Mavis reservoir could be rehabilitated. Undisturbed ecosystems surrounding lakes and water bodies of the Niagara should be assessed to guide any reclamation efforts of these ES sites.

3.5.4 Niagara

The Niagara forms the northern most catchment of the study area. It represents a large area with a great diversity of ecosystems and wildlife habitats. The wetland complexes located in the northern portion of this area very important due to their number and size. A large variety of species, including birds, insects, bats and other small mammals, potentially use these complexes as forage, breeding and nesting habitat. Small but very significant pockets of old growth in the Niagara represent some of the only old forest ecosystems in the study area. These sites are very valuable for deer winter habitat, bear denning, Marbled Murrelet nesting and Pileated Woodpecker forage. Much of the remaining old forest exists in narrow bands in the steep sided valley between Road 4N, the E&N railway trestle, Highway 1 and Goldstream Park.

Recommendations:

1. Protection and limited access to wetland complexes is recommended.
2. Protection and limited access to old forest ecosystems is recommended. If access routes are required they should be restricted to a single trail or access point.
3. Methods to control and minimize further spread of non-native species particularly in the dry forest and recently disturbed areas will need to be considered.
4. Given the extensive road network currently in place and the level of disturbance that new construction may cause, developing additional roads or trails is not recommended.
5. Where possible consideration should be given to decommissioning existing roads.

3.6 Soil and Terrain Considerations

Within the TEM database is found terrain information for each polygon. This data includes genetic materials, terrain texture, surface expression, geological processes and soil drainage. Each term is explained in the Terrain Classification System for British Columbia (Howes and Kenk, 1997) and is available on line at http://www.elp.gov.bc.ca/rib/wis/terrain. Interpretive maps showing sensitive sites could be generated from this database. Parks planning should consider the following guidelines for various interpretations and uses.

3.6.1 Surficial (Genetic) Materials

The physical characteristics of surficial materials such as texture, structure, cohesion and compactness, coupled with soils drainage characteristics can influence the engineering properties of surficial materials. For example surficial material erodability and stability on slopes would directly affect the location of trails and parking areas in park designs. The ecosystem database includes terrain and soil drainage codes for each polygon allowing the user to key out specific terrain codes for units containing highly erodable or unstable surficial materials. While not in the scope of this project, an interpretation table based on each type of surficial material could be generated from the existing data. This would illustrate the limitations and uses of specific materials for various park purposes.

3.6.1.1 Anthropogenic

Maps displaying roads and other anthropogenic features provide planning information for access and impacts for Parks. When anthropogenic information is overlain onto the ecosystem or terrain map, the user can easily view the ecosystems that have been historically compromised.

The ecosystem map contains some additional information over the TRIM base map features or custom base map developed for the Greater Victoria Water District (by Hugh Hamilton) . The CRD base maps are very complete as to roads and dams

3.6.1.2 Organic Deposits

Organic (**O**) soils, (which include peat bogs, marshes, fens and muck soils) should be classed as very sensitive to use. They have a high water table, often with water at the surface, creating a very low bearing capacity. With these conditions, the peat is very susceptible to compaction and degradation from any traffic, particularly trail use or access routes. If drained they are prone to subsidence. The organic deposits hold considerable water and store it during the wet season and release it to downstream ecosystems and stream during the dry season. As such, organics make critical contributions to life forms requiring aquatic environments. The mismanagement of hydrology, upland soils and vegetation cover can often seriously impact the natural functions of bog ecosystems and can cause adverse conditions such as siltation, subsidence, erosion and flooding.

Trails: Trails located on organic or bog deposits are not recommended as the water table is at the surface for most of the year and the bearing strength is very low. Boardwalks would likely have to be constructed over the deposits. Ecosystems containing these deposits are also very ecologically sensitive. Bicycle use is not suitable.

Toilets: Use of organics for any form of waste disposal is not suitable because the organics are often a part of connected waterways containing sensitive aquatic species. Such facilities should be located well away from wetland systems.

Roads: Organic materials will not support roads. The peat would have to be excavated and replaced with fill. This activity could be extremely disruptive and likely ruin parts of the local drainage system and wetland habitat.

Parking: Parking concerns would be the same as for roads.

Interpretative centres: This activity would have to be carefully constructed over portions of the wetland or kept to the stable soil upslope of the organics.

3.6.1.3 Fluvial Deposits

Fluvial materials (**F**) in the form of terraces **(t**), plains (**p**), veneers (**v**) and blankets (**b**) are usually located along the valley floors in association with streams. As such they may support riparian or wet loving vegetation, have poor drainage, and may be subject to compaction and erosion with moderate to heavy use. Another common term for fluvial is "stream bank soils or alluvium".

Trails: Trails on fluvial materials (symbols such as **zFp, v, b, t**) with silt **(z)** content or sands (**s**) and with imperfect (**i**) or poor (**p**) drainage are subject to compaction and erosion if disturbed. The eroded material could move into streams. Many such small areas are not mapped therefore, on-site surveys will help to flag such areas for management guidelines. Bicycle use will potentially cause the same problems noted above, but with greater intensity as the concentrated weight on the tires will cut into the wet soils and riders will widen trails to avoid riding in mucky areas.

Higher and drier terraces with flatter slopes (1% to 7%) with sand (**s**) and gravel (**g**) textures are more forgiving and durable. However steeper escarpments (7% to 60%+) will erode and ravel significantly. Escarpments were not mapped as such therefore, trail location surveys are required.

Roads: Considering the comments above, roads constructed on fluvial materials particularly in a riparian zone would potentially cause a significant impact to this 'natural' zone. Compaction, burial, and erosion of soils are all likely impacts. If possible, roads should stay up on the gravelly benches (**gFt, b, v**) away from the streams. Mining of gravels and sands is a potential use for these sediments as road fill and other uses. Park management will have to decide where borrow pits, if any, are to be located. An interpretative map derived from selecting the terrain codes for the **F** and/or **FG** materials along with any sand (**s**)or gravelly (**g**) textures will provide an overview of sand and gravel sources.

Parking: Parking considerations are generally the same as those described above for roads.

Toilets: If toilets are to be installed on these materials, drier fluvial sites only should be considered and toilets should be kept well away from streams and natural drainages. Untreated effluent from water type systems with septic fields could move into the deeper porous gravels eventually finding its way to streams and/or groundwater. The deeper morainal materials (**Mb**) are generally the best option for such installations.

Interpretative centres: If possible, these should be located on the drier well (**w)** and moderately well (**m)** drained fluvial sites. If located on the level areas, ensure that the materials can support a concentration of people without becoming muddy or dusty.

3.6.1.4 Glaciofluvial Deposits

Glaciofluvial (**FG**) materials, (deep gravelly sediments) were not common in the study area. However they were occasionally found along valley floors and lower slopes as veneers (**FGv**) estimated at being less than 1 m deep.

Trails: Trails located on glaciofluvial materials (**s, g FG v, b, t, m**) with rapid (**r**), well (**w**) or moderately well (**m**) drainage should be relatively stable. These materials are often mapped in a complex with other materials and their exact locations not are known. Trail surveys will likely identify these gravelly drier soils, usually found under salal. Some areas may have excess stones and cobbles making walking difficult if trails are not surfaced. These materials will not likely be damaged by bicycle use.

Roads: Glaciofluvial materials (**FG**) are some of the most stable materials for roads where well (**w**) and moderately well (**m**) drained soils occur on gentle to moderate slopes. The areas with imperfect (**i**) and poor (**p**) drainage will likely require roadwork such as drainage and fill. Damage to wetter and sensitive ecosystems are a concern on the wetter terrain components.

Parking: The same comments generally apply to parking as for roads. Some of this material can have many stones and cobbles making walking difficult and surfaces may require a smoother fill.

Toilets: These materials are very porous and if water-type septic fields are used, there is the chance untreated effluent could escape to groundwater and streams. Because toilets are often located at or near parking lots and interpretive centres sewage disposal processes other than water based systems should be explored.

Interpretative centres: Concerns for areas to be used for interpretative centres with concentrations of people will be the same as a small parking lot. The same general comments for roads and parking above would apply. Little to no dust or mud would be expected on these materials.

3.6.1.5 Morainal Deposits

Morainal or till deposits (**M**) in the study area consist of a mixture of gravels, sands and silts. Deposits in the Veitch, Niagara, Humpback and lower Waugh tend to be shallower deposits, classified as veneers, **Mv** (<1m). Deeper tills are more common in the upper Waugh. Soils developed in morainal materials are generally loose and porous with gravelly sand or gravelly loamy sand textures. They are usually very compact or cemented at depths of over 60cm.

Trails: Morainal veneers and blankets are one of the most stable materials for trails when located on types, having well (**w**) and moderately well (**m**) drained soils, and gentle to moderate slopes (3 to 20%). Thin soils reflected by the **Mv, x** types could create conditions for loose footing due to cobbles, stones and rubble. Furthermore, these shallow types when coupled to steep slopes (>30%) will be subject to some erosion and sloughing. Stable footing will also be compromised.

Trails located on imperfectly (**i**) and poorly (**p**) drained soils could be subject to compaction and muddy conditions. As well, sensitive 'wetter' ecosystems may be present. Use of trails for biking will have the same considerations, limitations and impacts as mentioned above however, most of the impacts will likely be accelerated.

Roads: Morainal materials are very suitable for stable roads. Most of the roads in the watershed are located on tills and are very stable, being relatively well drained, high and dry. The imperfectly (**i**) and poorly (**p**) drained sites are of concern, as sensitive 'wetter' ecosystems could be impacted. On slopes covered in thin till (**Mv, x**) greater than 20%, rock blasting and side cast would be required for road construction.

Parking: Parking areas generally have similar benefits and limitations as roads. These gravelly, sandy soils are predominantly deep (>1m), and when well drained are not prone to muddy conditions or dust sources. The use of level land is preferred. Cobbles and stones could be a concern if proper surfacing is not done.

Toilets: Most toilet types located on the deeper till (**Mb),** and veneers **(Mv)** with well (**w**) and moderately well (**m**) drained soils, on slopes less than 10% should pose few problems. Steeper slopes (>10%) coupled with shallow soils (**Mv, x**) are not suitable for septic systems, due to effluent escape and lack of treatment. Many of the shallow soils have a pan layer (duric) at about 60cm, which restricts drainage and could direct the untreated water down-slope. On-site inspections would be required. Imperfectly and poorly drained soils are not suitable.

Interpretative centres: Deep morainal soils such as blankets, and veneers that are well drained, are very suitable for these developments. Shallow sites on thin veneers (**Mx, v**) will limit secure footing and surface stability because the loose gravelly soils will move on the near surface bedrock. Poorly drained sites should be avoided.

3.6.1.6 Colluvial Deposits

Colluvial material **(C)** is usually thin, rubbly, porous and well to rapidly drained. Colluvium usually occurs directly over bedrock and over till at the base of steeper slopes. It is usually rubbly with large blocks and/or boulders when occurring at the base of steep slopes.

Trails: These materials may show some instability as shallow to bedrock rubble (**Cvx Rhm**), which could move under foot or possibly roll down-slope, particularly when on the steeper bedrock hills. Large blocks and boulders provide interesting viewing but large quantities will make it extremely difficult to construct trails. Holes in the large rubble could be hazardous. For the purpose of biking this material will likely be quite unstable resulting in erosion, particularly on slopes greater than 15% and on the thin **Cxv** (<50 cm) materials. These shallow and very shallow colluvial deposits are generally located on the upper bedrock hills.

Parking: Colluvial material can be found on slopes greater than 15% and are most common on slopes (>50%), therefore it is generally not suitable for parking. However, smaller gently sloping sites veneered with colluvium could be suitable.

Toilets: Colluvial material is porous, therefore, untreated waste could travel down slope during the wet seasons.

Roads: New construction methods allow roads to be built over most terrain types, but side-cast damage can be accelerated on steeper colluvium. Colluvial material is usually shallow to bedrock and blasting roadbeds may have to be an option. Access off the road may be somewhat limited due to steeper rubbly terrain.

Interpretative centres: Concentrations of people at viewing locations located on the thin (**Cxv**) soils could cause site degradation over time. The most stable areas on the colluvial terrain should be selected for such facilities.

Rock Climbing: Climbers will likely encounter small micro sites of thin colluvial material. This material is prone to slipping and could be hazardous.

3.6.1.7 Bedrock

In areas of extensive rock, the topography is often steep and hilly. Cliffs can be a hazard to park visitors and the lack of loose materials in rocky areas makes the cost of development high. Sensitive ecosystems that grow in the shallow soils that exist in pockets and patches on bedrock outcrops can be easily damaged by foot traffic. Soils and vegetation cover take many hundreds of years to form on bedrock, therefore disturbance of these precious soils can cause irreparable damage.

Trails: Because most rock outcrops occur at the crest of hills and often provide viewscapes, recreational trails to these areas will be in high demand. However, expansion of the existing trail system on the bedrock areas is not recommended due to the sensitive nature of the shallow soiled ecosystems associated with the rock outcrops. Softer bedrock, like the sedimentary and metasedimentary rock types found in the Waugh catchment, are more susceptible to esthetic damage by foot traffic than the harder rock types found in the Niagara and Veitch catchments. Public safety issues may need to be considered in areas with steep drop-offs; fencing along edges and signage to indicate hazards may be required. Where trails are placed near the base of cliffs and bluffs, upslope hazards such as rockfall should be considered. Items falling from above are even more likely where there is visitor traffic on the slopes above.

Parking: Bedrock outcrops tend to be rolling or steep and are not conducive for parking facilities. The costs involved to modify sites for parking is likely prohibitive. Ground water contamination from parking lot runoff (e.g., antifreeze or oil leaks) is also a concern.

Toilets: Areas dominated by bedrock outcrops are unsuitable for conventional out-house toilets. Shallow soils will inhibit the digging of pit style toilets. In addition, surface runoff over rock outcrops and into cracks and fissures is a potential source of groundwater contamination. Observations of the bedrock fractures in the Niagara and Veitch catchments showed that surface runoff was likely to penetrate into the groundwater system relatively quickly due to the size and extent of the joints.

Roads: Road construction on the bedrock areas would be costly and due to the sensitive nature of the adjacent ecosystems, bedrock is not recommended for this type of development.

Interpretive centres: Due to the concentration of people drawn to this type of development and again relating to the sensitivity of shallow soiled ecosystems associated with outcrops, it is not recommended that interpretive centres be located on bedrock. Other surficial materials, such as deep morainal deposits are preferred.

Rock climbing: Competent and steep rock is favored for rock climbing. The bedrock in the Veitch and Humpback catchments is relatively hard and the hills have some steep and near vertical faces. Rock climbing may be suitable in areas of bluffs and cliffs, but more definitive studies into rock suitability for climbing should be undertaken. Suitable rock types were not observed in the Waugh catchment.

4.0 Wildlife

4.1 Introduction

The relatively mediterranean conditions of Southeast Vancouver Island, including the Sooke Hills Wilderness and Mount Wells Regional Parks, result in a diversity of native, terrestrial wildlife species. Although the Sooke Hills Wilderness and Mount Wells Regional Parks occurs within the distribution range of many wildlife species, standardized inventory to quantify wildlife habitat and species has been limited (Dunster *et al*., 1998). However, based on species distribution maps, anecdotal information and other related sources such as the Ministry of Environment, Lands & Parks regionally important species tracking lists and the Conservation Data Centre tracking lists, suitable and capable wildlife habitats occur in the study area. Still, formal identification of wildlife habitat in this area has been limited. Based on a list of all possible wildlife species that can occur in the Sooke Hills Wilderness and Mount Wells Regional Parks (Stevens 1995) there is high potential biodiversity in the project area.

The Strategic Plan for Water Management – Volume 3: Water Management, identifies the "*location of suitable/capable wildlife habitat*" and "*wildlife presence and habitat use in the Water Supply Area*" as being "*key areas of interest*" (Acres International *et al*. 1999). As well, this plan stresses Ecosystem Management as a major goal, specifically risk management using ecosystem-based information, biodiversity and wildlife conservation (Acres International *et al*. 1999). In particular, the Strategic Plan mandates the long-term vigour, stability and resilience of the forest and its resources for the purpose of protecting water quality and compatible secondary values by maintaining and enhancing soil productivity and structure, vegetation, wildlife and hydrologic regimes (Acres International *et al*., 1999).

Based on the current state of wildlife habitat information in Sooke Hills Wilderness and Mount Wells Regional Parks, and the direction provided by the Strategic Plan for Water Management (Acres *et al*., 1999), wildlife interpretations based on TEM were initiated to document suitable and capable habitat for select wildlife species.

4.2 Objectives

The objective of wildlife habitat mapping the parks was to provide input to the Capital Regional District park management plan by estimating the potential value of the area's ecosystems to support selected wildlife species. Assessment of available habitat will enable park managers to direct management activities towards protecting and enhancing suitable habitats, enhancing habitats with a high capability for supporting wildlife needs, and allowing other, more intensive activities (e.g., recreation sites) on less suitable habitats. Habitat maps may also provide guidance towards development of wildlife viewing opportunities in or around the study area.

4.3 Methods

Habitat inventories assess available and potential habitat, they do not provide an indication of species presence or abundance. Wildlife habitat capability and suitability-maps are a product of habitat ratings that are applied to, for example, terrestrial ecosystem maps. Capability is the ability of a habitat under the optimal natural conditions, to support a particular animal species, irrespective of the current condition of the habitat. Suitability is the ability of a habitat in its current condition to support a particular species[3]. Habitat ratings indicate the value of a habitat to support a particular wildlife species for a specified habitat use (i.e. life requisite) compared to the best habitat in the province (i.e. the provincial benchmark) (RIC 1999).

The following key elements and concepts summarize the RIC-approved method for developing wildlife habitat rating in British Columbia (RIC 1999)

1. Alphanumeric ratings are provided for each species in one of three rating schemes, each reflecting the level of information available about the habitat requirements of the species being rated. A 6-class rating scheme is used when there is a detailed level of knowledge for a species'-habitat relationship. A 4-class rating scheme is used for an intermediate level of knowledge, and a 2-class rating scheme used when there is a limited level of knowledge.
2. These ratings reflect a percentage of the provincial benchmark habitat (Table 14). The provincial benchmark habitat has the highest suitability value for a given species in the province, against which all other habitats for that species must be rated. The benchmark is an actual location, not a theoretical habitat / location.
3. How an animal uses a particular habitat unit is closely associated with the season or time of year, and the specific activity or life requisite. Therefore, all ratings must be expressed as a value for a specified season and activity, or life requisite.
4. A habitat rating is provided for each project species over every mapped and potential ecosystem unit (i.e., every site series / structural stage / site modifier) combination.

Table 14. Three habitat capability and suitability rating schemes for different levels of knowledge of a species' habitat requirements.

% of Provincial Best*	Substantial Knowledge of Habitat Use (6-class)		Intermediate Knowledge of Habitat Use (4-class		Limited Knowledge of Habitat Use (2-class)	
	Rating	Code	Rating	Code	Rating	Code
100 - 76%	High	1	High	H	Habitat Useable	U
75 - 51%	Moderately High	2	Moderate	M		
50 - 26%	Moderate	3				
25 - 6%	Low	4	Low	L		
5 - 1%	Very Low	5			Likely No Value	X
0%	Nil	6	Nil	N		

* For example, habitat rated as Class 1 is 76-100% as good as the provincial benchmark.

To summarize the above criteria, a habitat suitability rating can be described as: ***a value assigned to a habitat for its potential to support a particular species for a specified season and activity compared to the best habitat in the province used by that species for the same season and activity.***

[3] For example, Pileated Woodpecker require a mature to old growth forest for nesting, so a clearcut is currently not very suitable for this species' reproducing habitat. However, given enough time, the clearcut site may have the potential to grow into a mature or old growth forest with a number of large, decadent trees capable of supporting a relatively high number of Pileated Woodpecker nests. The clearcut site would therefore have a low suitability, but a high capability for Pileated Woodpecker nesting habitat.

4.3.1 Project Wildlife Species

To select the wildlife species for this habitat mapping project, the provincially red-listed (endangered or threatened) and blue-listed (vulnerable) species (CDC Tracking List, 1997) were reviewed. From this extensive list, a preliminary subset of red- and blue-listed species whose habitat is likely to occur in the study area was developed (Table 15).

Table 15. Some red- and blue-listed vertebrate species* that could occur in Sooke Hills Wilderness and Mount Wells Regional Parks.

Red-listed	Blue-listed
Marbled Murrelet (*Brachyramphus marmoratus*)	Great Blue Heron (*Ardea herodias*)
Western Screech-Owl (*Otus kennicottii macfarlanei*)	Hutton's Vireo (*Vireo huttoni*)
Purple Martin (*Progne subis*)	Western Screech-Owl (*Otus kennicottii saturatus*)
Keen's Long-eared Myotis (*Myotis keenii*)	Vancouver Island Pygmy-Owl (*Glaucidium gnoma swarthi*)
Vancouver Island Water Shrew *(Sorex palustris brooksi)*	Roosevelt Elk *(Cervus elaphus roosevelti)*
Northern Goshawk (*Accipiter gentilis laingi)*	Vancouver Island Ermine *(Mustela erminea anguinae)*
Sharp tailed snake *(Contia tenuis)*	

(CDC Tracking List, 1998; Dave Fraser, pers. comm., 1998) *Note: this is not an exhaustive list, but was an initial review to assess the species that would most likely occur in the study area

However, since there have been no detailed wildlife inventories in the Sooke Hills Wilderness and Mount Wells Regional Parks, it remains uncertain whether any of these species actually occur in the project area. Additional criteria other than provincial vulnerability were therefore needed to choose the species to be rated for this project. Specifically, the following criteria were used to select wildlife species for habitat mapping according to the Resources Inventory Committee (RIC) standards (RIC 1999).

- the level of knowledge of the species' use of habitat;
- the ability of the habitat of the project species to act as surrogate habitat for other wildlife species;
- the ability of Site Series and ecosystem attributes to capture the habitat features required by the species;
- the range of wildlife habitat available in the study area and
- the likelihood of the species being observed in the study area.

Using these criteria, four vertebrate species were chosen for this habitat suitability mapping project and rated according to the noted rating schemes:

1. Columbian black-tailed deer (*Odocoileus hemionus columbianus*) – 6 class rating scheme.
2. black bear (*Ursus americanus)* – 6 class rating scheme.
3. Pileated Woodpecker (*Dryocopus pileatus*) – 6 class rating scheme.

4. Marbled Murrelet (*Brachyramphus marmoratus*) – 4 class rating scheme.

4.3.2 Species-Habitat Models

Wildlife habitat mapping for the Sooke Hills Wilderness and Mount Wells Regional Parks Terrestrial Ecosystem Mapping was conducted according to the standards outlined in the *BC Wildlife Habitat Ratings Standards - Version 2.0* (RIC 1999) (hereafter referred to as the Standards). A species-habitat model for rating wildlife habitat, according to the Standards, consists of a species account (Appendix 9), describing the habitat requirements and requisite natural history for the project species, and a preliminary ratings table. The preliminary ratings table, developed before field sampling, consists of an abbreviated table that provides habitat values for certain representative ecosystem units likely to occur in the project area. Essentially, it serves as a working hypothesis, for species-habitat values, which is tested during the field sampling.

Using the preliminary ratings and plot data from field sampling, a final ratings table was developed. In the final ratings table, a rating for each species and habitat use was assigned to each unique ecosystem unit (i.e., combination of site series, site modifier and structural stage) in the study area (based on the TEM ecosystem database). Final species-habitat models were submitted to a Ministry of Environment, Lands and Parks provincial wildlife-habitat correlator in Victoria to ensure that the Standards were met, and that the ratings corresponded to provincial Broad Ecosystem Mapping. The final ratings table was then used to produce habitat maps.

4.3.3 Field Sampling

Field assessment for the wildlife habitat mapping was conducted in conjunction with the ecosystem mapping. Survey intensity level 4 (15 - 25% plot visitation) was used (RIC, 1998). Fieldwork took place over several sessions in 1999, specifically, May 17 – 19; June 15 – 19; June 24; and July 20. During field sampling, a wildlife biologist recorded habitat values on the Wildlife Habitat Assessment form (FS 882HRE 98/5).

