Canadian Forest Service
Forest Ecosystem Processes Network

Chronosequences for research into the effects of converting coastal British Columbia old–growth forests to managed forests: an establishment report

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Abstract

A program of multidisciplinary research was initiated in 1991 by the Canadian Forest Service to study the changes caused by converting old-growth coastal temperate forests to managed forests. In 1992, plots were established on ten sites on southern Vancouver Island — five sites in Douglas-fir dominated stands on the dry leeward east side of Vancouver Island in very dry variants of the coastal western hemlock zone (CWHxm), and five sites in western hemlock dominated stands on the wetter windward west side of the island in very wet variants of the zone (CWHvm). Each site contained a basic suite of four seral stands — a chronosequence — representing four stages of stand development: regeneration, immature, mature and old growth. Chronosequences were selected so that stands within a site were on similar, slope, elevation and aspect. Most second-growth stands selected were of harvest origin and burned, though mature stands at three sites were of wild–fire or landslide origin.

This report details the background to the establishment of the coastal forest chronosequence experiment and thus serves as an important reference for future reports and publications. The report includes: information on site selection criteria, plot layout and maps; a general introduction to the ecology, physiography, geology and climate of the study area (southern Vancouver Island); and ecosystem descriptions for each site and plot including general site environment, soil descriptions, soil chemistry, general stand characteristics and lists of indicator plant species. Methods for ecosystem description are provided and results summarized and compared between subzones and among sites and seral stages. Brief summaries of each of the 18 studies of ecosystem structure, processes and diversity carried out on these sites during the first 5-year period of the experiment (1992 – 1997) are also provided. Structure studies examined differences in coarse woody debris, overstory and canopy gap distributions; process studies included investigations of changes in site carbon and nutrient levels, transformations of carbon pools, microenvironments and detrital carbon fluxes (litter fall, soil respiration and decomposition); biodiversity studies included characterization of various groups of soil fauna, carabid beetles, mycorrhizal fungi, mushrooms, salamanders, canopy lichens and vascular plants. During the first 5-year period, most of the more detailed process and diversity studies were conducted on east island Douglas-fir dominated sites. Future studies on ecosystem processes and diversity are planned for west island sites.

Chronosequence research offers scientists the opportunity to examine, over a period of a few years, long–term changes in forest succession. The knowledge gained from studies from these sites will assist foresters in improving their stewardship of these forest lands, upon which forest productivity and biodiversity ultimately depend.

Résumé

Le Service canadien des forêts a entrepris en 1991 un programme de recherches multidisciplinaires afin d'étudier les changements provoqués par la conversion de vieilles forêts côtières tempérées en forêts aménagées. En 1992, on a établi des placettes dans dix stations du sud de l'île de Vancouver, soit cinq stations dans des peuplements dominés par le douglas vert et situés à l'est de l'île, du côté sec et à l'abri du vent, dans les sous-zones très sèches de la zone côtière à pruche de l'Ouest (CWHxm) et cinq stations dans des peuplements dominés par la pruche de l'Ouest et situés à l'ouest de l'île, du côté exposé au vent et plus humide, dans les sous-zones très humides de la zone (CWHvm). Chaque station abritait une séquence évolutive de base de quatre peuplements - une chronoséquence - correspondant à quatre stades de développement : peuplement en voie de régénération, jeune peuplement, peuplement mûr et vieux peuplement. Les chronoséquences ont été choisies de façon que les peuplements d'une station présentent des caractéristiques similaires au niveau du versant, de l'élévation et de l'aspect. La plupart des peuplements de seconde venue choisis étaient issus d'activités d'exploitation et de brûlage; toutefois, dans trois stations, la présence de peuplements mûrs était attribuable à l'action de feux de forêt ou de glissements de terrain.

Le présent rapport donne des détails sur les circonstances entourant la mise en place de cette expérience sur les chronoséquences de la forêt côtière et, à ce titre, sert de point de repère important aux futurs rapports et publications qui paraîtront. Il présente notamment de l'information sur les critères de sélection des stations, sur l'implantation des placettes et sur l'établissement des cartes, un aperçu général des caractéristiques écologiques, physiographiques, géologiques et climatiques de la région à l'étude (le sud de l'île de Vancouver) et des descriptions des écosystèmes de chacune des stations et placettes, y compris des considérations générales sur le milieu, des descriptions des sols, les caractéristiques chimiques du sol, les caractéristiques générales du peuplement et des listes des espèces végétales indicatrices. Le rapport expose également les méthodes utilisées pour décrire les écosystèmes, un sommaire des résultats obtenus et des comparaisons entre les sous-zones et entre les stations et les stades évolutifs. Il présente aussi de brefs résumés des 18 études de la structure, des processus et de la diversité des écosystèmes effectuées dans ces stations au cours des cinq premières années (1992-1997). Les études sur la structure des écosystèmes examinaient les différences au niveau de la distribution des gros débris ligneux, de l'étage dominant et des ouvertures dans le couvert; les études sur les processus ont notamment porté sur les modifications des teneurs en éléments nutritifs et en carbone dans les stations, sur les transformations des réservoirs de carbone, sur les microenvironnements et sur les flux de carbone des débris (chute de litière, respiration et décomposition dans le sol); les études sur la biodiversité ont notamment consisté à caractériser divers groupes de la pédofaune, de carabidés, de champignons mycorhiziens, de champignons, de salamandres ainsi que de lichens et de plantes vasculaires du couvert. Au cours des cinq premières années, la plupart des études plus détaillées sur les processus et la diversité ont été menées dans les stations dominées par le douglas vert, dans l'est de l'île. Il est prévu que d'autres études sur les processus et la biodiversité seront effectuées dans les stations de l'ouest de l'île.

La recherche sur les chronoséquences donne aux chercheurs l'occasion d'étudier pendant quelques années les changements à long terme de la succession végétale en forêt. Les connaissances ainsi acquises aideront les forestiers à pratiquer une gestion plus saine de ces terrains forestiers, gestion dont dépendent en fin de compte la productivité et la biodiversité de ces forêts.

1. Introduction

In coastal British Columbia, mild climates and infrequent disturbance favour the development of long-lived forests with trees of great stature. These forests are admired the world over for their magnificent landscapes and diversity. Thus, changes caused by converting old-growth temperate forests to managed forests form a sharp focus for public concern. Some of the important questions raised over the past decade include: What are the impacts on the species diversity following conversion and does the diversity recover in older second-growth forests? Does conversion lead to changes in the site carbon (C) balance resulting in net releases of C to the atmosphere (Harmon et al. 1990; Kurz et al. 1992)? Does conversion lead to a loss of nutrient capital on a site and hence threaten future productivity (Kimmins 1985; Kimmins et al. 1990)?

These questions are especially relevant in coastal B.C. The Canadian Forest Service (CFS) biomass inventory has clearly identified B.C. as having the highest amount of live biomass — and hence C — in Canada: 40% of the national total. While biomass concentrations rarely exceed 200 t/ha outside B.C., they can reach 1100 t/ha on the coast (Bonnor 1985). As well, high rainfall and mild temperatures may lead to high losses of C and nutrients through accelerated decomposition and leaching; hence, the potential for losses following harvest in coastal forests could be very high (Kimmins 1985).

While reliable information on changes during secondary succession in timber biomass, and to some extent in nutrient contents, can be obtained using yield tables, much less data are available on the amounts of C and nutrients in coarse woody debris (Trofymow and Beese 1990) and soil organic matter, how the amounts change during post-harvest succession, and whether the amounts in mature second-growth forests recover to those in climax forests (Kimmins et al. 1985). These C and nutrient pools are substantial in older forests, where coarse woody debris can represent up to 45% of the aboveground C and 21% of the aboveground nitrogen (N) and phosphorous (P) (Harmon et al. 1986).

The sustainability of forest resources and their utilization are contingent on the continuation of essential ecological processes. These processes, affecting C, nutrient, and hydrologic cycles, are biological, and result from activities of all forest organisms. Among the most important are invertebrates and microorganisms inhabiting the soil and soil surface. Numbering many thousands of named and unnamed species, they perform a vital role in decomposing litter, by transforming dead organic matter into a complex web of new substances and food chains that characterize much of the edaphic environment (Marshall 1992). They are essential to the productivity, high level of biodiversity, and homeostasis of undisturbed forests. Also little is known about how the composition of the “non-crop” flora affects the microorganisms, invertebrates and other fauna, and influences the healthy functioning of forest ecosystems. Given the critical role of soil organisms in the forest, it is important to understand how they are affected by forestry practices and other types of environmental change.

In 1991, the Canadian Forest Service (Pacific and Yukon Region) initiated the Coastal Forest Chronosequence (CFC) experiment to study the changes occurring due to the conversion of coastal old-growth to second-growth forests in the Coastal Western Hemlock (CWH) zone of southern Vancouver Island. Investigations were begun to characterize soil fauna, mycorrhizal fungi, small vertebrates and plant diversity, as well as changes in C and nutrient distributions and fluxes in seral stands representing four stages of stand development: regeneration, immature, mature and old-growth. A basic suite of four seral stages (a chronosequence) was delineated at many sites. A workshop in 1993 (Marshall 1993) was the first opportunity to describe basic design of the experiment and studies that had been initiated.

This report builds upon the preliminary information provided at that workshop and serves as an important reference document for researchers currently working or who may in the future work on the plots. As such, it details the background to the establishment of the experiment (Section 2) including the site selection criteria, plot layout, and maps (Appendices I, II); a general introduction to the ecology, physiography, geology and climate of the study area (Section 3); the specific characteristics of each plot (Section 5) including the general site environmental characteristics (Appendix III), soil description and basic soil chemistry (Appendix IV), general stand characteristics (Appendix V), and lists of indicator plant species (Appendices VI, VII). Methods for ecosystem descriptions are given (section 4.1.1 – 4.1.4), detailed information for each plot provided (Appendices III – VI) and the results summarized and compared by site and sere (Section 6).

The report also provides information about the various studies of ecosystem structure (Sections 4.1.5 – 4.1.7), processes (Section 4.2) and diversity (Section 4.3) that have been carried out on these plots during the first 5-year period of the experiment. Included are a brief description of the methodologies used, plots examined, and time period for the studies. Methods for some of the studies are detailed in papers from the first workshop for the CFC experiment (Marshall 1993, with more detailed results for some of the studies found in the papers and reports cited in the study description (Section 4). A list of unpublished resources, such as file reports and contractors' reports, is included in this report.

2. Approach

Harvesting over the last 100 years and natural disturbance have created a mosaic of successional stages in B.C. forests, often adjacent to unharvested old-growth areas. These sites represent a unique opportunity to study changes with forest succession and the extent to which old-growth conditions are restored as forests mature. By studying several age sequences each with old-growth and successional stands in close proximity, the effects associated with stand development may be separated from those caused by between-site variability. Since conditions in old-growth stands change more slowly over time — compared to those in the first 90 years of secondary stand succession — these stands would serve as a control for between-site variability and for conditions in the pre-harvest stand. The effects of climate on successional processes could also be inferred through comparison of age sequences from two biogeoclimatic subzones.

2.1 Site and Stand Selection Criteria

Ten chronosequences were to be selected: five on east and five on west Vancouver Island. The specifications and age criteria (Table 1) used in locating sites were as follows:

Table 1. Stand age criteria used for selecting potential Coastal Forest Chronosequence sites

Name	Age in 1990 (years)	Period of origin
Regeneration	3–8	1982–1987
Immature	25–45	1945–1965
Mature	65–85	1915–1925
Old-growth	>200	<1790

East side - Douglas-fir dominated stands (small components of hemlock or red cedar acceptable) in dry leeward Coastal Western Hemlock subzone (CWHxm, preferably CWHxm1 variant, old CDFb) near the transition to the Coastal Douglas-fir subzone (CDFmm), mid-slope under 600 m elevation. Final sites selected included: Victoria Watershed South (VWS), Victoria Watershed North (VWN), Koksilah (KOK), Nanaimo River (NAN), Loon Lake (LOON).

West side - Western hemlock dominated stands (secondary components of amabilis fir, red cedar or Douglas-fir acceptable) in the wetter windward Coastal Western Hemlock subzone (CWHvm), mid-slope under 600 m elevation. Final sites selected included: Renfrew (REN), Red/Granite Creek (RGC), Nitinat (NIT), Klanawa KLA), Mt. Ozzard (OZZ).

Additional criteria used were: that each chronosequence was within a 5 × 5 km or smaller area; contained stands with similar slope, elevation (within 200 m), and aspect of four ages at a common reference year of 1990 (Table 1); had good accessibility; and had a guarantee of non-disturbance (no-logging or road building) for at least 4 years. Although second-growth stands of harvest and burn origin were preferred, some of the mature stands of wildfire or landslide origin were considered (stands with veterans were excluded). In some cases, the second-growth stands within a chronosequence were sufficiently spread apart that selecting a second old-growth stand as a control for site variation was necessary.

From January to July 1991 inquiries about possible sites were made with 21 different foresters from several divisions in Canfor, MacMillan Bloedel (MB), Fletcher Challenge (TimberWest), Western Forest Products, Canadian Pacific Forest Products, the Greater Victoria Water District, and the B.C. Ministry of Forests, Duncan Forest District. Maps were obtained from most foresters contacted and examined to locate potential suites of seral stands. As well, K. Rainer (MB Woodlands Division) completed a GIS search of all MB coastal forest lands. Biogeoclimatic zone, stand age, and stand type were used as the search criteria. The forest classes along with watercourse information were printed onto 1:250 000 maps. These maps were then used to identify areas containing all stand ages. The appropriate 1:20 000 forest cover maps were then selected for further examination. Forest cover and topographic maps and satellite photos of the areas selected were examined to identify suitable stands for a chronosequence. A total of 31 chronosequence locations were identified from this initial survey (Trofymow 1991, unpublished report). Several potential locations suggested by the foresters contacted were not included in this list as the stands were too small or were missing suitable areas of adjacent old-growth forest.

Site trips were completed from August to September 1991 to examine the suitability of the various suites of seral stands identified from the maps. After the site trips, the suitability of the chronosequences identified were reviewed and 10 chronosequences were selected (Figure 1). Criteria used to accept or reject the stands initially identified included: similarity in general site types and physical features (slope, aspect, elevation) among the suite or stand ages in the chronosequence; stand homogeneity (i.e. no creeks, large rock outcrops or cliffs); stand size; road access; and travel time required. Final stand selection and plot establishment were completed in September 1991 at three sites: Victoria Watershed South, Victoria Watershed North and Koksilah. Final plot establishment at the other seven sites was completed by April 1992.

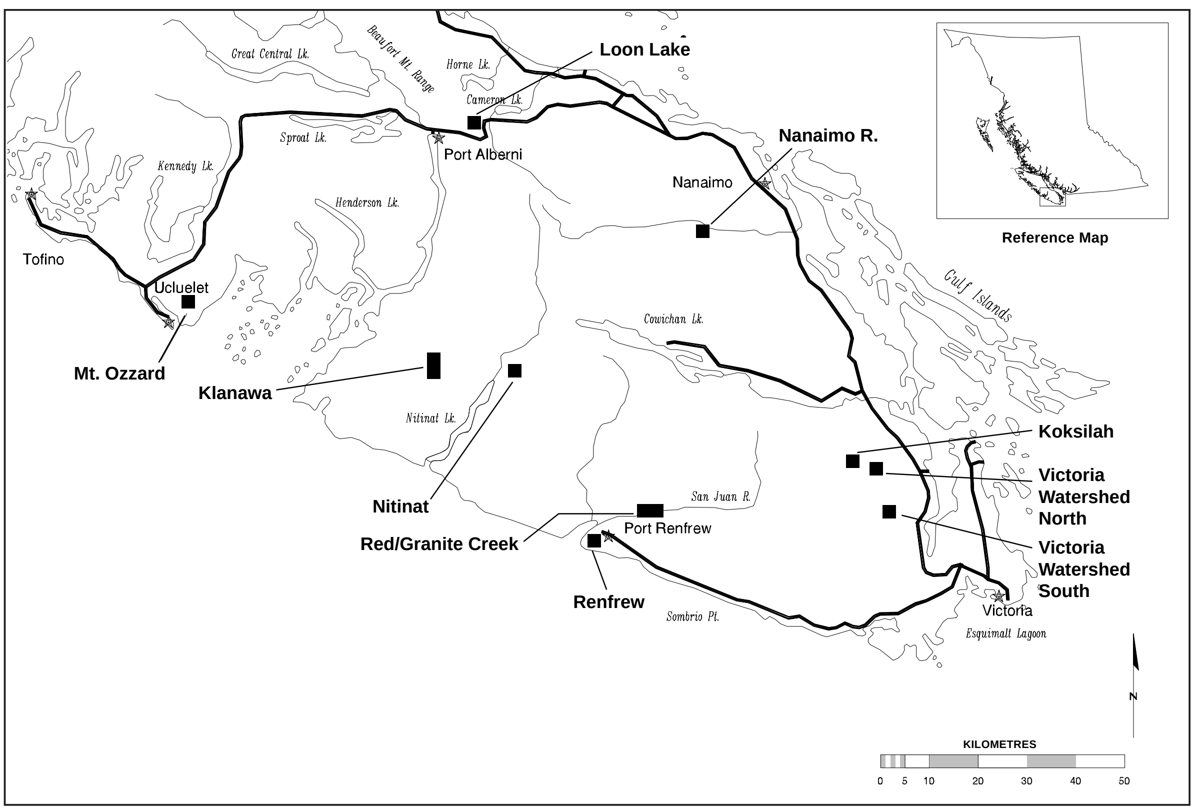

Figure 1. Locations of the 10 Coastal Forest Chronosequences on southern Vancouver Island. Map prepared by Canadian Forest Service National Forest Inventory from 1: 2 000 000 National Digital Maps by Geomatics Canada

2.2 Plot Design and Layout

Chronosequence location maps and plot descriptions for all 10 locations used in the survey portion of the experiment were detailed in a contract report (Blackwell 1992a, unpublished report). For each chronosequence this report included written and sketch maps describing the road directions and distances to plots at each site, forest cover maps identifying individual plots, and basic site description data for each plot. Appendix I provides the site name and its 3 – 4 letter code, the UTM coordinates of the individual plots along with the plot number as originally designated in the plot establishment report, and the final unique plot number used in subsequent years and throughout this report. Appendix II contains sketch maps, road directions, and copies of the 1:20 000 forest cover maps showing the plots at each site and forest types in the surrounding stands.

For each chronosequence site, individual plots are identified in the field by a yellow plastic sign and aluminum tag with fluorescent orange paint above and below the sign, located on the road side adjacent to each plot. From the sign, orange and lime ribbon marks the route to the plot benchmark. The distance and bearing to each plot benchmark is clearly indicated both on each plot's aluminum road tag and on the sketch maps (Appendix II) for each chronosequence. The benchmark position is identified with an orange painted 1.5-m cedar stake; blue, orange and lime ribbon on the stake; and a 15-cm spike (also flagged with blue, orange, and lime ribbon) inserted in the forest floor. Plot centre benchmarks were located 80 m or more from any stand edge boundary.

At all 10 chronosequences, triangular plots were established for the survey of site C and nutrient contents (Figure 2). From each benchmark, three 30-m radial lines were run to define three subplot centres 120° apart. Each subplot centre is identified with a 1.5-m orange painted cedar stake which is flagged with either a blue, orange, or lime ribbon. In addition, a 15-cm spike was inserted into the forest floor and flagged with the ribbon colour corresponding to the cedar stake. These subplot centres define the 51 m sides of an equilateral triangle used for the coarse woody debris survey, the centre points for 10 m radius plots for standing biomass measurements, and the points for forest floor and soil sampling (Figure 2). The sides were flagged; with either orange, blue or lime ribbon. At most locations the orientation of the subplots was random; however, at the three intensive sites the subplots were arranged at 0°, 120°, and 240° from the centre benchmark. Orientation of subplot 1 in reference to the centre is provided in Appendix I.

Although not part of the site C and nutrient survey, because of the detailed and repeated sampling conducted on the intensive study plots at the VWS, VWN, and KOK sites, larger 60 × 60 m plots were also established, superimposed upon the triangular plots and sharing a common centre benchmark (Figure 3). The 60 × 60 m plots were oriented along cardinal directions with corners defined by 1.5 m tall, 25 mm (1") angle aluminum stakes and midpoints by 12-mm (1/2") angle aluminum stakes. A nested 40 × 40 m plot was also established with 2.0-m blue-tipped, 25-mm (1") PVC pipe stakes at the corners and midpoints along each side. These outer and inner plot stakes were used to help define the 10 × 10 m subplots which were then assigned to the different studies being conducted on the intensive plots. Brush and woody debris along the 40 × 40 m nested plot were cleared to provide an access trail for researchers.

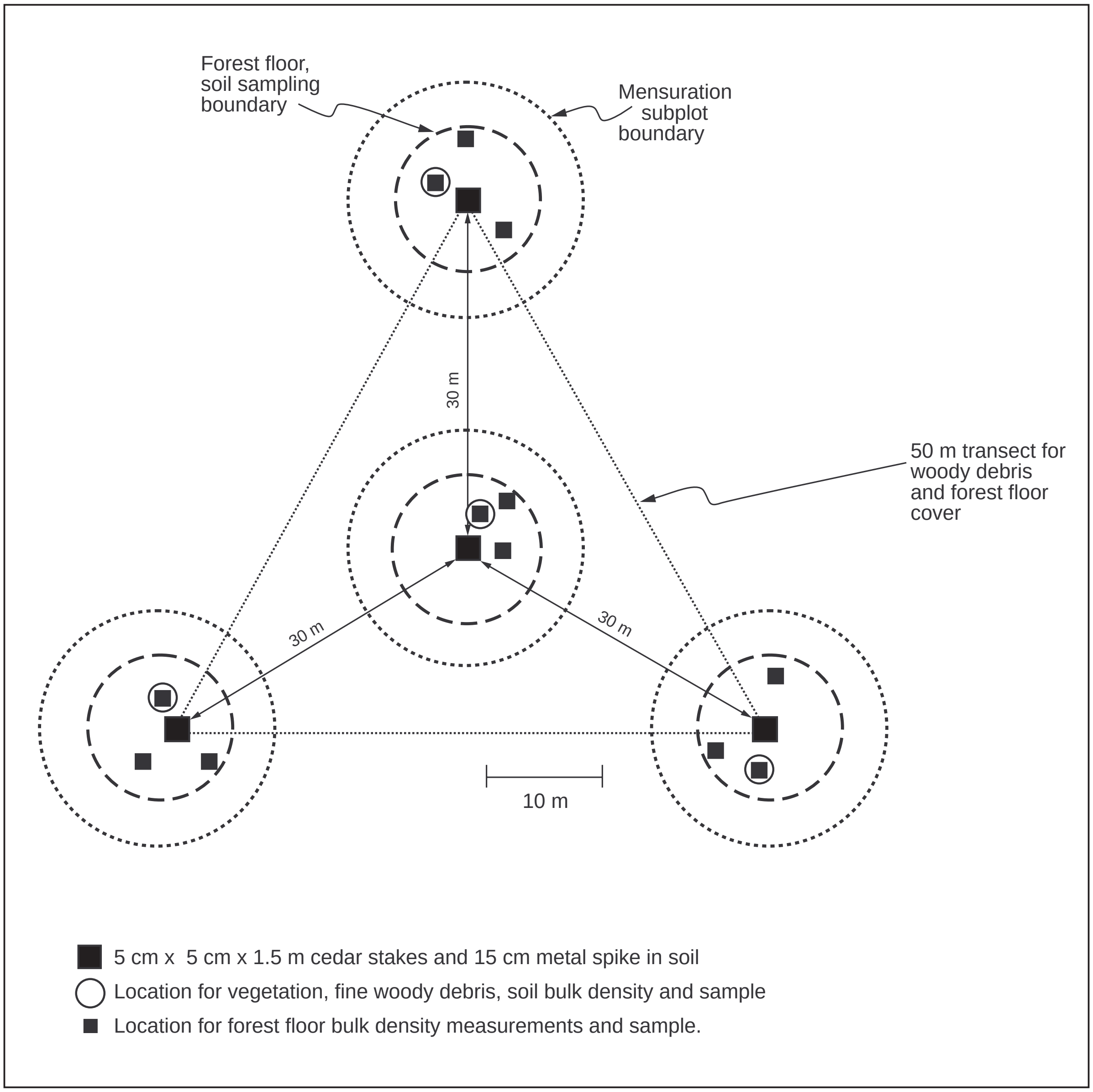

Figure 2. Example of triangular carbon and nutrient survey plot layout. Mensurational and sampling subplots with woody debris transects were established in all plots

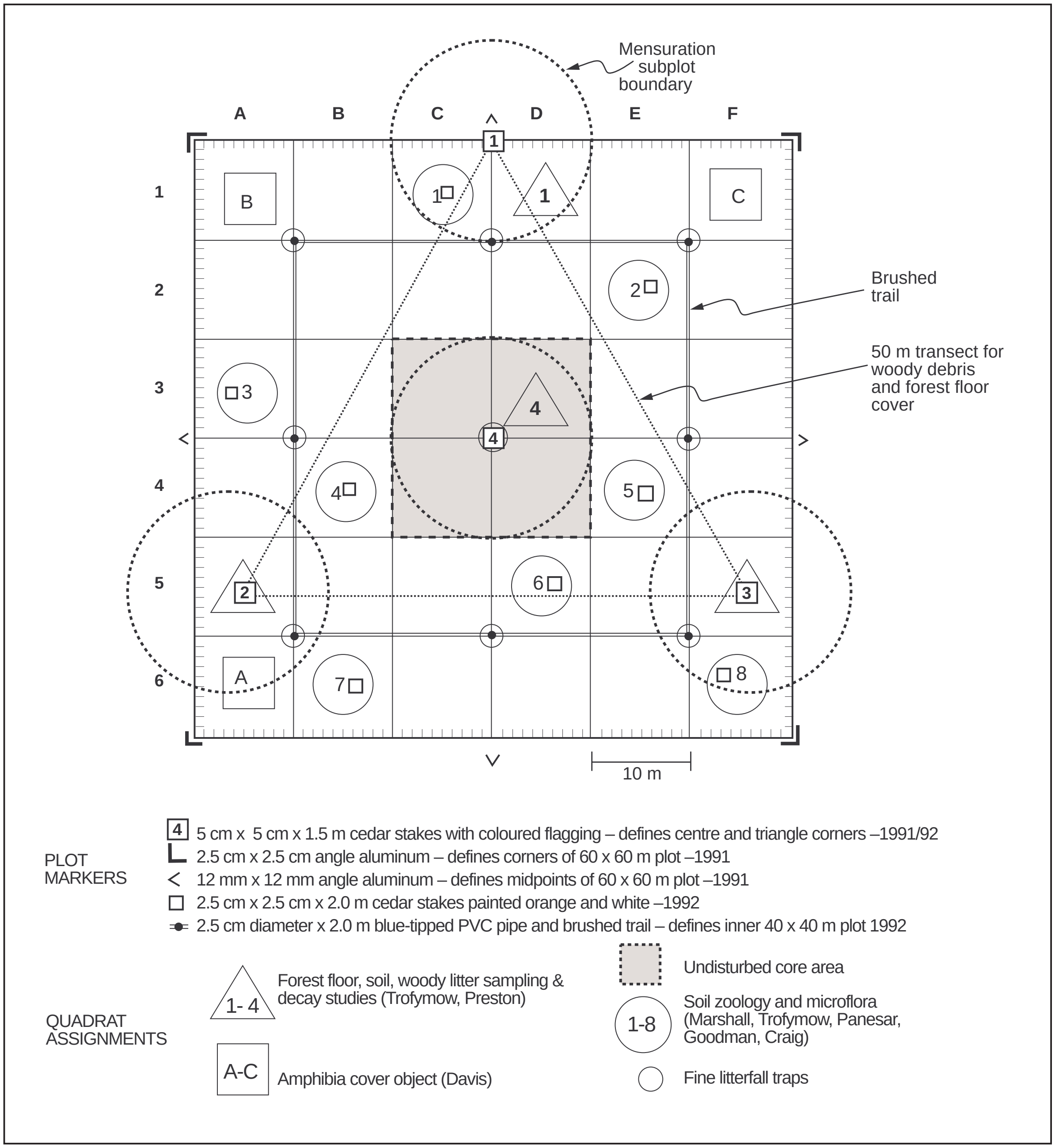

Figure 3. Triangular survey plot layout superimposed upon 60 × 60 m square plot at intensive study sites. Example of 10 × 10 m subplot assignments are for studies conducted at the intensive study sites

3. Description of Study Area, South Vancouver Island

3.1 Ecosystem Classification

3.1.1 Overview of biogeoclimatic ecosystem classification

The biogeoclimatic ecosystem classification system (Pojar et al. 1987; Pojar et al. 1991) is a system developed by the B.C. Ministry of Forests for the ecological classification of provincial forest and range lands, based on the biogeoclimatic system developed earlier by Dr. V.J. Krajina and his students (Krajina 1969). This hierarchical system incorporates climate, soil, and vegetation data, and provides a framework for resource management and scientific research.

At a regional level, climatic or zonal classification units are inferred from vegetation and soil data. The basic classification unit is the biogeoclimatic subzone. Based on climatic variations as expressed by differences in climax vegetation, subzones are usually subdivided into variants. At a local level, ecosystems are classified by vegetation and soil data into units called site associations. A site association represents those sites capable of producing similar climax vegetation, potentially over a range of climates. The site associations that occur within a particular subzone or variant are referred to as site series. A site series thus represents those sites capable of producing similar climax vegetation within a particular subzone or variant. A site series that is intermediate in terms of soil moisture, soil nutrient regime, soil texture, and topography is considered to best reflect the influence of local climate (rather than local topoedaphic variation) and is termed “zonal” for its subzone or variant.

Four biogeoclimatic zones (Alpine Tundra, Coastal Douglas-fir, Coastal Western Hemlock and Mountain Hemlock), defined by broadly similar climate and climax vegetation, occur in the southern part of Vancouver Island. All of the chronosequence plots are located within the Coastal Western Hemlock (CWH) biogeoclimatic zone. This zone occurs at low to middle elevations, mostly west of the Coast Range mountains, all along the British Columbia coast and into Alaska, Washington and Oregon as well (Pojar et al. 1991). It covers almost all of Vancouver Island, excluding only the higher mountain regions and a strip along the southeastern coast (B.C. Ministry of Forests 1992).

3.1.2 Site biogeoclimatic subzones

Four subzones of the CWH are represented in southern Vancouver Island, within which seven variants are recognized (Figure 4). The east-side chronosequences are all in the same subzone, the Very Dry Maritime CWH (CWHxm). The Greater Victoria Watershed South and Nanaimo chronosequences are in the Very Dry Maritime (Eastern) CWH variant (CWHxm1); the Koksilah and Loon Lake chronosequences are in the Very Dry Maritime (Western) CWH variant (CWHxm2); and the Greater Victoria Watershed North site straddles the boundary between the two variants. These two variants are considered very similar in properties and management interpretations by the B.C. Ministry of Forests (Green and Klinka 1994).

The west-side chronosequences are mostly in the Very Wet Maritime CWH (CWHvm) subzone, though one chronosequence is close to the transition with the Very Wet Hypermaritime CWH (CWHvh) subzone. The Mt. Ozzard, Klanawa, Nitinat, Red/Granite Creek and Renfrew (in part) chronosequences are in the Very Wet Maritime (Montane) CWH variant, or CWHvm1. Some of the Renfrew plots are slightly within the mapped area of the Very Wet Hypermaritime (Outer) CWH variant (CWHvh1) but the data from these plots fit the CWHvm1 more closely.

3.1.3 Overview of ecoregion classification

An ecoregion classification, based on the interaction of climatic processes and physiography, has been developed to provide a systematic view of broad geographic relationships in the province (Demarchi 1988; Demarchi et al. 1990). The classification is a five-level hierarchical system. At the highest levels (ecodomain and ecodivision), the criteria are very broad and place British Columbia in a global context. The three lower levels (ecoprovince, ecoregion, and ecosection) are progressively more detailed and narrow in scope and geographic scale, describing areas of similar climate, physiography, zonation, and wildlife potential.

The major practical difference between ecoregion classification and biogeoclimatic ecosystem classification is that an ecoregion unit includes the full elevation range within a geographical area, whereas biogeoclimatic units are largely altitudinal belts of ecological zones within a geographical area (Pojar et al. 1991).

3.1.4 Site ecosections

Northern and western Vancouver Island, including the west-side chronosequences, are in the Coast and Mountains ecoprovince and the Western Vancouver Island ecoregion. The west-side chronosequences (Renfrew, Red/Granite Creek, Nitinat, Klanawa, and Mt. Ozzard) are in the Windward Island Mountains ecosection. The eastern side of Vancouver Island is in the Georgia Depression ecoprovince, which has three ecoregions. The east-side chronosequences are in the Eastern Vancouver Island ecoregion. Of these, the Loon Lake, Nanaimo River, and Koksilah chronosequences are in the Leeward Island Mountains ecosection; the Greater Victoria Watershed North and South chronosequences are in the Nanaimo Lowland ecosection.

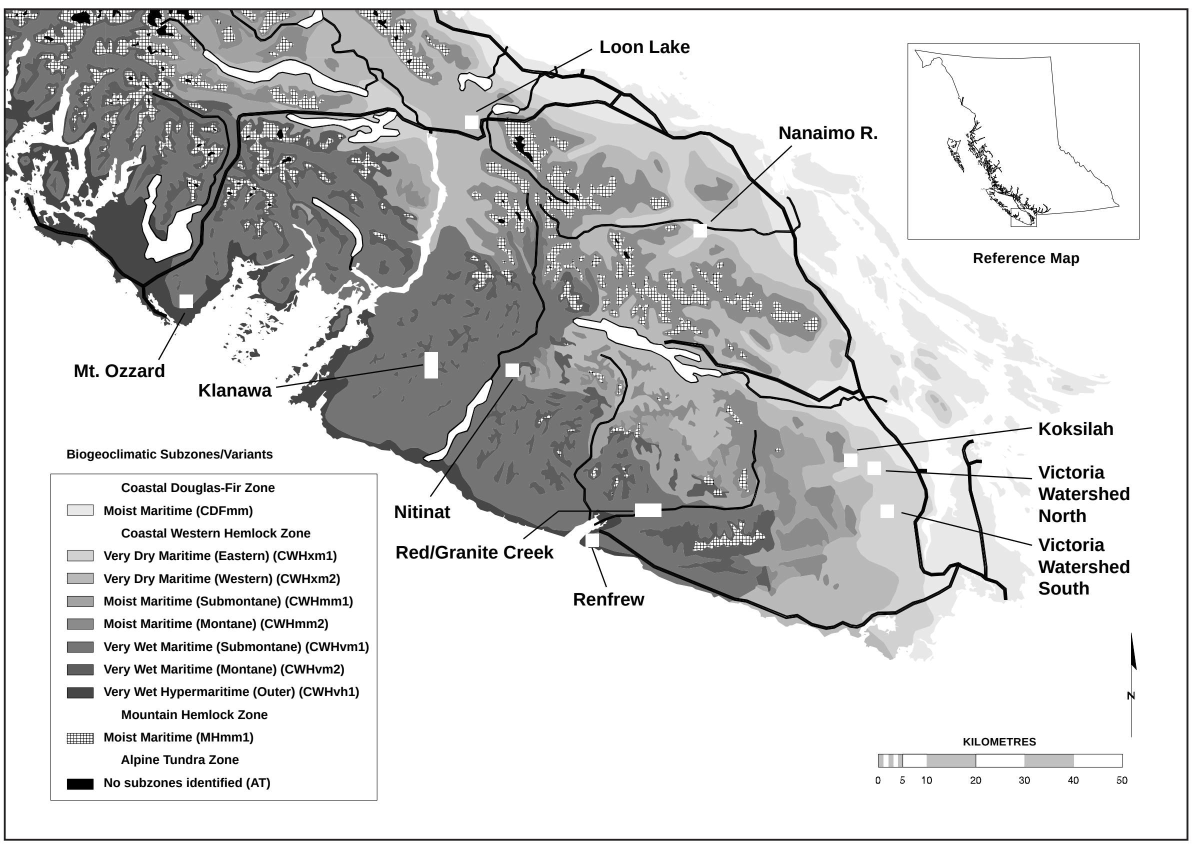

Figure 4. Biogeoclimatic zones, subzones, and variants of southern Vancouver Island. Map prepared by Canadian Forest Service National Forest Inventory from 1: 250 000 biogeoclimatic ecosystem classification maps by B.C. Ministry of Forests

3.2 Physiographic Regions

3.2.1 Overview

Vancouver Island, the largest island in the eastern Pacific Ocean, is oriented from northwest to southeast. It is 450 km long and averages 70 km in width with an area of 32 100 km^2. Most of the area is occupied by the mountains, which run down the centre of the island (Holland 1976). Many of the central valleys are occupied by finger lakes, the west coast is indented with numerous fjords, and the east and north coasts are gentle lowlands. The physiographic subdivisions of British Columbia described by Holland (1976) comprises three broad physiographic systems with four levels of subdivisions. The mountainous areas of Vancouver Island fall in the Western System, Outer Mountain Area, Insular Mountains, Vancouver Island Mountains. Broader low lying areas on north Vancouver Island and along the east coast of the Island fall in the Western System, Coastal Trough, Hecate Depression, Nahwitti Lowland and the Western System, Coastal Trough, Georgia Depression, Nanaimo Lowland, respectively. Although Holland (1976) recognizes a fourth level of minor subdivisions, the report and map do not provide a complete listing of all the minor subdivisions (Holland 1976, notation on Map No. 1JPS).

Yorath and Nasmith (1995) use a scheme of physiographic regions which recognizes several minor regions for Vancouver Island not listed in Holland (1976) but with broad categories similar to the third level subdivisions of Holland (1976). The three broad categories, interior mountains, highlands and plateaus below 600 m, and lowlands along the outer margins of the island, are further divided into several physiographic regions (Yorath and Nasmith 1995). The physiographic regions of the southern part of Vancouver Island outline areas of homogeneous topographic character and relief that are more or less distinct from adjacent areas (Figure 5). The relief varies from low, flat-lying areas along the east and west coasts to rugged mountains up to 2200 m high. Descriptions of seven physiographic regions on southern Vancouver Island follow.

The Southern Vancouver Island Ranges are lower and less rugged than the northern mountains of the Island ranges. There are no glaciers in the southern ranges. Valleys are commonly U-shaped and originate in cirques or tarn lakes. Valleys correspond closely to a network of faults formed by preferential erosion along major lineaments. In the region south of Alberni Inlet and north of Lake Cowichan, mountain peaks rise to 1800 m (Mount Arrowsmith). South and east of Lake Cowichan, peaks are generally between 900 and 1400 m.

The West Vancouver Island Fjordland is characterized by high mountains that are dissected by long, often narrow fjords. This physiographic region extends along the west coast from the northern extreme of the Brooks Peninsula, southeast for about 250 km to Alberni Inlet. Glacial erosion has incised characteristic U-shaped troughs into the steep sided rocky slopes. Incision occurred along old river valleys that have been deepened by glacial erosion and subsequently flooded by the sea. The inlets are generally perpendicular to the coast and extend from 10 to 40 km inland. Alberni Inlet is up to 330 m deep and extends inland 60 km from the west: at that point, Vancouver Island is only 25 km wide.

The Nanaimo Lakes Highland is a transition area between the South Vancouver Island Ranges and the Nanaimo Lowland. The region is west of Nanaimo and extends for approximately 50 km in a northwest-southeast direction. It is drained by the Nanaimo Lakes chain and the Nanaimo River. Elevations in this region vary from 200 to 1000 m. Summits are moderately rugged to gently rolling but lack the jagged character of the mountains to the west.

The Victoria Highland is a similar physiographic feature to the Nanaimo Lakes Highland, in that it is a transition between mountains and lowlands. This region extends from south of Duncan around the southern tip of Vancouver Island to Jordan River. It includes the Malahat area and the highlands around Victoria. Elevations range from 200 to 500 m. The low mountains are gently sloping, but incised valleys may be steep. Lakes are common and are part of the water supply for Greater Victoria.

The Estevan Lowland is a narrow, essentially flat and featureless region that extends for 290 km along the southwest coast of Vancouver Island. It extends from south of the Brooks Peninsula to Port Renfrew. The region averages about 3 km in width but at Hesquiat Peninsula is 12 km wide. It is underlain with easily erodible rocks and is commonly less than 50 m in elevation. In areas underlain by older, competent volcanic rocks, the topography is hummocky and locally steep. Most of the coastline is rocky.

Extending south from Campbell River to Victoria along the east side of Vancouver Island, bordering the Strait of Georgia, is an area of gently rolling hills and plains. This is the Nanaimo Lowland. The hills reach elevations of approximately 200 m. Most of the farmland, population, and infrastructure on Vancouver Island are located within this corridor.

The Alberni Basin, a small area extending 40 km northwest of Port Alberni, is 8 – 13 km wide and surrounded by mountains. The region, less than 200 m in elevation, is drained by a series of rivers into Alberni Inlet. This area is underlain by the same package of rocks that underlie the Nanaimo Lowland and has some of the best farmland on Vancouver Island.

3.2.2 Site physiography

Following the physiographic system of Holland (1976), the two Victoria Watershed chronosequences fall in Nanaimo Lowland while the other chronosequences are in Vancouver Island Mountains. Using the physiographic regions of Yorath and Nasmith (1995), the Victoria Watershed South and Victoria Watershed North chronosequences fall within the Victoria Highlands. The region is between 200 and 500 m in deviation and includes many lakes. The Koksilah site also lies within the Victoria Highlands region, very close to the boundary of the more rugged South Vancouver Island Ranges that are to the west. The Nanaimo River site is within the Nanaimo Highlands region which ranges between 100 and 200 m in elevation and is drained by Nanaimo Lakes and Nanaimo River. The Loon Lake site is within the South Vancouver Island Ranges just east of the Alberni Basin. The Renfrew, Red/Granite Creek, Nitinat, and Klanawa chronosequences all lie within the South Vancouver Island Ranges. The Mt. Ozzard site is in the West Vancouver Island Fjordland, characterized by high mountains dissected by deep narrow fjords, bordering the Estevan Lowlands which extend along much of the west coast of Vancouver Island.

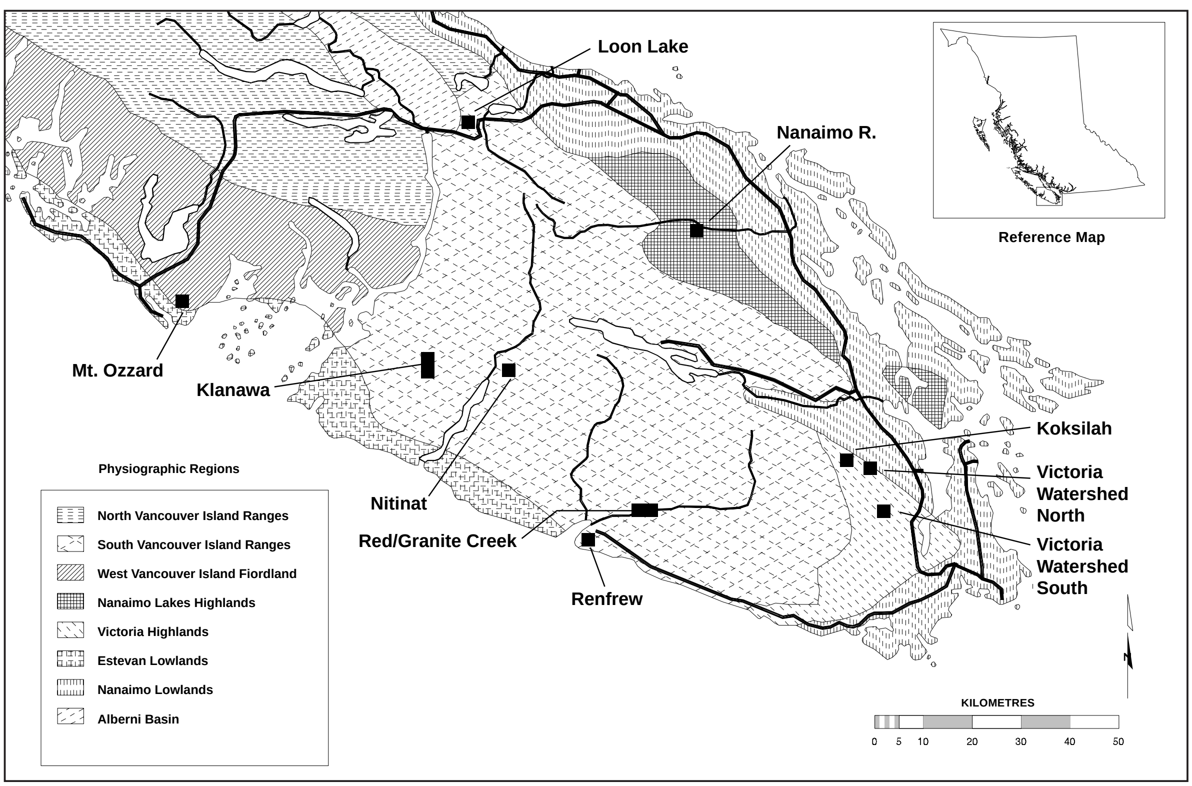

Figure 5. Physiographic regions of southern Vancouver Island. Map prepared by Canadian Forest Service National Forest Inventory from map by Yorath and Nasmith (1995)

3.3 Geology

Vancouver Island lies within the Insular Belt, the westernmost of the subdivisions of the Canadian Cordillera. The geological history of Vancouver Island is dominated by volcanic episodes separated by periods of sedimentation. More recently, glaciation has altered and continues to alter the landscape, carving out fjords, sculpting mountains, and depositing mounds of material.

3.3.1 Overview of bedrock geology

Vancouver Island, together with the Queen Charlotte Islands and St. Elias Mountains of northwestern British Columbia and southwestern Yukon, comprises the Insular Belt, the westernmost of five morphogeological subdivisions of the Canadian Cordillera. The geological architecture of the Insular Belt was formed by the accretion of several exotic fragments of crust, termed terranes, each with its unique geological history (Gabrielse and Yorath 1992). Some of these terranes amalgamated to form the Insular Superterrane before its accretion to the western margin of North America about 100 million years ago. On Vancouver Island the dominant terrane of the Insular Superterrane is Wrangellia, which, along the west and south coasts, was successively underthrust by the Pacific Rim and Crescent terranes between 54 and 42 million years ago.

The structural fabric of Vancouver Island is expressed by northwesterly trending plutons, large regional fold structures, and thrust faults resulting from accretion of the Insular Superterrane to the ancient continental margin. The Pacific Rim Terrane is separated from Wrangellia by the Westcoast Fault along the west coast and by the San Juan-Survey Mountain Fault in the south. Likewise, in the same areas the Crescent Terrane was thrust beneath the Pacific Rim Terrane along the Tofino and Leech River faults (Yorath 1997). The current plate tectonic regime involves the interactions of the North American, Juan de Fuca, and Pacific plates which meet at a triple junction off the mouth of Queen Charlotte Sound. North of the triple junction the Pacific Plate is moving northward relative to the North American Plate from which it is separated by the Queen Charlotte Transform Fault. South of the triple junction the Juan de Fuca Plate converges and is consumed beneath the North American Plate along the Cascadia subduction zone at the toe of the continental slope. Extending southwesterly from the triple junction, the segmented Juan de Fuca Ridge System separates the Pacific Plate from the Juan de Fuca Plate.

The geological history of Wrangellian southern Vancouver Island, for the most part, has resulted from three phases of volcanism, each separated by episodes of shallow-water carbonate sedimentation and followed by terrigenous clastic accumulations, the latter preserved mainly on the east and west coasts (Yorath and Namith 1995). The oldest rocks consist of a 4500-m-thick sequence of marine oceanic basalt (shades of green in appearance) and overlying explosive volcanic (tuff and volcanic sandstones) and lesser plutonic rocks of the Sicker Group (named after Mt. Sicker north of Duncan; also located at Duck Lake, Nitinat, and McLaughlin Ridge formations; Figure 6, DPS - lower part) of Late Devonian age (about 370 million years old). The overall character of the Sicker Group expresses a history similar to that of the modern Indonesian archipelago. The Sicker Group is overlain by shallow water carbonate sediments (limestone layered with volcanics, 360 – 260 million years old) of the Buttle Lake Group (Fourth Lake, Mt. Mark and St. Mary Lake formations; Figure 6. DPS - upper part), of Carboniferous age, which accumulated upon the wave-eroded tops of the older volcanic piles. The modern Ontong–Java Plateau is analogous.

About 230 million years ago, following a lengthy period that is not represented in the geological record of the island, the Upper Triassic oceanic volcanic lavas of the Karmutsen Formation, the lowermost formation (black shaded pillow basalts) of the Vancouver Group (Figure 6. TrK), were extruded across the surface of the older Sicker and Buttle Lake topography. The Karmutsen is an enormous pile (6000 m thick at Buttle Lake) of oceanic sea-floor lava that covers most of Vancouver Island, the Queen Charlotte Islands, and parts of southeastern Alaska. As such it is one of the most voluminous successions of volcanic rocks in the world, and was extruded over a period of probably less than 5 million years. Similar to the succession overlying the Sicker Group, the Karmutsen Formation is topped by a 300-m-thick unit of marine shallow water carbonate sediments (limestones and sedimentary rocks) of the remainder of the Vancouver Group (Quatsino, Parsons Bay, and Sutton formations).

The third and final episode of widespread volcanism on Wrangellian Vancouver Island occurred some 190 million years ago during the early part of the Jurassic Period. At that time, explosive volcanism deposited silica-, calcium-, potassium- and sodium-rich lava on the land surface resulting in the accumulation of the Bonanza Group (Figure 6, JB), as well as the equal age granitic rocks of the Island Intrusions (subsurface solidified magma) (Figure 6, MJgV and EjdW), the latter expressed as most of the highest peaks of the Vancouver Island ranges. Heat and pressure from these intrusions also metamorphosed deeper parts of the Sicker Group into gneiss. At the time of Bonanza volcanism, Wrangellia, including what was to become Vancouver Island, was probably far south of its present latitude. Through plate tectonic processes, Wrangellia is thought to have moved northward to become accreted to the westward-moving continent by about 100 million years ago.