For Columbian black-tailed deer, we assessed feeding, security and thermal life requisites for winter and feeding and security habitat the growing season. However, thermal habitat for the growing season was not assessed because thermal habitat was not considered to significantly influence habitat use during the growing season in this area.

For black bear, feeding and security/thermal habitat was assessed for the early spring season and the growing season. Security and thermal habitat was combined because of the difficulty in differentiating these life requisites for this species. Winter hibernating habitat was also assessed for black bear.

For Pileated Woodpecker and Marbled Murrelet, security habitat for the reproducing season was assessed. This life requisite reflects nesting habitat for Pileated Woodpecker and Marbled Murrelet.

In addition, qualitative wildlife notes were taken and incidental wildlife-species observations (e.g. for provincially listed red and blue-listed species) were captured on a Wildlife Sighting form.

4.3.4 Wildlife Habitat Mapping

After the field session, the preliminary ratings table was converted to a final ratings table. Some of the steps in converting a preliminary ratings table to a final ratings table involve;

- ensuring that all field habitat assessments were incorporated,
- confirming all habitat values (i.e., the assigned ratings matched the Broad Ecosystem Unit ratings),
- confirming that all unique, mapped ecosystem units received ratings, and
- updating ratings to incorporate any new information regarding species' habitat requirements.

The final ratings table and the ecosystem database were then used to generate wildlife habitat maps for the project (Appendix 11). To develop a wildlife habitat map for a single life requisite and season (e.g., Columbian black-tailed deer feeding habitat for the winter season), polygons generated from the ecosystem map were used as a base layer, and each polygon was assigned a wildlife habitat value based on the final ratings table. In instances where the polygon consisted of a single ecosystem unit, the corresponding wildlife habitat value was assigned to the entire polygon. However, in complex polygons (with 2 or 3 ecosystem units) it is possible for each component to have a different wildlife habitat value, based on the final ratings table. In instances where the map polygon consisted of more than one component (i.e., complex polygon), two approaches were taken depending on the wildlife species' habitat use: Largest Area and Highest Value methods. The Largest Area method was used for the security and thermal life requisites for Columbian black-tailed deer. In this method, the wildlife habitat rating associated with the largest area of a complex polygon was assigned to the entire polygon. For example, if a polygon had three different components in a 40%, 40%, 20% composition with ratings of Class 1, Class 2 and Class 2 respectively, the polygon would be assigned a Class 2 rating since the total percentage of Class 2 for all three components is 60% (40% +20%). For complex polygons in which the total area for a rating is equal (e.g. the total area of Class 1 and Class 2 equals 50% each), the polygon is rated according to the lower wildlife habitat rating (i.e., the better habitat). For example if a polygon had three components in a 50%, 40%, 10% composition with ratings of Class 2, Class 1 and Class 1 respectively, the polygon would be assigned a Class 1 rating. This approach was used for Columbian black-tailed deer because deer likely use the largest amount of area to maximize thermal and security habitat.

The Highest Value method was used for all other species and life requisites. In this method, the highest wildlife habitat value (i.e., lowest numerical value) associated with any of polygon components was assigned to the entire polygon. This approach was taken for the remaining wildlife species because these species likely use the best available habitat for the life requisites and seasons under consideration.

For presentation, and to facilitate interpretation, we prepared 7 maps including:

For Columbian black-tailed deer two habitat maps were produced: a 'living' habitat map for the growing season and one map for the winter season. The 'living' habitat map represents a compilation of the feeding, security and thermal (for winter only) life requisite. To generate this map, separate maps were produced for feeding, security and thermal habitat, and then each one of these maps was overlaid. The feeding habitat map was assigned twice the value of the security and thermal habitat maps as feeding likely governs habitat use for deer in the study area. Security and thermal values are likely less important constraining factors for deer in this region with limited weather extremes.

For black bear, three habitat maps were produced: a hibernating habitat map and a 'living' habitat map for the early spring season and the growing season. The 'living' habitat map represents a compilation of feeding and security/thermal life requisites. To generate this map, separate maps were produced for feeding and security/thermal habitat, then each of these maps was overlaid.

Because black bears habitat use is significantly governed by food values, feeding habitat was assigned three times the value of security/thermal habitat.

For Pileated Woodpecker, a single map for nesting habitat was produced. This map represents the habitat rating that was assigned to the security/thermal life requisite for the reproducing season.

For Marbled Murrelet, a single map for nesting habitat was produced. The nesting habitat map represents the habitat rating that was assigned to the security/thermal life requisite for the reproducing season.

4.4 Results

4.4.1 Wildlife Species Habitat Models

4.4.1.1 Species Accounts

For simplicity, brief summaries of some important habitat requirements for each project species are included below. Complete species accounts can be found in Appendix 9.

Columbian black-tailed deer

Columbian black-tailed deer require food, water and cover to ensure survival during the spring, summer, fall and winter seasons. During spring, deer favour areas with available early spring forage plants. (E.g., low elevation areas with warm aspect on moderate to steep slopes). Summer and fall habitat consists of areas with a suitable mix of young to old forest areas, with an adequate supply of forage and cover elements. Winter forces deer from high elevation habitat to low elevation areas, with south-facing, warm-aspect slopes or floodplain areas where snowpack is very low (i.e. CWHxm). Important forage species for Columbian black-tailed deer are outlined in Table 16. In general, old growth forests with a patchy conifer understory and most well - stocked stands of young trees with live branches satisfy security cover requirements. Canopy closure (i.e., stands, taller than 10 m, with greater than 60% crown completeness) provides the most snow interception, and creates areas with snow conditions that do not limit deer movement (Bunnell *et al.* 1985).

In the Sooke Hills, snow conditions are not likely a limiting factor for deer habitat because of typically low winter snowfall. However, in the study area deer likely use similar winter habitat, as described above, to shelter from rain, wind and other energetically expensive weather conditions.

Class 1 habitat will be assigned for each season when the above habitat conditions are observed. Habitat will be rated Class 2 when habitat is slightly less suitable, for example, if there is less diversity and/or abundance of forage plant species, and/or if canopy closure of less than 60%, and/or if stem density does not offer good security cover.

Table 16. Some important forage plants for Columbian black-tailed deer in southern British Columbia (taken directly from Nyberg & Janz 1990).

	Winter forage	Spring forage	Summer forage
TREES:	Douglas-fir western hemlock western redcedar	bigleaf-maple Douglas-fir	red alder
SHRUBS:	Alaskan blueberry five-leaved bramble oval-leafed blueberry red huckleberry rose spp. salal Saskatoon twinflower willow spp.	*Rubus* spp. (salmonberry, blackberry, thimbleberry, raspberry, bramble) salal willow spp.	salal willow spp.
FERNS	deer fern	bracken	
HERBS	bunchberry grass spp. kinnickinnick	bunchberry fireweed grass spp. hairy cat's-ear horsetail pearly everlasting	fireweed grass spp. hairy cat's-ear pearly everlasting
ARBOREAL LICHENS	*Alectoria* *Bryoria* *Lobaria oregana* *Usnea* spp.		

Black Bear

Black bears are very adaptable species, and inhabit a wide variety of plant communities. Black bears prefer forested and shrubby areas, but use wet-meadows, high tidelands, ridgetops, burned areas, riparian areas and avalanche chutes. In general, black bears prefer mesic over xeric sites and timbered over open areas. Black bears are opportunistic omnivores and alter their food habits according to the availability of food items throughout the seasons. In early spring, black bears feed on grasses, sedges and horsetails because these plants develop early. For the study area, succulent vegetation in wet meadows and skunk cabbage swamps likely provide important spring forage opportunities. In summer and fall, black bears feed on green leafy material, and wild berries found in old growth and mid-seral deciduous forests. Where available, in the fall, black bears will take advantage of fish in spawning rivers. However, this opportunity is not likely significant in the study area. Overall, black bears depend heavily on plant foods but will feed on fish, wildlife and domestic animals, carrion, and insects as available. Table 17 shows some preferred black bear forage species.

Black bears seek security habitat in immature forest stands with high cover values, and females with cubs will rarely forage farther than 100 m from the forest edge. In low elevation, coastal-habitats, black bears need to find hibernating sites that remain dry over winter. Typical hibernating sites for black bears in the coast include cavities in large old trees, stumps, root bolls and logs with a diameter greater than 85 cm.

Table 17. Some preferred black bear forage species

✓ cow parsnip (*Heracleum lanatum*)	✓ kinnikinnick (*Arctostaphylos* spp.)
✓ dogwood (*Cornus* spp.)	✓ *Vaccinium* spp.
✓ cranberry (*Vibernum* spp.)	✓ *Rubus* spp.
✓ *Ribes* spp.	✓ *Lupinus* spp.
✓ *Rosa* spp.	✓ thistle (*Cirsium* spp.)
✓ sarsaparilla (*Aralia nudicaulis*)	✓ *Lomatium* spp.
✓ soopallalie (*Sheperdia canadensis*)	✓ *Trifolium* spp.
✓ Labrador tea (*Ledum groenlandicus*)	✓ tree cambium
✓ mountain ash (*Sorbus* spp.)	✓ skunk cabbage (*Lysichiton americanum*)

Class 1 feeding habitat for black bears will be governed by the availability and abundance of preferred forage species. Habitat will be rated Class 1 if at least 3 preferred browse species are present with 3% or greater ground cover. This typically reflects 75 – 100% of the provincial benchmark habitat. Habitat rated less that class 1 will be a reflection of less diverse and abundant forage species.

Pileated Woodpecker

Wood-dwelling insects are the primary diet of Pileated Woodpeckers throughout the year, and carpenter ants are a major food item in all seasons (Beckwith and Bull 1985; Bull *et al.* 1992). In winter, Pileated Woodpeckers use deep excavations in sound wood to forage, whereas in summer, food occurs near the wood surface thereby precluding deep excavations. In coastal forests, Pileated Woodpeckers prefer foraging habitat with logs 50 cm in diameter or greater, and with snags 45 cm or greater diameter at breast height (dbh) with 5% or more bark remaining (C. Hartwig pers. comm.). In the interior of the province and in Alberta nest tree dbh ranges from 29 to 33 cm (Conner *et al.* 1976, Bonar & Bessie 1996), however, nests trees in coastal forests are much larger, and average 85 cm dbh (Hartwig 1999). Nests are usually located in high (4 m or higher) branch-free portions of the main trunk. In coastal forests, most nest trees were western hemlock (Aubry & Raley 1994), but Douglas-fir and western redcedar are also used (Hartwig 1999)

Class 1 reproducing habitat is assigned when plots have, on-average, trees with dbh 85 cm or larger. Class 2 habitat represents habitat with lower abundance of suitable diameter trees and/or trees in the stand with average dbh less than 85 cm. Habitat with trees averaging less than 30 cm dbh will be rated class 6 for reproducing habitat.

Marbled Murrelet

Marbled Murrelets typically nest in low elevation old-growth and mature coniferous forests, with multi-layered canopies (more than 2 layers), a high composition of low elevation conifer trees, located on the lower two-thirds of forested slopes, with moderate gradients (Hamer and Nelson 1995). Potential nesting trees should have large limbs higher than 15 m above the ground, with nesting platforms (horizontal limbs) greater than 18 cm in diameter (branch and moss or duff combined) available (Marbled Murrelet Recovery Team 1994). Certain species such as Sitka spruce and western hemlock tend to have more platforms (Rodway and Regehr 1999). An assessment of nesting habitat for Marbled Murrelets in the Coastal Douglas-fir zone on southeastern Vancouver Island identified several suitable nesting stands that contained structural characteristics known to be important for nesting (Burger *et al.* 1999). Occupied detections indicating near-nest activities were reported within the Greater Victoria Water District lands but no nests were found (Burger *et al.* 1999).

The following list summarizes information presented on Marbled Murrelet nest tree and nest stand characteristics in British Columbia (FPC 1999; Kaiser *et al*. 1994; Hamer and Nelson 1995).

- Age Class – Class 9 (250 years of age) is preferred, but class 8 is acceptable if older forest is not present.
- Height Class – In the CWH or CDF zones Classes 5 (37.5-46.4 m) or 6 (46.5-55.4 m) are preferred. In the MH zone Class 4 (28.5-37.4 m) is acceptable if higher height class is not present or appropriate classes of CWH or CDF are not present.
- Nest platforms – Nesting platforms greater than 18 cm in diameter (branch and moss or duff combined) should be available
- Distance from Salt Water – All habitat within 85 km of salt water is potential murrelet breeding habitat. Habitat within 30 km is preferred, although the strip of habitat directly adjacent to the ocean is unattractive to murrelets due to the increases in predation, lack of moss on branches and increased exposure to coastal storms (Rodway and Regehr 1999; Hamer and Nelson 1995).
- Biogeoclimatic Zone – CWH and CDF are preferred over MH but all are zones contain potentially suitable nesting habitat.
- Elevation – Prime nesting-habitat is located between sea level and 600 m. All habitat below 1200 m is considered potential nesting habitat.
- Fragmentation – Larger contiguous areas are preferred over smaller contiguous area and fragmented areas.

Habitat with seven or more suitable nesting platforms in at least two suitable nesting trees will be rated Class 1 Marbled Murrelet nesting habitat. Habitat with lower numbers of suitable nesting platforms will be rated Class 2 or lower.

4.4.1.2 Final Ratings Tables

The final ratings table appears in Appendix 10.

Table 18. Animal species that were observed in Sooke Hills Wilderness and Mount Wells Regional Parks

Species	Species
• **Amphibians and Reptiles**	Double-crested Cormorant (*Phalacrocorax auritus*)
Western Terrestrial Garter Snake (*Thamnophis elegans*)	Mallard (*Anas platyrhychos*)
Red-Legged Frog (Eggs) (*Rana aurora*)	Blue Grouse (*Dendragapus obscurus*)
Pacific Tree Frog (*Hyla regilla*)	Ruffed Grouse (*Bonasa umbellus*)
Western Redback Salamander (*Plethodon vehiculum*)	Rufous Hummingbird (*Selasphorus rufus*)
Roughskin Newt *Taricha granulosa*)	Chestnut-backed Chickadee (*Poecile rufescens*)
• **Mammals**	Golden-crowned Kinglet (*Regulus calendula*)
Townsend's Vole (tunnels) (*Microtus townsendii*)*	Winter Wren (*Troglodytes troglodytes*)
Red Squirrel (*Tamiasciurus hudsonicus lanuginosus*)	Pine Siskin (*Carduelus pinus*)
Pine Marten (*Martes americana*)	Song Sparrow (*Melospiza melodia*)
Columbian black-tailed deer (*Odocoileus hemionus columbianus*)	Golden-crowned Sparrow (*Zonotrichia atricpilla*)
Black Bear (*Ursus americanus vancouveri*)	Dark-eyed Junco (*Junco hyemalis*)
Wolf (*Canis lupis crassodon*)*	Western Flycatcher (*Empidonax occidentalis*)
• **Birds**	Orange-crowned Warbler (*Vermivora celata*)
Northern Pygmy-Owl (*Glaucidium gnoma*)	Townsend's Warbler (*Dendroica townsendi*)
American Kestrel (*Falco sparverius*)	Common Yellowthroat (*Geothlypis trichas*)
Cooper's Hawk (*Accipiter cooperii*)	Yellow-rumped Warbler (*Densroica coronata*)
Pileated Woodpecker (*Dryocopus pileatus*)	American Robin (*Turdus migratorius*)
Red-breasted Sapsucker (*Sphyrapicus rubus*)	Varied Thrush (*Ixoreus naevius*)
Bufflehead (*Bucephala albeola*)	Steller's Jay (*Cyanocitta stelleri*)
Canada Goose (*Branta canadensis*)	

* Sign only observed

4.4.2 Wildlife Habitat Maps

Wildlife habitat maps for the study area are included as Appendix 11. It is important for users to understand these wildlife maps are representations of particular life requisites and are not detailed wildlife inventories. For example, the Pileated Woodpecker nesting-habitat map does not represent the occurrence of actual Pileated Woodpecker nests. Rather, the Pileated Woodpecker nesting-habitat map represents currently suitable ecosystem units that offer suitable Pileated Woodpecker nesting habitat. Similarly, the Columbian black tailed deer growing season map does not represent actual occurrences of deer, rather indicates suitable ecosystem units that Columbian black tailed deer could use in the growing season.

4.4.3 Wildlife Species Inventory

It is unknown if sensitive, rare, threatened or endangered animal species actually occur in the parks as no standard, wildlife species inventories have been completed (T. Fleming pers. comm.). Wildlife habitat maps can provide a surrogate estimate of population numbers if, and only if, baseline information exists about the relationship between species' habitat and population numbers. The Resources Inventory Branch, Wildlife Inventory Section of the Ministry of Environment, conducted a reconnaissance-level inventory in the study area. Table 18 shows the wildlife species that were observed (Dennis Demarchi pers. comm.). However, logistical constraints (e.g., limited budget and time) precluded making definitive conclusions about a particular species' abundance in the parks.

4.5 Discussion

4.5.1 Wildlife Habitat

Ecosystem management can have many specific goals endorsed by ecological researchers including:

1. to maintain viable populations of all native species in situ;
2. representation, within protected areas, of all native ecosystem types across their natural range of variation;
3. to maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes, nutrient cycles and so forth);
4. to manage over periods of time long enough to maintain potential species and ecosystems; and
5. to accommodate human use and occupancy within these constraints. (Grumbine 1994.)

Within the aforementioned context of maintaining natural ecosystems and wildlife populations in the Sooke Hills Wilderness and Mount Wells Regional Parks, the following discussion and management recommendations provide some options for influencing native wildlife species and their habitats. Note, that we specifically avoided making polygon-specific recommendations for wildlife habitat as these recommendations depend heavily on a variety of factors beyond the scope of wildlife habitat mapping (e.g., specific goals for different areas, specific constraints put on particular areas from other resource users). Also, given the longevity of coastal ecosystems and the infrequency of natural disturbances, the text refers to habitat suitability or the current habitat conditions in most instances. Habitat capability is only discussed when reference is made to optimal, desired or future habitat conditions.

4.5.1.1 Columbian Black-tailed Deer – Growing Season

The Sooke Hills Wilderness Regional and Mount Wells Regional Parks currently has considerable suitable Columbian black-tailed deer habitat for both the growing and winter season.

Although there is relatively little High habitat in the project area, half the project area consists of High and Moderately-High Growing season habitat combined (Table 19). The primary reason that much more of the project area did not receive a High rating is that many of the field plots lacked the forage species' diversity and abundance necessary for Class 1 habitat (S.Rasheed pers. obs.). For the Growing Season, suitable deer habitat was located in all four catchments, including Niagara, Veitch, Waugh, and Humpback. In total 28 deer were seen during the sampling session, 17 of which were observed together at km 4 on Niagara Main Road (S.Rasheed pers. obs.). These observations suggest that the study area supports a resident deer population, as such high numbers of animals would not be migrating through the area all at once during the growing season. Moreover, several deer carcasses were found during the field sampling indicating that these deer likely serve as a prey base for either local or transient predators, such as cougars or wolves. Deer form an important part of the biodiversity in the Sooke Hills and Mount Wells Regional Parks so management for this species should not be overlooked.

The recommendations provided below are meant as general options. For context-specific management for Columbian black-tailed deer, the reader is strongly advised to refer to Nyberg and Janz (1990), specifically, Chapter 5 – Techniques for Managing Habitat.

During the growing season Columbian black-tailed deer are most likely constrained by forage biomass and diversity, and so management recommendations for the growing season are tailored to these constraints. Moreover, the management recommendations that increase forage biomass and diversity should typically lead to an increase in deer population numbers. Park managers need to identify specific management goals (e.g., more deer required in the parks) before entering into any management regime.

Table 19. Summary of the High and Moderately High habitat for the project wildlife species in Sooke Hills Regional and Mount Wells study area.

Each cell contains the following information for each described habitat type; the total number of polygons, the total area represented and the percent that the habitat represents of the total project area. Note: the study area contains a total of 602 polygons over 41 122 285 m^2 of area.

	PROJECT WILDLIFE SPECIES, LIFE REQUISITE AND SEASON						
Species	**Columbian black-tailed deer**		**Black bear**			**Pileated Woodpecker**	**Marbled Murrelet**
Habitat Type	**Living Growing Habitat**	**Living Winter Habitat**	**Living Early Spring Habitat**	**Living Growing Habitat**	**Hibernating habitat**	**Nesting habitat**	**Nesting Habitat**
High Habitat (Class 1)	8 polygons 492694 m^2 1.2 %	47 polygons 3339395 m^2 8.1 %	15 polygons 569545 m^2 1.4 %	5 polygons 98538 m^2 0.2 %	4 polygons 448586 m^2 1.1 %	123 polygons 11319199 m^2 27.5 %	2 polygons 281152 m^2 0.7 %
Moderately High Habitat (Class 2)	256 polygons 20284057 m^2 49.3 %	170 polygons 13722892 m^2 33.4 %	81 polygons 3998602 m^2 9.7 %	129 polygons 9752063 m^2 23.7 %	106 polygons 9576826 m^2 23.2 %	54 polygons 3371136 m^2 8.2 %	141 polygons 12489653 m^2 30.4 %
Class 1 and 2 Habitat Combined	264 polygons 20776751 m^2 50.5 %	217 polygons 17062287 m^2 41.5 %	96 polygons 4568147 m^2 11.1 %	134 polygons 9850601 m^2 23.9 %	110 polygons 10025412 m^2 24.3 %	177 polygons 14690335 m^2 35.7 %	143 polygons 12770805 m^2 31.1 %

Park management that would provide Growing-season habitat for Columbian black-tailed deer should include some of the following practices.

- Maintain spring, summer and fall forage species for deer by ensuring that forage areas become productive in a manner useable for deer over time. For example, in select polygons in each one of the major areas (e.g., Waugh) within the project area, a small, controlled burn would suppress dense shrubs and tree species encroachment, and allow for new forage species development. Although intense fires in coastal ecosystems are rare (Parminter 1990), burning could be conducted as a maintenance strategy in areas that already offer growing season forage for deer, or alternatively new burns could be used to establish new growing season forage areas. Site series offering moderate moisture and nutrient regimes (i.e., CWHxm1 /RS; CWHxm1/ RF) would respond most effectively to a controlled burn and result in the most diverse forage species production.
- Establish more suitable Class 1 growing season deer habitat. Only 1.2% of the park area was classified as Class 1 growing season habitat, and so management could focus on converting poorer habitat into Class 1 habitat. A strategy to establish more class 1 habitat would be to try and convert Moderately High habitat into High habitat by a controlled burning program.
- Thin tree stem density in stands to maintain <70% crown closure if a controlled burn program in the Capital Region Parks is not viable (Nyberg and Janz 1990).
- Ensure that growing-season foraging sites for deer are in close proximity to security habitat. Any forage production strategy should consider the spatial distribution of security habitat (see the complete Columbian black-tailed deer species account in Appendix 9 for detailed description of security habitat).

4.5.1.2 Columbian Black-tailed Deer – Winter Habitat

For Winter, the project area has slightly less (41.5%) High and Moderately High habitat (Table F), than in the Growing. Moreover, High habitat forms a higher proportion of the good winter habitat (Table 19). The study area has a small area of habitat that provides an excellent example of CWH old-growth forest, particularly in the Niagara and Veitch areas. These high-value landscape features contribute to the occurrence of High quality deer habitat. Habitat not exhibiting old-growth characteristics (e.g., young forests or older, second growth forests) were rated as poor winter habitat. The parks occur in the shallow snowpack zone as defined by Nyberg and Janz (1990). In the shallow snowpack zone, a wide variety of forest conditions provide suitable winter habitats, and security and forage are important constraints. Nyberg and Janz (1990) identify two conditions that satisfy winter range for deer in the shallow snowpack zone, specifically,

1. A mixture of open and closed canopies provided by heterogeneous forest stands; and
2. Interspersed clearcut and forested patches that are never more than about 200 m apart that provide forage and cover in different stands. Deer uses all aspects and slope positions during winter in the shallow snowpack zone.