Because of collisional accretion over several million years, the island was compressed and its surface elevated along several northwesterly trending fold structures and thrust faults. Along the central axis of the island most of the older rocks were eroded to expose the crystalline granitic rocks of the Island Intrusions. The eroded material was transported eastward to be deposited as the Upper Cretaceous Nanaimo Group (Figure 6. KTN) in a series of coal swamp and marine basins underlying the modern coastal lowlands, Gulf Islands, Strait of Georgia, and Alberni Valley.

Approximately 54 million years ago, a succession of continental margin sedimentary and volcanic rocks were transported northward, perhaps from near the San Juan Islands, and emplaced as the Pacific Rim Terrane beneath the southern and western edges of Wrangellia along the San Juan–Survey Mountain and Westcoast faults, respectively. These rocks are exposed as the Leech River and Pacific Rim complexes (Figure 6. JKPR) on the southern and western parts of the island. Some 12 million years later, a portion of the ancient Farallon

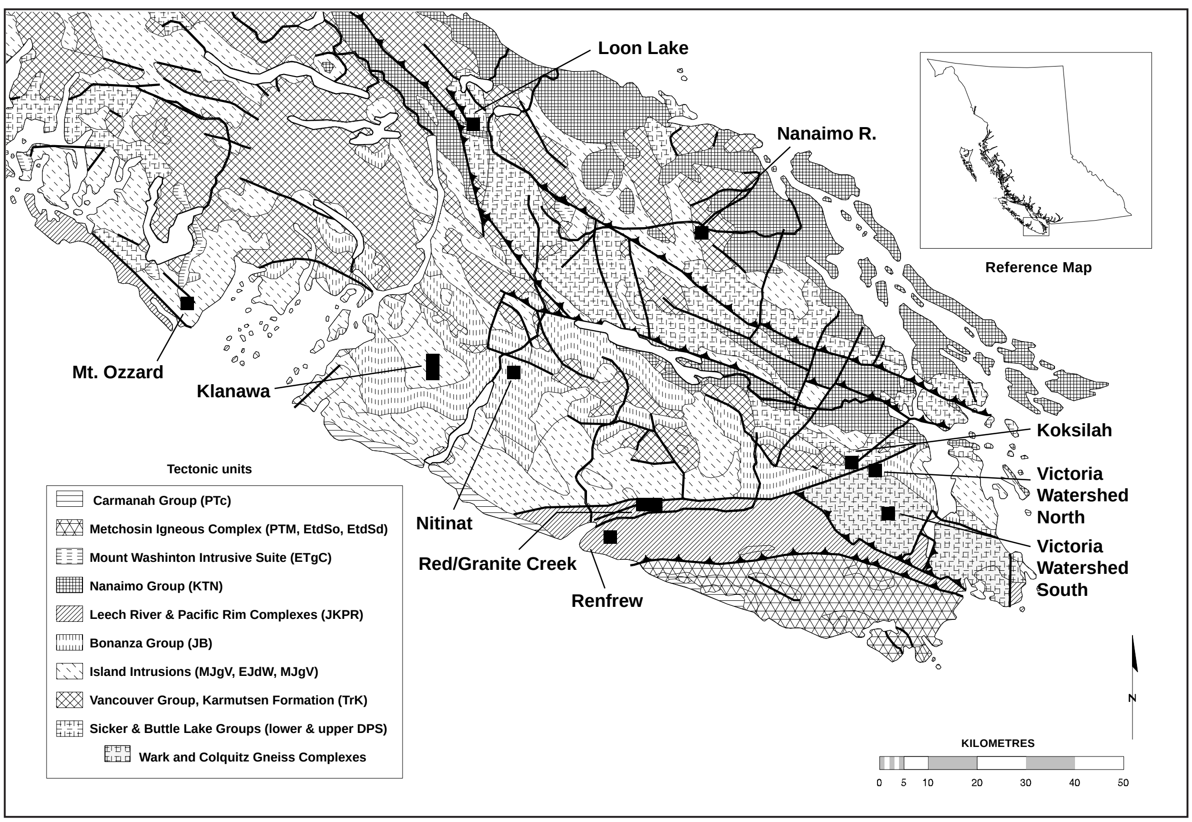

Figure 6. Bedrock geology of southern Vancouver Island. Map prepared by Canadian Forest Service National Forest Inventory from digital files of map by Wheeler et al. (1996) with modifications by Yorath (pers. comm.)

Oceanic Plate was emplaced as the Crescent Terrane beneath the western margin of the continent. On southern Vancouver Island these rocks occur as the Metchosin Igneous Complex (Figure 6. PTM) and occur beneath the Pacific Rim Terrane from which they are separated by the Leech River Fault extending from Sombrio Point to Esquimalt Lagoon (Massey 1986; Yorath and Nasmith 1995). Off the west coast, beneath the continental shelf and the Juan de Fuca Strait, the Crescent Terrane occurs beneath younger tertiary sediments (sandstones and conglomerates) of the Carmanah Group (Figure 6. PTc) which are enclosed within Tofino Basin. Concurrent with the emplacement of these small terranes were episodes of minor plutonism and volcanism. Because of the emplacement of the Pacific Rim and Crescent terranes, further uplift and compression occurred throughout the southern and western parts of the island resulting in the northwesterly trending folds and thrust faults of the Gulf Islands, Beaufort Range, and adjacent ranges. Along the west coast and throughout the Greater Victoria area, the uplift resulting from these underthrusting emplacements caused as much as 10 km of strata to be eroded from the southern and western margins of Wrangellia. Consequently the deepest crustal layers of the island, represented by igneous and metamorphic rocks (Figure 6. EJdW) that probably were originally Devonian Sicker Group strata converted to Wark and Colquitz gneissic rocks due to the Island Intrusions during Early Jurassic time, were exposed. The metamorphic grade and intensity of emplacement of plutonic rocks on Vancouver Island increases towards the southwest. The only rocks that do not show any significant changes in chemistry and mineralogy due to increased heat and pressure are the youngest (50–30 million years ago) clastic sediments of the Carmanah Group. These sediments have accumulated as a result of erosion during and after uplift.

A well developed northwest trending structural orientation on Vancouver Island is expressed as broad fold belts with a northwest-southeast trending axis, as a rough north and northwest orientation of plutons, and as northwest and southwest trending faults. The Karmutsen Formation, being the most competent unit, has been warped into broad culminations and depressions while other units above and below it have been more intensely deformed. The Sicker Group of rocks is incorporated into the large fold belt (Cowichan and Buttle Lake anticlinoria). The Nanaimo Group is another northwest trending fold belt that is cut by west-directed faults (Muller 1977; Muller 1983; Massey 1993). The Beaufort Range and Cowichan Lake faults are believed to be linked and to have been the locus of the 1946 earthquake.

3.3.2 Site bedrock geology

The Victoria Watershed South and North chronosequences are underlain by biotite hornblende diorite, quartz diorite, and granodiorite gneiss of the Wark and Colquitz Gneiss complexes. These 380 million year old metamorphic rocks are derived from sedimentary and igneous rocks. The Koksilah and Nanaimo River chronosequences lie within 230 million year old volcanic rocks of the Karmutsen Formation. This basaltic lava is up to 6000 m thick and underlies a large portion of Vancouver Island. At the Nanaimo River site quartz diorite and granite of the younger Island Intrusions have cut through the Karmutsen volcanics. The Island Intrusions also occur at the Klanawa chronosequence where they intrude 200 to 180 million year old basaltic to rhyolitic lava, tuff, and breccia of the Bonanza Group. The Bonanza Group is also found underlying the Nitinat site. At the Mt. Ozzard site, the Bonanza Group occurs with hornblende-plagioclase gneiss, amphibolite, quartz diorite, and tonalite of the Westcoast Complex (related to the Island Intrusions). The Loon Lake chronosequence is underlain by an older volcanic package (360 million year old Sicker Group) consisting of fine-grained tuffs, breccias, agglomerates, and flows. Both the Renfrew and Red/Granite Creek sites are underlain by the Leech River schist. The unit of schist is composed of a metamorphosed package of rocks that occur in a belt between the San Juan River and Leech River faults.

3.3.3 Overview of surficial geology

Southern Vancouver Island has been glaciated at least three times in the past 1.6 million years. The last glacial event (Fraser Glaciation) occurred from about 29 000 to 10 000 years ago (Alley and Chatwin 1979). Glacial ice covered the entire area of southern Vancouver Island and scoured away much of the previous glacial and interglacial deposits. Only surficial materials and features that are related to the Fraser Glaciation and post glacial processes of the last 10 000 years are widespread. Post–glacial geological processes may include destructive events such as avalanches and landslides to innocuous effects such as weathering, soil creep, and slow flows. All of these processes are potentially hazardous and may impose some physical restrictions to activity on the land base.

Southern Vancouver Island lies at the southwestern limit of the extent of glacial ice that formed on Vancouver Island and the Coast Mountains. The present landscape has been modified by erosional and depositional processes associated with glaciation. The direction of ice movement was generally in a south-southwest direction. It tended to be in a southwesterly direction in the Alberni valley and south along the San Juan Ridge. Ice movement trended toward the southeast in the Cowichan Valley (Halstaed 1968).

As ice advanced down the Strait of Georgia and surrounding lowlands a widespread deposit of sand and silt accumulated in front of the southward–moving ice mass. This material underlies many areas of the Nanaimo Lowlands. Ice covered the entire region of southern Vancouver Island and during the stage of maximum ice coverage, the only material deposited was till. Glacial till was deposited at the base of the ice sheet and is widespread along valley bottoms and the lower reaches of slopes, but it also occurs on subdued mountainous topography. Till thins to a veneer upslope and is often found intercalated with or overlain by colluvium. Till generally has a compact, sandy matrix and the coarse fragments (pebbles and cobbles) are dominated by lithologies of Vancouver Island. At higher elevations a low percentage of coarse fragments is derived from the Coast Mountains. In some drainages, such as San Juan, Klanawa, and Nitinat river valleys, and Loss, Kirby, and Muir creeks, glaciolacustrine clay underlies till. These deposits are interpreted to have formed as ice filled the Juan de Fuca Strait, damming streams that flowed off the coastal slope.

As the climate began to warm and the glaciers began to downwaste and recess, large amounts of water were released and channelled into streams and rivers. These deposits are characterized by their variability but tend to consist of gravel and sand. Silt and clay were washed further away from the glaciers and deposited in the sea. At that time the sea level was as much as 175 m higher than at present. As the land mass rebounded upwards after ice melting and sea level fell (relatively), these deposits were exposed along the lowlands of Vancouver Island. It is here where some of the best agricultural soils developed on Vancouver Island.

During the last 10 000 years, post–glacial processes have continued to shape the land base. Fluvial materials have been transported and deposited by channelized water. Downcutting by streams and rivers has locally incised through older sediments or bedrock forming terraces and deep canyons. Fluvial floodplains, fans, and deltas are sites of deposition of fluvial sand and gravel. Colluvial deposits have accumulated downslope due to movement of material by gravity. Colluvium derived from and overlying unconsolidated material is difficult to distinguish from the parent material. The colluvium is relatively loose and may be slightly stratified parallel to the slope upon which it resides. Organic material occurs in local depressions and poorly drained sites.

3.4 Climate

3.4.1 Overview of climate of the Coastal Western Hemlock zone

All of the study plots are located within the Coastal Western Hemlock (CWH) biogeoclimatic zone. On average, the CWH is the rainiest biogeoclimatic zone in British Columbia, with relatively cool summers (though hot dry spells can be frequent) and mild winters. The mean annual temperature is about 8°C (ranging among subzones from 5.2 to 10.5°C), while the mean monthly temperature is above 10°C for close to half the year (Table 2). The mean temperature of the coldest month is about 0.2°C (ranging from -6.6 to 4.7°C). The mean annual precipitation for the zone is 2228 mm (ranging from 1000 to over 4400 mm). The portion of total precipitation falling as snow ranges from under 15% in the south to as much as 50% in the north. The index on continentality, a measure of the differences in annual temperature, ranges from a low of 3 on the outer west coast to 16 for the mountainous interior. (Pojar et al. 1991).

Table 2. Means and standard deviations (in parentheses) of selected climate characteristics for biogeoclimatic units present in the study area (after Klinka et al. 1991)

	Biogeoclimatic unit					
Climatic parameter	**CDFmm**	**CWHxm1**	**CWHxm2**	**CWHmm**	**CWHvm**	**CWHvh**
Number of stations for precipitation data	112	69	12	13	34	28
Mean annual precipitation (mm)	1233 (368)	1425 (326)	1969 (387)	2349 (453)	2787 (680)	2951 (657)
Mean precipitation April-Sept. (mm)	289 (98)	346 (79)	462 (128)	470 (50)	752 (200)	890 (193)
Mean precipitation of the driest month (mm)	30 (12)	37 (10)	49 (20)	45 (5)	75 (21)	96 (22)
Mean precipitation of the wettest month (mm)	210 (64)	238 (63)	322 (63)	400 (75)	436 (103)	431 (113)
Number of stations for temperature data	73	46	8	13	21	21
Mean annual temperature (°C)	9.6 (0.5)	9.4 (0.5)	8.8 (0.7)	5.7 (0.9)	8.2 (1.1)	8.2 (0.9)
Mean temperature of the coldest month (°C)	2.3 (1.0)	1.8 (0.8)	1.4 (1.5)	2.2 (1.1)	0.3 (2.7)	3.0 (1.4)
Mean temperature of the warmest month (°C)	17.0 (0.8)	17.0 (0.7)	16.5 (0.7)	14.1 (1.0)	16.0 (1.1)	13.9 (0.8)
Number of months with mean temperature >10°C	5.5 (0.5)	5.4 (0.5)	5.2 (0.5)	3.9 (0.5)	4.8 (0.6)	4.4 (0.7)
Index of continentality[a]	12 (3)	13.8 (2.5)	13.1 (4.5)	16 (2)	14 (6.1)	3 (2)

[a] Index of continentality = $[1.7(\text{mean } T_{JULY} - \text{mean } T_{JAN})/\sin\theta] - 20.4$, where T = temperature (°C) and θ = degrees of latitude (from Pojar et al. 1991).

3.4.2 Climates of the east–side chronosequences

The chronosequences on the drier, warmer eastern side of southern Vancouver Island are all in the CWHxm subzone (Nuszdorfer et al. 1992). The Victoria Watershed South and Nanaimo chronosequences are in the rather drier, slightly warmer CWHxm1 variant; the Koksilah and Loon Lake chronosequences are in the rather wetter, slightly cooler CWHxm2 variant. The Victoria Watershed North site straddles the boundary between the two variants. The CWHxm is somewhat warmer and considerably drier than the CWHvh and CWHvm on the west side of the island. In the CWHxm1 and CWHxm2, respectively, the mean annual precipitation is 1425 mm and 1969 mm, and the mean precipitation from April to September is 346 mm and 462 mm. The mean precipitation of the driest summer month is 37 mm and 49 mm, respectively, and of the wettest winter month, 238 mm and 322 mm, respectively. The respective mean annual temperatures are 9.4°C and 8.8°C. The mean temperature of the warmest month is 17°C in the CWHxm1 and 16.5°C in the CWHxm2, and the mean temperature of the coldest month was 1.8°C and 1.4°C, respectively. The mean number of months with a mean temperature above 10°C is 5.4 and 5.2, respectively. For the subzone as a whole, historical temperature maximums range from 29.4 to 43.9°C; minimums range from -13.5 to -25.6°C. The mean annual snowfall ranges from 26 to 234 cm, and the frost–free period ranges from 137 to 244 days. The index of continentality is 13.8 for the CWHxm1 and 13.1 for the CWHxm2 (Green and Klinka 1994).

3.4.3 Climates of the west–side chronosequences

The chronosequences on the wetter, cooler western side of southern Vancouver Island (Red/Granite Creek, Renfrew, Nitinat, Klanawa, and Mt. Ozzard) are mostly within the CWHvm subzone, but at Renfrew some of the plots are slightly within the map area of the CWHvh subzone (Nuszdorfer et al. 1992). Both of these subzones are somewhat cooler and far wetter than the CWHxm on the east side of the island. In the CWHvh the climate is somewhat more moderate in temperature, but wetter, than in the CWHvm. For the CWHvh and CWHvm, the mean annual precipitation is 2951 mm and 2787 mm, respectively. In the CWHvh and CWHvm, respectively, mean precipitation from April to September is 890 mm and 752 mm. The mean precipitation of the driest summer month is 96 mm and 75 mm, respectively, and of the wettest winter month 431 mm and 436 mm, respectively. The mean annual temperature is 8.2°C in both subzones. The mean temperature of the warmest month is 13.9°C in the CWHvh and 16.0°C in the CWHvm and those of the coldest month, 3.0°C and 0.3°C, respectively. The mean number of months with a mean temperature above 10°C is 4.4 in the CWHvh and 4.9 in the CWHvm. Historical temperature maximums range from 22.8 to 37.8°C in the CWHvh and from 27.8 to 41.1°C in the CWHvm; minimums range from -7.5 to -17.2°C in the CWHvh and from -8.9 to -22.8°C in the CWHvm. The mean annual snowfall ranges from 25 to 272 cm in the CWHvh and from 20 to 548 cm in the CWHvm. The frost–free period ranges from 163 to 265 days in the CWHvh and from 165 to 252 days in the CWHvm. The index of continentality is 3 for the CWHvh and 14 for the CWHvm (Green and Klinka 1994).

4. Component Studies and Methods

This section provides brief summaries for all studies conducted on the Coastal Forest Chronosequence plots over the period 1992 – 1997. The studies are grouped into three broad categories: ecosystem characterization and structure, ecosystem process, and biodiversity. Ecosystem characterization and structure studies are primarily concerned with describing the edaphic and woody structure of the sites and plots. Results from the site characterization are summarized as part of this report. More detailed studies of ecosystem process and biodiversity were directed at areas in which Canadian Forest Service employees had expertise; this expertise was supplemented with contracts, graduate student theses, and post–doctoral research. In the brief descriptions below, the Canadian Forest Service collaborators or scientific authority are indicated in square brackets in the author list following the study title.

As previously indicated, many of the studies were conducted solely on three intensive sites on east Vancouver Island though some of the general survey studies were done on both east and west island sites. The list of plots examined in each study is summarized in Table 3. Abbreviations for the chronosequence sites mentioned in the text are: VWN = Greater Victoria Watershed North; VWS = Greater Victoria Watershed South; KOK = MacMillan Bloedel Cowichan Koksilah; NAN = Nanaimo River; LOON = Loon Lake; REN = Renfrew; RGC = Red/Granite Creek; KLA = Klanawa; OZZ = Mt. Ozzard; NIT = Nitinat; Abbreviations for forest ages (or seres) are: IMM = Immature; MAT = Mature; OLG = Old growth; and REG = Regeneration. Plot numbers are listed in Appendix I.

To minimize interference between the different studies at the intensive sites, 10 × 10 m subplots were assigned to different collaborators depending upon the nature and type of sampling and measurements (Figure 3). For some of the study descriptions that follow, the subplots sampled are given and identified by a two-character code, A-E for subplots in the west to east direction, and 1–6 for subplots in the north to south direction. Most of the studies listed were initiated in 1992 and lasted 1–2 years, though some began in 1995. The length of the studies ranged from 1 to 4 years.

4.1 Ecosystem Description and Structure

Biogeoclimatic classification (BGC) is a system designed in B.C. and used widely by the B.C. Ministry of Forests for ecologically based land management. According to the BGC system, ecosystems are classified at: the regional, climatic level (zones, subzones, and variants); at a local edaphic level (site units); and at a chronological, temporal level (forest succession, seral stage). At the regional level, biogeoclimatic zones, subzones and variants are influenced by similar climates and are distinguished by patterns of vegetation particularly the dominant major tree species and understory vegetation communities. The distribution of BGC subzones and variants for the Vancouver Forest Region has been compiled on a map and the locations of the chronosequence sites are described in section 3.1.2.

At the local (site association) level, ecosystem characteristics are influenced by physical environmental factors such as soil characteristics and slope position which in turn determine soil moisture and nutrient availability. Ecosystem classification was conducted for selected plots (Table 3) using the methods of Luttmerding et al. (1990) and include descriptions of environmental site characteristics (Section 4.1.1), soil description and chemistry (Section 4.1.2), general stand characteristics (Section 4.1.3), and Indicator vegetation species (Section 4.1.4). All sample plots for the site and vegetation descriptions were 20 × 20 m (0.04 ha) with the exception of the intensively studied plots where the 60 × 60 m (0.36 ha) plot size was used. Results for each plot are provided in Appendices III – VI. Summaries by site and sere are presented in Section 6.

Following the 1993 workshop, personnel from the B.C. Ministries of Forests and Environment, Lands and Parks working on the Forest Practices Code Biodiversity Guidelines requested more detailed analysis of the stand structure, age distributions, and canopy gap distributions on these plots. In 1994, a series of studies (Sections 4.1.5 – 4.1.7) were proposed to examine the structural attributes of these stands. Work began on these studies in 1995 with funding provided by Forest Renewal B.C.

le 3. Chronosequence plots examined by the various component studies for the period 1992 – 1997. See text for further details on the various lies. Plot type indicates if the plot established was survey type (S) or an intensive type (I) (Figure 3) plot.

	EAST (CWHxm)																										
	VWS								VWN						KOK					NAN					LOON			
umber	1	2	3	4	5	6	7	8	11	12	13	14	15	16	21	22	23	24	25	31	32	33	34	35	41	42	43	44
ype	I	I	S	S	I	I	S	S	I	I	I	S	I	S	I	I	I	I	S	S	S	S	S	S	S	S	S	S
ystem description																												
characteristics	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	x	x	x	x	.	.	.	.
description	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	x	x	x	x	.	.	.	.
d description	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	x	x	x	x	.	.	.	.
ator species	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	x	x	x	x	.	.	.	.
opy gap fraction	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	.	x	x	x	.	.	.	.
d structure	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	.	x	x	x	.	.	.	.
ages	.	.	.	.	x	x	.	.	.	.	x	.	x	.	.	.	x	x	.	.	.	x	x	.	.	.	.	.
stem processes																												
on & nutrient content	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	.	x	x	x	.	.	.	.
on & nutrient form	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	.	x	x	x	.	.	.	.
microbial activity	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
benvironment	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
gical diversity																												
t communities	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
mycorrhizae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.
atodes	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
les & spiders	x	x	.	.	x	x	.	.	.	.	.	.	.	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
p fauna	.	.	x	.	x	x	.	x	x	x	.	x	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
r microarthropods	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
nworms	x	x	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
manders	.	.	.	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
gal sporocarps	.	.	x	.	x	x	.	x	x	x	.	x	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.
er canopy lichens	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	.	x	x	x	.	.	.	.
st health survey	x	x	.	.	x	x	.	.	x	x	x	.	x	.	x	x	x	x	.	x	.	x	x	x	.	.	.	.

	WEST (CWHvm)																					
	REN				RGC				NIT					KLA					OZZ			
umber	51	52	53	54	61	62	63	64	71	72	73	74	75	81	82	83	84	85	91	92	93	94
ype	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
ystem description																						
characteristics	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
description	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
d description	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
ator species	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
opy gap fraction	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
d structure	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
ages	.	.	x	x	.	.	x	x	.	.	x	x	.	.	.	x	x	.	.	.	.	.
stem processes																						
on & nutrient content	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
on & nutrient form	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
microbial activity	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
benvironment	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
gical diversity																						
t communities	.	.	.	.	.	.	.	.	x	x	x	x	.	x	x	x	x	.	x	.	x	x
mycorrhizae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
atodes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
les & spiders	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
p fauna	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
r microarthropods	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
nworms	.	.	.	.	.	.	.	.	x	x	x	x	.	x	x	x	x	.	x	.	x	x
manders	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
gal sporocarps	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
er canopy lichens	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.
st health survey	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.

4.1.1 Plot environmental characteristics

Blackwell, B.A. (B.A. Blackwell and Associates), Porter, G. (Madrone), [Trofymow, J.A.]

Plot site description forms of Luttmerding et al. (1990) were completed for each plot (Blackwell 1993a, unpublished report) to document the environmental characteristics of each plot including its site association, location, elevation, aspect, slope position, exposure, surface shape, trophotope, hygrotope, terrain, soil classification based on interpretation of regional soil maps, and soil summary characteristics from the soil description (see Section 4.1.4). Information for each plot was then entered into the PC-VTAB program (Emanuel 1990; Kayahara 1992) to calculate site and sere mean and ranges for each subzone. Individual plot level data for each site are provided in Appendix III and summaries by site (Table 5) and sere (Tables 6) are discussed in Section 6.1.

4.1.2 Soils description and chemistry

Blackwell, B.A. (B.A. Blackwell and Associates), Porter, G. (Madrone), [Trofymow, J.A.]

Soil great groups were identified according to the Canadian system of soil classification (Agriculture Canada Expert Committee on Soil Survey 1987) by excavating a soil pit to a depth of 60 cm or more where possible and recording the data on the soil description form of Luttmerding et al. (1990). The following soil characteristics were described (Blackwell 1993a, unpublished report): forest floor classification (after Klinka et al. 1981), horizon types and depth, soil texture, drainage, root size and distribution, and soil colour by depth. Soil descriptions for each plot grouped by site are provided in Appendix IV.