As a result, in winter, Columbian black-tailed deer require a suite of features to ensure survival, and so management of winter habitat is tailored to the maintenance of food, security and thermal landscape features. The recommendations provided below are meant as general options. Again, the reader is strongly advised to refer to Nyberg and Janz (1990), specifically, Chapter 5 – Techniques for Managing Habitat for context-specific management strategies for Columbian black-tailed deer.

Park management that would provide Winter habitat for Columbian black-tailed deer should include some of the following practices.

- Ensure that Coastal Western Hemlock (CWH) and Coastal Douglas-fir (CDF) old-growth forests remain available throughout the landscape. On Vancouver Island the primary strategy employed to ensure deer winter range in forested zones is to designate High winter-habitat areas as protected Ungulate Winter Ranges (UWR) or alternatively Wildlife Habitat Areas (WHA). Within UWR or WHA, commercial activities, such as forestry are restricted. Management for winter habitat in the parks should follow a similar pattern. For example, restrict recreational activities, particularly in winter, or year-round recreation features (trails, viewing areas, boardwalks, parking areas) in high value winter habitat. Also, designate as many class 1 polygons as possible in the Niagara area as an UWR, and minimize recreational use in these polygons and surrounding area.
- Maintain the existing proportion of High rated winter deer-habitat by ensuring that no suitable old-growth, winter habitat is lost or removed from the landscape. Moreover, Moderately High habitat should be allowed to free-grow into High rated habitat.

4.5.2.1 Black Bear – Spring Habitat

In spring, black bears require succulent, new vegetation to gain weight after winter hibernation. For black bears, early spring habitat may be limiting in the study area. Only 11.1% of the project area was rated better than 51% (Class 2) of the best spring habitat in British Columbia. This suggests that any existing spring habitat that is rated Class 1 or 2 should be protected. Several healthy bears were observed in the study area (S. Rasheed pers.obs), and bears are regularly seen on the roads in the project area (Greater Victoria Water District Watershed gate logbook). However, given the low amount and diversity of early-spring forage species in the parks, the project area (4112 ha) is not likely large enough to support an extremely high density of black bears. In coastal British Columbia, high densities of black bears are 1 bear / km^2 (T. Hamilton pers. comm.). However, in the project area, given the high road density, the predominance of closed-canopy second-growth forest, the long history of localized, high human-caused mortality and the limited access to fish as a fall food source, a more realistic expectation of bear density would be 1 black bear / 4 - 5 km^2 (T. Hamilton pers. comm.).

Management of Spring bear habitat should focus on maintaining existing spring foraging sites, and if possible creating new forage opportunities.

Park management that would provide Spring habitat for black bear should include some of the following practices.

- Protect all sites or polygons identified as Class 1 or 2 Spring habitat in the study area (i.e., typically moist sites with a rich nutrient regime e.g., CWHxm1/Western redcedar - Sitka Spruce - skunk cabbage or wet meadows) from any year-round recreational activities or human disturbance regimes.
- Prevent encroachment by trees and possible elimination of availability of early, spring forage in areas or polygons currently identified as early spring habitat. This may require manual clearing of the periphery of these areas and will require caution to ensure that site preparation or disturbance does not cause the introduction of invasive, noxious weed species.
- Create new spring forage sites for black bears. These sites typically would be in valley bottoms or moist, rich sites with terrain features that promote early spring growth (i.e.,

south aspect) or wet meadow. A controlled burning program on these sites might create spring forage habitat, although generating burns on these wet sites may be challenging.

4.5.2.2 Black Bear – Growing Season

During the growing season, black bears are opportunistic foragers, and forage availability likely governs habitat use. Given black bear generalist feeding habits, it is of concern that only about one quarter of the project area can be considered good black bear growing season habitat (Table 19). This observation is likely a reflection of numerous ecosystem units dominated by salal (i.e., poor berry species diversity), and an extensive network of rock outcrops in the project area; both are features which do not lend themselves to black bear growing season habitat. Regardless, bears, in good condition, were seen in the project area during the growing season. Management of growing season habitat for black bears should focus on ensuring a continuous supply of palatable growing season forage, and ensuring that alternative food sources (e.g., insects) are also available. Fish provide a valuable fall food item for bears in other parts of their range. Fish availability in the creeks in the study area was beyond the scope of this study.

Park management that would provide Growing season habitat for black bear should include some of the following practices.

- Protect any ecosystem units containing berry-producing shrubs. Especially important in trying to maintain berry-producing shrub diversity, rather than just having salal berries available at one time in the fall. Given the amount of area involved, protecting all polygons that are suitable growing season habitat may not be feasible. If this is the case, then priority should be placed on polygons that are either already protected from disturbance regimes for other species or are very productive ecosystem units.

- Identify and protect the fish habitat in any salmon-bearing streams in the parks. Although identifying fish habitat is beyond the scope of this study, CRD parks should make the effort to identify these areas as localized salmon feeding is an important fall food source for black bears, when available.

- Maintain the current volumes of CWD by restricting any activities that remove CWD from the landscape (e.g., shingle harvesting, firewood harvesting, salvage logging). Retain wildlife tree abundance to provide a continued supply of CWD. Carefully scrutinize the elimination of wildlife trees for public or worker safety reasons. Black bears prey upon many insect species, including ants. Insect-prey species' diversity and abundance often correlates with the amount of coarse woody debris (CWD) (Stevens 1996).

4.5.2.3 Black Bear – Hibernating Habitat

Although, no black bear hibernating dens were recorded in this study, almost one quarter of the study area was ranked as good (i.e., Class 1 and 2) black bear hibernating habitat (Table 19). One of the primary constraints for hibernating black bears in coastal ecosystems is the availability of dry den sites (T. Hamilton pers. comm.). As a result, high value hibernating-habitat occurs in ecosystem units with structural attributes that offer these dry, den sites.

Management of hibernating habitat for black bear should have two major strategies, first, to protect general hibernating habitat. As black bear hibernating habitat shares many stand structure characteristics similar to deer winter range and Marbled Murrelet nesting habitat, protection of hibernating habitat can be accomplished in concert with protecting habitat values for other project species. Second, specific den sites should receive protection. Any historic den sites or newly discovered den sites should be identified, mapped and received a 'no disturbance' buffer zone. Standards for buffer zone width or radius under these circumstances have not been identified. However, in other situations 1-2 ha areas around the den site have been recommended (R. Diedrichs pers. comm.)

4.5.3.1 Pileated Woodpecker – Nesting Habitat

Pileated Woodpecker nesting habitat in coastal ecosystems has been defined as forests with large diameter trees, specifically, trees with average dbh of 82 cm (± 16 Standard Error: SE) (Hartwig 1999), although in other areas, smaller trees have been identified as nesting habitat. In the study area about 25% of the habitat was rated as class 1 nesting habitat (123 polygons). This assessment likely reflects that fact the Pileated Woodpeckers are primary excavators and as such can most likely find suitable nesting habitat in a variety of ecosystem units, as long as stand structure is maintained and suitable nest trees are available. Polygons rated as Moderately High generally had a lower density of adequate nesting trees. Regardless, numerous polygons had typical Pileated Woodpecker feeding sign (e.g., rectangular excavations in live and decomposing wood). Pileated Woodpeckers were heard drumming on several occasions and individuals were seen on four separate occasions, twice foraging in a mature forest stand near Veitch Creek, and twice in the Niagara area, in a mature western redcedar forest (S.Rasheed, C.Tolkamp, C.Erwin; pers. obs.).

Individual Pileated Woodpecker home ranges vary in size from 200 - 1586 hectares (Bull & Holthausen 1993). As a result, Sooke Hills Wilderness and Mount Wells Regional Parks, at 4112 hectares, has the capacity to harbour several breeding pairs of Pileated Woodpeckers. The Pileated Woodpecker population in the parks will depend on prey and nesting habitat availability.

Park management that would provide nesting habitat for Pileated Woodpecker should include some of the following practices.

- Protect some polygons identified as High nesting habitat to maintain existing high quality woodpecker nesting habitat. Identifying similar polygons that overlap with High-rated Columbian black-tailed deer winter habitat could prioritize polygons. Recreational activities within these polygons should be minimized.
- Ensure an adequate prey base for Pileated Woodpecker. Pileated Woodpeckers often prey upon insects in coarse woody debris (CWD), and so, maintain existing volumes of CWD (see the third management recommendation for the black bear growing season).
- Enhance feeding sites in the study area. Pileated Woodpeckers use wildlife trees and CWD as both nesting and feeding sites. Consequently, live trees can be recruited into the wildlife tree population and eventually into CWD. Examples for creating wildlife trees can be found in Deal (1995) and Parks et al. (1995).

4.5.4.1 Marbled Murrelet – Nesting Habitat

Marbled Murrelets typically nest in old-growth coastal forests in the Pacific Northwest (Ralph et al. 1995). To date, Marbled Murrelet nests have been found in forests with trees greater than 250 yr. old, 37.5 – 55.4 m high, and within 85 km of salt water. Nest trees should have nesting platforms greater than 18 cm in diameter. Recently, Burger et al. (1999) conducted an assessment of nesting habitat for Marbled Murrelets on Southeast Vancouver Island, including Sooke Hills Wilderness and Mount Wells Regional Parks. Although no nests were found in the parks, Burger et al. (1993) identified high value nesting habitat. Burger et al. (1993) was unable to relate murrelet habitat to ecosystem site series because of unequal sampling, however, this report and Burger et al. (1993) identified similar habitat as high value murrelet habitat, specifically, the older forests in the Niagara area. Only 2 polygons as Class 1 murrelet nesting habitat in this study, however, overall the study area had about 31% good (Class 1 and 2) murrelet habitat. Clearly, based on this report and Burger et al. (1993), Sooke Hills Wilderness and Mount Wells Regional Parks contain suitable murrelet habitat.

Marbled Murrelet appear in the Managing Identified Wildlife Strategy (MIWG) of the Forest Practices Code of British Columbia (FPC) (1999a). The MIWG recommends several procedures and measures to use when managing for Marbled Murrelets, however, the general measure section recommends developing a Wildlife Habitat Area (WHA). A Marbled Murrelet WHA should be a minimum of 200 ha but may be smaller where 200 ha of suitable habitat is not available (FPC 1999a). Larger WHAs are preferred in order to provide interior forest conditions, and WHAs should be a minimum of 600 m in width. If the actual nesting habitat is narrower than 500 m, a buffer of approximately 100 m of old forest or advanced second growth (>60 years) should be included around the nesting habitat (FPC 1999a). WHAs with less that 200 ha of suitable habitat should also include a 100 m buffer, and wherever possible, no more than 50% of the WHA boundary should be exposed to early seral stages (<40 years) (FPC 1999a). Marbled Murrelet nesting habitat management in the study area should consider the uniqueness of old, coastal ecosystems and that replacing traditional murrelet habitat can be difficult.

Park management that would provide Nesting habitat for Marbled Murrelet should include some of the following practices.

- Protect any ecosystem units/polygons identified as high class murrelet habitat. For example, restrict any disturbance during the nesting period - mid-April to late September (Rodway and Regehr 1999) and any activities that may compromise the structural integrity of nesting habitat throughout the year. For murrelets and other wildlife species, the Niagara area is an area of high habitat value, and so should receive special consideration. Carefully evaluate recreational use in the Niagara area. Given the high importance of the Niagara area to several project wildlife species, limit recreational activities and permanent recreational facilities on the Niagara area.
- Ensure recruitment of habitat into high value Marbled Murrelet nesting habitat by identifying ecosystem units capable of offering high value habitat (e.g., CWHxm1HK, CWHxm1 Western redcedar - Sitka Spruce - skunk cabbage / CDFmm Western redcedar – Douglas-fir – Kindbergia), and allowing these polygons to free-grow to old-growth habitat.

5.0 Summary

Sooke Hills Wilderness and Mount Wells Regional Parks represent a significant area of wilderness in close proximity to metropolitan Victoria. Both the CWHxm1 and CDFmm biogeoclimatic subzones occur within the park boundaries making the study area an important addition to the provincial representation of these subzones in protected areas. The parks contain ecosystems and plants that are considered provincially rare and endangered.

The geomorphological history of the area is interesting in that the area lies at the convergence of three terranes, which have influenced the soil and ecosystem development in the different subareas of the parks. A variety of surficial materials are found here, each has implications relating to the development of park facilities.

The four catchment areas have undergone varying degrees of disturbance in the past including forestry, road building, fire and water course alterations. The type and degree of disturbance varies between the catchment areas and as a result ecosystems within each catchment area have varying ranks for quality, condition (naturalness) and long term ecosystem viability.

There is an abundance of young forests throughout the study area while mature, old and pole sapling structural stages are not well represented. Upland ecosystem complexes are common in the parks. Wetland ecosystems range from those in the upper Niagara catchment, which are in good condition to those in the Waugh, which have been seriously compromised by water management activities.

The Sooke Hills Wilderness and Mount Wells Regional Parks contains valuable wildlife habitat. Within the project area, over 25% of the habitat represented high value habitat regardless of the project species, life requisite or season under consideration. In particular the older forest in the Niagara area, east of Niagara Main were identified as having high suitability for several project species. Some ecosystem units/polygons in the Veitch area were also rated as high value habitat.

Wildlife habitat management in Sooke Hills and Mount Wells Regional Parks should take four broad approaches to maintain current levels of wildlife species abundance and diversity. First, habitat for species that require old-growth forest habitat (e.g., all the project species) should be protected from disturbance, as this habitat-type fulfils security and thermal requirements. This strategy should serve the parks for many years given the longevity of old-growth forests in coastal ecosystems.

Forest stands in young, structural stage (i.e., 2 and 3) offer abundant food value for Columbian black-tailed deer and black bear. In fact, the current distribution and density of deer and black bear are likely a reflection of available forage habitat and structural stage distribution. In order to manage wildlife species adaptively, park management needs to clearly identify goals for wildlife species abundance and diversity. If the desired goal is current or higher levels of species abundance, then forage availability has to mimic current conditions. Forage stands however, grow rapidly in coastal environments, and so food habitat can be removed from the landscape as succession progresses. As result, to maintain forage levels in the park, forested stands could be manipulated (e.g., fire, thinning) to maintain food quality and quantity. Moreover, in general, recreational use and facilities in these areas should receive careful scrutiny in order to maintain the food values.

Third, natural disturbance regimes in coastal ecosystems should be identified and approximated. However, for this strategy to be effective, park managers have to recognize that current stand structure and distribution in the Sooke Hills and Mount Wells Regional Parks are a result of both natural and anthropogenic influences. As a result, relying solely on natural disturbance regimes will likely change the observed distribution and abundance of wildlife species. If park management requires maintenance of current wildlife distribution and abundance, then the abundance of stands that are a result of anthropogenic disturbances has to be maintained. This may involve use of stand initiation events, such as infrequent controlled burns.

Fourth, existing wildlife tree and CWD volumes should be maintained. Wildlife tree creation and CWD replacement would ensure that these stand features remain on the landscape. Further, initiatives, such as recruitment of live trees into the wildlife tree population will ensure long-term supply of this stand feature.

In addition, Sooke Hills Wilderness and Mount Wells Regional Parks likely represent valuable wildlife habitat in context of Southeast Vancouver Island. Locally, these parks represent the largest contiguous area of protected wildlife habitat for many wildlife species (J.Ussery pers. comm.). As a result, these areas likely represent the closest habitat refuge for many wildlife species, especially given the proximity to nearby urban centres. This characteristic should factor importantly into any management decisions made over land-use activities within Sooke Hills Wilderness and Mount Wells Regional Parks. The challenge for park managers will be to balance the demand for recreational activities while retaining the wilderness features and biodiversity of the parks.

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PERSONAL COMMUNICATIONS

Brunt, Kim - Regional Biologist (Nanaimo region).

Ceska, Adolf - Conservation Data Centre, Ecologist

Chatwin, Trudy - Rare and endangered species specialist (Nanaimo region).

Demarchi, Dennis - Provincial wildlife habitat correlator

Diedrich, R – Forest Ecosystem Specialist, Vancouver Island Region

Douglas, George - Conservation Data Centre, Botanist

Fleming, Tracy – CRD Parks Ecologist

Fraser, Dave - Provincial Endangered Species Specialist

Hamilton, Tony - Ministry of Environment, Lands and Parks, Victoria, B.C.

Hartwig, Carol - Pileated Woodpecker species expert

Hatter, Ian - Provincial Ungulate Specialist

Himmer, Stephan - Biologist, Hagenborg, B.C.

Machuthon, Grant - Biologist, Comox, B.C.

Massey Vic – Geologist, BC Ministry of Energy and Mines

McLellan, Bruce - Ministry of Forests, Revelstoke, B.C.

Penny, Jenifer - Conservation Data Centre, Assistant Botanist

Ussery, Joel – CRD ParksPlanner

Appendix 1: Terrain Legend

The terrain legend is usually attached to a published terrain map that includes all mapped symbols. This map was not produced for the Sooke Hills Project. All the spatial (digital linework) and associated databases are available to do this in a GIS system.

The legend is presented to facilitate someone who wishes to make a terrain map and more importantly to provide the reader with a list of definitions for the many terms and symbols used in this report.

The terrestrial ecosystem database has terrain and soil drainages recorded for each polygon. The morainal deposits maybe recorded as **Mvb w – i** for example, meaning the **M** is Morainal or Till genetic material (or soil parent material), the **v** and **b** are surface expressions meaning the **v** veneer is dominant and is the mappers' estimate that most (>70%) of the map unit, has till which is less than 1 meter deep or generally shallow, the **b** blanket is subdominant and the estimate is that about 30% of the map unit may have soils deeper than 1 meter; the w means that it is estimated that most of the unit is well drained which grades (**-** by use of the dash) to **I** imperfectly drained. Howes and Kenk 1997, and available at http://www.elp.gov.bc.ca./rib/wis/terrain explain these symbols in the Terrain Classification Manual for B.C.

Note; the Ministry of Environment Technical Report 30, Soils of Southeast Vancouver Island is available at this WEB http://www.bcsoils.gov.bc.ca/XReport_Orderform.htm. For some interpretations of the till materials the physical and chemical soil data, can be referenced to the 'Shawnigan Soils'.

Terrain Unit Symbol

One or more groups of letters are used to describe each terrain unit. The relative position of a letter within its group indicates the characteristic that it represents.

EXAMPLE

$spF^{A}pf\text{-}BA$

In this symbol '**s**' and '**p**' represent texture; '**F**' superscript '**A**' represents an active fluvial surficial material; '**p**' and '**f**' represent surface expression; and '**B**' and '**A**' represent geomorphological processes.

Composite Terrain Unit Symbol

Terrain units that include two or three different kinds of terrain are indicated by two or three groups of letters always arranged in decreasing order of importance. A number that indicates the percentile representing approximate proportions separates the components.

EXAMPLE

^{8} Mb ^{2} gFt means that there is roughly 80% 'Mb' and 20% 'gFt'

Terrain that constitutes less than 10% of a terrain unit is normally not included in the terrain unit symbol.

Stratigraphic Information

Where two or more kinds of surficial material are superimposed, or where the surface expression of buried bedrock is shown, a stratigraphic symbol is used.

EXAMPLE

$\frac{\text{rCw}}{\text{Mb}}$ means that 'rCw' (Colluvial) material overlies 'Mb' (morainal) material

Texture of Surficial Material

Symbol	Name	Description	In the Study Area:
a	blocks	angular particles <256 mm	A few blocks can be found scattered over the lower slopes located below steeper cliffs and bedrock walls. They blocks are most common in the Vietch and lower Waugh catchments.
b	boulders	rounded and subrounded particles >256 mm	Boulders are reasonably common in the valley floors of the major streams. They were likely deposited in association with glacial meltwaters and some have been subsequently exposed by recent fluvial action (within the last 10 000 years).
k	cobbles	rounded and subrounded particles 64-256 mm	Cobbles are a common clast size in the tills or morainal deposits which occur throughout the study area as well as the fluvioglacial deposits in the valleys.
p	pebbles	rounded and subrounded particles 2-64 mm	Pebbles are not common. Pebbles are mainly formed from water washing, such as along beach strands and in river pools, these environments are not common in the study area.

g	gravels	rounded and particules, greater than 2mm in size, a mixture of pebbles and cobbles	Gravels are very common in the study area, they are one of the dominant clast sizes in the tills and fluvioglacial sediments. They are mainly subangular and subrounded; gravels contribute significantly to the porous nature of the soils allowing air and soil water to move freely through the soil system.
s	sand	particles 2-.062 mm	Sands are very common in the study area, they are also one of the dominant clast sizes 'mixed' in the matrix of tills and fluvioglacial sediments. They appear to be mainly medium sands with noteable inclusions of fine and coarse sized fractions. There are few deposits of clean 'sorted' sand depostis. Sands also contribute significantly to the porous nature of the soils allowing air and soil water to move freely through the soil system.
z	silt	particles .062-.002 mm	Silts are a common sized soil particule and are found mainly in the tills and comprise about 15 to 30% of the fine' (<2mm) fraction. They are a major nutrient and mositure holding component of the soil.
c	clay	particles <.002 mm	Clays are not common throughout the study area, there may be small local pockets of clay rich sediments in the fluvioglacial deposits. Clays comprise only about 5 to 12% of the fine fraction of the till soils.
r	rubble	angular particles 2 - 256 mm	Rubble is common mainly in colluvial deposits along the base of slopes in the hilly areas and in assiciation with the near surface bedrock. Both areas are common in the study area. Rubble is generally sharp and angular is derived from the local metamorphosed volcanic rock. Deeper rubbly colluvial deposits are loose open soils, which hold very little moisture, mositure may however be available at depth on the rock or soil contact.
m	mud	mix of clay and silt particles <.062	Mud likely occurs in pockets along drainages where small settling ponds are located. Little mud was found in the coarse of the study. However 'Muck' a mixture of mud and organic matter was common at the base of some organic deposits and in some swamps.
f	fibric	Least decomposed of the organic materials; well-preserved fibre (40% or more) of original botanical origin can identified after rubbing	Fibric organic textures are common at the surfaces of most organic deposits in the study area classified as (fens or bogs). The fens consist mainly of fibrous sedge peat, which is about 20 to 50cm thick in the surface tier of some organic deposits.
m	mesic	Intermediate stage of decomposition between fibric and humic.	Mesic organic textures are common in the middle tiers of most organic deposits in the study area classified as (fens or bogs). The mesic peat consists mainly of sedge peat, which occurs at depths from 20 to 80cm in the middle tiers of some organic deposits.
h	humic	Most advanced and compact of the decomposed organic material; 10% of original origins identified after rubbing	Humic organic textures are common in the middle and lower tiers of most organic deposits in the study area classified as (fens or bogs). The humic peat consists mainly of sedge peat, which occurs at depths from 60 to 120cm in the middle and lower tiers of some organic deposits.

Surficial (Genetic) Materials

Surficial materials are classified according to their mode of formation because this influences their physical characteristics such as texture, structure, cohesion, and compactness. These characteristics influence the engineering properties of surficial materials and their erodability and stability on slopes.

Symbol	Name	Description
A	Anthropogenic	Man-made or man-modified material. These materials are mainly roads, dams and borrow pits
C	Colluvial	Materials deposited as a result of downslope movements due to gravity. Includes loosely packed, coarse, angular material. Colluvial in the study area is very common particularly in the hilly areas of the Veitch, lower Waugh and Niagara catchments. It is derived from eroding till often coupled with rubble from the steeper metamorphized volcanic slopes. This material is usually gravelly rubbly sand but will include a wide range of textures related to the material it is derived from. Colluvial is usually very thin over the bedrock (Cx) hills, and has very fine sandy textures; deeper areas (Cv and Cb) occur on more rolling bedrock with thin till terrain, and has gravelly and rubbly loamy sand textures; the deep (talus-like) deposits (rCb) along the base of steep slopes, have rubbly sand textures. Some sites that include 'slope-wash' influence contain textures, which are more silty. Colluvial is mainly well drained loose and porous.
F	Fluvial	Materials (recently) deposited by streams. Fluvial deposits in this area are mainly contained to the valley floors and are usually associated with stream courses. The textures are generally gravelly sands but pockets of sands and silts can be expected along the small floodplains and the lower wet terraces. The steeper gradient streams often show gravels mixed with cobbles and boulders.
FG	Glaciofluvial	Materials that exhibit clear evidence of having been deposited by glacial meltwater streams either directly in front of, or in contact with glacier ice. These materials are common in the study area and are often found as veneers and blankets (likely over the tills) along the valley floors, particularly where the last lobes of ice melted away. At some locations, deeper stratified deposits of gravels and sands occur usually at the junctions of drainages. The textures are usually gravels and sands, the materials are well drained.
M	Morainal	Materials deposited by glaciers. Morainal or till deposits are the most common deposits in the study area, usually on gentle to moderately sloping terrain. The area consists of hard-metamorphosed volcanic bedrock in the form of rolling and hilly terrain, this creates conditions for gravelly, sandy till not to accumulate to any great depths. About 0.5 to 4m depth is thought to be a nominal depth range for most tills over 'rocky' terrain. Such areas are classified and mapped as Mvb and Mbv i.e. mixtures of veneers and blankets. There are deep deposits of compact basal till in the lower portions of some valleys. The tills have a pan layer at about 60 to 90cm depth, which is usually impenetrable to roots, but when wet will slowly transmit water. The soil textures are gravelly sandy loam and gravelly loamy sand, the soils are moderately well drained, with well drained crests and imperfectly drained hollows.
O	Organic	Material resulting from the accumulation and decay of vegetative matter. In the study area most wetlands are classified as 'organics'. These deposits are found in drainage routes that have 'hollows' that became natural impoundments. The textures are generally fibric in the surface tier and stratas of humic and mesic in the middle and bottom tiers. Water tables are

		at the surface and the drainge is classed as very poor and poor.
R	Rock	Outcrops mainly and rock covered by a thin (<40cm) mantle of colluvium. Rocks in the study area belong to three terranes.

Surface Expression

Surface expression is the topography or shape of the land surface. The terms listed below provide information that augments those provided by the contours of the topographic base map.

Symbol	Name	Description
a	moderate slope	unidirectional surface; 16 to 26^o (26 to 50%)
b	blanket	a mantle of unconsolidated materials; >1 m thick
h	hummocky	hillocks and hollows, irregular plan; 15 to 35^o (26 to 70%)
j	gentle slope	unidirectional surface; 4 to 15^o (5 to 26%)
k	moderately steep	unidirectional surface; 27 to 35^o (50 to 70%)
m	rolling	elongate hillocks with slopes 3 to 15o (5 to 26%)
p	plain	unidirectional surface; 0 to 3^o (3 to 5%)
s	steep	steep slopes; >35^o (>70%)
r	ridge(s)	steeper elongated hillocks 15 to 35^o (26 to 70%)
t	terraced	step-like topography
v	veneer	mantle of unconsolidated material; 10 cm to 1 m thick
x	thin veneer	similar to veneer (2-20 cm thick)

Geomorphological Processes

These processes are either active at the present time or former processes that may be reactivated by disturbance of the environment. Many of these processes constitute potential hazards or constraints to land use.

Symbol	Name	Description
V	**Gully Erosion** Active Process	The modification of unconsolidated surfaces by various processes such as running water that results in the formation of ravines. In the study area there was not a lot of gully erosion observed, likely due to the coarse nature of the materials and near surface bedrock. Gullies are more common in silty or fine sandy soils and often on softer bedrock such as phyllites or shales, but this area has gravelly soils and very hard bedrock. Some gully erosion likely occurs directly in the stream coarse of the major drainages.
E	**Channelled by meltwater** Inactive Process	Erosion and channel formation by meltwater alongside, beneath, or in front of a glacier or ice sheet. In the study area there may be some weakly expressed channels in the deeper sediments on the valley floors and side slopes. They were not mapped but may be identified in future studies by CRD Parks.
(A)	**Active process**	This modifier is used mainly with Fluvial materials to indicate that active stream erosion or cut and fill processes are occurring. Only very small areas along some streams have been observed to have active fluvial processes, such as along the stream banks of Veitch Creek and an active fluvial fan running into the upper end of Jack Reservoir.
U	Inundated	Terrain seasonally under water which results from high watertable. In the study area the wetlands could be considered inundated but that process in usually considered a part of organic materials. Also the drawdown margins of the decommissioned reservoirs can be considered seasonally inundated.

Description of Soil Drainage Classes

Symbol	Name	Description
x	very rapidly drained	Water is removed from the soil very rapidly in relation to supply. Water source is precipitation and available water storage capacity following precipitation is essentially nil. Soils are typically fragmental skeletal, or both.
r	rapidly drained	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Water source is precipitation. Soils are generally coarse textured.
w	well drained	Water is remover from the soil readily, but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Water source is precipitation. On slopes, subsurface flow may occur for short duration, but additions are equalled by losses. Soils are generally intermediate in texture and lack restricting layers.
m	moderately well drained	Water is removed from the soil somewhat slowly in relation to supply because of imperviousness or lack of gradient. Precipitation is the dominant water source in medium-to fine-textured soils; precipitation and significant additions by subsurface flow are necessary in coarse textured soils.
i	imperfectly drained	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major source. If subsurface water or groundwater (or both) is the main source the flow rate will vary but the soil remains wet for a significant part of the growing season. Precipitation is the main source if available water storage capacity is high; contribution by subsurface or groundwater flow (or both) increases as available water storage capacity decreases. Soils generally have a wide range of texture, and some mottling is common.
p	poorly drained	Water is removed so slowly in relation to supply that the soil remains wet for much of the time that it is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface or groundwater flow (or both), in addition to precipitation, are the main water sources. A perched water table may be present. Soils are generally mottled and/or gleyed.
v	very poorly drained	Water is removed from the soil so slowly that the water table remains at or near the surface for most of the time the soil is not frozen. Groundwater flow and subsurface flow are the major sources. Precipitation is less important, except where there is a perched water table with precipitation exceeding evapotranspiration. Typically associated with wetlands.

Appendix 2: Vegetation Species List

LatinName	CommonName
Abies grandis	grand fir
Acer macrophyllum	bigleaf maple
Achillea millefolium	yarrow
Achlys triphylla	vanilla-leaf
Adenocaulon bicolor	pathfinder
Adiantum aleuticum	maidenhair fern
Agoseris sp.	*Agoseris sp.*
Aira caryophyllea	silver hairgrass
Aira praecox	early hairgrass
Allium acuminatum	Hooker's onion
Alnus rubra	red alder
Amelanchier alnifolia	saskatoon
Antennaria neglecta	field pussytoes
Anthoxanthum odoratum	sweet vernalgrass
Arbutus menziesii	arbutus
Arctostaphylos columbiana	hairy manzanita
Arctostaphylos sp.	*Arctostaphylos sp.*
Arctostaphylos uva-ursi	kinnikinnick
Arrhenatherum elatius	tall oatgrass
Aster sp.	Aster sp.
Athyrium filix-femina	lady fern
Blechnum spicant	deer fern
Boykinia elata	coast boykinia
Brodiaea coronaria	harvest brodiaea
Brodiaea sp.	*Brodiaea sp.*
Bromus hordeaceus	soft brome
Bromus sp.	brome
Bromus vulgaris	Columbia brome
Camassia quamash	common camas
Carex anthoxanthea	yellow-flowered sedge
Carex deweyana	Dewey's sedge
Carex echinata	star sedge
Carex hendersonii	Henderson's sedge
Carex inops	long-stoloned sedge
Carex inops ssp. inops	long-stoloned sedge
Carex lenticularis var. lipocarpa	lens-fruited sedge
Carex livida	pale sedge
Carex obnupta	slough sedge
Carex sitchensis	Sitka sedge
Carex sp.	sedge
Cerastium arvense	field chickweed
Chimaphila umbellata	prince’s pine
Cicuta douglasii	Douglas' water-hemlock
Cinna latifolia	nodding wood-reed
Circaea alpina	enchanter's-nightshade
Cirsium arvense	Canada thistle
Cirsium edule	edible thistle
Cirsium palustre	marsh thistle
Cladina sp.	*Cladina sp.*
Cladonia macilenta	*Cladonia macilenta*
Cladonia sp.	*Cladonia sp.*
Cladina rangiferina	grey reindeer
Cladonia uncialis	*Cladonia uncialis*
Claytonia sibirica	Siberian miner's-lettuce
Claytonia sp.	*Claytonia sp.*
Climacium dendroides	*Climacium dendroides*
Collinsia parviflora	small-flowered blue-eyed Mary
Corallorhiza sp.	coralroot
Cornus canadensis	bunchberry
Corydalis scouleri	Scouler's corydalis
Crepis sp.	*Crepis sp.*
Cytisus scoparius	Scotch broom
Danthonia californica	California oatgrass
Danthonia sp.	oatgrass
Deschampsia cespitosa	tufted hairgrass
Dicentra formosa	Pacific bleeding heart
Dicranum sp.	*Dicranum sp.*
Dicranum fuscescens	curly heron's-bill moss
Dicranum scoparium	broom moss
Digitalis purpurea	common foxglove
Dodecatheon hendersonii	*Dodecatheon hendersonii*
Dryopteris expansa	spiny wood fern
Dryopteris sp.	wood fern
Elymus glaucus	blue wildrye
Epilobium angustifolium	fireweed
Epilobium sp.	willowherb
Equisetum arvense	common horsetail
Equisetum fluviatile	swamp horsetail
Equisetum sp.	horsetail
Eriophyllum lanatum	woolly eriophyllum

LatinName	CommonName
Erythronium oregonum	white fawn lily
Festuca idahoensis	Idaho fescue
Festuca occidentalis	western fescue
Festuca rubra	red fescue
Festuca subulata	bearded fescue
Festuca sp.	fescue
Fragaria sp.	strawberry
Fragaria vesca	wood strawberry
Fragaria virginiana	wild strawberry
Galium aparine	cleavers
Galium trifidum	small bedstraw
Galium triflorum	sweet-scented bedstraw
Galium sp.	bedstraw
Gaultheria shallon	salal
Gentiana sceptrum	king gentian
Glyceria elata	tall mannagrass
Gnaphalium sp.	*Gnaphalium sp.*
Goodyera oblongifolia	rattlesnake-plantain
Heuchera cylindrica	round-leaved alumroot
Heuchera micrantha	small-flowered alumroot
Hieracium albiflorum	white hawkweed
Holcus lanatus	common velvet-grass
Holodiscus discolor	oceanspray
Hylocomium splendens	step moss
Hypericum anagalloides	bog St. John's-wort
Hypochoeris radicata	hairy cat's-ear
Ilex sp.	holly
Ilex aquifolium	English holly
Juncus effusus	common rush
Juncus ensifolius	dagger-leaved rush
Kindbergia oregana	Oregon beaked moss
Kindbergia praelonga	*Kindbergia praelonga*
Koeleria macrantha	junegrass
Lactuca muralis	wall lettuce
Ledum groenlandicum	Labrador tea
Leucolepis acanthoneuron	palm tree moss
Leucanthemum vulgare	oxeye daisy
Lilium columbianum	tiger lily
Linnaea borealis	twinflower
Listera cordata	heart-leaved twayblade
Listera sp.	twayblade
Lomatium utriculatum	spring gold

LatinName	CommonName
Lotus micranthus	small-flowered birds-foot trefoil
Luzula multiflora	many-flowered woodrush
Lysichiton americanum	skunk cabbage
Madia sp.	Madia sp.
Mahonia aquifolium	tall Oregon-grape
Mahonia nervosa	dull Oregon-grape
Maianthemum dilatatum	false lily-of-the-valley
Malus fusca	Pacific crab apple
Melica subulata	Alaska oniongrass
Mentha arvensis	field mint
Mimulus alsinoides	chickweed monkey-flower
Mitella breweri	Brewer's mitrewort
Mitella sp.	mitrewort
Mitella pentandra	five-stamened mitrewort
Mnium sp.	leafy moss
Moehringia macrophylla	big-leaved sandwort
Monotropa uniflora	Indian-pipe
Montia sp.	indian-pipe
Myrica gale	sweet gale
Oenanthe sarmentosa	Pacific water-parsley
Osmorhiza chilensis	mountain sweet-cicely
Osmorhiza sp.	sweet-cicely
Pachistima myrsinites	falsebox
Peltigera britannica	freckle pelt
Picea sp.	spruce
Picea sitchensis	Sitka spruce
Pinus albicaulis	whitebark pine
Pinus contorta	lodgepole pine
Pinus monticola	western white pine
Piperia unalascensis	Alaska rein orchid
Plagiomnium insigne	coastal leafy moss
Plagiothecium undulatum	flat moss
Platanthera sp.	orchid
Platanthera dilatata	white bog orchid
Plectritis congesta	sea blush
Pleurozium schreberi	red-stemmed feathermoss
Poa sp.	bluegrass
Pogonatum sp.	*Pogonatum sp.*
Polypodium glycyrrhiza	licorice fern
Polytrichum juniperinum	juniper haircap moss
Polystichum munitum	sword fern

LatinName	CommonName	LatinName	CommonName
Polytrichum piliferum	awned haircap moss	*Spiraea betulifolia*	birch-leaved spirea
Polytrichum sp.	Polytrichum sp.	*Spiraea douglasii*	hardhack
Potentilla palustris	marsh cinquefoil	*Stachys cooleyae*	Cooley's hedge-nettle
Pseudotsuga menziesii	Douglas-fir	*Stachys sp.*	hedge-nettle
Pterospora andromedea	pinedrops	*Symphoricarpos albus*	common snowberry
Pteridium aquilinum	bracken fern	*Tellima grandiflora*	fringecup
Pyrola sp.	wintergreen	*Thuja plicata*	western redcedar
Racomitrium canescens	grey rock moss	*Tiarella trifoliata*	three-leaved foamflower
Racomitrium elongatum	*Racomitrium elongatum*	*Tofieldia glutinosa*	sticky false asphodel
Racomitrium sp.	*Racomitrium sp.*	*Tolmiea menziesii*	piggy-back plant
Ranunculus occidentalis	western buttercup	*Trichophorum cespitosum*	tufted clubrush
Rhizomnium glabrescens	large leafy moss	*Trientalis arctica*	northern starflower
Rhizomnium sp.	Rhizomnium sp.	*Trientalis latifolia*	broad-leaved starflower
Rhynchospora alba	white beak-rush	*Trifolium tridentatum*	tomcat clover
Rhytidiadelphus sp.	*Rhytidiadelphus sp.*	*Trillium ovatum*	western trillium
Rhytidiopsis sp.	*Rhytidiopsis sp.*	*Trisetum spicatum*	spike trisetum
Rhytidiadelphus loreus	lanky moss	*Triteleia hyacinthina*	white triteleia
Rhytidiadelphus triquetrus	electrified cat's-tail moss	*Tsuga heterophylla*	western hemlock
Ribes lacustre	black gooseberry	*Ulex europaeus*	gorse
Ribes lobbii	gummy gooseberry	*Umbilicaria sp.*	rocktripe lichens
Rosa sp.	rose	*Vaccinium parvifolium*	red huckleberry
Rosa acicularis	prickly rose	*Veratrum viride*	Indian hellebore
Rosa gymnocarpa	baldhip rose	*Veronica arvensis*	wall speedwell
Rosa nutkana	Nootka rose	*Vicia americana*	American vetch
Rubus leucodermis	black raspberry	*Viola sp.*	violet
Rubus parviflorus	thimbleberry	*Viola glabella*	stream violet
Rubus spectabilis	salmonberry	*Vulpia bromoides*	barren fescue
Rubus ursinus	trailing blackberry	*Zigadenus elegans*	mountain death-camas
Rumex acetosa	green sorrel	*Zigadenus venenosus*	meadow death-camas
Salix lucida ssp. lasiandra	Pacific willow		
Salix scouleriana	Scouler's willow		
Salix sitchensis	Sitka willow		
Salix sp.	willow		
Sanicula crassicaulis	Pacific sanicle		
Satureja douglasii	yerba buena		
Saxifraga sp.	saxifrage		
Scirpus microcarpus	small-flowered bulrush		
Scirpus validus	soft-stemmed bulrush		
Sedum spathulifolium	broad-leaved stonecrop		
Selaginella wallacei	Wallace's selaginella		
Sphagnum sp.	*Sphagnum sp.*		
Spiraea sp.	*Spiraea sp.*		

Appendix 3: Expanded Legend

Complete accounts for each ecosystem unit are provided in the expanded legend. Each unit is described over two pages. The first includes a description of the ecosystem; the typical location, site, soil and terrain characteristics, and a photo showing the appearance of the unit. A small distribution map indicates all polygons where the unit is mapped in at least one of the three deciles, regardless of how small a component. The second page provides a summary of dominant, indicator and associate plant species at each developmental stage.

Dominant species are defined as those having 5% or higher cover and occurring in the unit with 75% frequency; indicators are those species found greater than 60% of the time; and associates are all others that occur with a minimum of 40% frequency. Six potential structural stages are listed for the forested ecosystem units. Structural stages that were not sampled are extrapolated from other developmental stages, known seral community types and plot information from other studies in similar areas. For the edaphic units only the herb or shrub stages are described. Notes to further describe the unit or explain how the findings on Jedediah may differ from sites found in other areas of the CDFmm are provided at the bottom of the table. Because vegetation has been highly impacted by disturbance on Jedediah, a species list is provided, on the right side of the table, to show the normal expected species in a mature, undisturbed, forested site series within the CDFmm. These list have been generated based upon the Ministry of Forests Environment and Vegetation tables (Inselberg, 1991).

Appendix 4: Ecosystem Map

Appendix 5: Summary of Ecosystem Units by Catchment

CWHxm1								
	Humpback		Niagara		Veitch		Waugh	
Ecosystem Unit	Area (ha)	% of Humpback	Area (ha)	% of Niagara	Area (ha)	% of Veitch	Area (ha)	% of Waugh
AM	1.8755	0.6101		0.0000	23.1931	1.5689	0.6980	0.0674
CD		0.0000		0.0000	3.7886	0.2563		0.0000
CS		0.0000	19.3072	1.5277	2.2848	0.1546	2.8215	0.2725
DC	71.1292	23.1383	155.3871	12.2947	433.1386	29.2993	72.5292	7.0055
DF	13.1169	4.2669	36.7978	2.9116	11.8636	0.8025		0.0000
DM		0.0000		0.0000		0.0000	1.1897	0.1149
DS	47.9066	15.5840	417.4194	33.0276	383.3716	25.9329	232.3962	22.4469
ES		0.0000		0.0000		0.0000	16.1405	1.5590
FC	7.2634	2.3628	1.6481	0.1304	102.7219	6.9485	5.6727	0.5479
HK	9.3294	3.0348	409.9732	32.4384	202.0506	13.6675	399.7795	38.6144
HL		0.0000	13.9259	1.1019	6.9589	0.4707	6.2860	0.6072
LA		0.0000	6.2542	0.4949		0.0000		0.0000
LS		0.0000	5.1147	0.4047	5.0586	0.3422	2.2440	0.2168
OW		0.0000	2.9714	0.2351		0.0000		0.0000
RC		0.0000	6.3747	0.5044	13.3068	0.9001	20.4721	1.9774
RE		0.0000		0.0000		0.0000	16.1639	1.5613
RF		0.0000	24.0277	1.9012	55.0666	3.7249	67.8520	6.5538
RO	15.4938	5.0401		0.0000	8.6600	0.5858	3.2872	0.3175
RR		0.0000		0.0000	2.3579	0.1595	0.2305	0.0223
RS	25.7095	8.3633	127.1441	10.0601	158.8613	10.7460	151.1988	14.6042
RZ	0.5925	0.1927	17.4916	1.3840	2.2111	0.1496	22.9743	2.2191
SC	21.4159	6.9666	7.6470	0.6051	56.7833	3.8411	1.9919	0.1924
SW		0.0000	12.3666	0.9785	6.6468	0.4496	11.3851	1.0997
Total CWHxm1	**213.8327**		**1263.8507**		**1478.3243**		**1035.3131**	
CDFmm								
Ecosystem Unit	**Humpback**							
DA	9.6893	3.1519						
DS	29.7926	9.6915						
HL	1.1158	0.3630						
OW	0.1847	0.0601						
RC	2.6975	0.8775						
RE	9.3140	3.0298						
RF	18.6583	6.0695						
RK	15.3175	4.9828						
RR	1.6141	0.5251						
RZ	5.1925	1.6891						
Total CDFmm	93.5763	30.4403						
Total area	**307.4090**	**100.0000**	**1263.8507**	**100.0000**	**1478.3243**	**100.0000**	**1035.3131**	**100.0000**

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Appendix 6: Provincial List Status and CDC Ranks

All rare entities tracked by the B.C. Conservation Data Centre have been assigned provincial and global conservation status ranks. Most entities also have a designation on the Ministry of Environment's Red or Blue list. Definitions of the Ministry's Red and Blue lists, and the relationship between list status and the CDC provincial conservation status rank ("S" rank) are explained below.

The provincial rank will always be less than or equal to the global rank. An element cannot be given a provincial rank that indicates that it is more common locally than globally.

RED LIST:

Includes any indigenous species or subspecies (taxa) 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 if limiting factors are not reversed. Red-listed taxa include those that have been, or are being, evaluated for these designations.

BLUE LIST:

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

YELLOW LIST:

Any indigenous species or subspecies (taxa) which is not at risk in British Columbia. The CDC tracks some Yellow listed taxa which are vulnerable during times of seasonal concentration (eg breeding colonies).

Relationship between Provincial List Status and CDC Ranks

	Red List	**Blue List**
Animals	**S1 S1S2 S2 S2?**	**S2S3 S2S4 S3 S3? S3S4**
Plants	**S1 S2**	**S1S3 S2S3 S3 [S3 only if G3]**
Plant Communities	**S1 S1S2 S2 S2?**	**S2S3 S3 S3?**

Global Ranks

The Global (G) Rank reflects the conservation status of a species from a global (i.e. rangewide) perspective, characterizing the relative rarity or imperilment of the species. Global conservation status ranks are based primarily on three factors: the number of occurrences; the total overall abundance of the element; and the overall size of the geographic range. Additional considerations include quality of the occurrences, ecological fragility, threats from human activity, and difficulty in providing appropriate management.

For discussion of factors used in determining species status ranks see: L. L. Master. 1991. Assessing threats and setting priorities for conservation. *Conservation Biology* 5:559-563.

BASIC GLOBAL RANKS

GX = Presumed Extinct: Believed to be extinct throughout its range. Not located despite intensive searches and virtually no likelihood that it will be rediscovered.

GH = Possibly Extinct: Known only from historical occurrences. Still some hope of rediscovery.

G1 = Critically Imperilled: Critically imperilled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000).

G2 = Imperilled: Imperilled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000).

G3 = Vulnerable: Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations) , or because of other factors making it vulnerable to extinction. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals

G4 = Apparently Secure: Uncommon but not rare, and usually widespread. Possibly cause for long-term concern. Typically more than 100 occurrences globally or more than 10,000 individuals.

G5 = Secure: Common, typically widespread and abundant.

VARIANT GLOBAL RANKS

G#G# = Range Rank: A numeric range rank (e.g., G2G3) is used to indicate uncertainty about the exact status of a taxon.

GU = Unrankable: Currently unrankable due to lack of available information about status or trends.

G? = Unranked: Global rank not yet assessed.

HYB = Hybrid

RANK QUALIFIERS

? = Inexact numeric rank: Denotes inexact numeric rank.

Q = Questionable taxonomy: Taxonomic status is questionable; numeric rank may change with taxonomy.

C = Captive or cultivated only: Taxon at present is extant only in captivity or cultivation, or as a reintroduced population not yet established.

Z = Moving: Occurs in the province, but as a diffuse, usually moving population; difficult or impossible to map static occurrences.