As part of the total ecosystem C and nutrient distribution survey (Section 4.2.1) mineral soils were sampled by depth (0–10 cm, 10–30 cm, 30–50 cm) at each of the four subplots centres (Blackwell 1992b, unpublished report), volumes were recorded for bulk density determinations, and soils were returned for nutrient analysis. Twelve samples of forest floor organic matter (LFH) were also taken (three at each of the subplots), volumes were recorded in the field, and samples were returned for nutrient analysis (Trofymow 1993, unpublished report). Variables measured on the LFH sample included total oven dry (70°C) mass, pH, %C, %N, %P, %Sulphur(S). Total oven dry (70°C) <6 mm mass and <2 mm mass were determined on the mineral soil samples and subsamples taken to determine soil texture, soil colour, pH, %C, %N, %P, %S, cation exchange capacity (CEC), %Iron (Fe) + Aluminum (Al), exchangeable calcium (Ca), magnesium (Mg), and potassium (K). Surface organic horizon (LFH) chemistries (pH, C/N ratio, %C, total N kg/ha) and 0–30 cm mineral soil chemistries (pH, C/N ratio, %C, %Fe + Al, total N kg/ha, and Ca + Mg + K kg/ha) for each plot are provided in Appendix IV. Results are summarized by site (Table 7) and sere (Table 8) and discussed in Section 6.2.

4.1.3 Stand description

Blackwell, B.A. (B.A. Blackwell and Associates), Porter, G. (Madrone), [Trofymow, J.A.]

Mensurational variables (DBH, height to live crown and total height) (Luttmerding et al. 1990) for all dead trees and living trees at least 3 m by species and class (suppressed, intermediate, co-dominant, and dominant) were measured primarily to estimate plot biomass (Blackwell 1992b, unpublished report). Increment cores of six to eight of the dominant trees in each plot were also taken to estimate stand age. Within each plot three of the four previously established subplots centres were used for the tree inventory plots which were either 78.5 m^2 or 314 m^2 (circular plots with 5.0 or 10.0 m radius, respectively), depending upon stand density. For the 10-m plots a minimum of 10 trees was required. In regeneration plots and in some other plots, trees less than 3 m in height contributed significantly to the biomass. These trees were inventoried by measuring total height and caliper at 5 cm from the base of the tree. All trees were tagged in 1992 and tags were checked and retagged if necessary during a foliar and branch sampling in 1995. Stand summary mensurational characteristics (stand density, basal area, mean DBH, mean height, maximum height, mean age of dominants) for each plot grouped by site are provided in Appendix V and results summarized by sere (Tables 9a, 9b) and discussed in Section 6.3. More detailed analysis of the stand characteristics including examination of the age, diameter, and height class distributions were undertaken as part of the stand structural attribute studies described in section 4.1.6.

4.1.4 Indicator plant species

Blackwell, B.A. (B.A. Blackwell and Associates), Porter, G. (Madrone), [Trofymow, J.A.]

Within each plot at eight sites (VWS, VWN, KOK, NAN, REN, RGC, NIT, KLA) (Table 3) all significant indicator species were recorded (Blackwell 1993a, unpublished report) according to the vertical layer (dominant tree, main canopy tree, understory tree, tall shrub, low shrub, herb, mosses/liverworts/lichens) percent cover, vigour and distribution. Data were then entered into the PC-VTAB program (Emanuel 1990; Kayahara 1992) to prepare a consolidated vegetation species list (Appendix VII) and vegetation species tables for each plot grouped by site (Appendix VI). Summary indicator vegetation species tables by site (Table 10) and by seral stage (Table 11) were prepared along with similarity matrices (Tables 12 and 13) and results are discussed in Section 6.4.

4.1.5 Canopy gap fractions and leaf area index

Measurement of canopy gap fraction distribution and effective leaf area index in chronosequences of coastal forests
Fraser, G.; Lertzman, K. (Simon Fraser University), [Trofymow, J.A.]

Forest canopy structure has long been known to play a significant role in the determination of understory microclimate. Gap fraction and leaf area index (LAI) are particular measures of canopy structure that have received increased attention as useful variables in various models of mass and energy balance. In total 24 plots were measured in the immature, mature, and old-growth seral stage plots at each of eight sites (VWS, VWN, KOK, NAN, REN, RGC, NIT, KLA) (Table 3). Gap fraction distribution and effective LAI were measured using hemispherical photography and the LAI-2000 Plant Canopy Analyzer. All field measurements took place between August 8 and September 12, 1995. Seven subplots were established in each plot, a central plot and six additional subplots 30 m away and each separated by 60° of azimuth. A hemispheric photo was taken at each subplot centre (seven photos for each plot) and measurements with the LAI-2000 PCA instrument were made at six stations in each in each of the seven subplots (42 readings in each plot). A technical report on canopy photos and methods of data analysis has been prepared (Fraser et al. 1997) as has an unpublished report on the LAI-2000 measurements (Trofymow and Leach 1996, unpublished report). A paper comparing the two methods is in preparation (Frazer, G.W.; Trofymow, J.A. Optical measurement of gap fraction distribution and effective leaf area index in coastal western hemlock chronosequences: A comparison of two hemispheric methods. Can. For. Serv., Pac. For. Cent., Victoria, B.C. In preparation.).

4.1.6 Stand structural attributes

Overstory structure and coarse woody debris in chronosequences of coastal forests
Blackwell, B.A. (Blackwell and Associates), Wells, R. (University of British Columbia), [Trofymow, J.A.]

Understanding stand structural attributes in old forests and how they change with stand succession is important in developing better guidelines for managing these attributes in second-growth forests. A detailed analysis of the stand characteristics, including examination of the species, diameter, and height class distributions of living and dead trees was undertaken as part of this study as well as examination of the size, species, and decay class distributions of the downed coarse woody debris. Field measurements were made on all seres at eight sites (VWS, VWN, KOK, NAN, REN, RGC, NIT, KLA) as part of the ecosystem C and mass distribution study (Section 4.2.1). Separate reports on the coarse woody debris data (Wells and Trofymow 1997) and overstory (Hedberg, H.; Blackwell, B.A.; Trofymow, J.A. Overstory structure in chronosequences of coastal forests (CWHvm and CWHxm). Can. For. Serv., Pac. For. Cent. Victoria, B.C. In preparation.) will be published in 1997 and a paper synthesizing the stand structural attribute, stand age and canopy gap fraction data is planned for 1998.

4.1.7 Tree ages

Tree ages and dendrology in coastal forest chronosequences
Zhang, Q. (University of Victoria), [He, F.; Trofymow, J.A.]

Ringwidths of increment core samples from 20 to 30 trees in each of the mature and old-growth plots at eight sites (VWS, VWN, KOK, NAN, REN, RGC, NIT, KLA) were measured. The data were used to produce tree-ring chronologies, to determine tree age distributions, and to calculate past 10-year basal area growth increments of the trees. An interim report has been produced (Zhang 1996, unpublished report) and the results will be incorporated into the synthesis paper on stand structure to be prepared in 1998.

4.2 Ecosystem Processes

The diverse and highly productive forests of the Pacific and Yukon Region are increasingly being perceived as significant elements of the global biosphere. The forests of B.C. alone contain 40% of Canada's wood volume (Bonnor 1985). The living C reservoir in B.C. forests is 5 billion tonnes (Kurz et al. 1992), and could be a major element of Canada's carbon budget (Kurz et al. 1992). The use and management of these forests are viewed by some as indicators of national responsibility in the context of the global atmospheric environment.

An understanding of the biological roles of forests, and of how they are affected by forestry practices, is needed for rational land use decision–making. This is especially evident for coastal forests, where productivity and biomass accumulations are high. Unfortunately, the principles underlying the biological roles of coastal forests are poorly understood. We do know, however, that some coastal forests are sensitive to disturbance. Harvesting, silviculture, and post-harvesting practices strongly influence succession, growth, formation of detritus, and decomposition These processes determine the organic structure of the forest and are strongly associated with nutrient conservation, the hydrologic cycle, and provision of habitat for a multitude of organisms. It is generally assumed that the productive capacity and biological diversity of a forest diminish with harvest. Less readily acknowledged is the restoration of these values as trees become re-established, as productivity becomes diffused among more elements of the ecosystem, and as habitat for organisms becomes more diversified. We do know, however, that some sites — especially those with low nutrient capital — are sensitive to disturbance. This has made their capacity to sustain repeated harvest the subject of some concern (Kimmins 1985).

The overall objective of the various ecosystem process studies is to establish how attributes of sustainable forestry, and specifically nutrient dynamics and C retention, are affected by harvesting and other practices, and identify opportunities for enhancing these attributes through forest management.

4.2.1 Carbon, mass, and nutrient distribution

Ecosystem C and nutrient contents in age sequences of coastal forest on southern Vancouver Island
Blackwell, B.A. (B.A. Blackwell and Associates), [Trofymow, J.A.]

Plant and tree biomass, coarse woody debris, forest floor organic matter, and soils were measured to determine changes in site C and nutrient contents with succession. On eight chronosequences (VWS, VWN, KOK, NAN, REN, RGC, NIT, KLA) (Table 3) mineral soil (0–10 cm, 10–30 cm, 30–50 cm) and forest floor organic matter (LFH) were sampled at four subplots; sub-plot centre points are defined by the centre and ends of the triangular plot. Samples were returned for chemical analyses as described is Section 4.1.2. The triangular plot sides were used as three 50-m transects for measurements of coarse woody debris by the line intercept method (Trowbridge et al. 1989), and of forest floor class and depth. Two samples of wood of each species, size, and decay class were returned for determination of density and C, N, P, and S concentrations. Fine woody debris (<1 cm) and live plant materials were harvested from four 1-m^2 quadrats, one adjacent to each subplot centre. Samples were returned, oven dry weight determined (70°C) and subsamples ground for determination of total %C, %N, %P, and %S (Trofymow 1993, unpublished report). Tree biomass estimates were made by measuring trees in subplots the centre and two of the three triangle endpoints in each plot as described in Section 4.1.3.

Published biomass regression equations were used to calculate mass of each overstory component for each tree based on its diameter and height (Blackwell 1993b, unpublished report). Initial analysis of the data revealed problems in overstory nutrient content calculations based on literature values of nutrient concentration in various overstory components (Trofymow and Blackwell 1994).

To improve overstory estimates, breast height bark samples, wood increment cores and branches from the sixth to eighth whorl of three trees of each species in each plot were also collected in the fall of 1995 (Blackwell 1996, unpublished report). The branches were separated into twigs and current and non-current needles; nutrient concentrations (C, N, P, S) were determined on each component (Trofymow 1996, unpublished report). Measurements, sampling, and chemical analyses of overstory branch samples were completed by March 1996 and the combined and revised results are to be reported starting in 1997.

4.2.2 Organic carbon and nutrient transformations

Transformations of organic carbon and nutrient pools in forest ecosystems of coastal British Columbia.
[Preston, C.; Trofymow, J.A.]

Understanding how soil C and nutrient dynamics change with secondary succession and how they function in low-productivity sites requires knowledge of the chemical identity of the material in the various pools and their transformations. Chemical investigations aim to characterize the nature of organic C in forest floor, coarse woody debris and mineral soil fractions using C-13 CPMAS NMR and extractable soil organic P pools using P-31 CPMAS NMR. Samples from four seres at six sites (VWS, VWN, KOK, REN, NIT, KLA) (Table 3) collected as part of the C and nutrient distribution survey (Section 4.2.1) were examined. A draft paper on coarse woody debris chemistries has been completed (Preston, C.; Trofymow, J.A.; Niu, J.; Fyfe, C.A. CPMAS 13C CPMAS NMR spectroscopy and chemical analysis of coarse woody debris in coastal forests of Vancouver Island. Can. For. Serv., Pac. For. Cent., Victoria, B.C. submitted.) and additional papers and reports on soil organic C and P are in preparation.

4.2.3 Microbial activity and detrital carbon fluxes in Douglas-fir

Soil respiration and microbial activity in coastal old-growth and managed Douglas-fir forests.
[Trofymow, J. A.]

Understanding the changes in detrital C fluxes as forests develop is critical to improving the accuracy and reliability of C budget models. Other than losses from stand disturbances such as harvesting or fire, C is lost from the soil and detrital pools primarily as CO_2 through the respiration of roots and soil organisms, the latter respiring C derived from the decomposition of plant detritus. The activity and respiration of roots and soil organisms is controlled primarily by soil temperature and moisture. At the three intensive sites (VWS, VWN, KOK) (Table 3) a 4-year study was established to determine the effect of seral stage on rates of aboveground litter fall, litter decomposition, microbial activity, and soil respiration. During the year of intensive sampling (VWN -1993/94, VWS -1994/95, KOK - 1995/96, once a season at all three site 1996/97), CO_2 evolution was measured once a month over a 1-day period using NaOH base traps. Every three months samples of forest floor were taken adjacent to the traps and the amounts and activity of the heterotrophic populations monitored by substrate-induced respiration and basal respiration using a multichannel infrared gas analyzer. Rates of aboveground litter fall were measured over the entire 4 years using 10 litter traps per plot, sampled every 3 months. To integrate the effects of stand and site conditions on cumulative decay rates over the 4-year period, a litter bag experiment was installed in October 1992 in all 12 plots using seven different combinations of material type (Douglas-fir needles, hemlock wood blocks, hemlock wood chips), mesh size (0.4 or 5.0 mm), or placement (forest floor surface or buried 10–15 cm below surface). The bags were sampled after 12, 24, 36, and 48 months. To determine annual decay rates, aspen chopsticks were installed in October 1992 at the surface or buried, sticks replaced each year, and mass loss determined. Reports from this study will be available commencing in 1998.

4.2.4 Microenvironments in Douglas-fir

Predicting variation in surface and soil microenvironmental conditions in age sequences of coastal Douglas-fir forests.
[Benton, R.; Trofymow, J.A.]

Changes in vegetative or forest cover can greatly influence (1) the near surface microenvironment through their effects on the amount of insolation penetrating the canopy and on wind speed, and (2) the surface soil microenvironment through their effects on net precipitation and insolative heat gain. Since May 1993, soil temperature, moisture, and weather measurements using data loggers and electronic sensors were made for the entire period in the regeneration plots at all three of the Douglas-fir dominated CWHxm sites (VWS, VWN, KOK) (Table 3). Weather data collected include daily and monthly air temperature, humidity, precipitation, and solar radiation. Thermistors and moisture blocks were installed at three soil depths (LFH/soil interface, 10 cm, and 50 cm) to measure soil temperature and moisture on a daily maximum, minimum, and average basis. In successive years additional microenvironment stations were installed in the three other seres within a chronosequence to measure air temperature, humidity, soil temperatures, and soil moistures. Monitoring of all four seres in a site commenced with VWN (1993/94), VWS (1994/95), KOK (1995/96) with all seres at all three sites monitored in the final year (1996/97). Although soil moisture blocks can be monitored continuously their calibration requires data from other methods. Thus, in the chronosequence under study the daily soil moisture measurements were supplemented with monthly measurements of volumetric soil moisture by neutron probe at 10, 20, 40, and 50 cm. Four access tubes, one in each subplot were installed in each plot adjacent to areas where soil respiration, microbial biomass, and litter decomposition were measured (Section 4.2.3). The data will be crucial for interpreting results from the various studies underway on those plots. The data will help to determine how much of the variation observed between seres and sites is due to microenvironment and how much is due to direct effects of stand development (i.e., differences in vegetation or other ecological processes). In addition to reporting the results of the 4 years of data, the database will also be used to calibrate and test some existing soil temperature and water balance models (eg. Spittlehouse and Black 1981; Arp and Yin 1992). Such calibrated models could then be used to extend results to similar forest types in the region. Reports on the first 4 years of data will become available commencing in 1998.

4.3 Biological Diversity

The sustainability of forest resources and their utilization depend on many ecological processes. These processes result from activities of the entire complement of forest organisms. Among the most important are invertebrates and microorganisms inhabiting the soil and soil surface. Numbering many thousands of named and unnamed species, they perform a vital role in decomposing litter by transforming the dead organic matter into a complex web of new substances and food chains that characterize much of the edaphic environment. These organisms are essential to the productivity, high level of biodiversity, and homeostasis of undisturbed forests (Marshall 1993). Little is known about these decomposer organisms or about the “non-crop” flora, and how they interact and influence the healthy functioning of forest ecosystems.

In addition to the role played by these organisms in ecosystem productivity and stability, Burton et al. (1992) listed four other reasons for promoting biodiversity: (1) non-timber values, notably the securing of furs, foods, and pharmaceutical products; (2) the use of indicator species in monitoring and predicting ecological changes; (3) the retention of alternative resources for future use as insurance against economic and climatic changes; and (4) for esthetic and ethical considerations. Foresters and other land managers must recognize all these biological assets and learn how to manage them.

A prerequisite to proper management of biodiversity is an inventory of all biological components. This is currently difficult in forests because of the many species expected to be present in any given ecosystem. Consequently, we have started with a catalogue of relevant and interesting groups whose taxonomy is well known or where expertise is available. Canadian Forest Service expertise has been supplemented with contracts, graduate student theses, and post-doctoral research.

4.3.1 Plant communities

Plant diversity and indicators of ecosystem recovery of Douglas-fir and western hemlock forests in Vancouver Island chronosequences following conversion of old-growth to second-growth
Ryan, M., Fraser, D.F. (Arenaria Research and Interpretation); [Marshall, V.G.; Pollard, D.F.W.; He, F.]

Between 1992 and 1995, plant diversity was studied in six chronosequences: KLA, KOK, VWN, VWS, OZZ, and NIT (Table 3). In each sere, all plants species (including bryophytes and lichens) in the core plots were identified and percentage cover of each species visually estimated. Each core plot was divided into four quarters; in each quadrant sampling transects were drawn at 5, 15, and 25 m from the plot centre. Plant specimens were collected for subsequent species verification. In addition, two species, *Allotropa virgata* and *Hemitomes congestum*, were assessed as indicators of ecosystem recovery. An unpublished report has been prepared (Ryan and Fraser 1994) and a scientific publication is in preparation.

4.3.2 Ectomycorrhizae in Douglas-fir

Diversity of ectomycorrhizal fungi in old–growth and second–growth stands of Douglas–fir on Vancouver Island
Goodman, D. (University of Victoria); [Trofymow, J.A.]

Between 1992 and 1995, ectomycorrhizas were studied at KOK and at a site near Goldstream Lake just south of VWS in MAT and OLG seres to relate the distribution of ectomycorrhizal fungi to stand age and soil environment. Soil cores, 5 cm in diameter and 15 cm deep, were taken from seven different habitats including stumps, logs, forest floor on rock, and forest floor and mineral soil distant and adjacent to dominant trees. Ectomycorrhizal root systems were carefully cleaned of adhering material and the number of tips counted and the ectomycorrhizae described, photographed, and separated into “morphotypes” by numerous morphological features. In some cases fungal species were identified if the descriptions matched published descriptions or if the mycorrhizae could be traced to a sporocarp. A Ph.D. dissertation was completed (Goodman 1995), descriptions of some ectomycorrhizal types published (Goodman and Trofymow 1996; Goodman et al. 1996) and two journal papers are completed or in review (Goodman and Trofymow 1998; Goodman, D.M. and Trofymow, J.A. 1998. Distribution of ectomycorrhizas in micro-habitats in mature and old-growth stands of Douglas-fir on southeastern Vancouver Island. Soil Biol. Biochem. submitted.).

4.3.3 Nematode diversity in Douglas-fir

Soil nematode abundance and diversity in successional stages of Douglas-fir forests
Panesar, T.S. (Royal Roads University); [Marshall, V.G.; Barclay, H.]

The nematode study involved two phases: a preliminary sampling of eight “soil-rhizosphere” habitats in the old-growth forests at KOK and VWS, and a sampling of “soil under salal” in all four seres of the three chronosequences at KOK, VWS, and VWN. In the first phase (October 1991 and February 1992), soil-rhizosphere habitats were randomly selected in areas outside the study plots. In the second phase, soil sampling was carried out in July and December 1993. In each sere nine samples were taken randomly at three locations: one inside the core plot and two outside at distances of 30 – 50 m from its border. The quadrates (10 × 10 m subplots, Figure 3) sampled inside the plots at each site were: VWS (plots 1, 2, 5, 6) 1C; VWN (plots 11, 12, 13, 15) 6F for REG, 3A for IMM, and 1C for MAT and OLG; KOK (21, 22, 23, 24) 1C for REG, 6B for IMM, 3A for MAT, and 4B for OLG. Nematodes were extracted by modified Baermann funnels, sorted into functional groups, and identified to genus and species where possible. A journal paper is in preparation (Panesar, T.S.; Marshall, V.G.; Barclay, H. Soil nematode abundance and diversity in successional stages of Douglas-fir forests. Can. For. Serv., Pac. For. Cent., Victoria, B.C. In preparation.).

4.3.4 Carabid beetles and spiders in Douglas-fir

Variation in carabid community structure and litter spiders associated with successional Douglas-fir forests
Craig, K.G., Brumwell, L.J., Scudder, G. (University of British Columbia); [Marshall, V.G.].

Carabid beetle species diversity was compared among the four forest seres at two chronosequences, KOK and VWS. In each sere, three pitfall traps were set out in each of eight quadrates (10 × 10 m subplots, Figure 3) (1C, 2E, 3A, 4B, 4E, 5D, 6B, 6F) for plots 1, 2, 5, 6 at VWS and plots 21, 22, 23, 24 at KOK. Beetles and spiders were collected from June 1992 to August 1993, but data collected after May 1993 were not analyzed. Two M.Sc. Theses have been completed (Craig 1995, Brumwell 1996) and manuscripts for journal publication are in preparation.

4.3.5 Douglas-fir stump fauna

Succession of Collembola in stumps of Douglas-fir seres representing clearcuts to old-growth forests
Setälä, H. (University of Jyväskylä, Finland); [Marshall,V.G.]

The natural succession of stump Collembola was studied in all seres in three chronosequences: KOK, VWN, and VWS. In each sere, three decay stages of stumps were sampled and Collembola were extracted by high gradient funnels. Each decay stage was not always plentiful; therefore, stumps were selected at random anywhere in the experimental area near the core plot. Sampling was carried out in September and October 1991 and January and April 1992 in the following plots: 3, 11, 21 for REG; 5, 12, 22 for IMM; 6, 14, 23 for MAT; and 8,15, 24 for OLG. Published results are available (Setälä and Marshall 1994; Setälä et al. 1995).

4.3.6 Douglas-fir litter microarthropods

Soil microarthropod diversity in old-growth and managed coastal forests
Addison, J. (Royal Roads University); [Trofymow, J.A.]

To better understand the effects of stand development on rates of decomposition and the types of organisms affecting litter decay the microbial biomass and abundance and diversity soil fauna were examined in a subset of the bags from the 4-year (1992–1996) litterbag study (Section 4.2.3). Litterbags were sampled at 12, 24, 36, and 48 months after placement for determination of cumulative mass loss. As well, subsamples from the Douglas-fir litterbags, wood chips in fine mesh litterbags, wood chips in coarse mesh litterbags, and forest floor adjacent to the bags were taken to measure microbial biomass or extracted by a high gradient apparatus and numbers and species of soil fauna determined. Comparisons of coarse and fine mesh bags will test for the effects of macrofauna on decomposition. Reports from this study should be available commencing in 1998.

4.3.7 Earthworms

Taxonomy and ecology of native and introduced earthworm fauna in coastal forests
Fender, W.; [Marshall, V.G.].

A preliminary survey showed that earthworms were too sparse to be reliably surveyed in some chronosequences. Therefore, earthworm abundance was studied in all seres of three chronosequences only: KLA, OZZ and NIT in April and November 1994. Worms were hand-sorted from 10 pits selected in a Z-shaped transect across the slope of the experimental area. Pits measured 100 × 50 cm on the surface, were at least 10 m apart, and avoided trees and rock outcrops. Specimens were counted in the field, preserved in 4% formalin, and brought to the laboratory for species confirmation. Some results have been included in McKey-Fender et al. (1994). Two other manuscripts are in preparation.

4.3.8 Salamanders in Douglas-fir

Differential resource use, interspecific interactions, and the effects of logging on the distribution and abundance of terrestrial salamanders on southern Vancouver Island
Davis, T.M. (University of Victoria); [Marshall, V.G.; Pollard, D.F.W.]

Between 1992 and 1995, salamander populations were studied in different sites on southern Vancouver Island. Only one of these (VWS) is in the chronosequences (near plots 3, 5, 6, 8). These plots represent IMM, MAT, OLG and REG, respectively, and have been located near water and not in the core plots. Plot 8 is no longer included in the main set chronosequence plots, but is a regeneration site near plot 7. Artificial cover objects (ACO) were used to monitor salamander abundance. Six ACOs were established for each sere and data from these were supplemented with time-constrained searches. Specimens were collected and stomach contents examined for an analysis of differential prey use. Some results have been published and a Ph.D. dissertation was completed (Davis 1996).

4.3.9 Mushroom diversity in Douglas-fir

Sporocarp surveys in age-sequences of coastal Douglas-fir.
Countess, R., Kendrick, B. (University of Victoria); [Trofymow, J.A.]