INFRASPECIFIC TAXON RANKS

T = Infraspecific Taxon (trinomial): The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T ranks follow the same principles outlined above. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1.

Provincial Ranks

The Provincial or "Subnational" (S) Rank reflects the conservation status of a species from a local perspective, characterizing the relative rarity or imperilment of the species within the province of British Columbia. The status of an element is indicated on a scale of one to five; the score is based on the estimated number of extant occurrences of the element and other factors such as trends, threats and abundance.

The process by which ranks are determined is described briefly on our tracking list page. For a more thorough discussion of factors used in determining species conservation status ranks, see: Harcombe, A., Bill Harper, Sydney Cannings, David Fraser and William T. Munro. 1994. Terms of endangerment. Pages 11-28 *in* Harding, Lee E. and Emily McCullum, eds. Biodiversity in British Columbia: our changing environment. Environ. Canada, Can. Wildl. Serv., Pacific and Yukon Region, Vancouver. 425 pp.

BASIC PROVINCIAL RANKS

SX = Presumed Extirpated
Believed to be extirpated. Not located despite intensive searches and virtually no likelihood that it will be rediscovered.

SH = Possibly Extirpated
Known only from historical occurrences. Still some hope of rediscovery.

S1 = Critically Imperilled
Critically imperilled provincially because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000).

S2 = Imperilled
Imperiled provincially because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 6 to 20 occurrences or few remaining individuals (1,000 to 3,000).

S3 = Vulnerable
Vulnerable provincially either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations) , or because of other factors making it vulnerable to extinction. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals

S4 = Apparently Secure
Uncommon but not rare, and usually widespread. Possibly cause for long-term concern. Typically more than 100 occurrences provincially or more than 10,000 individuals.

S5 = Secure
Common, typically widespread and abundant.

VARIANT PROVINCIAL RANKS

S#S# = Range Rank: A numeric range rank (e.g., S2S3) is used to indicate uncertainty about the exact status of a taxon.

SU = Unrankable: Currently unrankable due to lack of available information about status or trends.

S? = Unranked: Provincial rank not yet assessed.

HYB = Hybrid

RANK QUALIFIERS

? = Inexact numeric rank: Denotes inexact numeric rank.

Q = Questionable taxonomy: Taxonomic status is questionable; numeric rank may change with taxonomy.

C = Captive or cultivated only: Taxon at present is extant only in captivity or cultivation, or as a reintroduced population not yet established.

B = Breeding: The associated rank refers to breeding occurrences of mobile animals.

N = Non-breeding: The associated rank refers to non-breeding occurrences of mobile animals.

Z = Moving: Occurs in the province, but as a diffuse, usually moving population; difficult or impossible to map static occurrences.

INFRASPECIFIC TAXON RANKS

T = Infraspecific Taxon (trinomial) The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' provincial rank. Rules for assigning T ranks follow the same principles outlined above. For example, the provincial rank of a critically imperilled subspecies of an otherwise widespread and common species would be G5T1.

Appendix 7: Results of Rare Vascular Plant Survey - June 1999

Taxon Name	Melp List	Collection Date/ Number	Locality	UTM/NAD/Elev.	Habitat	Notes
Agrostis pallens	B	99-06-17/ Observ.	Mount Braden, 1st view point off marked trail off Jack main (1st branch)	10U 56124 5365499 83 299m	In Douglas-fir-Arbutus menziesii forest at trail edge a dominant with Arctostaphylos columbiana, with Madia minima, Polystichum juniperinum, Achillea millefolium, & Aira caryophyllea	pop'n. of 25 ramets over 3 m^2; also with *Cytisus scoparius*; asp 169^O, slope 3%; shallow soils
Agrostis pallens	B	99-06-28/ 282	Mount Braden, below west peak, east side	10U 55904 5365679 83 355m	Under Arctostaphylos columbiana with Hypochaeris radicata, Zygadenus venosus, Vulpia microstachys & Cytisus scoparius seedlings; asp 120°, slope 13%	at least a dozen ramets over 6 m^2
Agrostis pallens	B	99-07-05/ 283	Mount McDonald, northern-most bald, northwest of peak	10U 57504 5365849 83 360m	In Quercus garryana-Arbutus menziesii-Pinus contorta in small forest opening with Holodiscus discolor, Arctostaphylos columbiana, Racomitrium canescens, Aira praecox, Hypochaeris radicata	in 5 m x 1 m long area along *Arctostaphylos columbiana*, ~60 stems/1 m^2; rhizomatous;
Githopsis specularioides	R	99-06-17/ Observ.	Mount Braden, below west peak, southwest side	10U 455758 5365753 83 407m	On seepage slope with Triteleia hyacinthina, Allium acuminatum, Dodecatheon pulchellum, Selaginella wallacei, Aspidotis densa with Heterocodon rariflorum; asp 210°, 25% slope	Total of 437 plants in a total area of 73.2 m^2 in 5 different aggregations separated by rock outcrops; mostly fruiting

Githopsis specularioides	R	99-06-28/ Observ.	Mount Braden, below west peak, eastside	10U 455904 5365724 83 375m	In seepy portion of Racomitrium canescens-Bromus hordeaceus community with Trifolium tridentatum, Brodeiea coronaria, Allium acuminatum, Aira caryophyllea, A. praecox; Asp 310°, slope 18%	34 plants over 25 cm x 20 cm
Githopsis specularioides	R	99-06-28/ Observ.	Mount Braden, east peak	10U 456229 5365724 83 398m	At bottom of seepage area in Racomitrium canescens-Aira caryophyllea, A. praecox, Vulpia bromioides; asp E, slope 22%	with *Cytisus scoparius* seedlings; 37 plants over 1m^2
Madia minima	R	99-06-17/ 275	Mount Braden, 1st view point off marked trail off Jack main (1st branch)	10U 56124 5365499 83 299m	In Douglas-fir -Arbutus menziesii forest at trail edge in Arctostaphylos columbiana -Agrostis with Broom, Polystichum juniperinum, Achillea millefolium, Aira caryophyllea; asp 169°, slope 3%	shallow soils; small pop'n of 20 plus over .5m^2

Voucher collections have been deposited at the Royal British Columbia Museum herbarium (V; J. Penny 275, 276, 277, 278, 282, 283, 284, 285, 286 and 287).

Appendix 8: Sooke Hills Wilderness Regional Park 1996 Rare Vascular Plant Summary (by Hans Roemer)

Taxon Name	Melp List	Collection Date/Number	Locality	UTM/NAD/Elev.	Habitat	Notes
Agrostis pallens	B	1996-06-20/ 96063	Mount McDonald, W of access road, within HR plot #963424	10U 4573 53650 27	In Festuca idahoensis - Eriophyllum lanatum community within plot #963424. Slope 15% SE	confirmed by M. Joe Harvey
Agrostis pallens	B	1996-06-24/ 96082	Mount Braden, E peak, near top, in HR plot #963380	10U 4562 53656 27	Forming co-dominant sp. in Festuca idahoensis - Agrostis sp.- Carex inops community. 25% S slope	confirmed by M. Joe Harvey
Githopsis specularioides	R	1996-06-20/ 96070A	Mount McDonald, W Of Access Road, W Of Sw Summit Of Mount	10U 4572 53651 27 320m	In SW-facing draw with shallow, rocky soil with Cryptogramma crispa, Arenaria stricta, & Triteleia hyacinthina, & saxif rufid	Site marked on air photo BC90144:24; close to plot 96342; 15 individuals
Githopsis specularioides	R	1996-06-26/ 96077	Mount Braden, E Peak	10U 4557 53653 27 340m	On small ledge within seepage cascades; short-term seep; with Selaginella wallacei, Triteleia hyacinthina, Brodiaea coronaria	with mimulus gutt, small annuals; 30 individuals
Lupinus lepidus var. lepidus	R	1996-06-24/ 96081	Mount Braden, E Peak, top of,	10U 4563 53657 27 360m	In discontinuous Rhacomitrium carpet among sparse Agrostis & Festuca idahoensis on level, rocky ground	HR plot #963381; air photo BC90144:22

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Appendix 9: Species Accounts for Project Wildlife Species

Columbian Black-tailed Deer

PROJECT NAME: Sooke Hills Wilderness and Mount Wells Regional Parks

Scientific Name: *Odocoileus hemionus columbianus*
Species Code: M-ODHE
Status: Yellow-listed (Any indigenous species or subspecies (taxa) which is not at risk in British Columbia).

I. DISTRIBUTION

Provincial Range
Occurs in the southwestern corner of British Columbia, on most islands south of Rivers Inlet, including Vancouver Island, and ranges east to near the summits of the Cascade and Coast ranges. Their range extends south into the United States where the deer range through Washington and Oregon, into California.

Elevational Range
Sea-Level to Sub-alpine Habitat, although elevations greater than 1,000 metres are rarely used as winter habitat.

Provincial Context
The Columbian black-tailed deer occurs commonly throughout their range. Populations in BC are stable, and currently approximately 180,000 Columbian black-tailed deer reside in BC (Ian Hatter, pers. comm.).

Project Area:	CRD Parks Sooke Hills Watershed
Ecoprovince:	Georgia Depression
Ecoregions:	Eastern Vancouver Island
Ecosections:	Nanaimo Lowlands (NAL)
Biogeoclimatic Zones:	CDFmm, CWHxm1

Project Map Scale: 1:20,000

II. ECOLOGY AND KEY HABITAT REQUIREMENTS

General
Columbian black-tailed deer are a subspecies in interior mule deer, however Columbian black-tailed deer have smaller bodies, smaller ears and a largely black tail surrounded by a smaller white rump patch.

Columbian black-tailed deer require food, water and cover to ensure survival during the spring, summer and winter seasons. During spring, deer favour areas with early green up (e.g., low elevation areas with warm aspect on moderate to steep slopes). Summer habitat consists of areas with a suitable mix of young to old forest areas, with an adequate supply of forage and cover elements. Winter forces deer from high elevation habitat to low elevation areas, with south-facing, warm-aspect slopes or floodplain areas where snowpack is very low (i.e., CWHxm).

Plant material comprises a significant portion of Columbian black-tailed deer diet. Although deer are capable of digesting a wide variety of plants, forage preferences are determined, in part, by seasonal variations in forage digestibility and protein content, and by the nutritional requirement of the animals (Nyberg & Janz, 1990). Optimum growth occurs in the spring when plant proteins are easily digestible, whereas fall and winter represent periods of maintenance.

Columbian black-tailed deer breed during November and early December. Fawns are born during the first half of June. Females 2 years and older have higher rate of conception, than younger females.

It remains unclear whether specific habitats are used for Columbian black-tailed deer reproduction habitat. Reproduction habitat will not be rated separately.

Columbian black-tailed deer populations can have either resident or migratory individuals.

Average annual home range for migratory deer in the moderate snowpack zone is 1770 ha, whereas the home range for resident deer in the same zone is 140 ha (Nyberg & Janz, 1990).

III. Habitat Use: Life Requisites

- **Living Habitat (LI)**

The Living life requisites for Columbian black-tailed deer are satisfied by the presence of suitable feeding and security habitat which are described in detail below.

- **Feeding Habitat (FD)**

Feeding requirements for Columbian black-tailed deer are tied closely to food availability and season. During spring, deer favour areas with early green up (e.g., low elevation areas with warm aspect on moderate to steep slopes). Important spring forage species include Fireweed, Pearly Everlasting, Bunchberry, *Rubus* species, *Vaccinium*, willow and many herbs and grasses (Nyberg & Janz, 1990). Summer habitat consists of areas with a suitable mix of young to old forest areas, with adequate supply of forage and cover elements. Key summer forage species include fireweed, pearly everlasting, salal, *Rubus* species, *Vaccinium*, willow and alder (Nyberg & Janz, 1990). Forage quality and variety is reduced in summer, although summer forage is typically greater in quantity (Walmo, 1981). Winter forces deer from high elevation habitat to low elevation areas, with south-facing, warm-aspect slopes or floodplain areas where snowpack is very low (i.e., CWHxm). The height of key browse species, such as salal and huckleberry is important on winter ranges. During severe winters, arboreal lichens (e.g., *Alectoria*, *Bryoria*, and *Usnea*) and branches of Douglas-fir and Western Redcedar are major food sources. Key winter forage species include Western Redcedar, Douglas-fir, Red Huckleberry, Salal, deer Fern and arboreal lichens (Nyberg & Janz, 1990). Salal is only digestible when eaten in combination with other species. Table A1 illustrates important forage plants for Columbian black-tailed deer.

Table A1. Important forage plants for Columbian black-tailed deer in southern British Columbia (taken directly from Nyberg & Janz, 1990). The most important or preferred species are in bold type.

	WINTER FORAGE	SPRING FORAGE	SUMMER FORAGE
TREES	**Douglas-fir** western hemlock **western redcedar**	bigleaf-maple **Douglas-fir**	red alder
SHRUBS	Alaskan blueberry five-leafed bramble kinnickinnick oval-leafed blueberry	***Rubus* spp**. (salmonberry, blackberry, thimbleberry, raspberry, bramble) salal	**salal** willow spp.

	red huckleberry rose spp. **salal** saskatoon twinflower vine maple willow spp.	**willow spp**.	
FERNS	**deer fern**	**bracken**	
HERBS	bunchberry grass spp.	bunchberry **fireweed** grass spp. hairy cat's-ear horsetail **pearly everlasting**	**fireweed** grass spp. hairy cat's-ear **pearly everlasting**
ARBOREAL LICHENS	***Alectoria; Bryoria*** *Lobaria oregana* ***Usnea* spp**.		

- **Security habitat (SH)**

Security habitat for Columbian black-tailed deer conceals deer from hunters and predators. Foliage and trunks of trees provide the best security cover, however Columbian black-tailed deer may also use short, dense vegetation, logs or take advantage of topography (e.g., swales) as security cover. Very dense stands of young trees (e.g., sum of basal diameter exceeding 311 m (Smith & Long, 1987)) may form adequate security habitat, as they do with elk. For mule deer, a slightly larger but similar species, the most effective security cover hides 90% of the animal at a distance of 60 m or less, and security cover patches need to be 180 m or more in diameter. In general, old growth forests with a patchy conifer understory and most well-stocked stands of young trees with live branches satisfy security cover requirements. Deer forage more often in clearcuts within 100 m of cover (Kremsater, 1989).

- **Thermal habitat (TH)**

Thermal habitat allows deer to expend less energy to maintaining body temperature, allowing allocation of conserved energy to growth and reproduction. Thermal habitat can vary daily, seasonally, with prevailing weather conditions, and age, size and nutritional condition of the animal. In general, nighttime thermal cover should trap longwave radiation and maintain warmer air temperatures (occurring under a closed canopy above a deer's head or above 3 m), reduce wind at deer height (occurring in a forest stand or dense underbrush) and intercept precipitation (occurring under a closed canopy and large crown volume). In general, daytime thermal requirements are met by areas that gather heat (on or near rock bluffs, in clearcuts) or intercept excessive solar radiation (canopy closure) (Parker, 1988).

➢ **Winter**

Winter represents a critical season for Columbian black-tailed deer, because of energetic costs of maintaining body temperature and moving through snow. Forest cover influences snow depth, density and surface hardness (Nyberg & Janz, 1990), and deer typically expend most energy walking through crustless, dense, deep snow (i.e., sinking depths greater than 25 cm). Conditions that produce favourable snow conditions for Columbian black-tailed deer include dense young-growth (>10 m tall) and old-growth forests (Nyberg & Janz, 1990). Canopy closure (i.e., stands, taller than 10 m, with greater than 60% crown completeness) exerts the most influence on snow interception, and creates areas with snow conditions that don't limit deer movement (Bunnell, *et al.*, 1985).

IV. Seasons of Use

Columbian black-tailed deer require thermal, security and feeding habitat differentially throughout the year. Table A2 summarizes the life requisites for Columbian black-tailed deer for each month of the year.

Table A2. Monthly Life Requisites for Columbian Black-Tailed Deer.

Month	Season*	Life Requisite
January	Winter	Living
February	Winter	Living
March	Winter	Living
April	Early Spring	Living
May	Late Spring	Living
June	Summer	Living
July	Summer	Living
August	Summer	Living
September	Fall	Living
October	Fall	Living
November	Winter	Living
December	Winter	Living

*Seasons defined for Coast and Mountains Ecoprovinces per the Chart of Seasons by Ecoprovince (RIC, 1999, Appendix B).

For the final ratings table, ratings will be provided for the Growing (an amalgamation of Early Spring, Late Spring, Summer and Fall seasons), and Winter seasons.

- Winter Season (November - April)
- Growing Season (May - October)

Separate ratings will be assigned for thermal cover (TH); security cover (SH); and feeding habitat (FD).

V. Habitat Use and Ecosystem Attributes

Table A3 outlines how each life requisite relates to specific ecosystem attributes (e.g., site series/ecosystem unit, plant species, canopy closure, age structure, slope, aspect, terrain characteristics)

Table A3. Terrestrial Ecosystem Mapping (TEM) Relationships for each Life Requisite for Columbian Black-tailed Deer.

Life Requisite	TEM Attribute
Living habitat (feeding)	• site: site disturbance, elevation, slope aspect, structural stage • soil/terrain: bedrock, terrain texture, flooding regime • vegetation: % cover by layer, species list by layer, cover for each species for each layer,
Living Habitat (security)	• site: elevation, slope, aspect, structural stage

	• soil/terrain: terrain texture • vegetation: % cover by layer • mensuration: tree species, dbh, height
Living Habitat (thermal)	• site: elevation, slope, aspect, structural stage • soil/terrain: terrain texture • vegetation: % cover by layer • mensuration: tree species, dbh, height

VI. Ratings

There is a detailed enough level of knowledge of the habitat requirements of Columbian black-tailed deer in British Columbia to warrant a 6-class rating scheme.

Provincial Benchmark

Ecosection: Nanaimo Lowlands (NAL)
Biogeoclimatic Zone: CWHxm1
Habitats: **Critical habitat varies with season and snowpack conditions. Table A4 shows a summary of important habitat features on different seasons and different snowpack conditions.**

Ratings Assumptions

1. Structural stage 1-4 have minimal winter value (suitability ≤ 4) for food, security and thermal values. Although these stands may be available to deer in low elevation subzones, heavy snowpack will not allow access to these habitats. Structural stage 4 may provide limited winter thermal/security habitat depending on adjacent habitat.
2. Young forests (structural stage 5) may provide security and thermal habitat (suitability ≤ 2) depending on forage availability, subzone and snowpack.
3. Mature forests (structural stage 6) provide high winter habitat (suitability = 1) because of the combination well developed shrub layers, arboreal lichen abundance, and canopy closure.
4. Old forests (structural stage 7) provide the best food availability in winter, however, because of the presence of canopy gaps offer limited thermal habitat. Regardless, with the appropriate slope, aspect, and adjacency with uneven-aged stands, old forests can be excellent Columbian black-tailed deer winter habitat (suitability = 1).
5. Structural stage 2 and 3 should provide abundant forage and be rated high (suitability = 1), when adjacent to security habitat.
6. Structural stage 5-7 provide adequate thermal and security cover for deer during the living season, however, value of the stand increases with age so that mature forests are rated highest (suitability = 1).
7. Riparian habitat should provide high habitat throughout the living season (suitability = 1).

Table A4. Important habitat features for different seasons and snowpack conditions for Columbian black-tailed deer (Nyberg & Janz, 1990).

Season/Snowpack	Habitat Feature
winter/shallow snowpack	• topographic features that reduce snowpack • patches of cover with shrub understory • small clearcut or burned openings (less than 400 m across)

spring	• topographic features that encourage early growth • openings that encourage early growth of herbaceous forage • cover near forage (i.e., within 200m)
summer	• abundant forage, especially herbs and shrubs • patches of cover interspersed with food.

VI. Regional Habitat Values

For Columbian black-tailed deer the benchmark habitat is the Leeward Island Mountains (LIM) ecosection, specifically the Coastal Western Hemlock (CWH) very wet maritime (vm) and dry maritime (dm) subzones (RIC 1999). Within these ecosection/subzones the Coastal Western Hemlock-Douglas-fir (CW) Broad Ecosystem Unit is benchmark winter habitat, and the Douglas-fir-Arbutus (DA) is the benchmark growing-season habitat (RIC 1999). Within this context, the Nanaimo Lowlands (NAL) (in which the Sooke Hills Wilderness and Mount Wells Regional Parks occur), is also rated as high habitat. In particular, in the NAL, the Coastal Douglas-fir (CD) Broad Ecosystem Unit in the CWHvh (CWH very wet, hypermaritime subzone) is rated as Class 3 winter habitat; and the Douglas-fir – Arbutus (DA) Broad Ecosystem Unit is rated Class 1 growing season habitat.

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PERSONAL COMMUNICATIONS

Hatter, Ian - Provincial Ungulate Specialist

Demarchi, Dennis, - Provincial Wildlife Habitat Correlator

Pileated Woodpecker

PROJECT NAME: Sooke Hills Wilderness and Mount Wells Regional Parks

Scientific Name: *Dryocopus pileatus*
Species Code: B-PIWO
Status: Yellow-listed (Any indigenous species or subspecies (taxa) which is not at risk in British Columbia).

I. DISTRIBUTION

Provincial Range

Pileated Woodpeckers are widely distributed in southern British Columbia, becoming relatively sparse across central BC, north through the Peace Lowlands to the northeastern regions of the province. Breeding likely occurs throughout their range (Campbell *et al.*, 1990).

Elevational Range

Sea-Level to Sub-Alpine

Provincial Context

Pileated Woodpeckers occur more commonly in southern BC than in northern parts of their range.

Project Area: CRD Parks Sooke Hills Watershed
- Ecoprovince: Georgia Depression
- Ecoregions: Eastern Vancouver Island
- Ecosections: Nanaimo Lowlands (NAL)
- Biogeoclimatic Zones: CDFmm, CWHxm1

Project Map Scale: 1:20,000

II. ECOLOGY AND KEY HABITAT REQUIREMENTS

General

Pileated Woodpeckers are the largest woodpecker in North America (40-49 cm long; 250-350 g body mass). This species occurs in mature, coastal and interior Douglas-fir and western hemlock forests, including adjacent logged and second growth areas, to the open deciduous and mixed woods of the Chilcotin-Cariboo Basin (Campbell *et al.*, 1990). Breeding occurs in a variety of different forest types from open deciduous forests to dense, mature coniferous stands (Campbell *et al.*, 1990). This species excavates its own nest cavities and nests occur mostly in deciduous trees, however conifers and man-modified structures (e.g., power poles) may also be used. Nests typically occur in the main trunk of large live trees (i.e., >25 cm DBH). The breeding period extends from April to early June. The Pileated Woodpecker feeds primarily on carpenter ants which it extracts from large diameter logs, stumps or standing dead trees. This species requires large territories and takes advantage of late successional stages of coniferous or deciduous forest, but also younger forests that have scattered, large, dead trees (Bull & Jackson, 1995).

Territory size can be variable. Studies in Oregon show that territory size of individual birds varies from 200 - 1586 ha, with pair territories slightly larger than either partner (Bull & Holthausen, 1993)

Pileated Woodpeckers are year-round residents, although growing season and winter behaviour can be distinguished.

III. HABITAT USE: LIFE REQUISITES

- **Living Habitat (LI)**

The Living life requisite for Pileated Woodpeckers is satisfied by the presence of suitable feeding and security (roosting) habitat, which are described in detail below.

- **Feeding Habitat (FD)**

Wood-dwelling insects are the primary diet of Pileated Woodpeckers throughout the year, and carpenter ants are a major food item in all seasons (Beckwith and Bull, 1985; Bull *et al.*, 1992). Carpenter ants are particularly important in winter, when they form the majority of the diet. Diet can vary seasonally, with woodpeckers making excavations in fairly sound wood to access carpenter ant colonies in winter. Foraging in summer can be excavations in soft wood, surface gleaning and probing. Pileated Woodpeckers can be opportunistic taking advantage of outbreaks in western spruce budworm larvae, as well as berries, nuts ands fruits. In winter Pileated Woodpeckers use deep excavations in sound wood, whereas summer food occurs near the wood surface precluding deep excavations. On southeastern Vancouver Island, Pileated Woodpecker used large snags and defective trees (mean dbh ± SE; 56 ± 3cm), decayed snags, with less remaining bark (49% ± 4% SE), and foraged in the upper and main canopy strata (Hartwig, 1999).

- **Security (Roosting/Reproduction) Habitat (SH)**

Eggs are laid in late April or early May and hatch after an 18 day incubation. Fledged young remain with the parents for most of the summer and leave in August or September. Reproductive habitat contains suitable trees for nesting. Pileated Woodpeckers almost always excavate their own cavity, and only trees with main trunks large enough to hold a large cavity high above the ground are used for nesting. In Alberta, minimum nest tree dbh ranges from 29 to 33 cm dbh (Conner *et al.*, 1976, Bonar and Bessie, 1996). Recently, in southeastern Vancouver Island, Hartwig (1999) found Pileated Woodpeckers nesting in much larger (mean±SE; 82 ± 16 cm), taller trees (22 ± 5.2 m), with 91% (± 9%) remaining bark. Nests are usually located in high (≥ 4 m) branch-free portions of the main trunk. In coastal forests, most nest trees were western hemlock. Pileated Woodpeckers show a preference for trees with fungal-softened heartwood at the cavity location, as softer hardwood is easier to excavate, and fungal respiration may heat the cavity (Aubry & Raley, 1994).

Pileated Woodpeckers are closely associated with tree cover for nesting, roosting and foraging. In spring and summer, habitat use occurs in both open and closed canopied areas. In winter, use of open areas declines as logs and stumps are unavailable due to snow cover. Pileated Woodpecker habitat will be rated for the entire year only.

IV. SEASONS OF USE

Pileated Woodpeckers are year round residents of the project area. Table A5 summarizes the life requisites required for each month of the year, although for this project a habitat rating for security/thermal habitat and feeding habitat will be provided for the entire year.

Table A5. Monthly Life Requisites for Pileated Woodpecker

Month	Season*	Life Requisite
January	Winter	Living
February	Winter	Living
March	Growing	Living
April	Growing	Living
May	Growing	Living
June	Growing	Living
July	Growing	Living
August	Growing	Living
September	Growing	Living
October	Growing	Living
November	Winter	Living
December	Winter	Living

*Seasons defined for Coast and Mountains Ecoprovinces per the Chart of Seasons by Ecoprovince (RIC, 1998, Appendix B).

A single rating, for the entire year (All season) will be assigned to Pileated Woodpecker habitat. In addition, a rating for the Reproducing Season will also be assigned.

Ratings will be assigned for feeding habitat (FD) and security/thermal (ST) habitat. For Pileated Woodpecker security/thermal habitat will be equivalent to roosting and reproducing habitat.

V. HABITAT USE AND ECOSYSTEM ATTRIBUTES

Table A6 outlines how each life requisite relates to specific ecosystem attributes (e.g., site series/ecosystem unit, plant species, canopy closure, age structure, slope, aspect, terrain characteristics)

Table A6. Terrestrial Ecosystem Mapping (TEM) Relationships for each Life Requisite for Pileated Woodpecker.

Life Requisite	TEM Attribute
Living Habitat (Feeding, Security/Thermal)	• site: structural stage • soil/terrain: flooding regime • vegetation: % cover by layer, coarse woody debris (CWD) (dbh, decay class, abundance) • tree species, dbh, height, wildlife tree characteristics

VI. RATINGS

A 6-class rating scheme will be used for Pileated Woodpecker habitat. Although the 'BC Wildlife Habitat Ratings Standards' (RIC, 1999) recommends a 4-class rating scheme, 1:5 000 mapping scale should allow habitat discrimination into 6 classes.

Provincial Benchmark

Ecosection: Shuswap Highland (SHH); Nanaimo Lowland (NAL)

Biogeoclimatic Zone: ICHmw, CWHxm
Habitats: mature - old growth forests with high abundance of large diameter trees and high abundance of CWD on the forest floor.

Ratings Assumptions

1. Units with large trees (≥ 70 cm dbh), such as mature and old-growth coniferous forests will be rated high roosting and reproducing habitat (class = 1). Abundance and average suitable tree diameter will govern ratings lower than class 1.
2. Units without large diameter trees will generally be rated low (≤5), and abundance of large diameter, usable nest and feeding trees will govern ratings >5.
3. Units with high coarse woody debris abundance will be rated as high feeding habitat.
4. Units with closed canopy will be rated higher than units with open canopy.
5. Units with high amounts of Pileated Woodpecker feeding sign will be rated as high feeding habitat.

Table A7 summarizes the habitat requirements for Pileated Woodpeckers in the study area for the seasons and life requisites being modeled.

Table A7. Summary of habitat requirements for Pileated Woodpeckers in the study area.

Season	Life Requisite	Structural Stage	Requirements
Growing Season/Winter Season	Feeding (FD)	2-3, 5-7	• Mature and old-growth coniferous forests (high abundance of CWD) • Mixed conifer/deciduous mature forest. Shrub cover >50% and canopy closure >66%.
Growing Season/ Winter Season	Security/ Thermal (TH)	2-3, 5-7	• Mature and old-growth coniferous forests. • Mixed conifer/deciduous mature forest. Shrub cover >50% and canopy closure >66%.

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Black Bear

PROJECT NAME: Sooke Hills Wilderness and Mount Wells Regional Parks

Scientific Name: *Ursus americanus*
Species Code: M_URAM
Status: Yellow-listed (any indigenous species or subspecies (taxa) which is not at risk in British Columbia).

I. DISTRIBUTION

Provincial Range

Black bears inhabit all forested regions of British Columbia. They can be found within all biogeoclimatic zones and occupy a wide variety of habitats ranging from coastal estuaries to alpine meadows.

Elevational Range
Sea-Level to Alpine

Provincial Context

Black bears occur commonly throughout their range. Populations in BC are stable, and currently, approximately 140 000 - 160 000 black bears occur in BC (T. Hamilton, pers. comm.). Black bears occur from sea level in coastal estuaries, up to high elevation alpine meadows; and are present in every biogeoclimatic zone in the province. The highest coastal concentrations of black bears occur in the Kitimat Range (KIR) and Nass Ranges (NAR) ecosections, whereas, the Chilcotin and Okanagan areas have low densities. Relative densities of black bear are lower on southern Vancouver Island due to the preponderance of closed canopy second growth forest and human settlements.

Project Area: CRD Parks Sooke Hills Watershed
Ecoprovince: Georgia Depression
Ecoregions: Eastern Vancouver Island
Ecosections: Nanaimo Lowlands (NAL)
Biogeoclimatic Zones: CDFmm, CWHxm1

Project Map Scale: 1:20,000

II. ECOLOGY AND KEY HABITAT REQUIREMENTS

General

Black bears prefer forested and shrubby areas, but use wet meadows, high tidelands, ridgetops, burned areas, riparian areas and avalanche chutes (Pelton, 1979). They prefer mesic over xeric sites and timbered over open areas (Unsworth *et al*., 1989).

Black bears are very adaptable and inhabit a wide variety of plant communities. In the Northwest black bears are found in spruce-western redcedar-hemlock forests as well as pine and fir forests (Pelton, 1987).

Black bears are omnivorous and opportunistic in their feeding habits. Green leafy material forms the bulk of their diet, especially in late spring and early summer. They also feed on insects, fruits, berries, fish, garbage, carrion, and small mammals. Occasionally, black bears will prey on young/small deer.

During periods of inactivity, black bears periodically utilize bed sites in forest habitat with thick understudy vegetation. These sites are often a simple shallow depression in the forest leaf litter, but may become deeper with use.

Seasonal movement of black bears within a geographic area are influenced by the juxtaposition or availability of seasonally important food resources or habitat components, breeding activity, reproductive status of individuals and availability of denning habitat (Rogers, 1977).

Black bears make extensive seasonal movements to areas of food abundance such as spring green-up sites, spawning areas, berry patches and garbage dumps (Amstrup & Beecham, 1976, Rogers, 1977, Modafferi, 1978). In particular, these extensive movements occur to and from winter den sites and during the late summer and fall when foraging activities increase (Pelton, 1982).

Migrating black bears will use movement corridors such as game trails, human trails, open edges, shorelines, ridges, creek beds, snow filled avalanche chutes, logging roads, sandbars or rivers (Stevens & Lofts, 1988).

Generally, adult males have the largest home ranges, which may be several times as large as those of females and overlap more than those of females (Amstrup & Beecham, 1976, Rogers, 1977, Young & Ruff, 1982). Females have well-defined home ranges of between 12 and 50 km^2. Male black bears, especially subadults, have much larger home ranges, sometimes traveling 50 km or more to a preferred food source or winter denning site (Rogers, 1977).

Breeding occurs in May and June (Stevens & Lofts, 1988). Gestation is 6 to 7 months long with one to three cubs being born from late November through February. Birth and early maternal care occurs in the winter den. The cubs remain with their mother for 1 to 2 years. Hollow trees or fallen logs are used for hibernating habitat.

III. HABITAT USE: LIFE REQUISITES

- **Living Habitat (LI)**

The living life requisite for black bears is satisfied by the presence of suitable feeding and security habitat, which are described in detail below.

- **Feeding Habitat (FD)**

➢ **Early Spring**

In early spring, black bears on the coast feed on the early green vegetation found in the estuaries and seepage sites that become snow-free first. Grasses, sedges and horsetails are the most commonly selected spring food items of bears, mainly because these plants develop early (Hatler, 1967, Lloyd & Fleck, 1977, Ruff, 1978). In early spring bears require high-protein, digestible forage and so feed on succulent vegetation in wet meadows, riparian inclusions, skunk cabbage swamps, avalanche chutes and burns (Steven & Lofts, 1988). Beaches, estuaries and open riparian areas are also important feeding habitat. Warm aspect avalanche tracks, slides and clearcuts are important feeding habitat because of early exposed vegetation.

➢ **Late Spring / Summer**

Green leafy material and wild berries in old-growth and mid-seral, deciduous forests provide summer food for black bears. Recent clearcuts (5-15 years old) are important feeding areas. Salmonberry (*Rubus spectabilis*) is important in early summer, and other berries are utilized as they become available (e.g., red huckleberry (*Vaccinium parvifolium*), raspberry (*Rubus leucodermis*), blueberry (*Vaccinium* spp.), currants (*Ribes* spp.), black twinberry (*Lonicera involucrata*), elderberry (*Sambucus racemosa*), devil's club (*Oplopanax horridus*), highbush-cranberry (*Vibernum edule*), red-osier dogwood (*Cornus stolonifera*) and salal (*Gaultheria shallon*)). Habitats with predictably high species-specific berry production (e.g., salal) may be rated more suitable. Insects, especially ants and wasps are also important summer food. Late spring feeding habitat for black bears is difficult to distinguish from summer feeding habitat. Refer to Appendix A for a more detailed list of forage species preferences of black bears.

- **Fall**

In the late summer and fall, ecosystem units with spawning rivers and streams represent important feeding habitat. Black bears continue to feed on the late-producing berry species (e.g., salal) and other available vegetation. Although black bear diet is seasonal, black bears are opportunistic omnivores. Black bears will also feed on fish, wildlife, domestic animals, carrion and insects, such as carpenter ants (*Camponotus* spp.), yellow jackets (*Vespula* spp.), bees (*Apidae*), and termites (*Isoptera*) as available. Ecosystem units with high coarse woody debris loadings are also suitable foraging habitat for black bears. Black bears will also climb trees to eat young shoots so ecosystem units at structural stages with trees large enough to support bears will also be rated as moderate feeding habitat (Stevens & Lofts, 1988).

- **Security habitat (SH)**

Security habitat for black bears bears is variable, but is used to avoid interspecific (e.g., adult bear to juvenile bears) and intraspecific (e.g., bear to human and black bear to grizzly bear) contact.

1) Bear/bear avoidance - During the growing season, shrub and tree cover are used as security from other bears. To avoid aggressive males, females with cubs rely on wildlife tree patches (with a structural stage beyond pole-sapling), and will rarely forage greater than 100 m from a stand that provides this type of security habitat (Jonkel, 1978). Black bears also prefer immature forest stands (14-23 yr. preferred over 5-12yr. stands and stands older than 38 years) (Lindzey & Meslow, 1977), likely because of the cover value associated with these stands. In order to forage close enough to security cover, some black bears rarely use habitat beyond 183 m of forest cover (Rogers & Allen, 1987).

2) Bear/human avoidance: Black bears typically will avoid high-traffic roads (e.g., highways or active logging roads) and human settlements, unless attracted by atypical food sources (e.g., garbage dump, fruit trees). Suitable habitat adjacent to such non-habitat features are less suitable.

- **Thermal habitat (TH)**

Black bears will temporarily seek shelter from precipitation under forests/patches with low canopy or rock overhangs. Bears will also seek relief from heat by using open water (e.g., ponds, lakes, rivers, streams, springs), and using beds in cool, sandy areas. Generally, these habitat features are too small to map as TEM polygons, and are difficult to rate. If located, these features will be identified in the 'Evidence of Use' section in the Wildlife Habitat Assessment form.

- **Hibernating Habitat (HI)**

Suitable dens for black bears are warm, dry and secure. Black bears hibernate between October and May. However, black bears in coastal habitats may not enter their dens until late November or early December, emerging in April. Some coastal black bears, given suitable climate regimes, do not enter dens. Typically dens are underground and in locations that catch early snow and maximize the snow's insulative qualities. Cavities in old-growth structures, including large old trees, stumps, root bolls and logs having a diameter greater than 85 cm are suitable dens. Yellow cedar and western redcedar are important hibernating sites, although sites are likely based on den structure, rather than tree species. Hibernating in second growth forest stands is limited by suitable hibernating locations.

IV. SEASONS OF USE

Black bears require different feeding, security and thermal habitat throughout the year. Table A8 summarizes the life requisites of black bear for each month of the year for the Coast and Mountains ecoprovince.

Table A8. Monthly Life Requisites for Black Bear.

Month	Season*	Life requisites
January	Winter	Hibernating
February	Winter	Hibernating
March	Winter	Hibernating
April	Early Spring	Feeding/Security&Thermal
May	Late Spring	Feeding/Security&Thermal
June	Summer	Feeding/Security&Thermal
July	Summer	Feeding/Security&Thermal
August	Summer	Feeding/Security&Thermal
September	Fall	Feeding/Security&Thermal
October	Fall	Feeding/Security&Thermal
November	Winter	Hibernating
December	Winter	Hibernating

*Seasons defined for Coast and Mountains Ecoprovinces per the Chart of Seasons by Ecoprovince (RIC, 1999, Appendix B).

Based on the habitat requirements identified in this species account and the location of the project (i.e., Coast and Mountains Ecoprovince), Early Spring (PE), Summer (S), Fall (F) and Winter (W) seasons will be rated for black bear.

V. HABITAT USE AND ECOSYSTEM ATTRIBUTES

Table A9. Relationship between Terrestrial Ecosystem Mapping (TEM) attributes and each life requisite for black bear.

Life Requisite	TEM attribute
Feeding (FD)	• site -site series, site disturbance, elevation, slope, aspect, structural stage, site modifier • vegetation - % cover by layer, species list by layer, structural stage modifier, stand composition modifier, available forage • soil - flooding regime
Security & Thermal (ST)	• site - site series, slope, structural stage, structural stage, modifier • vegetation - total % cover, % cover by layer, stand composition modifier
Hibernating (HI)	• site - site series, site disturbance, elevation, slope, aspect • soil - terrain classification, rooting depth, rooting zone particle size, root restricting layer, seepage water depth, flooding regime, soil depth, soil texture, percent coarse fragments

VI. RATINGS

There is a detailed enough level of knowledge of the habitat requirements of black bears in British Columbia to use a 6-class rating scheme (RIC, 1999).

Provincial Benchmark

Ecosection:	Kitimat Ranges (KAR)
Biogeoclimatice Zone:	CWHvm1 (Coastal Western Hemlock - very wet maritime)
Broad Ecosystem Unit:	
Habitats:	skunk cabbage, floodplains, wetlands, estuaries/beaches; the highest densities of black bears are associated with extensive areas of early seral stages complexed with salmon bearing streams, marine beach habitats, and forested ecosystem units for security/thermal cover.

Ratings Assumptions

1. Black bears make discrete choices of the plant food items consumed, and therefore, availability and abundance of food items are key factors in habitat selection by the bear. Recorded habitat use is assumed to reflect habitat preferences, and habitat preferences are assumed to reflect habitat requirements.
2. The importance value of food items determined from scat analysis accurately reflects the importance of that food item to the bear in that time period, and that forage plant availability is correctly predicted by the site unit.
3. Feeding and security habitats in close proximity are assumed to be the limiting factors for black bears.
4. Although it is recognized that other factors such as predation, disease, intra/inter specific competition and hunting influence black bear population growth and distribution, this model does not include these factors.
5. Black bear habitat use is strongly influenced by intraspecific social interactions and the presence and activities of people.
6. Ecosystem units with high forage plant diversity and abundance in a lush herb layer with an abundance of grasses, Sedges (*Carex spp*.), horsetails (*Equisetum spp*.), skunk cabbage, cow parsnip, stinging nettle, hellebore, and dandelion represents class 1 black bear spring, feeding habitat. Habitat with lower plant diversity and abundance will be rated poorer than class 1.
7. Ecosystem units with total shrub cover of 15-30%, shrub height < 2.5 m, shrub species dominated (i.e., >15%) by *Vaccinium* or other berry producers (e.g. soopolallie, thimbleberry, twinberry, devil's club, elderberry, high bush cranberry), and high coarse woody debris will be rated class 1 black bear summer, feeding habitat.
8. Ecosystem units consistently occurring near salmon spawning streams, berry producing areas (see assumption 6), and high coarse woody debris (e.g., moist forests with abundant forage plants) will be rated class 1 black bear fall, feeding habitat.
9. Ecosystem units with tree species composition of mixed conifer/deciduous species, and/or mature shrub cover (e.g., >35%), and/or high canopy closure (e.g., >50%) or any equivalent combination will be rated class 1 security/thermal habitat for black bears across all seasons.
10. High elevation ecosystem units on steep slopes, with dry stable, fine-textured soil conditions will be rated class 1 for hibernating habitat.

11. In coastal ecosystems, black bear hibernating habitat can occur in the old-growth forests with, for example, large diameter trees which offer hollow boles, and/or large diameter downed hollow, coarse woody debris.

Table A10. Summary of general habitat attributes for black bears.

Habitat Use	Specific Attributes for Suitable Black Bear Habitat	Structural Stage
Spring Feeding	• high forage plant diversity in lush herb layer with an abundance of grasses, sedges (Carex spp.) horsetails (Equisetum spp.); cow parsnip, stinging nettle, hellebore, dandelion, skunk cabbage, etc. • (See Appendix A for detailed preferred forage species).	2-3, 6-7
Summer Feeding	• 15-30% total shrub cover • shrub species composition dominated (>15%) by Vaccinium or other berry producers (e.g. soopolallie, thimbleberry, twinberry, devil's club, elderberry, high bush cranberry) • shrub Height < 2.5 m • high coarse woody debris	3, 6-7
Fall Feeding	• salmon spawning areas • berry-producing areas close to salmon streams • high coarse woody debris • moist forests with abundant forage plants	-
Security/ Thermal Cover	• tree species composition mixed conifer/deciduous • mature conifer • shrub cover >50% • canopy closure >66%	3, 5-7
Hibernating Habitat	• deep, fine-textured soils • dry, moisture-shedding site • higher elevation, steep slope site • old-growth coastal forests, with large diameter tress and coarse woody debris.	6,7

VII. Ratings Adjustments

Table A11outlines some general ratings assumptions that can be applied to black bear habitat suitability.

Table A11. Some suggested adjustments to initial field habitat ratings for black bears.

Attribute	Adjustment
Proximity of mature forest cover to suitable open feeding areas	(e.g., > 100m -200m downgrade FD by 1 >200m-400m downgrade FD by 2 >400m downgrade FD to nil)
Road density (km/km^2)	*project specific*
Distance to road (m)	*project specific*
Presence of salmon stream within unit	(e.g., increase to class 1 FD for fall)

VIII. Literature Cited

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Personal Communications:
McLellan, Ministry of Forests, Revelstoke, B.C.
Tony Hamilton, Ministry of Environment, Lands and Parks, Victoria, B.C.
Grant Machuthon, Biologist, Comox, B.C.
Stephan Himmer, Biologist, Hagenborg, B.C.

XI. Appendix A. Bear Food items and Preference Ranks

Species	Black Bear	Grizzly Bear
Graminoids		
Bromus spp.	Lvs (1)	Lvs (1)
Carex spp. / *Juncus* spp.	Lvs (3)	Lvs (3)
Leymus spp.	Lvs (1)	Lvs (1)
Luzula spp.	Lvs (1)	Lvs (1)
Phleum spp.	Lvs (1)	Lvs (1)
Poa spp.	Lvs (2)	Lvs (2)
Trisetum spp.	Lvs (1)	Lvs (1)

Forbs		
Achillea millefolium	Lvs (1)	Lvs (1)
Allium cernuum	St (1)	St (1)
Angelica arguta	Lvs (2)	Lvs (3)
Aster conspicuus	Lvs (1)	Lvs (1)
Aster foliaceus	Lvs (1)	Lvs (1)
Astragalus spp.		St (2)
Claytonia lanceolata		St (3)
Circium spp.	Lvs, St (1)	Lvs, St (1)
Equisetum arvense	Lvs, St (3)	St (3), Lvs (3)
Epilobium spp	Lvs, St (1)	Lvs, St (1)
Erythronium grandiflorum		R (3)
Fragaria virginiana	Lvs, Fr (2)	Lvs, Fr (2)
Gymnocarpium dryopteris	Lvs (1)	Lvs (1)
Hedysarum boreale		R (2)
Hedysarum sulphurescens		R (2)
Heracleum lanatum	Lvs, St (2)	Lvs (3)
Lathyrus spp.	Lvs (3)	Lvs (3)
Ligusticum canbyi		Lvs (2)
Lomatium dissectum, Lomatium triternatum	St (3)	St, R (3)
Lysichiton americanum	Lvs, St (3)	Lvs, St (2)
Osmorhiza chilensis	Lvs, St (2)	Lvs (2)
Osmorhiza spp.	Lvs, St (2)	Lvs (2)
Oxytropis campestris		St (2)
Polygonum bistortoides		St (1)
Rhamnus alnifolia	Fr (2)	Fr (2)
Senecio triangularis		Lvs (1)
Streptopus amplexifolius	Lvs, Fr (1)	Lvs, Fr (1)
Taraxacum officinale	Lvs (3)	Lvs (3)
Tiarella trifoliata	St (1)	St (1)
Trifolium hybridum	Lvs (3)	Lvs (3)
Trifolium repens	Lvs (3)	Lvs (3)
Valeriana sitchensis		Lvs (2)
Veratrum viride		Lvs (1)
Viola glabella		Lvs (1)
Shrubs		
Amelanchier alnifolia	Fr (3)	Fr (3)
Arctostaphylos uva ursi	Fr (2)	Fr (2)
Cornus stolonifera	Fr (2)	Fr (2)
Empetrum nigrum		Fr (2)
Lonicera involucrata	Fr (1)	Fr (1)
Oplopanax horridum	Fr, Lvs (1)	Fr, Lvs

		(1)
Rhamnus alnifolia	Fr (2)	Fr (2)
Ribes hudsonianum	Fr (1)	Fr (1)
Ribes lacustre	Fr (1)	Fr (1)
Rosa acicularis	Fr (2)	Fr (1)
Rosa woodsii	Fr (2)	Fr (1)
Rubus idaeus	Fr (2)	Fr (1)
Rubus parviflorus	Fr (2)	Fr (1)
Salix spp (catkins)	Fr (2)	Fr (1)
Sambucus racemosa	Fr (2)	Fr (2)
Shepherdia canadensis	Fr (3)	Fr (3)
Sorbus scopulina	Fr (2)	Fr (2)
Vaccinium membranaceum	Fr (3)	Fr (3)
Vaccinium scoparium	Fr (2)	Fr (2)
Vaccinium spp.	Fr (3)	Fr (3)
ANIMALS		
Coccinellidae (lady bugs)	E	E
Noctuidae (army cutworms)		E
Camponotus spp. (carpenter ants)	E	E
Formica spp. (ants)	E	E
Vespula spp. (wasps)	E	E
Bombus spp. (bumblebees)	E	
Marmota caligata (hoary marmots)		E
Alces alces (moose calves)	E	E
Odocoileus hemionus (mule deer fawns)	E	E
Odocoileus virginiana (white-tailed deer fawns)	E	E
Spermophilus columbianus (golden mantled ground squirrel)		E
Carrion	E	E
Legend: E - entire organism, Fl - flower, Fr - fruit, Lvs - leaves, R - root, St - stem		
Preference Ranking: (1) - low use, (2) - moderate use, (3) - high use		
Reference Sources: Chapman et al. (1953), Tisch (1961), Taylor (1964), Burt and Grossenheider (1976), Herrero (1978), Servheen (1983), Holcroft and Herrero (1984), Irwin and Hammond (1985), Eggers (1986), Almack (1986), Mace (1986), Mace and Bissell (1986), McLellan (1986), Kansas et al. (1989), MacHutchon (1989), Holcroft and Herrero (1991), McLellan and Hovey (1995), MacHutchson (1996), McCann (1997), pers. comm. B.McLellan (1999), pers. comm. F. Hovey (1999).		