Fungi are an important group of organisms with a variety of ecological roles in forests including: parasites or pathogens of trees; mycorrhizal symbionts with trees; decomposers of dead plant materials; and food sources for many animals including insects and other arthropods, molluscs and mammals. A survey, commenced in the fall of 1995 and expanded in 1996 and 1997 examined the diversity of macrofungi sporocarps in all four seres of the three intensive east island sites (VWS, VWN, KOK) (Table 3). Sections of the 40 × 40 m trail established at these plots were used as the base of four 20-m transects through each plot. All fungal sporocarps with caps greater than 2 cm in diameter within 2 m of the trail were counted and identified. Smaller fungi were assayed in 2 × 2 m quadrates randomly established along the transects. Fungal surveys were conducted monthly with all 12 plots examined within an 8-day period. An M.Sc. thesis of the study is to be completed in 1998.

4.3.10 Upper canopy lichens

Upper forest canopy lichen diversity in age-sequences of forests of southern Vancouver Island
Enns, K. (Larkspur Biological Consultants); [Trofymow, J.A.]

Branch samples from the upper canopy (sixth to eighth whorl) collected in fall 1995 as part of the nutrient distribution study (Section 4.2.1) were examined and the numbers of lichen species present tallied. Branch samples had been collected from three individuals of each species in each of the 24 plots at the four east (VWS, VWN, KOK, NAN) and four west (REN, RGC, NIT, KLA) island sites (Table 3). This undirected sampling was supplemented with a more detailed directed field survey of the KOK site in the fall 1996 which examined boles and fallen branches. Comparison between the two would help determine how many more species could be expected to be obtained with the directed sample effort. A contract report on the study was completed (Enns, K.A.; Trofymow, J.A. Lichens of coastal forest chronosequences of southern Vancouver Island. Unpublished contract report. Can. For. Serv., Pac. For. Cent., Victoria, B.C.) and a final report on the study should be published in 1998.

4.3.11 Forest health surveys

Forest health surveys of coastal forest chronosequences on southern Vancouver Island
[Garbutt, R., Humphreys, N., Allen, E.]

Insects and diseases can strongly influence tree growth and forest productivity; severe outbreaks can greatly impact the successional trajectory of the stand and its structural attributes. In the spring of 1995 technicians with the Forest Health Network of the Canadian Forest Service were asked to examine selected plots at eight sites (VWS, VWN, KOK, NAN, REN, RGC, NIT, KLA) (Table 3) and report on any current or chronic insect and disease problems that may influence the growth and condition of the plot trees. Work began in 1995 with examination of plots on east Vancouver Island and continued in 1996 and 1997 with examinations of the west coast plots. Reports from the initial field survey of the all east island sites and west island sites have been prepared (Garbutt and Humphreys 1997, unpublished report). A final report is expected in 1998.

5. Plot Descriptions by Chronosequence

The following section summarizes the general environmental characteristics for each chronosequence and its plots. Appendices at the end of the report contain detailed tabulations of the site characteristics (Appendix III), soil descriptions and chemistry (Appendix IV), stand descriptions (Appendix V), and indicator vegetation species (Appendix VI) for each plot grouped by chronosequence.

5.1 East Island Sites

5.1.1 Victoria Watershed South

The Victoria Watershed South site is located on gentle to moderate slopes covered by a mantle of till with a well-drained gravelly sand matrix. Local prominences of bedrock protruding through the surficial cover give the slope some surface irregularity. Soils within the plots are Orthic Dystric Brunisols and some Duric Dystric Brunisols, fine-silty to coarse-loamy (or loamy) in family particle size, with mainly moder and some mull humus forms. The average elevation of the plots is 303 m. The plots are in the Very Dry Maritime (Eastern) CWH variant (CWHxm1) and the zonal CWHxm1/01 (Western hemlock – Douglas-fir – Kindbergia) site series, except one plot intermediate between the 01 and the moister 07 (Western redcedar – Foamflower) site series. Forests in the area contain a mix of second-growth stands of varying age of harvest origin adjacent to a large intact area of old-growth forest (Figure 7). The area is administered by the Greater Victoria Water District (Table 4). Refer to 1:20, 000 map sheet 92B052.

The regeneration plot (01) is on gently sloping (15%) morainal material with a concave surface profile. The plot, at 280 m elevation, is on an upper slope position and faces northeast. The site is mesic and mesotrophic, and the soil is a well-drained Orthic Dystric Brunisol overlain by a mull-like moder (Bernier 1968) humus form. The site series is the zonal CWHxm1/01 (Western hemlock – Douglas-fir – Kindbergia).

The immature plot (02) is on moderately steeply sloping (40%) morainal material with a straight surface profile. The plot, at 305 m elevation, is on a mid-slope and faces northeast. The site is mesic and mesotrophic, and the soil is a well-drained Orthic Dystric Brunisol overlain by a conifero-typical moder (Bernier 1968) humus form. The site series is the zonal CWHxm1/01 (Western hemlock – Douglas-fir – Kindbergia).

The mature plot (05) is on gently sloping (11%) fluvial material with a straight surface profile. The plot, at 315 m elevation, is on a lower slope and faces southeast. The site is subhygric and permesotrophic, and the soil is a moderately well–drained Duric Dystric Brunisol overlain by a conifero-zoomull (Bernier 1968) humus form. The site appears to be transitional from the zonal 01 towards the moister 07 (Western redcedar - Foamflower) site series.

The old-growth plot (06) is on moderately steeply sloping (40%) morainal material with a straight surface profile. The plot, at 390 m elevation lies on a mid slope and faces is northeast. The site is submesic and mesotrophic; the soil is a well-drained Orthic Dystric Brunisol overlain by a mull-like moder (Bernier 1968) humus form.

Table 4. Land tenures and company contacts for the various chronosequence plots, as of June 1997

Site	Plots	Map	TFL	Licensee/Administrator	Office	Contact	Contact Phone
Victoria Watershed South	1, 2, 3, 4, 5, 6, 7, 8	92B052	(a)	Greater Victoria Water District	479 Island Highway, Victoria, B.C. V9B 1H7 (250) 474-9600	Gordon Joyce	(250) 474-9600 ext. 121
Victoria Watershed North	11, 14, 15, 15	92B062	(a)	Greater Victoria Water District	479 Island Highway, Victoria, B.C. V9B 1H7 (250) 474-9600	Gordon Joyce	(250) 474-9600 ext. 121
	12		46	TimberWest Honeymoon Bay Operation	1537 Chaplin St. Crofton, B.C. V0R 1R0 (250) 246-3232	Tom Jones	(250) 749-6805
	13		(b)	MacMillan Bloedel South Island Woodlands Div.	P.O. Box 271, Cassidy, B.C. V0R 1H0 (250) 245-6300	Carl Blumensaat	(250) 245-6331
Koksilah	21, 22, 23, 24, 25	92B062	44	MacMillan Bloedel South Island Woodlands Div.	P.O. Box 271, Cassidy, B.C. V0R 1H0 (250) 245-6300	Carl Blumensaat	(250) 245-6331
Nanaimo River	31, 32, 33, 34, 35	92F010	44	MacMillan Bloedel South Island Woodlands Div.	P.O. Box 271, Cassidy, B.C. V0R 1H0 (250) 245-6300	Carl Blumensaat	(250) 245-6331
Loon Lake	41, 42, 43, 44	92F027	44	MacMillan Bloedel Franklin Woodlands Div.	Port Alberni, B.C. V9Y 7N3 (250) 720-4200	Greg Ferris	(250) 720-4228
Renfrew	51, 52, 53, 54	92C058	46	TimberWest Honeymoon Bay Operation	1537 Chaplin St. Crofton, B.C. V0R 1R0 (250) 246-3232	Tom Jones	(250) 749-6805
Red/Granite Creek	61, 62, 63, 64	92C059	46	TimberWest Honeymoon Bay Operation	1537 Chaplin St. Crofton, B.C. V0R 1R0 (250) 246-3232	Tom Jones	(250) 749-6805
Nitinat	71, 72, 73, 74, 75	92C087	44	MacMillan Bloedel Franklin Woodlands Div.	Port Alberni, B.C. V9Y 7N3 (250) 720-4200	Greg Ferris	(250) 720-4228
Klanawa	81, 82, 83, 84, 85	92C086	44	MacMillan Bloedel Franklin Woodlands Div.	Port Alberni, B.C. V9Y 7N3 (250) 720-4200	Greg Ferris	(250) 720-4228
Mt. Ozzard	91, 92, 93, 94, 95	92C093	44	MacMillan Bloedel Kennedy Lake Div.	Ucluelet, B.C. V0R 3A0 (250) 726-3600	Shawn McLennan	(250) 726-3616

(a) Lands administered by the Greater Victoria Water Board.

(b) Private holding.

Note: All sites are within the B.C. Ministry of Forests South Island District: 4227 6th Ave., Port Alberni, B.C. V9Y 4N1; Phone (250) 724-9205.

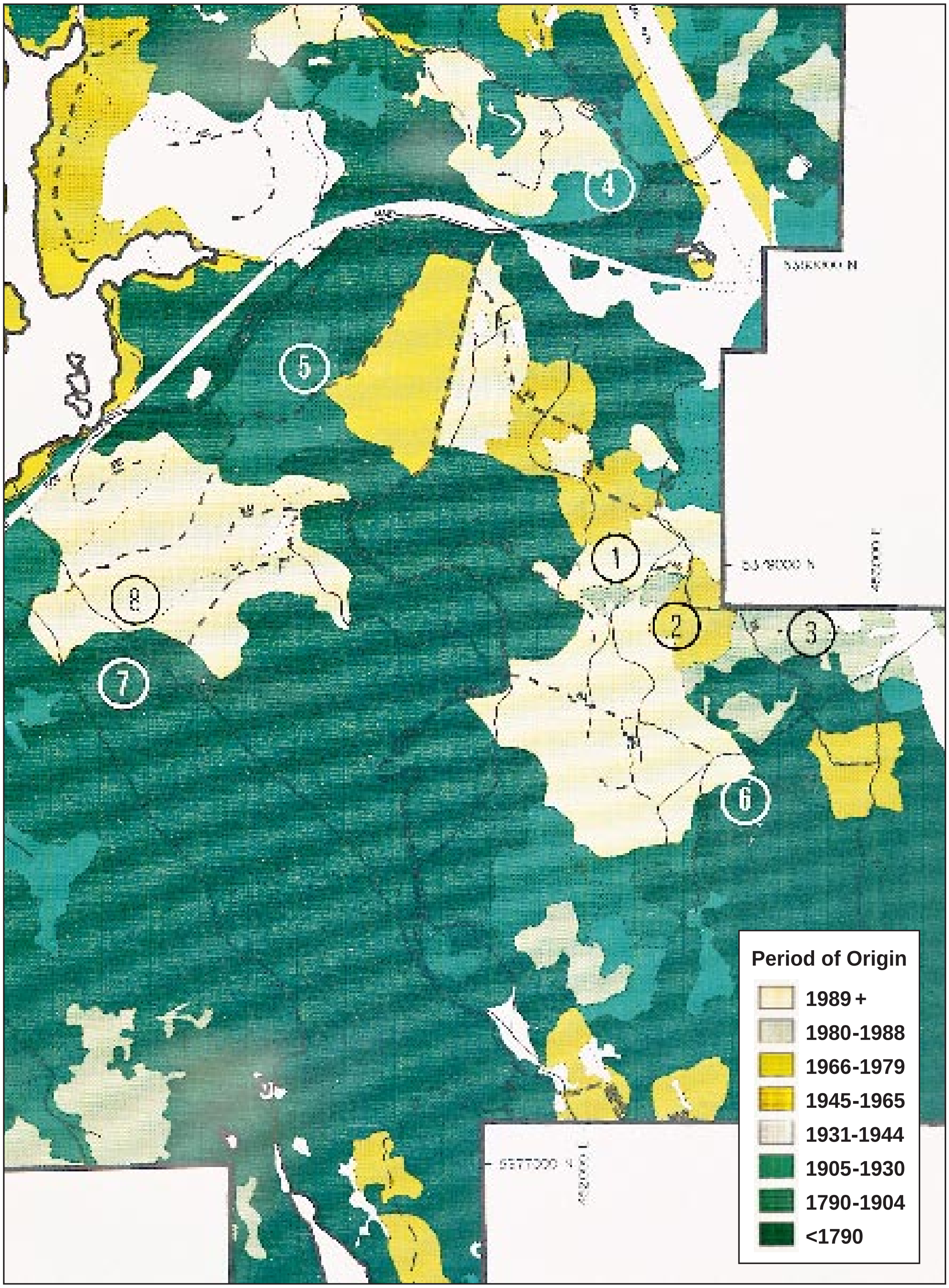

Figure 7. Map (1:20 000) of the Greater Victoria Watershed South (VWS) chronosequence showing stand ages and plot locations. Base thematic map produced by H. Hamilton and Associates

5.1.2 Victoria Watershed North

The Victoria Watershed North plots are located on the gently to moderately sloping middle portions of irregular hill slopes, with an average elevation of 382 m. The area is covered by a mantle of till with a well-drained coarse sand matrix, and has bedrock outcrops at the surface. Soils within the plots are Orthic Humo–ferric Podzols and Duric Dystric Brunisols in a variety of family particle sizes, with humi-fibrimor (Bernier 1968) humus forms. All plots are well-drained, mesic, and mesotrophic. The area is in the Very Dry Maritime (Western) CWH variant (CWHxm2), and the plots all belong to the zonal CWHxm2/01 (Western hemlock – Douglas-fir – Kindbergia) site series. Most of the area is covered with second-growth stands of harvest origin though more extensive areas of old-growth forest occur on the southern margin in Greater Victoria Water District lands (Figure 8) The chronosequence spans three tenure holders: TimberWest Forest Ltd. (Tree Farm Licence 46), MacMillan Bloedel, and the Greater Victoria Water District (Table 4). Refer to 1:20, 000 map sheet 92B062.

The regeneration plot (11) is on a 25% slope on morainal material with a concave surface profile. The plot, at 450 m elevation, faces west. The soil is an Orthic Humo-Ferric Podzol with loamy and fine-silty family particle size classes.

The immature plot (12) is gently sloping (5%) on morainal material with a convex surface profile. The plot is at 355 m elevation and faces due north. The soil is a Duric Dystric Brunisol with loamy and sandy family particle size classes.

The mature plot (13) is on gently sloping (15%) morainal material with a straight surface profile. The plot is at 260 m elevation and faces northeast. The soil is a Duric Dystric Brunisol with fine-silty and coarse-loamy family particle size classes.

The old-growth plot (15) slopes moderately (40%) on weathered bedrock with a straight surface profile. The plot is at 465 m elevation, facing southwest. The soil is an Orthic Humo-Ferric Podzol with fine-silty and loamy family particle size classes.

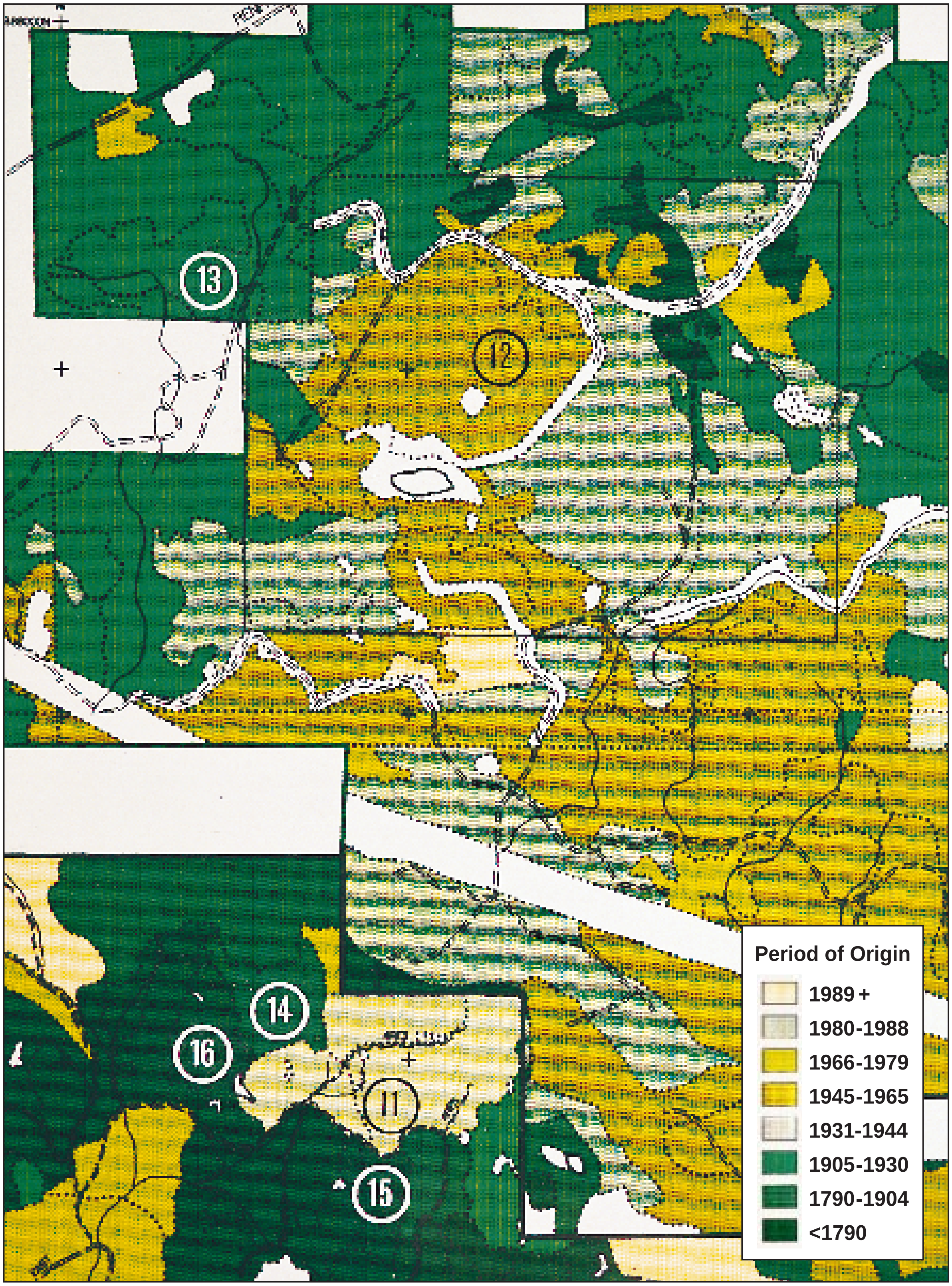

Figure 8. Map (1:20 000) of the Greater Victoria Watershed North (VWN) chronosequence showing stand ages and plot locations. Base thematic map produced by H. Hamilton and Associates with additional digital data provided by TimberWest Associates and MacMillan Bloedel

5.1.3 Koksilah

The plots in the Koksilah area are on gently rolling to hilly topography on middle slopes with a south to southwesterly aspect, at an average elevation of 631 m. A blanket of colluvium with a silty and rubbly texture covers the area. The sites are all rapidly drained. Soils within the plots are Orthic Humo–Ferric Podzols, fine-silty to loamy in family particle size, with hemihumimor (Klinka et al. 1981) humus forms. The area is in the Very Dry Maritime (Western) CWH variant (CWHxm2). Two of the plots are in the zonal CWHxm2/01 (Western hemlock – Douglas-fir – Kindbergia) site series, and two are in the drier CWHxm2/03 (Douglas-fir – Western hemlock – Salal) site series. Most of the area is covered with second-growth stands of harvest origin, with some mature stands of stand–destroying wildfire origin and small patches of remnant old-growth forest (Figure 9). The area is in Tree Farm Licence (TFL) 44, held by MacMillan Bloedel (Table 4). Refer to 1:20, 000 map sheet 92B062.

The regeneration plot (21) is on gently sloping (15%) colluvium with a straight surface profile. The plot is at 595 m elevation and faces south. The site is mesic and mesotrophic. The site series is the zonal CWHxm2/01 (Western hemlock – Douglas-fir – Kindbergia).

The immature plot (22) is on gently sloping (15%) colluvium with a straight surface profile. The plot is at 710 m elevation and faces south. The site is mesic and mesotrophic. The site series is the zonal CWHxm2/01 (Western hemlock – Douglas-fir – Kindbergia).

The mature plot (23) is on moderately sloping (35%) colluvium with a straight surface profile. The plot is located in a stand of wildfire origin at 590 m elevation and faces southwest. The site is subxeric and mesotrophic. The site series is the moderately dry CWHxm2/03 (Douglas-fir – Western hemlock – Salal).

The old-growth plot (24) is on gently sloping (15%) colluvium with a convex surface profile. The plot is at 630 m elevation and faces due south. The site is submesic and submesotrophic. The site series is the moderately dry CWHxm2/03 (Douglas-fir – Western hemlock – Salal).

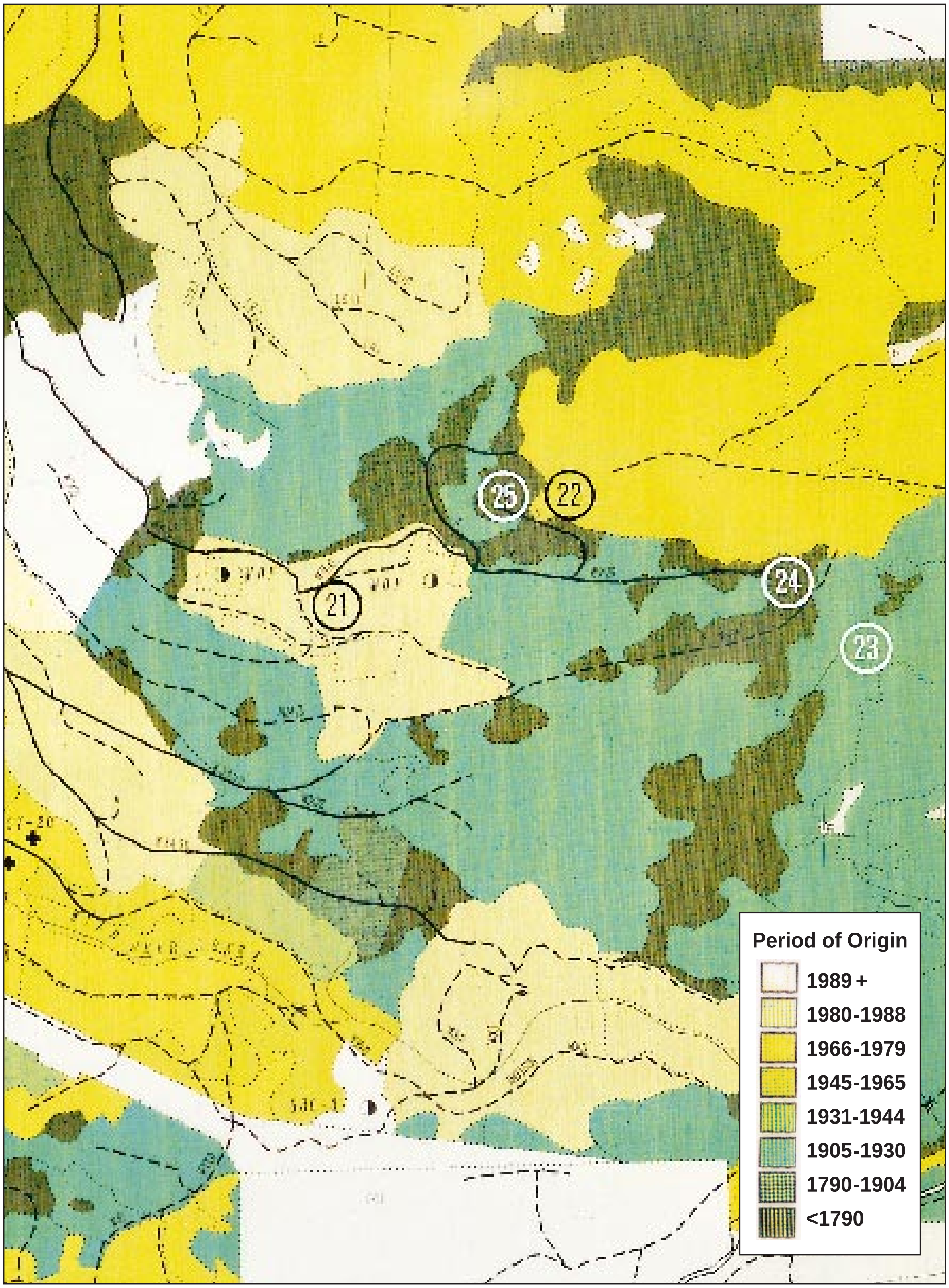

Figure 9. Map (1:20 000) of the Koksilah (KOK) chronosequence showing stand ages and plot locations. Base thematic map produced by MacMillan Bloedel

5.1.4 Nanaimo River

The cluster of plots in the Nanaimo River area is on the mid to upper portions of gentle slopes covered with a blanket of till, at an average elevation of 447 m. Slope aspects range from southeast to southwest. The plots are all well-drained, submesic and submesotrophic. Soils within the plots are all Duric Humo–Ferric Podzols, loamy or fine-silty in family particle size class, with hemihumimor (Klinka et al. 1981) humus forms. The area is in the Very Dry Maritime (Eastern) CWH variant (CWHxm1). All of the plots are in the zonal CWHxm1/01 (Western hemlock – Douglas-fir – Kindbergia) site series. Forests in the area are mostly second growth of harvest origin with some patches of remnant old-growth forest (Figure 10). The area is in MacMillan Bloedel's TFL 44 (Table 4). Refer to 1:20 000 map sheet 92F010.