Marbled Murrelet

PROJECT NAME: Sooke Hills Wilderness and Mount Wells Regional Parks

Scientific Name: *Brachyramphus marmoratus*
Species Code: B_MAMU
Status: **Red-listed** (Includes any indigenous species or subspecies (taxa) 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 if limiting factors are not reversed. Red-listed taxa include those that have been, or are being, evaluated for these designations.)

Threatened (COSEWIC **-** A species likely to become endangered if limiting factors are not reversed.**)**

I. DISTRIBUTION

Ecosections

COM: NWC, HEL, KIR, NAB, NAR, APM, BOR, EPR, NPR, OUF, SPR, SKP, WQC, NWL, NIM, WIM
GED: LIM, NAL, FRL, GEL, SGI, SOG

Biogeoclimatic Units

CDF, CWH, MH

Broad Ecosystem Units

CB, CD, CG, CH, CP, CS, CW, DA, ES, FR, HB, HL, HS, IM, IS, LL, LS, MF, RB, RD, RR, RS, SR, YB, YM, YS

Provincial Range

Marbled Murrelets occur from the Bering Sea to central California. Marbled Murrelets have been recorded in most inshore marine areas of BC (Sealy, 1975a; Carter, 1984; Sealy and Carter, 1984), with the largest concentrations of breeding birds found on the east coast of Moresby Island (Queen Charlotte Islands), certain inlets on the mianland coast, and off SW Vancouver Island from Clayoquot Sound to Port San Juan (Campbell *et al.*, 1990; Rodway, 1990; Rodway *et al.*, 1992; Burger, 1995). During the breeding season, murrelets are found offshore of late successional and old-growth forests, located mostly within 60km of the coast (Ralph *et al*., 1995).

Elevational Range

Marbled Murrelet nests in BC averaged 321 m above sea level but the elevation range extended from 14 to 1100 meters above sea level (Ralph *et al.*, 1995). The absence of large trees and platforms at high altitudes limits suitable habitat (Burger, 1995).

Provincial Context

The BC population of Marbled Murrelets is estimated to be approximately 45,000-50,000 breeding birds (Rodway *et al.*, 1992). Lougheed et al. (1998) estimated the approximately 5000 birds in Desolation Sound.

Project Area: CRD Parks Sooke Hills Watershed
Ecoprovince: Georgia Depression
Ecoregions: Eastern Vancouver Island
Ecosections: Nanaimo Lowlands (NAL)
Biogeoclimatic Zones: CDFmm, CWHxm1

Project Map Scale: 1:20,000

II. ECOLOGY AND KEY HABITAT REQUIREMENTS

General

The Marbled Murrelet belongs to a group of diving seabirds known as alcids or auks, which inhabit cool, temperate waters of the northern hemisphere, and include such species as puffins, murres, auklets, and guillemonts. The recent decline of Marbled Murrelet populations has been attributed to the loss and degradation of nest sites as old-growth forests are harvested and fragmented; and associated increases in nest predation; oil spills; and possibly fish net drowning (Burger, 1997).

Though widespread, this species has a clumped distribution pattern that is determined during all seasons by the availability of food, and in summer by both food and nesting habitat. Important foraging sites include tidal rips through narrow passages, shelves at the mouths of inlets, and shallow banks. Large feeding concentrations have been reported at Sechelt Inlet, Cortes Island, Flores Island, Barkley Sound, Clayoquot Sound and off the West Coast Trail. In British Columbia, Marbled Murrelets are largely restricted to the relatively sheltered inshore water (usually <40m in depth), where their principal prey are sand lance, juvenile herring, anchovies and other small schooling fish. Other prey include epipelagic crustaceans, mainly larger euphausiids and mysids, juvenile rockfish, juvenile salmon and small seaperch (Sealy, 1975a; Carter, 1984; Vermeer *et al*., 1987).

Marbled Murrelets nest in natural platforms in the canopy of old-age forests. They typically nest in old-growth coniferous stands located on valley bottoms and the lower portions of forested slopes with moderate gradients. Large diameter old-growth trees with large moss-covered limbs are used for nesting platforms. Nesting stands generally have multi-layered canopies with openings in the canopy for access, and trees well spaced allowing three dimensional corridors of space for flight routes (Hamer and Nelson, 1995). Nests have been found in Sitka spruce, western redcedar, yellow cedar, Douglas-fir, western hemlock and mountain hemlock (FPC, 1997). Nesting habitat for the Marbled Murrelet may occur up to 85 km inland from salt water, but is likely more important within 30 km of the ocean (FPC, 1997).

The reproductive rate of this species is extremely low as only one egg is laid each year (FPC, 1997). The breeding season is protracted, extending from mid-April through late September (Rodway et al., 1992). Eggs are laid from mid-May through late June and early July at Langara Island (Sealy, 1974), and slightly earlier in Barkley Sound (Carter, 1984). Hammer and Nelson (1995) gave the incubation period in BC as May 2 to July 4, the nestling period as 1 June to 30 August, and the duration of the breeding season as 118 days. Chicks hatch after an estimated 30 day incubation period and remain in the nest for 26-36 days (Sealy, 1974; Nelson and Hamer, 1995). Both members of the pair incubate and deliver food to the chick at the nest. Fledged chicks have been reported on the water from May 28 (unusually early) through October 5, but were most common in July (Sealy, 1974; Rodway et al., 1992; Hamer and Nelson, 1995).

Known predators of adult Marbled Murrelets include Peregrine Falcons, Bald Eagles, Northern Goshawks, and Sharp-shinned Hawks. In forested habitat, jays, ravens, crows and owls prey on chicks and eggs. Western Gulls have taken chicks at sea.

III. HABITAT USE: LIFE REQUISITES AND SEASONS

The limiting factor for Marbled Murrelet populations appears to be nesting habitat (Burger, 1997).

- **Reproductive habitat (RE) - Security-Thermal Habitat (ST)**

Known Marbled Murrelet nests in British Columbia are located in low elevation old-growth and mature coniferous forests, with multi-layered canopies (>2), a high composition of low elevation conifer trees and, on the lower two-thirds of forested slopes, with moderate gradients (Hamer and Nelson, 1995). Several forest stand structural characteristics show strong correlations with known Marbled Murrelet nesting habitat. These include density of trees with platforms, density of large trees, epiphyte cover and mean dbh of all trees (Rodway and Regehr, 1999; Bahn et al., 1999). Marbled Murrelet nests are typically in the largest diameter old-growth trees available in the stand, on limbs covered with moss. Stand structure and the processes within a stand may be more important than tree size alone in producing nesting platforms and suitable murrelet nesting habitat (Hamer and Nelson, 1995). Potential nesting trees should have large limbs > 15 m above the ground, with nesting platforms greater than 18 cm in diameter (branch and moss or duff combined) available (Marbled Murrelet Recovery Team, 1994). Certain species such as Sitka spruce and western hemlock tend to have more platforms (Rodway and Regehr, 1999).

Most of the Marbled Murrelet nests in BC have been found in the CWH biogeoclimatic zone (Burger, 1995). Within this zone, detection frequencies were highest in the moister ecosections and in low elevation forests (Burger, 1995). Nests and moderately high levels of activity were also found in some forest patches in the subalpine Mountain Helock zone on the southern mainland of BC (Burger, 1995). An assessment of nesting habitat for Marbled Murrelets in the Coastal Douglas-fir zone on southeastern Vancouver Island identified several suitable nesting stands that contained structural characteristics known to be important for nesting. Occupied detections indicating near-nest activities were reported within the Greater Victoria Water District lands but no nests were found (Burger et al., 1999). If Murrelets in this area behave as like murrelets in other parts of the Pacific Northwest, then urbanization and increased fragmentation, conditions being met in the CDF, will likely result in increased predation on Marbled Murrelet eggs and chicks. There has been no evidence of nesting in the subalpine scrub forest, lowland bog forest, or alpine tundra (Burger, 1995).

Marbled Murrelet nesting habitat requirements are defined by the following list of criteria summarized from the Marbled Murrelet Recovery Team (1994) and the Forest Practices Code (1999):

- Age Class – Class 9 (250 years of age) is preferred, but class 8 is acceptable if older forest is not present.
- Height Class – In the CWH or CDF zones Classes 5 (37.5-46.4 m) or 6 (46.5-55.4 m) are preferred. In the MH zone Class 4 (28.5-37.4 m) is acceptable if higher height class is not present or appropriate classes of CWH or CDF are not present.
- Nest platforms – Nesting platforms greater than 18 cm in diameter (branch and moss or duff combined) should be available
- Distance from Salt Water – All habitat within 85 km of salt water is potential murrelet breeding habitat. Habitat within 30 km is preferred, although the strip of habitat directly adjacent to the ocean is unattractive to murrelets due to the increases in predation, lack of

moss on branches and increased exposure to coastal storms (Rodway and Regehr, 1999; Hamer, 1995).

- Biogeoclimatic Zone – CWH and CDF are preferred over MH but all are zones contain potentially suitable nesting habitat.
- Elevation – Prime nesting habitat is located between sea level and 600 m. All habitat below 1200 m is considered potential nesting habitat.
- Fragmentation – Larger contiguous areas are preferred over smaller contiguous area and fragmented areas.

IV. Seasons of Use

Table A12 identifies the nesting season months for Marbled Murrelets. Security/thermal (ST) habitat will be rated for Marbled Murrelets over these months.

Table A12. Monthly Life Requisites for Marbled Murrelet.

Month	Season	Life requisites
April	Reproductive	Security & Thermal
May	Reproductive	Security & Thermal
June	Reproductive	Security & Thermal
July	Reproductive	Security & Thermal
August	Reproductive	Security & Thermal
September	Reproductive	Security & Thermal

V. Habitat Use and Ecosystem Attributes

Table A13 outlines how each life requisite relates to specific ecosystem attributes (e.g., site series/ecosystem unit, plant species, canopy closure, age structure, slope, aspect, terrain).

Table A13. Relationship between Terrestrial Ecosystem Mapping (TEM) attributes and each life requisite for Marbled Murrelet Life Requisites and Associated TEM Attributes

Life Requisite	TEM attribute
Security & Thermal	• site -elevation, slope, structural stage, aspect • vegetation – tree species, tree height, canopy layers, understory vegetation, • mensuration – large dbh, number of suitable platforms

VI. Ratings
A 4-class rating scheme of high (H), moderate (M), low (L), and nil (N) is recommended by the Resource Inventory Committee (1999) due to the intermediate level of knowledge on habitat use of Marbled Murrelets. This rating scheme is defined in Table A14 below.

Table A14: Habitat capability and suitability 4-class rating scheme (RIC, 1999)

% of Provincial Best	Rating	Code
100% - 76%	High	H
75% - 26%	Moderate	M
25% - 6%	Low	L
5% - 0%	Nil	N

Provincial Benchmark (coastal British Columbia)

Ecosection:	Windward Island Mountains (WIM)
Biogeoclimatice Zone:	CWH (Coastal Western Hemlock)
Broad Ecosystem Unit:	variable depending on platform availability; CB, CD, CG, CH, CP, CS, CW, DA, ES, FR, HB, HL, HS, IM, IS, LL, LS, MF, RB, RD, RR, RS, SR, YB, YM, YS
Habitats:	old-growth forest with appropriate stand structure (i.e., age class, height class, platform availability, low elevation forests), and low stand closure.

Ratings Assumptions

1. Forest stands with structural stage 6 or 7 will be rated class High or Moderate Marbled Murrelet nesting habitat.
2. Plots with large dbh (ca. 80 cm), tall trees (37.5 - 55.4 m), with > 3 suitable nesting platforms / branches (≥ 18cm dbh), trees with deformations and mistletoe growths suitable for nesting platforms, and epiphyte cover on branches will be rated class High Marbled Murrelet nesting habitat.
3. Plots without large dbh, tall trees, but with 2 – 5 suitable nesting platforms (≥ 18 cm dbh branches) will be rated Moderate to Low nesting habitat. These plots can be assigned moderate habitat because in such instances we assume that all nesting platforms cannot be accurately assessed from the ground.
4. Plots without large dbh, tall trees will be rated Nil Marbled Murrelet nesting habitat.

Table A15. Summary of general habitat attributes for Marbled Murrelets.

Habitat Use	Specific Attributes for Suitable Marbled Murrelet Nesting Habitat
Security/ Thermal	Structural Stage: • Structural stages 1 to 5 have no nesting value due to the absence of potential nesting platforms. • Structural stage 7 is assumed to provide the most suitable nesting habitat. Stage 7 stands have the largest stature trees (providing more potential nesting platforms) and more open forest structures generating access and flyways. Hamer and Nelson (1995) report that decadence, unusual limb deformations, tree damage, and dwarf mistletoe blooms, all common in old growth and mature stands, also appear to create nest platforms. Vegetation Characteristics: • Stand closure is often low (50%) in stands used for nesting (Hamer and Nelson, 1995). • The most important nest tree species within BC are likely Sitka spruce and western hemlock. Douglas-fir and western redcedar may also be used (Hamer and Nelson, 1995). • Rodway and Regehr (1999) reported that vegetation site series with poorer nutrient and moisture regimes in Clayoquot Sound generally contained less of the forest structural characteristics important to nesting murrelets Other: • In CWHvh1, the coastal strip is not as attractive to nesting murrelets. Although suitable habitat is present low detections were observed (Rodway and Regehr, 1999). The CWHvh1 may have higher value in sheltered bays or inlets as more protection for nests is afforded.

VII. Regional Habitat values

Burger et al. (1999) conducted an assessment of nesting habitat for Marbled Murrelet in the Coastal-Douglas (CDF) fir zone on SE Vancouver Island in 1998. Although Burger et al. (1999) did not find any nests, they did find suitable nesting habitat in the CDF. In addition, audio-visual surveys during the breeding season confirmed the presence of murrelets in the Greater Victoria Water District (GVWD). Burger et al. (1999) concluded that Marbled Murrelets are almost certainly nesting in the GVWD lands. The lack of random systematic sampling did not allow drawing reasonable conclusions about habitat values and correlations with nesting habitat in the CDF zone. However, Burger et al. (1999) did conclude that uncritical assignment of Marbled Murrelet nesting habitat based exclusively on stand age would lead to an overestimation of available habitat as all old-age stands did not provide suitable habitat. Burger et al. (1999) suggested that habitat inventory work be complimented with audio-visual surveys along with ground truthing work.

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Appendix 10: Final Ratings Table

The codes used in the column headings in the final ratings table are defined below.

Column Heading Code	Description
ECO_SEC	Ecosection
BGC_ZONE	Biogeoclimatic Zone
BGC_SUBZONE	Biogeoclimatic Subzone
BCG_VRT	Biogeoclimatic Variant
BGC_PHASE	Biogeoclimatic Phase
SITE_S	Site Series
SITEMC_S	Site Series Map Code
SITE_MA	Site Modifier A
SITE_MB	Site Modifier B
STRCT_S	Structural Stage
STAND_A	Stand Association
MODHC_FDW	Columbian black-tailed deer – Feeding Habitat - Winter
MODHC_FDG	Columbian black-tailed deer – Feeding Habitat - Growing
MODHC_SHW	Columbian black-tailed deer – Security Habitat- Winter
MODHC_SHG	Columbian black-tailed deer – Security Habitat – Growing
MODHC_THW	Columbian black-tailed deer – Thermal Habitat – Winter
MODHC_THG	Columbian black-tailed deer – Thermal Habitat – Growing
MURAM_FDPE	Black bear – Feeding Habitat – Early Spring Season
MURAM_FDG	Black bear – Feeding Habitat – Growing Season
MURAM_STPE	Black bear – Security / Thermal Habitat Early Spring Season
MURAM_STG	Black bear – Security / Thermal Habiat Growing Season
MURAM_HI	Black bear – Hibernating Habitat Winter Season
BPIWO_FDA	Pileated Woodpecker - Feeding Habitat - All Season
BPIWO_STA	Pileated Woodpecker - Security/Thermal Habitat - All Season
BPIWO_RE	Pileated Woodpecker – Reproducing Habitat
BMAMU_RE	Marbled Murrelet – Reproducing Habitat

Wildlife Habitat Final Ratings Table for Sooke Hills Wilderness and Mount Wells Regional Parks Terrestrial Ecosystem Mapping Project

ECO_SEC	BGC_ZONE	BGC_SUBZON	BGC_VRT	BGC_PHASE	SITE_S	SITEMC_S	SITE_MA	SITE_MB	STRCT_S	STRCT_M	STAND_A	BMAMU_SHRE	BPIWO_SHRE	MODHC_FDW	MODHC_FDG	MODHC_SHW	MODHC_SHG	MODHC_THW	MURAM_FDPE	MURAM_FDG	MURAM_STPE	MURAM_STG	MURAM_HI
NAL	CDF	mm				DA			2		C	6	6	4	2	6	6	6	3	2	6	6	6
NAL	CDF	mm				DA			3		C	6	6	3	1	4	3	5	3	2	4	4	6
NAL	CDF	mm				DA			4		C	6	6	4	3	1	1	4	4	4	2	1	6
NAL	CDF	mm				DA			5		C	6	6	4	3	1	1	4	4	4	3	2	6
NAL	CDF	mm				DA			6		C	5	4	4	2	2	2	3	3	3	3	3	3
NAL	CDF	mm				DA			7		C	4	3	3	1	2	2	3	3	2	2	2	2
NAL	CDF	mm				DA	v		2		C	6	6	5	4	6	6	6	3	2	6	6	6
NAL	CDF	mm				DA	v		3		C	6	6	3	1	4	3	5	3	2	4	4	6
NAL	CDF	mm				DA	v		4		C	6	6	4	3	1	1	4	4	4	2	1	6
NAL	CDF	mm				DA	v		5		C	6	6	4	3	1	1	4	4	4	3	2	6
NAL	CDF	mm				DA	v		6		C	5	4	4	2	2	2	3	3	3	3	3	3
NAL	CDF	mm				DA	v		7		C	4	3	3	1	2	2	3	3	2	2	2	2
NAL	CDF	mm				DS			2		C	6	6	4	2	6	6	6	3	2	6	6	6
NAL	CDF	mm				DS			3		C	6	6	1	1	4	3	5	3	2	4	4	6
NAL	CDF	mm				DS			4		C	6	6	3	2	2	1	3	4	3	2	1	6
NAL	CDF	mm				DS			5		C	6	5	3	2	2	1	3	4	3	3	2	6
NAL	CDF	mm				DS			6		C	5	3	2	2	1	1	2	2	2	3	3	3
NAL	CDF	mm				DS			7		C	4	2	1	1	1	1	1	2	2	2	2	2
NAL	CDF	mm				DS	s		2		C	6	6	4	2	6	6	6	2	2	6	6	6
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NAL	CDF	mm				DS	w		2		C	6	6	4	2	6	6	6	3	2	6	6	6
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NAL	CDF	mm				DS	w		4		C	6	6	3	2	2	1	3	4	3	2	1	6
NAL	CDF	mm				DS	w		5		C	6	5	3	2	2	1	3	4	3	3	2	6
NAL	CDF	mm				DS	w		6		C	5	3	2	1	1	1	2	2	2	3	3	3
NAL	CDF	mm				DS	w		7		C	4	2	1	1	1	1	1	2	2	2	2	2
NAL	CDF	mm				HL			3	a		6	6	5	2	6	6	6	2	2	5	5	6
NAL	CDF	mm				HL			3	b		6	6	5	2	6	6	6	2	2	4	2	6
NAL	CDF	mm				OW						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CDF	mm				RC			2		C	6	6	5	3	6	6	6	1	2	6	6	6
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NAL	CDF	mm				RC			3		C	6	6	4	3	5	5	5	1	1	4	4	6
NAL	CDF	mm				RC			3		M	6	6	4	3	5	5	5	1	1	4	4	6

NAL	CDF	mm				RC			4		C	6	6	4	3	1	1	3	2	2	2	1	6
NAL	CDF	mm				RC			4		M	6	6	4	3	1	1	3	2	2	2	1	6
NAL	CDF	mm				RC			5		C	5	4	4	3	1	1	3	2	2	3	2	6
NAL	CDF	mm				RC			5		M	6	4	4	3	1	1	3	2	2	3	2	6
NAL	CDF	mm				RC			6		C	4	2	2	3	2	2	2	1	2	3	3	2
NAL	CDF	mm				RC			6		M	4	2	2	3	2	2	2	1	2	3	3	2
NAL	CDF	mm				RC			7		C	3	1	1	3	2	2	1	1	1	2	2	1
NAL	CDF	mm				RC			7		M	3	1	1	3	2	2	1	1	1	2	2	1
NAL	CDF	mm				RE						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CDF	mm				RF			2			6	6	5	1	6	6	6	2	1	6	6	6
NAL	CDF	mm				RF			2		B	6	6	5	1	6	6	6	2	1	6	6	6
NAL	CDF	mm				RF			2		C	6	6	5	1	6	6	6	2	1	6	6	6
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NAL	CDF	mm				RF			3		B	6	6	4	2	5	5	3	2	1	4	4	6
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NAL	CDF	mm				RF			5		C	5	4	4	2	1	1	5	3	3	3	2	6
NAL	CDF	mm				RF			6			4	2	2	2	2	2	1	2	1	3	3	2
NAL	CDF	mm				RF			6		B	3	2	2	2	2	2	1	2	1	3	3	2
NAL	CDF	mm				RF			6		C	4	2	2	2	2	2	1	2	1	3	3	2
NAL	CDF	mm				RF			7			3	1	1	1	2	2	1	2	1	2	2	1
NAL	CDF	mm				RF			7		B	2	1	1	1	2	2	1	2	1	2	2	1
NAL	CDF	mm				RF			7		C	3	1	1	1	2	2	1	2	1	2	2	1
NAL	CDF	mm				RK			2		C	6	6	5	2	6	6	6	2	2	6	6	6
NAL	CDF	mm				RK			3		C	6	6	4	2	5	4	5	2	1	4	4	6
NAL	CDF	mm				RK			3			6	6	4	2	5	4	5	2	1	4	4	6
NAL	CDF	mm				RK			3	a	C	6	6	4	2	5	5	5	2	2	5	5	6
NAL	CDF	mm				RK			4		C	6	6	4	2	1	1	3	3	3	2	1	6
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NAL	CDF	mm				RK			6		C	4	2	2	2	2	2	2	2	2	3	3	2
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NAL	CDF	mm				RK	s		5		C	5	4	4	1	1	1	3	3	3	3	2	6
NAL	CDF	mm				RK	s		6		C	4	2	1	1	2	2	2	1	2	3	3	2