The regeneration plot (31) is on gently sloping (20%) morainal material with a straight surface profile. The plot, at 460 m elevation, lies on an upper slope position and faces south. Family particle size classes are loamy and fine-silty.

The immature plot (35) is on gently sloping (20%) morainal material with a straight surface profile. The plot, at 440 m elevation lies on a mid slope position and faces southeast. Family particle size classes are loamy and fine-silty.

The mature plot (33) is on gently sloping (20%) morainal material with a straight surface profile. The plot, at 430 m elevation lies on a mid-slope position and faces due south. Family particle size classes are fine-silty and loamy.

The old-growth plot (34) is on gently sloping (25%) morainal material with a convex surface profile. The plot, at 430 m elevation is on a mid slope position and and faces southeast. Family particle size classes are fine-silty and loamy.

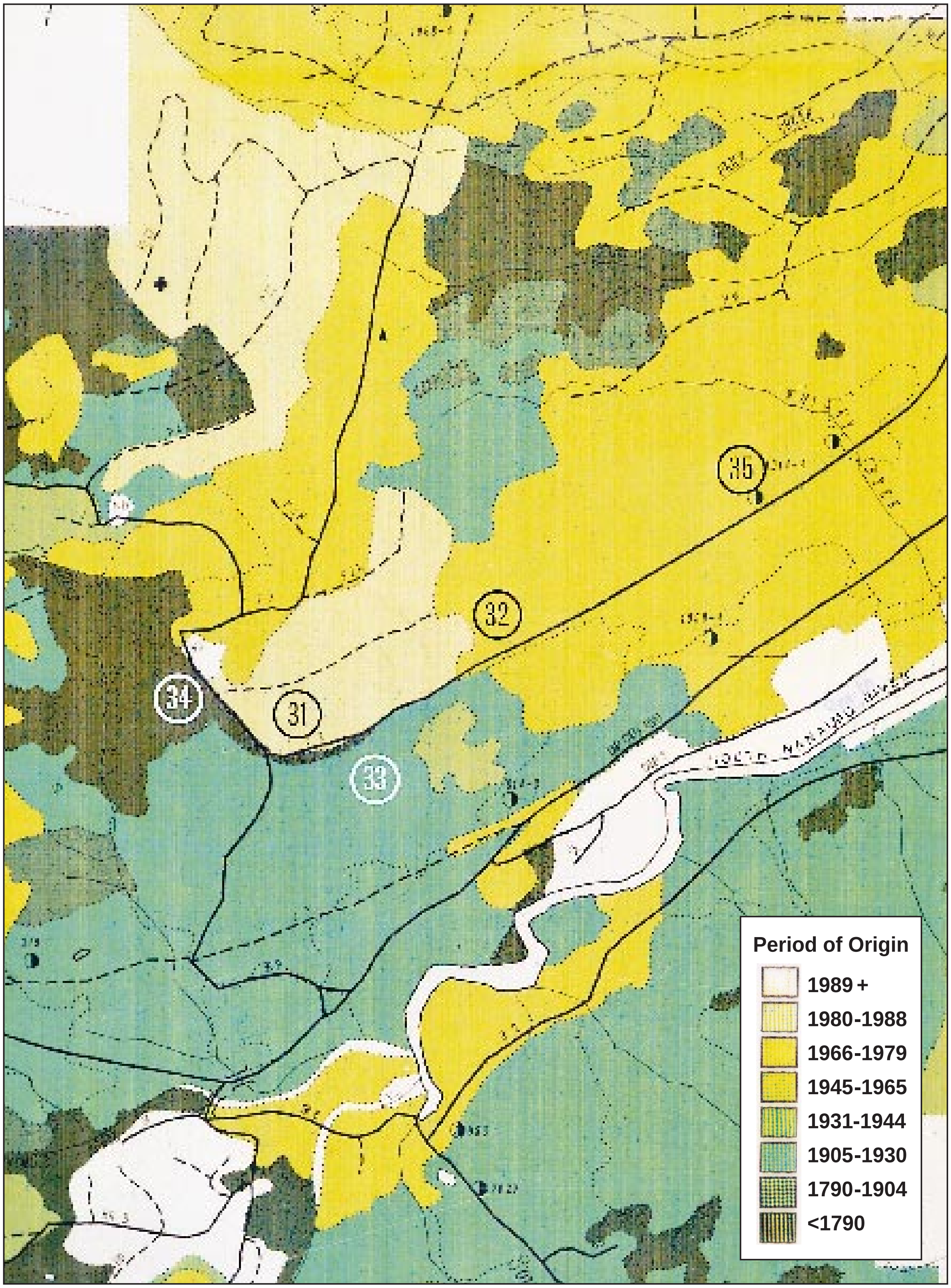

Figure 10. Map (1:20 000) of the Nanaimo River (NAN) chronosequence showing stand ages and plot locations. Base thematic map produced by MacMillan Bloedel

5.1.5 Loon Lake

The plots in the Loon Lake area are located on the mid-slopes of a gently rolling topography having a south to southeast aspect, at an average elevation of 450 m. A mantle of till covers the region but local bluffs of bedrock protrude through the cover. The site is west of the Alberni summit and all plots have some exposure to west winds. Though plots were established, soil and site association data were not collected and are not available. Forests in the area are predominantly second-growth stands of harvest origin and in similar age classes. Most of the old-growth forest is in small patches, though larger areas of old forest are found upslope to the east (Figure 11). The area is in MacMillan Bloedel's TFL 44 (Table 4). Refer to 1:20,000 map sheet 92F027.

The regeneration plot (41) is at 440 m on a moderate slope (42%) with convex surface shape, slightly mounded microtopography and faces east (70°). The immature plot (42) is at 460 m on a moderate slope (40%) with convex surface shape, slightly mounded microtopography and faces south (190°). The mature plot (43) is at 450 m on a steeper slope (80%) with convex surface shape, moderately mounded microtopography and faces east (80°). The old-growth plot (44) is at 440 m on a moderate slope (37%) with straight surface shape, slightly mounded microtopography and faces southeast (106o).

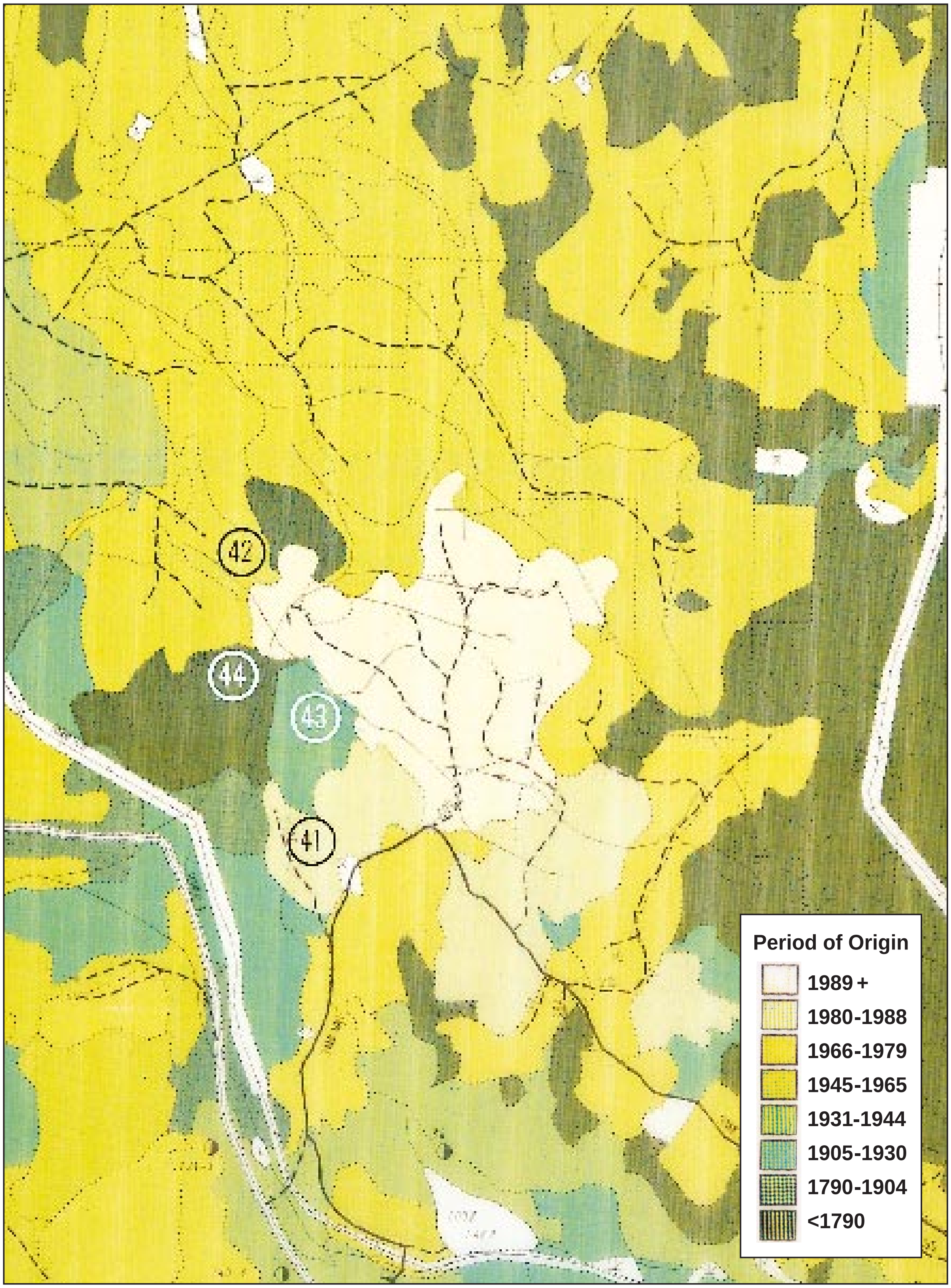

Figure 11. Map (1:20 000) of the Loon Lake (LOON) chronosequence showing stand ages and plot locations. Base thematic map produced by MacMillan Bloedel

5.2 West Island Sites

5.2.1 Renfrew

The four plots south of Port Renfrew are on the middle portions of moderate slopes having a west to nearly north aspect, at an average elevation of 206 m. The moderately strongly rolling, irregular slopes are covered with a blanket of colluvial material. The parent material is comprised of angular fragments in a silty sand matrix. The soils are well to locally poorly drained. Soils within the plots are mainly Orthic Humo–Ferric Podzols with some Gleyed Humo–Ferric Podzols, variable in family particle size, with orthihemimor (Klinka et al. 1981) humus forms. The area is in the transition region between the Very Wet Maritime (Submontane) CWH variant (CWHvm1) and the Very Wet Hypermaritime (Outer) CWH variant (CWHvh1). On floristic grounds it is probably best to regard all plots as being in the CWHvm1, though three of the plots appear to lie within the area mapped CWHvh1 (Nuszdorfer et al. 1992). Much of the forest in the area is second growth of harvest origin, much in immature and mature age classes with old-growth forests confined to larger upslope areas to the south extending over the watershed divide and towards the ocean (Figure 12). The area is in TFL 46, held by TimberWest (Table 4). Refer to 1:20, 000 map sheet 92C058.

The regeneration plot (51) is on moderately steeply sloping (50%) colluvial material with a straight surface profile. The plot is at 240 m elevation and faces northwest. The site is well drained, mesic and mesotrophic, and the soil is an Orthic Humo-Ferric Podzol, overlain by an orthihemimor (Klinka et al. 1981) humus form. Family particle size classes are loamy-skeletal and sandy. The site series is zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry). The plot is very close to the mapped boundary between the CWHvm1 and the CWHvh1, but the elevation is a little high for the CWHvh1. The vegetation, aside from an abundance of deer fern, does not exhibit the characteristics of the CWHvh1.

The immature plot (52) is on moderately steeply sloping (45%) colluvial material with a convex surface profile. The plot is at 135 m elevation and faces north. The site is well drained, mesic and mesotrophic. The soil is an Orthic Humo–Ferric Podzol, overlain by an orthihemimor (Klinka et al. 1981) humus form. Family particle size classes are sandy and loamy. The site series is the zonal CWHvm1/01 (Western hemlock - Amabilis fir - Blueberry). The plot appears to be within the area mapped as CWHvh1, but the characteristic vegetation of the CWHvh1 is not present.

The mature plot (53) is on gently sloping (25%) colluvial material with a concave surface profile. The plot is at 130 m elevation and is north-west facing. The site is well-drained, mesic and mesotrophic, and the soil is an orthic humo-ferric podzol, overlain by an orthihemimor (Klinka et al. 1981) humus form. Family particle size classes are fine-silty and loamy. The site series is the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry). The plot appears to be within the area mapped as CWHvh1, but the characteristic vegetation of the CWHvh1 has not developed.

The old-growth plot (54) slopes moderately (35%) on colluvial material with a straight surface profile. The plot is at 320 m elevation and faces due west. The site is poorly drained, subhygric, and submesotrophic, with a Gleyed Humo–Ferric Podzol soil overlain by an orthihemimor (Klinka et al. 1981) humus form. Family particle size classes are fine-silty and loamy. The site unit is the salal phase (CWHvm1/06s) of the relatively moist CWHvm1/06 (Western hemlock – Amabilis fir – Deer fern) site series.

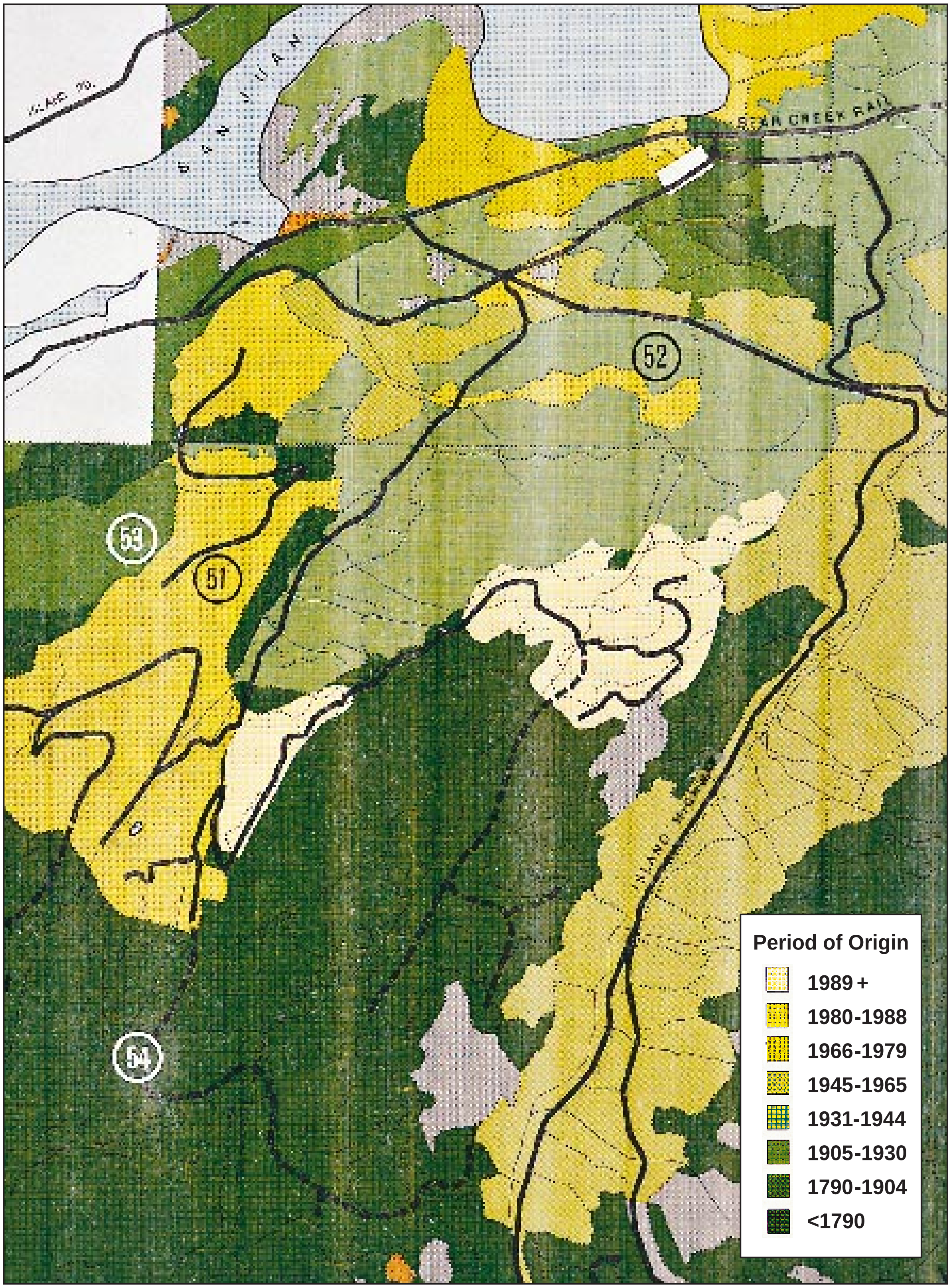

Figure 12. Map (1:20 000) of the Renfrew (REN) chronosequence showing stand ages and plot locations. Base thematic map produced by TimberWest Associates

5.2.2 Red/Granite Creek

This chronosequence spreads out in the San Juan River Valley adjacent to Red and Granite Creek. The slope gradients range from gentle to very steep. Plot aspects are mostly north (one plot faces east). The average elevation is 172 m. The plots are well drained and underlain by a complex of till and colluvium with a silty matrix. Soils within the plots are mainly Orthic Humo–Ferric Podzols with some Duric Ferro–Humic Podzols, fine-silty to loamy in family particle size, with mor and moder humus forms. The chronosequence is in the Very Wet Maritime (Submontane) CWH variant (CWHvm1). Two of the plots are in the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry) site series; the other two are in the more nutrient-rich CWHvm1/05 (Amabilis fir – Western redcedar – Foamflower) site series. Most of the forest is second growth of harvest origin, most in immature age classes with some older-age class stands in riparian areas in the valley bottom. Old-growth forests are confined to remnant patches with larger areas upslope and towards the ridge top (Figure 13). The area is in TFL 46, held by TimberWest (Table 4). Refer to 1:20, 000 map sheet 92C059.

The regeneration plot (61) is on moderately sloping (45%) colluvial material with a convex surface profile. The plot is at 300 m elevation and faces north. The site is well drained, mesic, and mesotrophic, with an Orthic Humo–Ferric Podzol soil overlain by an orthihemimor (Klinka et al. 1981) humus form. Family particle size classes are fine-silty and loamy. The site series is the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry).

The immature plot (62) is on moderately sloping (35%) colluvium with a straight surface profile. The plot is at 130 m elevation and faces due north. The site is well drained, mesic, and eutrophic nutrient status. The soil is an Orthic Humo–Ferric Podzol overlain by an orthimormoder (Klinka et al. 1981) humus form. Family particle size classes are fine-silty and loamy. The site series is the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry).

The mature plot (63) is on gently sloping (10%) till with a straight surface profile. The plot is located in a side valley at 80 m elevation and faces east. The site is well drained, mesic, and mesotrophic, with a Duric Ferro–Humic Podzol soil overlain by an orthihemimor (Klinka et al. 1981) humus form. Family particle size classes are fine-silty and loamy. The site series is the relatively nutrient-rich CWHvm1/05 (Amabilis fir - Western redcedar - Foamflower).

The old–growth plot (64) is on steeply sloping (100%) colluvium with a straight surface profile. The plot is at 180 m elevation and faces due north. The site is well drained, mesic, and permesotrophic, with an Orthic Humo–Ferric Podzol soil overlain by an orthivelomoder (Klinka et al. 1981) humus form. Family particle size classes are sandy and loamy. The site series is the relatively nutrient-rich CWHvm1/05 (Amabilis fir – Western redcedar – Foamflower).

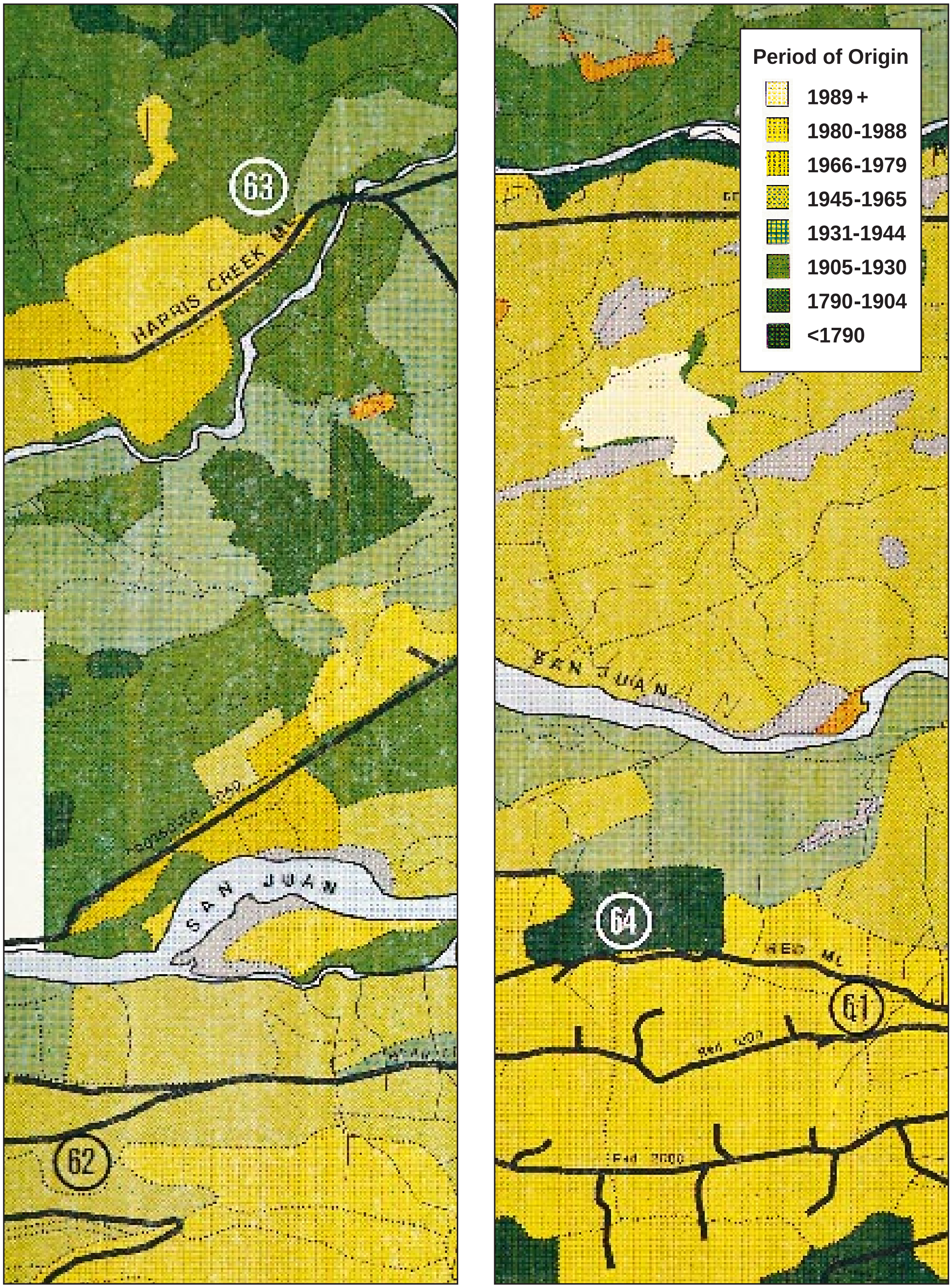

Figure 13. Map (1:20 000) of the Red/Granite Creek (RGC) chronosequence showing stand ages and plot locations. Base thematic map produced by TimberWest Associates

5.2.3 Nitinat

The Nitinat chronosequence is underlain by a rapidly drained colluvial blanket with a gravelly-sandy-silt texture. The plots lie on the mid to lower portions of moderate slopes. The slope aspect is to the southwest and west. The average elevation of the plots is 227 m. Soils within the plots are Orthic Humo–Ferric Podzols, fine-silty to loamy in family particle size, with mainly hemihumimor and some moder humus forms. The area is in the Very Wet Maritime (Submontane) CWH variant (CWHvm1). Two to three site series are represented among the plots. Much of the forest in the area is second-growth of harvest origin, although large areas of old-growth can be found on the steeper sloped areas and bench above the river valley (Figure 14). The area is in TFL 44, held by MacMillan Bloedel (Table 4). Refer to 1:20, 000 map sheet 92C087.

The regeneration plot (71) is moderately sloping (30%) with a concave surface profile. The plot, at 315 m elevation, is on a mid-slope, faces southwest, and exposed to wind. The site is submesic and submesotrophic. Family particle sizes are fine-silty and loamy, and the humus form is hemihumimor (Klinka et al. 1981). The site is in the salal phase (CWHvm1/01s) of the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry) site series.

The immature plot (72) is moderately sloping (45%) with a straight surface profile. The plot, at 185 m elevation, is on a mid-slope, faces southwest and exposed to wind. The site is mesic and mesotrophic. Family particle sizes are loamy and fine-silty, and the humus form is hemihumimor (Klinka et al. 1981). The site series is apparently the relatively dry and nutrient-rich CWHvm1/04 (Western redcedar – Western hemlock – Sword fern), though the difference in vegetation from the zonal site series could reflect seral stage rather than a genuine site difference.

The mature plot (73) is moderately sloping (30%) with a concave surface profile. The plot, at 85 m elevation, is on a lower slope and faces west. The site is mesic and permesotrophic. Family particle sizes are fine-silty and loamy. The humus form seems to have been mis-coded, but is probably a velomoder (Klinka et al. 1981). The site series is the relatively nutrient-rich CWHvm1/05 (Amabilis fir – Western redcedar – Foamflower).

The old-growth plot (74) is moderately sloping (22%) with a straight surface profile. The plot, at 325 m elevation, is on a mid–slope and faces southwest. The site is mesic and submesotrophic, and the humus form is hemihumimor (Klinka et al. 1981). Family particle sizes are fine-silty and loamy. The site is in the salal phase (CWHvm1/01s) of the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry) site series.

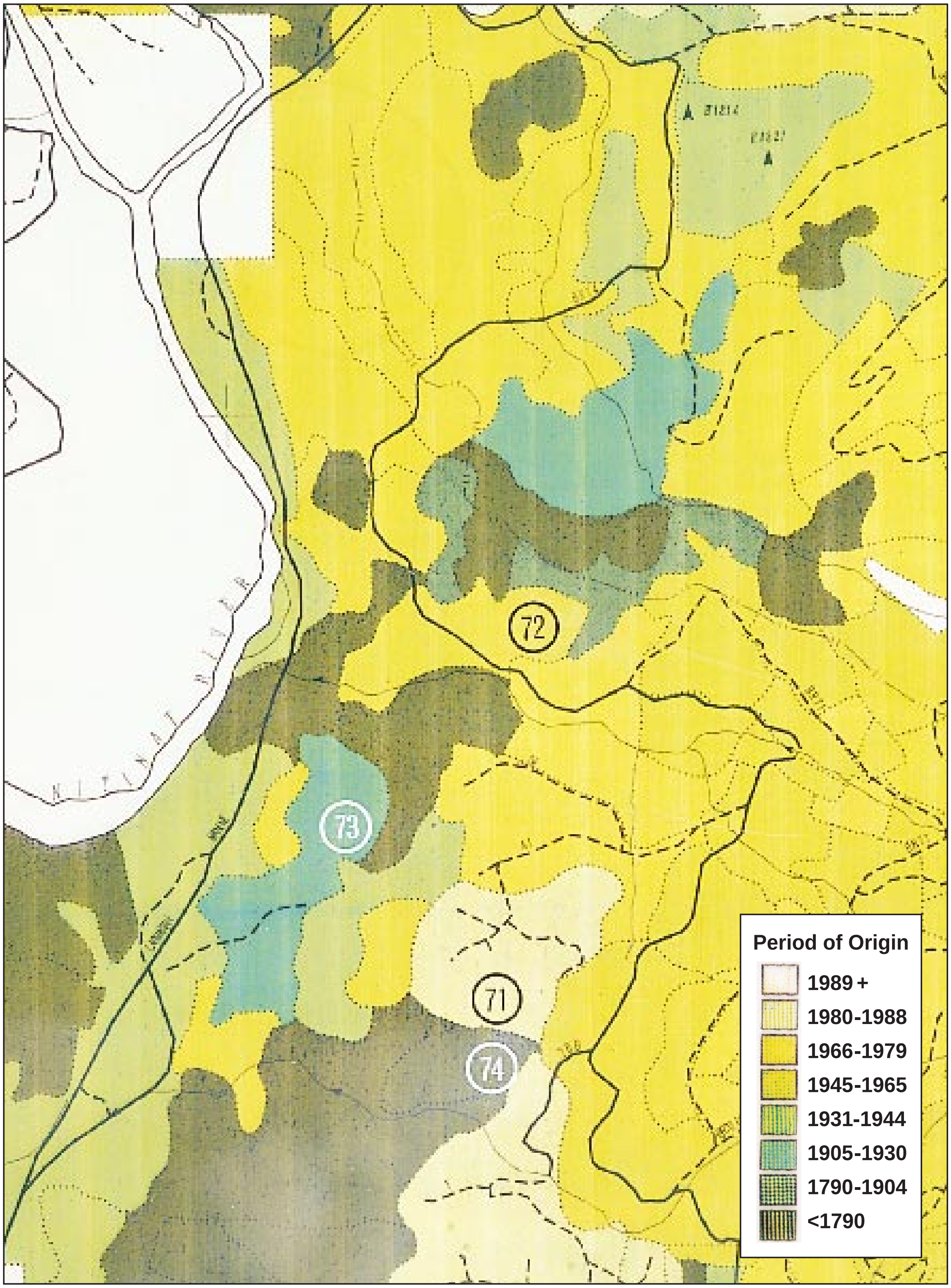

Figure 14. Map (1:20 000) of the Nitinat (NIT) chronosequence showing stand ages and plot locations. Base thematic map produced by MacMillan Bloedel

5.2.4 Klanawa

The plots in the Klanawa area are widely spread but are generally on gentle lower to mid slopes with a mostly northwest (one plot southeast) aspect. The average elevation of the plots is 155 m. The area is strongly rolling to hilly and covered with moderately well to well-drained colluvium having a gravelly sand matrix. Soils within the plots are Orthic Humo-Ferric and Ferro–Humic Podzols, fine-silty to loamy in family particle size, with variable mor humus forms. Two of the plots are in the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry) site series. The other two plots are in the moister CWHvm1/06 (Western hemlock – Amabilis fir – Deer fern) site series. Much of the forest in the area especially along the main river valley is younger second growth of harvest origin, though a large patch of older mature forest of fire origin occurs in the southwest. Old-growth forest is found in a riparian strip with larger areas on the upper slopes and in southern portion of the main valley bottom (Figure 15). The area is in TFL 44, held by MacMillan Bloedel (Table 4). Refer to 1:20, 000 map sheet 92C086.

The regeneration plot (81) is gently sloping (15%) with a straight surface profile. The plot, at 120 m elevation, is on a lower slope, faces northwest and is exposed to wind and cold air drainage. The site is subhygric and mesotrophic. Family particle sizes are fine-silty and loamy, and the humus form is orthihumimor (Klinka et al. 1981). The site is in the relatively moist CWHvm1/06 (Western hemlock – Amabilis fir – Deer fern) site series.

The immature plot (82) is moderately sloping (35%) with a concave surface profile. The plot, at 230 m elevation, is on a mid–slope, faces southeast and is exposed to wind. The site is submesic and mesotrophic. Family particle sizes are fine-silty and loamy, and the humus form is orthihemimor (Klinka et al. 1981). The site is in the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry) site series.

The mature plot (83) is gently sloping (15%) with a convex surface profile. The plot, located in a stand of wildfire origin, is at 120 m elevation, on a lower slope, faces northwest and is exposed to wind. The site is subhygric and mesotrophic. Family particle size is loamy, and the humus form is lignohumimor (Klinka et al. 1981). The site series is the relatively moist CWHvm1/06 (Western hemlock – Amabilis fir – Deer fern).

The old-growth plot (84) is moderately sloping (27%) with a convex surface profile. The plot, at 150 m elevation, is on mid-slope, faces northwest and is exposed to wind. The site is mesic and mesotrophic. Family particle sizes are sandy and loamy, and the humus form is orthihumimor (Klinka et al. 1981). The site is in the salal phase (CWHvm1/01s) of the zonal CWHvm1/01 (Western hemlock – Amabilis fir – Blueberry) site series.

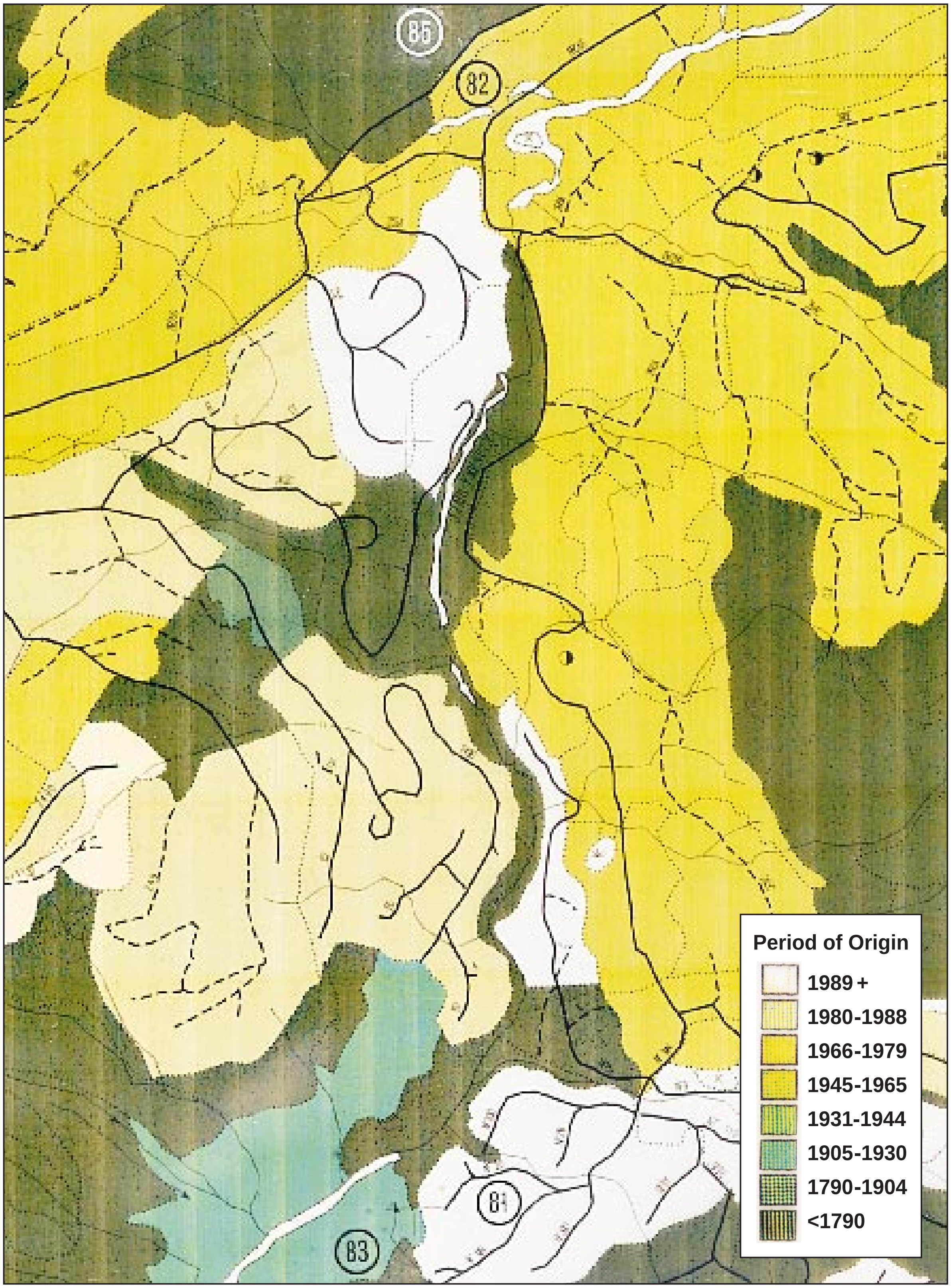

Figure 15. Map (1:23 250) of the Klanawa (KLA) chronosequence showing stand ages and plot locations. Base thematic map produced by MacMillan Bloedel

5.2.5 Mt. Ozzard

The plots in the Mt. Ozzard area are on moderately steep slopes that have a south to southeast or northwest aspect. The average plot elevation is 325 m. All plots are exposed to wind and possibly saltspray at lower elevations. This region is underlain with a blanket of morainal material that is moderately well drained but has local seepage. Although plots were established, soil and site association data were not collected and are not available. Most of the forests in the area are young second growth of harvest origin with patches of more mature forest of landslide origin. Large patches of old-growth forest are found at various elevations (Figure 16). The area is in TFL 44, held by MacMillan Bloedel (Table 4). Refer to 1:20, 000 map sheet 92C093.

The regeneration plot (91) is at 370 m on a moderately steep upper slope (60%) with convex surface shape, slightly mounded microtopography, and faces northwest (200°). The immature plot (93) is at 100 m on a moderate lower slope (30%) with straight surface shape, moderately mounded microtopography and faces southeast (145o). The mature plot (94) is at 390 m on a moderately steep mid-slope (55%) with concave surface shape and slightly mounded microtopography and faces south (190°). The old-growth plot (95) is at 440 m on a moderately steep slope (62%) with straight surface shape, moderately mounded microtopography and faces southeast (160°).

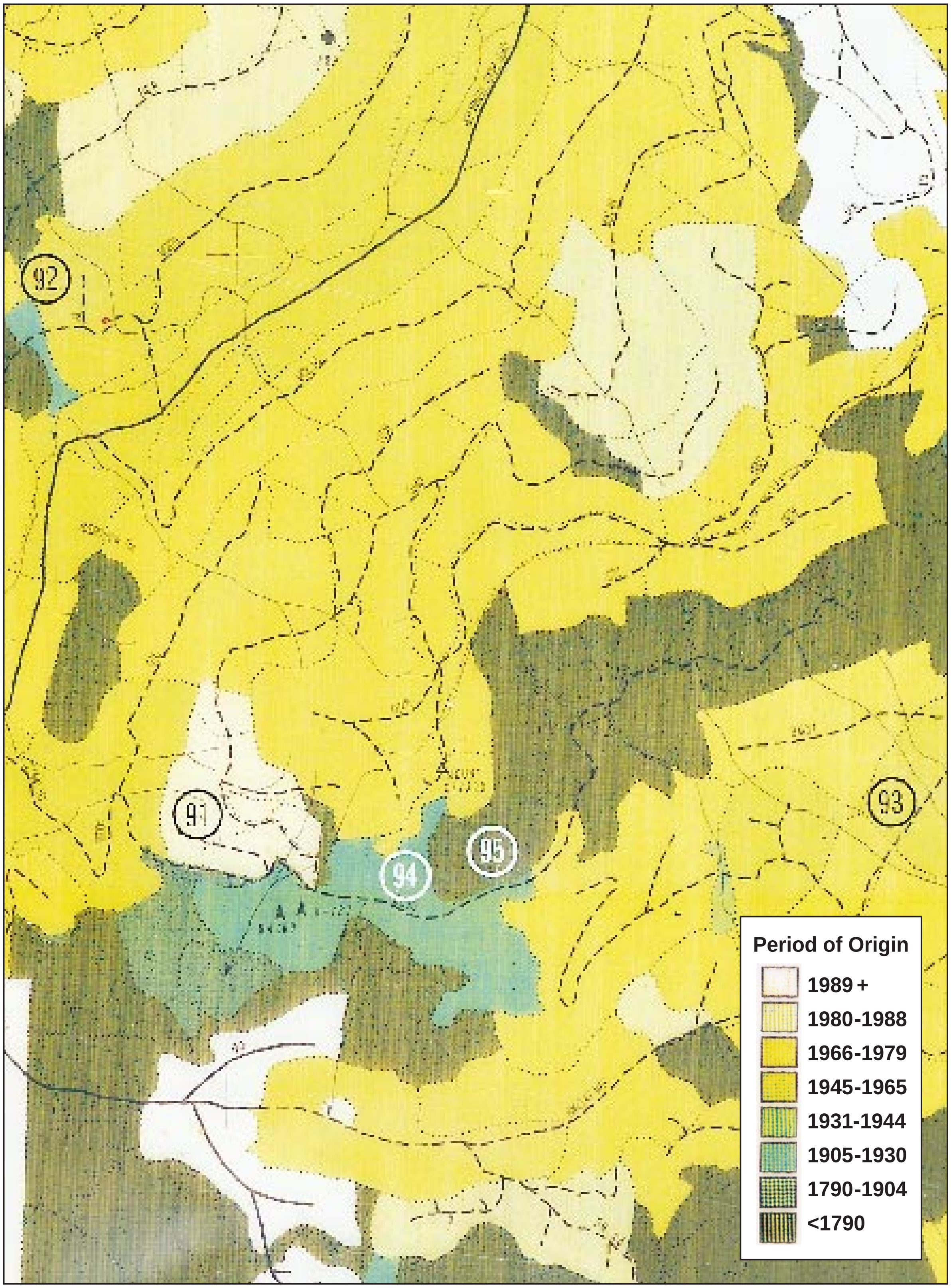

Figure 16. Map (1:20 000) of the Mt. Ozzard (OZZ) chronosequence showing stand ages and plot locations. Base thematic map produced by MacMillan Bloedel

6. Comparisons by Site and Sere

6.1 Environmental Characteristics

The site data for the plots in each of the eight chronosequences are summarized in Table 5. See Appendix III for the full tabulation of chronosequence site data by PC-VTAB (Emanuel 1990) and Appendix IV for soil descriptions for each plot. The site data for the plots in each of the four seral stage categories, with the east-side and west-side chronosequences tabulated separately, are summarized in Table 6.

When plots are grouped by chronosequence (Table 5) there is relatively low variability within and relatively high variability between plot groups. The situation is reversed when plots are grouped by seral stage (Table 6): the plots are highly variable within groups, but relatively similar among groups. The within-group similarity evident in the chronosequence plot groups is lost when the groups are fragmented and the plots reorganized in seral stage units.

Some broad geographical patterns may be noted, as follows. The chronosequences on the east side of Vancouver Island are generally higher in elevation. Slope gradients are greater in the west side chronosequences. Wind is a near-universal exposure factor on the west side, but is uncommon and local on the east. The east-side chronosequences are mainly on morainal material; the west-side chronosequences are on colluvial material. Brunisolic soils occur on the east side but not on the west.

Table 5. Environmental characteristics summary by chronosequence

Attribute	Location							
	VWS	**VWN**	**KOK**	**NAN**	**REN**	**RGC**	**NIT**	**KLA**
BEC zone	CWHxm1	CWHxm2, xm1	CWHxm2	CWHxm1	CWHvm1	CWHvm1	CWHvm1	CWHvm1
Elevation (m) (mean: range)	303: 240 – 390	382: 260 – 465	631: 590 – 710	440: 430 – 460	206: 130 – 320	172: 80 – 300	227: 85 – 325	155: 120 – 230
Slope (%) (mean: range)	26: 11 – 40	21: 5 – 40	20: 15 – 35	21: 20 – 25	38: 25 – 45	47: 10 – 100	31: 22 – 45	23: 15 – 35
Aspect	NE (NW)	W, N, NE	S	S, SE, SW	W – N	N (E)	SW – W	NW (SE)
Slope position	upper, middle, lower	middle	middle	middle (upper)	middle	middle (level)	middle (lower)	middle, lower
Exposure	n/a	n/a	wind	n/a (wind)	wind (n/a)	wind	wind (n/a)	wind
Surface shape	straight, (concave)	straight, (convex, concave)	straight, (convex)	straight, (concave)	straight, (convex, concave)	straight, (convex)	straight, concave	convex, (straight, concave)
Hygrotope	mesic, subhygric	mesotrophic	mesic (subxeric, submesic)	submesic (subxeric)	mesic (subhygric)	mesic (subhygric)	mesic (submesic)	submesic – subhygric
Trophotope	mesotrophic, permesotrophic	mesotrophic	mesotrophic (submesotrophic)	submesotrophic	mesotrophic (submesotrophic)	mesotrophic – permesotrophic	submesotrophic – permesotrophic	mesotrophic
Terrain	gravelly sandy inactive morainal, (fluvial)	gravelly (fragmental) sandy inactive morainal, (weathered bedrock)	gravelly silty, inactive colluvial	gravelly silty, gravelly sandy, inactive morainal	sandy fragmental and silty fragmental inactive colluvial	silty fragmental inactive colluvial	gravelly silty (sandy) inactive colluvial	gravelly sandy, inactive colluvial
Soil	Orthic (Duric) Dystric Brunisols	Orthic Humo-Ferric Podzols and Duric Dystric Brunisols	Orthic Humo-Ferric Podzols	Duric Humo-Ferric Podzols	Orthic (gleyed) Humo-Ferric Podzols	Orthic Humo-Ferric Podzols (Duric Ferro-Humic Podzols)	Orthic Humo-Ferric Podzols	Orthic Humo-Ferric and Ferro-Humic Podzols
Family particle size	fine-silty, coarse-loamy	variable	fine-silty, loamy	fine-silty, loamy	variable	fine-silty (silty), loamy	fine-silty, loamy	fine-silty (silty), loamy
Rooting depth (cm) (mean: range)	37: 23 – 46	65: 45 – 78	47: 40 – 50	52: 30 – 60	38: 25 – 50	57: 50 – 60	40: 10 – 75	45: 40 – 60
Root restrict depth (cm) (mean: range)	63: 44 – 83	71: 45 – 95		35	61: 25 – 100	60	30: 26 – 35	130
Soil drainage	well (moderately well)	well	rapid	well	well (poor)	well	rapid	moderately well (well)
Humus form[a]	mull-like moders (conifero- typical moders, conifero zoomulls)	Humi–fibrimors	Hemihumimors	Hemihumimors	Orthihemimors	Orthihemimors, Moders	Hemihumimors, (Moders)	Orthi(ligno)humi(hemi)mors

[a]from Bernier (1968) for VWS and VWN; otherwise from Klinka (1981).

NOTE: Where a cell contains more than one attribute, the most common attribute (if there is one) is listed first. Attributes separated by commas are approximately equal in frequency among the plots in the group; those enclosed in parentheses are from a single plot only.

Table 6. Environmental characteristics summary by seral stage

Attribute	East side seral stage				West side seral stage			
	Regeneration	**Immature**	**Mature**	**Old-growth**	**Regeneration**	**Immature**	**Mature**	**Old-growth**
BEC zone	CWHxm1, xm2	CWHxm1, xm2	CWHxm1, xm2	CWHxm1, xm2	CWHvm1	CWHvm1	CWHvm1	CWHvm1
Elevation (m) (mean: range)	446: 280 – 595	452: 305 – 710	380: 240 – 590	478: 390 – 630	243: 120 – 315	170: 130 – 185	103: 80 – 130	243: 150 – 325
Slope (%) (mean: range)	18: 15 – 25	20: 5 – 40	20: 11 – 35	30: 15 – 40	35: 15 – 50	40: 35 – 45	20: 10 – 30	46: 22 – 100
Aspect	S, W, NE	N, SE, S	NE, S, SW, W	NE, S, SW, W	SW – N	N, SE, SW	N, E, W, NW	W – N
Slope position	upper, middle	middle	middle (lower)	middle	middle (lower)	middle	lower (middle, level)	middle
Exposure	wind, n/a	n/a (wind)	n/a (wind)	n/a (wind)	wind	wind	wind, n/a	wind
Surface shape	straight, concave	straight, (concave)	straight	straight, convex	straight, (convex, concave)	straight, (convex, concave)	concave, (straight, convex)	straight, (concave)
Hygrotope	mesic (submesic)	mesic (subxeric)	subxeric , subhygric	submesic (mesic)	submesic, subhygric	mesic (submesic)	mesic	mesic (subhygric)
Trophotope	mesotrophic (submesotrophic)	mesotrophic (submesotrophic)	submesotrophic – permesotrophic	submesotrophic, mesotrophic	mesotrophic (submesotrophic)	mesotrophic	mesotrophic (permesotrophic)	submesotrophic – permesotrophic
Terrain	gravelly sandy (silty) inactive morainal (colluvial)	gravelly sandy (silty) inactive morainal (colluvial)	gravelly sandy (silty) inactive morainal (colluvial, fluvial)	highly variable	gravelly sandy (fragmental, silty) inactive colluvial	variably textured inactive colluvial	variably textured inactive colluvial (morainal)	variably textured inactive colluvial
Soil	Orthic (Duric) Humo-Ferric Podzols (Orthic Dystric Brunisols)	Orthic & Duric Humo-Ferric Podzols, Orthic & Duric Dystric Brunisols	Duric Dystric Brunisols (Orthic and Duric Humo-Ferric Podzols)	Orthic (Duric) Humo-Ferric Podzols (Orthic Dystric Brunisols)	Orthic Humo-Ferric (Ferro-Humic) Podzols	Orthic Humo-Ferric Podzols	Orthic (Duric) Humo-Ferric Podzols	Orthic (Gleyed) Humo-Ferric Podzols
Family particle size	fine-silty, loamy (coarse-loamy)	fine-silty, loamy (coarse-loamy, sandy)	fine-silty, loamy, coarse-loamy	fine-silty, loamy, coarse-loamy	fine-silty, loamy (loamy-skeletal, sandy)	loamy, fine-silty (sandy)	fine-silty, loamy	loamy, fine-silty, sandy
Rooting depth (cm) (mean: range)	44: 23 – 60	49: 30 – 74	56: 37 – 78	47: 40 – 60	44: 26 – 60	55: 50 – 60	51: 30 – 75	31: 10 – 50
Root restrict depth (cm) (mean: range)	83	51: 35 – 74	95	45	72: 26 – 130		100	40: 25 – 60
Soil drainage	well (rapid)	well (rapid)	well (rapid, moderately well)	well (rapid)	well (rapid, moderately well)	well (rapid)	well (rapid, moderately well)	rapid, well, moderate well, poor
Humus form[a]	Hemihumimors (mull-like moders, Humi-fibrimors)	Hemihumimors (Humi-fibrimors, conifero-typical moders)	Hemihumimors (Humi-fibrimors, conifero zoomulls)	Hemihumimors (mull-like moders, Humi-fibrimors)	Orthihemimors (Hemihumimors, Orthihumimors)	Orthihemimors (Orthimormoders, Hemihumimors)	Orthihemimors (Lignohumimors, Velomoders)	Orthihemimors, Hemihumimors, Orthihumimors, Orthivelomoders

[a]usually from Klinka (1981), sometimes from Bernier (1968).