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NAL	CDF	mm				RK	w		7		C	3	1	1	1	2	2	1	2	1	2	2	1
NAL	CDF	mm				RR						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CDF	mm				RZ						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				AM			3	a		6	6	5	3	6	5	6	4	4	5	5	6
NAL	CWH	xm				AM			3	a	B	6	6	5	3	6	5	6	4	4	5	5	6
NAL	CWH	xm				AM			3	b		6	6	4	3	6	5	5	4	4	4	2	6
NAL	CWH	xm				AM			3	b	B	6	6	4	3	6	5	5	4	4	4	2	6
NAL	CWH	xm				AM			4			6	6	4	4	2	2	3	5	5	2	1	6
NAL	CWH	xm				AM			4		B	6	6	4	4	2	2	3	5	5	2	1	6
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NAL	CWH	xm				AM			6			5	5	3	3	2	2	3	4	4	3	3	6
NAL	CWH	xm				AM			6		B	5	5	3	3	2	2	3	4	4	3	3	6
NAL	CWH	xm				AM			7			5	5	3	2	2	2	3	4	4	2	2	5
NAL	CWH	xm				AM			7		B	5	5	3	2	2	2	3	4	4	2	2	5
NAL	CWH	xm				AM	k		3	a	B	6	6	5	3	6	5	6	4	4	5	5	6
NAL	CWH	xm				AM	k		3	b	B	6	6	4	3	6	5	5	4	4	4	2	6
NAL	CWH	xm				AM	k		4		B	6	6	4	4	2	2	3	5	5	2	1	6
NAL	CWH	xm				AM	k		5		B	6	6	4	4	2	2	3	5	5	3	2	6
NAL	CWH	xm				AM	k		6		B	5	5	3	3	2	2	3	4	4	3	3	6
NAL	CWH	xm				AM	k		7		B	5	5	3	2	2	2	3	4	4	2	2	5
NAL	CWH	xm				AM	v		3	a	M	6	6	5	3	6	5	6	4	4	5	5	6
NAL	CWH	xm				AM	v		3	b	M	6	6	4	3	6	5	5	4	4	4	2	6
NAL	CWH	xm				AM	v		4		M	6	6	4	4	2	2	3	5	5	2	1	6
NAL	CWH	xm				AM	v		5		M	6	6	4	4	2	2	3	5	5	3	2	6
NAL	CWH	xm				AM	v		6		M	5	5	3	3	2	2	3	4	4	3	3	6
NAL	CWH	xm				AM	v		7		M	5	5	3	2	2	2	3	4	4	2	2	5
NAL	CWH	xm				AM	w		3	a		6	6	5	3	6	5	6	4	4	5	5	6
NAL	CWH	xm				AM	w		3	a	B	6	6	5	3	6	5	6	4	4	5	5	6
NAL	CWH	xm				AM	w		3	a	M	6	6	5	3	6	5	6	4	4	5	5	6
NAL	CWH	xm				AM	w		3	b		6	6	4	3	6	5	5	4	4	4	2	6
NAL	CWH	xm				AM	w		3	b	B	6	6	4	3	6	5	5	4	4	4	2	6
NAL	CWH	xm				AM	w		3	b	M	6	6	4	3	6	5	5	4	4	4	2	6
NAL	CWH	xm				AM	w		4			6	6	4	4	2	2	3	5	5	2	1	6
NAL	CWH	xm				AM	w		4		B	6	6	4	4	2	2	3	5	5	2	1	6
NAL	CWH	xm				AM	w		4		M	6	6	4	4	2	2	3	5	5	2	1	6
NAL	CWH	xm				AM	w		5			6	6	4	4	2	2	3	5	5	3	2	6
NAL	CWH	xm				AM	w		5		B	6	6	4	4	2	2	3	5	5	3	2	6
NAL	CWH	xm				AM	w		5		M	6	6	4	4	2	2	3	5	5	3	2	6
NAL	CWH	xm				AM	w		6			5	5	3	3	2	2	3	4	4	3	3	6

NAL	CWH	xm				AM	w		6		B	5	5	3	3	2	2	3	4	4	3	3	6
NAL	CWH	xm				AM	w		6		M	5	5	3	3	2	2	3	4	4	3	3	6
NAL	CWH	xm				AM	w		7			5	5	3	2	2	2	3	4	4	2	2	5
NAL	CWH	xm				AM	w		7		B	5	5	3	2	2	2	3	4	4	2	2	5
NAL	CWH	xm				AM	w		7		M	5	5	3	2	2	2	3	4	4	2	2	5
NAL	CWH	xm				CD			2		B	6	6	5	3	6	5	6	1	1	6	6	6
NAL	CWH	xm				CD			3		B	6	6	4	3	6	5	5	2	1	4	4	6
NAL	CWH	xm				CD			4		B	6	6	4	4	2	2	3	3	3	2	1	6
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NAL	CWH	xm				CS			2		B	6	6	5	4	6	5	6	1	1	6	6	6
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NAL	CWH	xm				CS			3		B	6	6	4	4	6	4	5	2	1	4	4	6
NAL	CWH	xm				CS			3		C	6	6	4	4	6	4	5	2	1	4	4	6
NAL	CWH	xm				CS			3		M	6	6	4	4	6	4	5	2	1	4	4	6
NAL	CWH	xm				CS			3	a	M	6	6	5	4	6	5	6	1	1	5	5	6
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NAL	CWH	xm				CS			7		B	5	3	4	3	2	2	1	1	1	2	2	2
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NAL	CWH	xm				DC			2			6	6	5	3	6	5	6	3	4	6	6	6
NAL	CWH	xm				DC			2		B	6	6	5	3	6	5	6	3	4	6	6	6
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NAL	CWH	xm				DC			3	a		6	6	3	2	5	3	6	3	3	5	5	6
NAL	CWH	xm				DC			3	a	B	6	6	3	2	5	3	6	3	3	5	5	6

NAL	CWH	xm				DC			3	a	C	6	6	3	2	5	3	6	3	3	5	5	6
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NAL	CWH	xm				DC			3	b		6	6	3	2	4	3	5	3	3	4	2	6
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NAL	CWH	xm				DC			4		M	6	6	3	4	2	1	3	4	4	2	1	6
NAL	CWH	xm				DC			5			6	5	3	4	2	2	3	4	4	3	2	6
NAL	CWH	xm				DC			5		B	6	5	3	4	2	2	3	4	4	3	2	6
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NAL	CWH	xm				DC	v	w	2		B	6	6	5	3	6	5	6	3	3	6	6	6
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NAL	CWH	xm				DF	k	s	4		C	6	6	3	4	2	1	3	4	3	2	1	6
NAL	CWH	xm				DF	k	s	5		C	6	4	3	4	2	2	3	4	4	3	2	6
NAL	CWH	xm				DF	k	s	6		C	3	1	1	3	2	1	2	3	4	3	3	2
NAL	CWH	xm				DF	k	s	7		C	3	1	1	2	2	1	1	3	3	2	2	1
NAL	CWH	xm				DM						6	6	6	6	6	6	6	6	6	6	6	6

NAL	CWH	xm				DS			2			6	6	5	4	5	5	6	2	3	6	6	6
NAL	CWH	xm				DS			3		C	6	6	3	2	4	3	6	2	3	4	4	6
NAL	CWH	xm				DS			3	a	C	6	6	3	2	5	4	6	2	2	5	5	6
NAL	CWH	xm				DS			3	b	C	6	6	3	2	4	3	5	2	2	4	2	6
NAL	CWH	xm				DS			4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS			5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS			6		C	2	1	1	2	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS			7		C	1	1	1	1	1	1	1	2	3	2	2	1
NAL	CWH	xm				DS	c	j	2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	c	j	3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				DS	c	j	4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	c	j	5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	c	j	6		C	2	1	1	2	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	c	j	7		C	1	1	1	1	1	1	1	2	3	2	2	1
NAL	CWH	xm				DS	g		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	g		3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				DS	g		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	g		5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	g		6		C	2	1	1	2	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	g		7		C	1	1	1	1	1	1	1	2	3	2	2	1
NAL	CWH	xm				DS	j		2		B	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	j		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	j		3	a	B	6	6	3	2	5	4	6	2	2	5	5	6
NAL	CWH	xm				DS	j		3	a	C	6	6	3	2	5	4	6	2	2	5	5	6
NAL	CWH	xm				DS	j		3	b	B	6	6	3	2	4	3	5	2	1	4	2	6
NAL	CWH	xm				DS	j		3	b	C	6	6	3	2	4	3	5	2	2	4	2	6
NAL	CWH	xm				DS	j		4		B	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	j		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	j		5		B	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	j		5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	j		6		B	2	1	1	2	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	j		6		C	2	1	1	2	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	j		7		B	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	j		7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	j	s	2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	j	s	2		M	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	j	s	3		C	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	j	s	3		M	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	j	s	3	a	C	6	6	3	2	5	4	6	2	2	5	5	6
NAL	CWH	xm				DS	j	s	3	b	C	6	6	3	2	4	3	5	2	1	4	2	6
NAL	CWH	xm				DS	j	s	4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	j	s	4		M	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	j	s	5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	j	s	5		M	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	j	s	6		C	2	1	1	2	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	j	s	6		M	2	1	1	2	2	1	2	2	3	3	3	2

NAL	CWH	xm				DS	j	s	7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	j	s	7		M	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	k		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	k		3		C	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	k		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	k		5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	k		6		C	2	1	1	2	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	k		7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	k	s	2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	k	s	3		C	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	k	s	4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	k	s	5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	k	s	6		C	2	1	1	2	2	1	1	2	3	3	3	2
NAL	CWH	xm				DS	k	s	7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	s		2			6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	s		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	s		3			6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	s		3		C	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	s		3	b	C	6	6	3	2	5	4	5	3	1	4	2	6
NAL	CWH	xm				DS	s		4			6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	s		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	s		5			5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	s		5		C	5	4	3	3	2	2	3	2	4	3	2	6
NAL	CWH	xm				DS	s		6			2	1	1	1	2	1	1	2	3	3	3	2
NAL	CWH	xm				DS	s		6		C	2	1	1	2	2	1	1	2	3	3	3	2
NAL	CWH	xm				DS	s		7			1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	s		7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	s	w	2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	s	w	3		C	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	s	w	4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	s	w	5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	s	w	6		C	2	1	1	1	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	s	w	7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	v		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	v		3		C	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	v		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	v		5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	v		6		C	2	1	1	1	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	v		7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				DS	w		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				DS	w		3		C	6	6	3	2	5	4	5	2	2	4	4	6
NAL	CWH	xm				DS	w		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				DS	w		5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				DS	w		6		C	2	1	1	1	2	1	2	2	3	3	3	2
NAL	CWH	xm				DS	w		7		C	1	1	1	1	1	1	1	2	2	2	2	1
NAL	CWH	xm				ES			1			6	6	6	6	6	6	6	6	6	6	6	6

NAL	CWH	xm				FC			1	b		6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				FC			2	b		6	6	6	4	6	6	6	3	3	6	6	6
NAL	CWH	xm				FC	k		2	b		6	6	4	5	6	6	6	3	3	6	6	6
NAL	CWH	xm				FC	w		2	b		6	6	4	5	6	6	6	3	3	6	6	6
NAL	CWH	xm				HK			2			6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK			2		B	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK			2		M	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK			3			6	6	3	2	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK			3		B	6	6	3	2	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK			3		C	6	6	5	2	5	3	6	1	2	4	4	6
NAL	CWH	xm				HK			3		M	6	6	3	2	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK			3	a	C	6	6	3	2	5	4	6	1	2	5	5	6
NAL	CWH	xm				HK			4			6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK			4		B	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK			4		C	6	6	3	1	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK			4		M	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK			5			5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK			5		B	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK			5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK			5		M	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK			6			2	2	2	2	2	2	2	2	3	3	3	2
NAL	CWH	xm				HK			6		B	2	2	2	2	2	2	2	2	3	3	3	2
NAL	CWH	xm				HK			6		C	2	2	2	2	2	2	2	2	3	3	3	2
NAL	CWH	xm				HK			6		M	2	2	2	2	2	2	2	2	3	3	3	2
NAL	CWH	xm				HK			7			1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK			7		B	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK			7		C	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK			7		M	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK	c		2		C	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK	c		3		C	6	6	3	2	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK	c		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK	c		5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK	c		6		C	2	2	2	2	2	2	2	2	3	3	3	2
NAL	CWH	xm				HK	c		7		C	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK	k		2		C	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK	k		3		C	6	6	3	2	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK	k		4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK	k		5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK	k		6		C	2	2	2	2	2	2	2	2	3	3	3	2
NAL	CWH	xm				HK	k		7		C	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK	k	s	2		C	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK	k	s	3		C	6	6	3	2	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK	k	s	4		C	6	6	3	3	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK	k	s	5		C	5	4	3	3	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK	k	s	6		C	2	2	2	2	2	2	1	2	3	3	3	2
NAL	CWH	xm				HK	k	s	7		C	1	1	1	1	2	2	1	1	2	2	2	1

NAL	CWH	xm				HK	s		2		C	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK	s		2		M	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK	s		3		C	6	6	3	1	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK	s		3		M	6	6	3	1	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK	s		4		C	6	6	3	2	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK	s		4		M	6	6	3	2	2	1	3	3	4	2	1	6
NAL	CWH	xm				HK	s		5		C	5	4	3	2	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK	s		5		M	5	4	3	2	2	2	3	3	4	3	2	6
NAL	CWH	xm				HK	s		6		C	2	2	1	1	2	2	1	2	3	3	3	2
NAL	CWH	xm				HK	s		6		M	2	2	1	1	2	2	1	2	3	3	3	2
NAL	CWH	xm				HK	s		7		C	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK	s		7		M	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HK	w		2		C	6	6	5	4	6	5	6	1	2	6	6	6
NAL	CWH	xm				HK	w		3		C	6	6	3	2	5	3	5	1	2	4	4	6
NAL	CWH	xm				HK	w		4		C	6	6	3	3	2	1	3	3	4	2	1	6
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NAL	CWH	xm				HK	w		6		C	2	2	1	2	2	2	2	2	3	3	3	2
NAL	CWH	xm				HK	w		7		C	1	1	1	1	2	2	1	1	2	2	2	1
NAL	CWH	xm				HL			2		B	6	6	5	3	6	6	6	4	3	6	6	6
NAL	CWH	xm				HL			2	b		6	6	5	3	6	6	6	4	3	6	6	6
NAL	CWH	xm				HL			3	a		6	6	3	2	5	5	6	4	3	5	5	6
NAL	CWH	xm				HL			3	a	B	6	6	3	2	5	5	6	4	3	5	5	6
NAL	CWH	xm				HL			3	b		6	6	3	2	5	5	5	4	3	4	2	6
NAL	CWH	xm				HL			3	b	B	6	6	3	2	5	5	5	4	3	4	2	6
NAL	CWH	xm				HL			4			6	6	3	4	4	4	4	5	5	2	1	6
NAL	CWH	xm				HL			4		B	6	6	3	4	4	4	4	5	5	2	1	6
NAL	CWH	xm				HL			5			6	6	3	4	4	4	4	5	5	3	2	6
NAL	CWH	xm				HL			5		B	6	6	3	4	4	4	4	5	5	3	2	6
NAL	CWH	xm				HL			6			6	6	3	3	4	4	4	5	5	3	3	4
NAL	CWH	xm				HL			6		B	6	6	3	3	4	4	4	5	5	3	3	4
NAL	CWH	xm				HL			7			6	6	3	3	4	4	4	5	5	2	2	1
NAL	CWH	xm				HL			7		B	6	6	3	3	4	4	4	5	5	2	2	4
NAL	CWH	xm				LA						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				LS			2			6	6	5	4	5	5	6	3	2	6	6	6
NAL	CWH	xm				LS			3			6	6	4	3	4	4	6	3	3	4	4	6
NAL	CWH	xm				LS			3	a		6	6	4	3	5	5	6	3	4	5	5	6
NAL	CWH	xm				LS			3	a	C	6	6	4	3	5	5	6	3	4	5	5	6
NAL	CWH	xm				LS			3	b	C	6	6	4	3	4	4	5	3	2	4	2	6
NAL	CWH	xm				LS			4		C	6	6	4	4	2	2	3	5	5	2	1	6
NAL	CWH	xm				LS			5		C	6	5	4	4	3	3	3	5	5	3	2	6
NAL	CWH	xm				LS			6		C	4	3	3	3	2	2	2	3	4	3	3	4
NAL	CWH	xm				LS			7		C	2	3	2	3	2	2	2	3	3	2	2	3
NAL	CWH	xm				OW						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				RC			2			6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RC			2		B	6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RC			2		C	6	6	5	4	5	5	6	1	2	6	6	6

NAL	CWH	xm				RC			2		M	6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RC			3			6	6	3	3	4	4	5	1	2	4	4	6
NAL	CWH	xm				RC			3		B	6	6	3	3	4	4	5	1	2	4	4	6
NAL	CWH	xm				RC			3		C	6	6	3	3	4	4	5	1	2	4	4	6
NAL	CWH	xm				RC			3		M	6	6	3	3	4	4	5	1	2	4	4	6
NAL	CWH	xm				RC			4			6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RC			4		B	6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RC			4		C	6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RC			4		M	6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RC			5			4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RC			5		B	4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RC			5		C	4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RC			5		M	4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RC			6			2	2	3	3	2	2	2	2	3	3	3	2
NAL	CWH	xm				RC			6		B	2	2	3	3	2	2	2	2	3	3	3	2
NAL	CWH	xm				RC			6		C	2	2	3	3	2	2	1	2	3	3	3	2
NAL	CWH	xm				RC			6		M	2	2	3	3	2	2	2	2	3	3	3	2
NAL	CWH	xm				RC			7			1	1	2	3	2	2	1	1	3	2	2	2
NAL	CWH	xm				RC			7		B	1	1	2	3	2	2	2	1	3	2	2	2
NAL	CWH	xm				RC			7		C	1	1	2	3	2	2	1	1	3	2	2	2
NAL	CWH	xm				RC			7		M	1	1	2	3	2	2	2	1	3	2	2	2
NAL	CWH	xm				RC	p		2		C	6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RC	p		3		C	6	6	3	3	4	4	5	1	2	4	4	6
NAL	CWH	xm				RC	p		4		C	6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RC	p		5		C	4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RC	p		6		C	2	2	3	3	2	2	2	2	3	3	3	2
NAL	CWH	xm				RC	p		7		C	1	1	2	3	2	2	2	1	3	2	2	2
NAL	CWH	xm				RE						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				RF			2			6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RF			2		B	6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RF			2		C	6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RF			2		M	6	6	5	4	5	5	6	1	2	6	6	6
NAL	CWH	xm				RF			3			6	6	3	2	4	4	5	1	2	4	4	6
NAL	CWH	xm				RF			3		B	6	6	3	2	4	4	5	1	2	4	4	6
NAL	CWH	xm				RF			3		C	6	6	3	2	4	4	5	1	2	4	4	6
NAL	CWH	xm				RF			3		M	6	6	3	2	4	4	5	1	2	4	4	6
NAL	CWH	xm				RF			4			6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RF			4		B	6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RF			4		C	6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RF			4		M	6	6	3	3	2	2	3	2	3	2	1	6
NAL	CWH	xm				RF			5			4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RF			5		B	4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RF			5		C	4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RF			5		M	4	4	3	3	3	3	3	2	3	3	2	6
NAL	CWH	xm				RF			6			2	1	3	2	2	2	2	2	2	3	3	2
NAL	CWH	xm				RF			6		B	2	1	3	2	2	2	2	2	2	3	3	2

NAL	CWH	xm				RF			6		C	2	1	3	2	2	2	2	2	2	3	3	2
NAL	CWH	xm				RF			6		M	2	1	3	2	2	2	2	2	2	3	3	2
NAL	CWH	xm				RF			7			1	1	2	2	2	2	1	1	2	2	2	1
NAL	CWH	xm				RF			7		B	2	1	2	2	2	2	2	1	2	2	2	1
NAL	CWH	xm				RF			7		C	1	1	2	2	2	2	1	1	2	2	2	1
NAL	CWH	xm				RF			7		M	2	1	2	2	2	2	2	1	2	2	2	1
NAL	CWH	xm				RO			1	a		6	6	6	5	6	6	6	6	6	6	6	6
NAL	CWH	xm				RO	k		1	a		6	6	6	5	6	6	6	6	6	6	6	6
NAL	CWH	xm				RO	q		1	a		6	6	6	5	6	6	6	6	6	6	6	6
NAL	CWH	xm				RO	w		1	a		6	6	6	5	6	6	6	6	6	6	6	6
NAL	CWH	xm				RO	z		1	a		6	6	6	5	6	6	6	6	6	6	6	6
NAL	CWH	xm				RR						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				RS			2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS			3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS			4		C	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS			5		C	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS			6		C	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS			7		C	2	1	1	1	2	1	1	2	2	2	2	1
NAL	CWH	xm				RS	j		2		B	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	j		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	j		2		M	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	j		3		B	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	j		3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	j		3		M	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	j		4		B	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	j		4		C	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	j		4		M	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	j		5		B	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	j		5		C	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	j		5		M	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	j		6		B	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	j		6		C	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	j		6		M	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	j		7		B	2	1	1	1	2	1	2	2	2	2	2	1
NAL	CWH	xm				RS	j		7		C	2	1	1	1	2	1	1	2	2	2	2	1
NAL	CWH	xm				RS	j		7		M	2	1	1	1	2	1	2	2	2	2	2	1
NAL	CWH	xm				RS	j	n	2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	j	n	3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	j	n	4		C	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	j	n	5		C	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	j	n	6		C	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	j	n	7		C	2	1	1	1	2	1	1	2	2	2	2	1
NAL	CWH	xm				RS	j	s	2		M	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	j	s	3		M	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	j	s	4		M	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	j	s	5		M	5	4	3	3	2	2	3	3	3	3	2	6

NAL	CWH	xm				RS	j	s	6		M	3	1	1	1	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	j	s	7		M	2	1	1	1	2	1	2	2	2	2	2	1
NAL	CWH	xm				RS	k		2		B	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	k		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	k		2		M	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	k		3		B	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	k		3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	k		3		M	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	k		4		B	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	k		4		C	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	k		4		M	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	k		5		B	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	k		5		C	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	k		5		M	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	k		6		B	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	k		6		C	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	k		6		M	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	k		7		B	3	1	1	1	2	1	2	2	2	2	2	1
NAL	CWH	xm				RS	k		7		C	2	1	1	1	2	1	1	2	2	2	2	1
NAL	CWH	xm				RS	k		7		M	2	1	1	1	2	1	2	2	2	2	2	1
NAL	CWH	xm				RS	k	s	2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	k	s	3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	k	s	4		C	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	k	s	5		C	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	k	s	6		C	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	k	s	7		C	2	1	1	1	2	1	1	2	2	2	2	1
NAL	CWH	xm				RS	w		2		C	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	w		2		M	6	6	5	4	5	5	6	2	2	6	6	6
NAL	CWH	xm				RS	w		3		C	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	w		3		M	6	6	3	2	4	3	5	2	2	4	4	6
NAL	CWH	xm				RS	w		4		C	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	w		4		M	6	6	3	3	2	1	3	3	3	2	1	6
NAL	CWH	xm				RS	w		5		C	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	w		5		M	5	4	3	3	2	2	3	3	3	3	2	6
NAL	CWH	xm				RS	w		6		C	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	w		6		M	3	1	1	2	2	1	2	3	2	3	3	2
NAL	CWH	xm				RS	w		7		C	2	1	1	1	2	1	1	2	2	2	2	1
NAL	CWH	xm				RS	w		7		M	2	1	1	1	2	1	2	2	2	2	2	1
NAL	CWH	xm				RZ						6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				SC			1	b		6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				SC	k		1	a		6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				SC	k		1	b		6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				SC	q		1	b		6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				SC	w		1	b		6	6	6	6	6	6	6	6	6	6	6	6
NAL	CWH	xm				SW			2	b		6	6	5	4	6	6	6	4	4	6	6	6

Appendix 11: Wildlife Habitat Maps