NOTE: Where a cell contains more than one attribute, the most common attribute (if there is one) is listed first. Attributes separated by commas are approximately equal in frequency among the plots in the group; those enclosed in parentheses are from a single plot only.

6.1.1 Comparison by site

The Victoria Watershed South plots, the lowest in elevation range of the east-side chronosequences, are characterized by: gentle to moderate slope gradients, northeast (to one plot northwest) aspects, a range of slope positions from upper to lower, no significant exposure factors, mesic and subhygric moisture regimes, mesotrophic and permesotrophic nutrient regimes, mostly morainal (one plot fluvial) terrain types, mostly Orthic Dystric Brunisol soils that are well or moderately well drained, relatively shallow rooting depths, and mostly moder (one mull) humus forms.

The Victoria Watershed North plots are a little higher in elevation range than the Victoria Watershed South plots. They have gentle to moderate slope gradients, variable aspects, mid-slope positions, no significant exposure factors, mesic moisture regimes, mesotrophic nutrient regimes, mostly morainal (one plot weathered bedrock) terrain types, Orthic Humo–Ferric Podzol and Duric Dystric Brunisol soils that are well drained, relatively deep rooting depths, and humifibrimor humus forms.

The Koksilah plots are the highest in elevation range of the east-side chronosequences. They have gentle to moderate slope gradients, all southerly aspects, mid–slope positions, exposure to wind, mesic or drier moisture regimes, mesotrophic and submesotrophic nutrient regimes, colluvial terrain types, Orthic Humo–Ferric Podzol soils that are rapidly drained, average rooting depths but a deeper than average root restricting layer, and hemihumimor humus forms.

The Nanaimo plots are intermediate in elevation range among the east-side chronosequences, with the narrowest elevation range of all the chronosequences. They have gentle to moderate slope gradients, southeast to southwest aspects, mid or upper slope positions, minor wind exposure (one plot), submesic (one plot subxeric) moisture regimes, submesotrophic nutrient regimes, morainal terrain types, Duric Humo–Ferric Podzol soils that are well drained, relatively deep root restricting depths, and hemihumimor humus forms.

The Renfrew plots are average in elevation among the west-side chronosequences, and have gentle to moderate slope gradients, west to north aspects, mid–slope positions, exposure to wind, mesic (one plot subhygric) moisture regimes, mesotrophic (one plot submesotrophic) nutrient regimes, colluvial terrain types, mostly well-drained Orthic Humo–Ferric Podzol soils (though one plot is poorly drained), and orthihemimor humus forms.

The Red/Granite Creek plots are average in elevation among the west-side chronosequences, though with a fairly wide elevational range, and have gentle to steep slope gradients, mostly north (one plot east) aspects, mostly mid–slope positions (one plot level), wind exposure, mesic (one plot subhygric) moisture regimes, mesotrophic and permesotrophic nutrient regimes, colluvial terrain types, well-drained Humo–Ferric Podzol soils, and orthihemimor and moder humus forms.

The Nitinat plots are a little higher than average in elevation among the west-side chronosequences, and they have the widest elevational range of all the chronosequences. They have gentle to moderate slope gradients, southwest to west aspects, mostly mid–slope positions (one plot lower), exposure to wind, mostly mesic (one plot submesic) moisture regimes, submesotrophic to permesotrophic nutrient regimes, colluvial terrain types, rapidly drained Orthic Humo–Ferric Podzol soils, and hemihumimor or moder humus forms. The root restricting layer is consistently close to the surface in these plots.

The Klanawa plots are average in elevation among the west-side chronosequences, with gentle to moderate slope gradients, mostly northwest (one plot southeast) aspects, mid and lower slope positions, wind exposure, submesic to subhygric moisture regimes, mesotrophic nutrient regimes, colluvial terrain types, moderately well–drained Humo–Ferric and Ferro–Humic Podzol soils, and a variety of mor humus forms. The root restricting layer is deeper than usual.

The plots within each chronosequence (Table 5) are generally well matched, but note the following points as possible sources of error.

- Victoria Watershed South: slope positions range from upper to lower; moisture regimes range from submesic to subhygric.
- Victoria Watershed North: aspects vary through 165°.
- Koksilah: recorded moisture regimes range from subxeric to mesic.
- Red/Granite Creek: elevations range from 80 to 300 m; slope gradients range from 10 to 100%; one plot is coded as eutrophic.
- Nitinat: elevations range from 85 to 325 m.
- Klanawa: three plots have a northwest aspect, while the fourth faces southeast.

6.1.2 Comparison by sere

As previously explained, the seral stage plot groupings (Table 6) are highly diverse for the tabulated attributes, with little difference among the seral groups within one side of the island or the other. Nonetheless differences, are noted below.

The regeneration (east) plots range in slope position from middle to upper. Most of the plots are exposed to wind. Surface profiles are straight to concave. Moisture regimes range from mesic to submesic; nutrient regimes, from mesotrophic to submesotrophic. Terrain is morainal or colluvial. Soils are Podzols and Brunisols.

The immature (east) plots are on mid-slope positions only. There is minor exposure to wind. Surface profiles are straight to concave. Moisture regimes range from mesic to subxeric; nutrient regimes, from mesotrophic to submesotrophic. Terrain is morainal or colluvial. Soils are Podzols and Brunisols.

The mature (east) plots range in slope position from middle to lower. There is minor exposure to wind. Surface profiles are straight. Moisture regimes range from subxeric to subhygric; nutrient regimes, from submesotrophic to permesotrophic. Terrain is morainal or colluvial. Soils are Brunisols and Podzols.

The old-growth (east) plots are all on mid–slope positions. There is minor exposure to wind. Surface profiles are straight to convex. Moisture regimes are submesic to mesic; nutrient regimes are submesotrophic and mesotrophic. Terrain is morainal, colluvial, or weathered bedrock. Soils are Brunisols and Podzols.

The regeneration (west) plots are in the CWHvm1 variant. Slope positions range from middle to lower. All of the plots are exposed to wind. Surface profiles range from convex to concave. Moisture regimes range from submesic to subhygric; nutrient regimes, from mesotrophic to submesotrophic. Terrain is colluvial. Soils are Podzols.

The immature (west) plots are on mid-slope positions only. All of the plots are exposed to wind. Surface profiles range from convex to concave. Moisture regimes are mesic to submesic; nutrient regimes are mesotrophic. Terrain is colluvial. Soils are Orthic Humo–Ferric Podzols.

The mature (west) plots are on mid, lower and level slope positions. Most of the plots are exposed to wind. Surface profiles range from convex to concave. Moisture regimes are mesic; nutrient regimes range from mesotrophic to permesotrophic. Terrain is mostly colluvial. Soils are Podzols.

The old-growth (west) plots are all on mid–slope positions. All of the plots are exposed to wind. Surface profiles are straight to concave. Moisture regimes are mesic to subhygric; nutrient regimes range from submesotrophic to permesotrophic. Terrain is colluvial. Soils are Humo–Ferric Podzols.

Note the following points as possible sources of error.

- Regeneration plots, east side: elevations range from 280 to 595 m; aspects are variable (south, west, northeast).
- Regeneration plots, west side: aspects vary through 125°; moisture regimes range from submesic to subhygric.
- Immature plots, east side: elevations range from 305 to 710 m; aspects vary through 170°; recorded moisture regimes range from subxeric to mesic.
- Immature plots, west side: aspects are variable (north, southeast, southwest); one plot is coded as eutrophic.
- Mature plots, east side: elevations range from 240 to 590 m; aspects are variable (northeast, northwest, south, southwest); moisture regimes range from subxeric to subhygric.
- Mature plots, west side: aspects vary through 165°.
- Old-growth plots, east side: elevations range from 390 to 630 m; aspects are variable (northeast, south, southwest, west).
- Old-growth plots, west side: slope gradients range from 22 to 100%; aspects vary through 115°.

6.2 Soils

Soil chemistry is summarized in Tables 7 and 8 (values are means) and are given for each plot in Appendix IV. The main pattern visible is a sharp difference between the west–side and the east–side chronosequences. The east side has: higher pH in both LFH and mineral soil (difference greater in humus); lower N in both LFH and mineral soil (difference greater in mineral soil); lower % C and higher C/N ratio in both LFH and mineral soil (difference greater in mineral soil); lower % Fe + Al, higher cations (Ca, Mg, and K), and lower cation exchange capacity; and lower total N. These differences can be pronounced. The analytical results permitted an assessment of the accuracy of the trophotope attribute that is subjectively assigned in the field. It appears that the trophotope is loosely correlated with total N. In two plots the assigned trophotope appears to reflect cation status instead, as is the case with the plot (62) coded as eutrophic.

6.2.1 Comparison by site

Looking at the chronosequences (Table 7), Victoria Watershed South fits the pattern described above except for a lower mineral soil C/N ratio (higher total N) than the other plots. The mature plot is particularly nitrogen-rich. Victoria Watershed North is the opposite: high C, low total N (very low in mineral soil but higher than the norm in the LFH layer), and high C/N ratio. Koksilah has the highest pH and by far the highest cations. Nanaimo has the lowest total N and the highest C/N ratio.

Renfrew is about average for its side of the island. Red/Granite Creek has the highest total N and the highest mineral soil N of all the chronosequences (though N levels in the LFH are relatively low), and the highest cations on the west side. Nitinat has the highest mineral soil C, the highest cation exchange capacity, the lowest cations, and the highest LFH layer C/N ratio of all the chronosequences. Nitinat also has the lowest mineral soil nitrogen and the lowest total N of the west–side chronosequences. Klanawa has the LFH with the highest N and the highest % Fe + Al of all the chronosequences.

Table 7. Soil chemistry summary by chronosequence averaged across all four plots at a site and all four samples within a plot

	LFH				Mineral soil (0–30 cm)							LFH& mineral
Site	pH	C/N ratio	C (%)	Total N (kg/ha)	pH	CEC (cmol)	C/N ratio	C (%)	Fe+Al (%)	Total N (kg/ha)	Ca+Mg+K (kg/ha)	Total N (kg/ha)
East side												
VWS	4.43	56.23	40.47	231.68	4.54	17.96	58.41	2.68	0.70	1260.15	877.10	1491.83
VWN	4.73	49.41	43.45	286.62	4.58	16.13	120.15	3.30	0.57	511.87	653.91	798.49
KOK	4.90	45.64	40.02	240.34	4.88	17.34	100.21	2.97	0.49	942.00	1440.22	1182.34
NAN	4.37	57.30	42.98	210.00	4.96	9.50	138.20	1.90	0.39	432.59	723.04	642.59
West side												
REN	3.41	48.85	44.13	688.97	4.07	25.85	27.89	4.95	1.74	2548.50	274.49	3273.23
RGC	3.61	42.04	43.80	463.53	4.43	23.66	35.79	4.24	1.83	3351.50	370.44	3815.03
NIT	3.43	70.09	45.55	371.77	4.08	36.90	35.07	7.49	2.29	2003.63	201.43	2375.40
KLA	3.47	44.76	41.85	723.33	4.37	29.47	37.14	6.19	2.76	2841.63	250.55	3494.93

Al = aluminum; Ca = calcium; CEC = cation exchange capacity; Fe = iron;
K = potassium; Mg = magnesium; N = nitrogen.

Table 8. Soil chemistry summary by seral stage and subzone averaged across all four plots in a sere and all four samples within a plot

	LFH				Mineral soil (0–30 cm)							LFH& mineral
Sere	pH	C/N ratio	C (%)	Total N (kg/ha)	pH	CEC (cmol)	C/N ratio	C (%)	Fe+Al (%)	Total N (kg/ha)	Ca+Mg+K (kg/ha)	Total N (kg/ha)
East Side												
Regeneration	4.40	53.89	39.63	252.67	4.69	16.92	113.06	2.61	0.53	793.16	1052.49	1045.83
Immature	4.72	51.27	42.31	216.79	4.64	16.42	108.02	2.63	0.56	882.70	920.97	1099.49
Mature	4.67	57.94	41.94	161.73	4.81	13.69	90.27	2.46	0.53	908.03	901.29	1069.76
Old-growth	4.55	45.49	42.99	337.46	4.59	12.35	112.80	2.10	0.50	562.08	819.53	899.54
West Side												
Regeneration	3.74	52.18	39.63	458.15	4.36	26.01	46.07	4.33	1.81	2267.13	213.59	2725.28
Immature	3.54	47.69	44.91	294.30	4.17	25.35	32.04	4.84	1.77	2536.70	408.65	2831.00
Mature	3.26	44.99	41.94	740.03	4.50	29.84	27.11	5.90	2.59	3614.19	203.15	4354.22
Old-growth	3.39	60.89	44.18	755.13	4.03	24.73	35.84	5.63	1.83	2326.75	271.53	3081.88

Al = aluminum; Ca = calcium; CEC = cation exchange capacity; Fe = iron;
K = potassium; Mg = magnesium; N = nitrogen.

6.2.2 Comparison by sere

Generally it is difficult to discern trends in the soil variables along the seral gradient (Table 8), though cation exchange capacity and total cations clearly show a declining trend with time in the east-side plots. There appears also to be an increase in the N level in the LFH, more clearly so in the west–side plots. A statistical analysis might reveal additional trends.

The east-side regeneration plots have the highest total cations of all the seres, and tie with the west-side regeneration plots for the lowest percentage C in the LFH layer. The east-side immature sere is average. The east-side mature sere has the lowest N in the LFH of all the seres, and the lowest C/N ratio in mineral soil for its side of the island. The east-side old-growth has the highest N in the LFH and the lowest C/N ratio in the LFH of the east-side seres. It also has the lowest mineral soil pH, cation exchange capacity, % C, % Fe + Al, total N, and total cations for its side of the island.

The west-side regeneration plots tie with the east-side regeneration plots for the lowest % C in the LFH layer. They also have the lowest mineral soil N and total N, and the highest mineral soil C/N ratio, of the west-side seres. The west-side immature sere is lower in N in the LFH and higher in cations than the other west-side seres. The west-side mature sere has the most acidic LFH of all the seres, though it has the highest mineral soil pH for its side of the island. It has the highest cation exchange capacity, % Fe + Al, mineral soil % C, mineral soil N, and total N of all the seres. It has the lowest C/N ratio on the west side and the lowest total cations of all the seres. The west-side old-growth has the highest C/N ratio in the LFH and the highest N in the LFH of all the seres. It also has the lowest mineral soil pH of all the seres, and the lowest cation exchange capacity of the west-side plots.

6.3 Stand Characteristics

6.3.1 Live trees

Mensurational data are summarized in Table 9a and tabulated for each plot in Appendix V. Some differences are apparent between the east and west sides of the island. Mean stand densities in the east–side plots are considerably higher through the first three age classes, though stand densities on both sides drop to about the same level by old–growth stage. Mean basal area is generally higher on the west side, and much higher in the old- growth sere. (The high mean basal area value in the west-side old–growth results considerably from the singularly high basal area of western redcedar in the Klanawa old-growth plot.)

Of course, there are differences in performance of individual tree species. Western redcedar grows to an impressive diameter and height in old-growth plots on the west side, but remains relatively small in the east-side old–growth plots. (The especially high mean diameter at breast height [DBH] for western red cedar in the west–side old–growth plots results in part, however, from only a single very large western red cedar tree in the Red/Granite Creek old–growth plot.) Western hemlock is consistently larger in diameter and height on the west side. Douglas-fir increase in diameter and height with stand age on the east side, but do not occur in plots after the immature stage on the west side.

Between seral stages, some simple patterns can be observed. As stand age increases, so does basal area, DBH, and height. Stand density, however, peaks in the immature stage, then declines to a low value in the old-growth stage.

6.3.2 Dead trees

Mensurational data are summarized in Table 9b and tabulated for each plot in Appendix V. All stumps were measured in the regeneration plots, primarily snags were measured in the immature, mature, and old-growth plots.

For stand density, the chronological trends in dead-tree data reflect those observed in live-tree data: an initial rise, then a fall towards a low point in the old-growth stands. For the west side, the data series for dead trees closely follows the rise and fall in number of live trees; on the east side, the relationship is much looser.

For basal area and DBH, if the regeneration data are set aside, the dead-tree trends are similar to the live-tree trends: a general increase over time. (In the regeneration plots, the dead trees are massive old-growth stumps, while the live trees are saplings.) Mean basal area is higher on the west side.

On the west side, the redcedar stumps in the regeneration plots are a little smaller in mean DBH than the live old–growth redcedar trees, largely because of the single large live red cedar in the Red/Granite Creek old–growth plot. The hemlock and amabilis fir stumps are larger in mean DBH than the live old–growth hemlock and amabilis fir. These data would suggest that the logged stands were more mature than the existing old-growth stands. On the east side, the mean DBH of the redcedar and hemlock stumps in the regeneration plots is much greater than of those species in the living old growth, but the live old-growth Douglas-fir and dead Douglas-fir stumps in the regeneration plots are about the same size. This would suggest that the old–growth plots have the potential for substantial increase in DBH of the red cedar and hemlock trees, but perhaps not for the Douglas–fir.

Dead trees are 6 to 10 m in height in all seres in the west , but tend to be shorter in the east.

Table 9a. Stand characteristics summary by seral stage and subzone for all live trees

		East				West			
		Regen.	Imm.	Mat.	Old	Regen.	Imm.	Mat.	Old
Number of plots containing species	BA	np	np	np	np	1	1	2	3
	CW	2	2	3	3	4	4	1	4
	DR	1	np	1	1	1	2	np	np
	FD	4	4	4	4	2	2	np	np
	FG	1	np	np	np	np	np	np	np
	HW	1	2	2	4	4	4	4	4
	PW	2	np	2	1	np	np	np	np
	SS	np	np	np	np	1	1	np	np
Age (bh)		5	29	77	285	5	33	90	276
Stand density (stems/ha)	BA	np	np	np	np	32	42	334	102
	CW	286	223	62	47	700	297	3	132
	DR	32	np	4	3	42	85	np	np
	FD	1082	1920	1666	290	170	202	np	np
	FG	11	np	np	np	np	np	np	np
	HW	95	350	407	252	1114	1093	523	370
	PW	191	np	14	11	np	np	np	np
	SS	np	np	np	np	64	11	np	np
	Total	1697	2493	2153	603	2122	1730	860	604
Basal area (m^2/ha)	BA	np	np	np	np	< 0.1	2.1	8.5	4.2
	CW	0.1	0.8	1.9	2.5	0.1	2.7	0.1	73.9
	DR	< 0.1	np	0.4	0.2	< 0.1	7.3	np	np
	FD	0.5	36.4	69.3	76.0	0.3	12.2	np	np
	FG	< 0.1	np	np	np	np	np	np	np
	HW	< 0.1	2.5	7.0	3.8	0.3	31.8	60.5	49.8
	PW	< 0.1	np	< 0.1	< 0.1	np	np	np	np
	SS	np	np	np	np	< 0.1	1.0	np	np
	Total	0.6	39.7	78.6	82.5	0.7	57.1	69.1	127.9
Mean DBH (cm)	BA	np	np	np	np	2.6	23.5	18.8	18.7
	CW	1.7	6.2	19.3	25.1	0.7	9.6	25.6	66.1
	DR	2.8	np	36.2	32.5	2.8	30.0	np	np
	FD	1.8	13.6	20.8	51.9	4.1	25.2	np	np
	FG	0.6	np	np	np	np	np	np	np
	HW	1.0	7.2	13.2	12.2	1.5	16.7	35.8	28.8
	PW	1.3	np	4.3	3.9	np	np	np	np
	SS	np	np	np	np	1.0	35.0	np	np
Mean height (m)	BA	np	np	np	np	1.1	19.6	17.5	13.7
	CW	0.9	5.3	13.7	15.4	0.6	9.2	20.2	26.1
	DR	2.3	np	37.4	16.9	2.9	23.8	np	np
	FD	1.0	13.6	18.5	28.9	3.1	21.2	np	np
	FG	0.3	np	np	np	np	np	np	np
	HW	0.6	7.9	10.9	9.4	1.6	17.2	31.9	18.3
	PW	0.6	np	5.5	3.8	np	np	np	np
	SS	np	np	np	np	0.7	17.6	np	np

Notes:
A value of 'np' indicates trees of the given species were not present in the listed sere/subzone combination.
BA = amabilis fir; CW = western redcedar; DR = red alder; FD = Douglas-fir; FG = grand fir; HW = western hemlock; PW = western white pine; SS = Sitka spruce

Table 9b. Stand characteristics summary by seral stage and subzone for all stumps and snags

		East						West					
		Reg.	Imm.		Mat.		Old	Reg.	Imm.		Mat.		Old
		Stump	Stump	Snag	Stump	Snag	Snag	Stump	Stump	Snag	Stump	Snag	Snag
Number of plots containing species	BA	np	np	np	np	np	np	1	np	np	np	2	1
	CW	3	np	1	np	np	1	2	np	3	1	1	2
	DR	np	np	1	np	1	1	np	np	1	np	1	np
	FD	4	3	4	1	4	4	np	np	np	np	np	np
	HW	1	np	2	np	1	3	4	2	4	1	4	4
	unknown	np	np	np	np	np	np	1	1	np	1	1	np
Stand density (stems/ha)	BA	np	np	np	np	np	np	3	np	np	np	207	5
	CW	98	np	11	np	np	5	45	np	191	11	5	47
	DR	np	np	21	np	14	3	np	np	32	np	32	np
	FD	212	74	393	5	789	103	np	np	np	np	np	np
	HW	8	np	106	np	85	191	119	21	1199	37	385	73
	unknown	np	np	np	np	np	np	16	32	np	5	21	np
	Total	318	74	531	5	888	302	183	53	1422	53	650	125
Basal area (m^2/ha)	BA	np	np	np	np	np	np	0.5	np	np	np	0.8	0.4
	CW	17.1	np	< 0.1	np	np	0.2	59.6	np	0.8	< 0.1	0.1	6.7
	DR	np	np	< 0.1	np	1.0	0.1	np	np	0.2	np	2.7	np
	FD	65.7	22.7	0.9	1.8	8.5	6.5	np	np	np	np	np	np
	HW	0.1	np	0.1	np	0.2	2.1	42.0	5.4	5.8	10.9	20.6	8.0
	unknown	np	np	np	np	np	np	0.9	4.3	np	0.6	3.3	np
	Total	82.9	22.7	1.0	1.8	9.7	8.9	103.0	9.7	6.8	11.5	27.5	15.1
Mean DBH (cm)	BA	np	np	np	np	np	np	50.0	np	np	np	6.9	32.6
	CW	41.6	np	2.0	np	np	19.8	109.5	np	6.8	< 0.1	15.8	35.6
	DR	np	np	5.1	np	29.3	26.6	np	np	8.5	np	32.1	np
	FD	60.1	58.1	4.4	65.0	8.8	28.1	np	np	np	np	np	np
	HW	13.3	np	3.0	np	4.9	6.7	57.9	45.1	6.3	54.6	14.6	32.7
	unknown	np	np	np	np	np	np	24.0	39.4	np	28.0	40.7	np
Mean height (m)	BA	np	np	np	np	np	np	1.7	np	np	np	4.7	13.9
	CW	0.4	np	1.7	np	np	12.9	1.2	np	np	0.8	13.7	9.6
	DR	np	np	6.8	np	15.5	4.9	np	np	7.4	np	12.5	np
	FD	0.4	0.7	5.6	0.5	7.4	9.5	np	np	10.4	np	np	np
	HW	0.3	np	3.7	np	3.8	3.8	0.9	2.5	np	1.4	7.0	7.6
	unknown	np	np	np	np	np	np	0.7	4.8	7.3	2.8	2.5	np

Notes:
A value of ‘np’ indicates the given species and form was not present in the listed sere/subzone combination.
BA = amabilis fir; CW = western redcedar; DR = red alder; FD = Douglas-fir; HW = western hemlock

6.4 Indicator Vegetation Species

The vegetation data for the plots in each of the eight chronosequences are summarized in Table 10. The plot data organized by the four seral stage categories, with the east-side and west-side chronosequences tabulated separately, are summarized in Table 11. Only ecological indicator species as per Klinka et al. (1989) were recorded, so some elements of floristic diversity may not be reflected in these summaries.

Both tables reveal a major floristic distinction between the east–side and west–side plots. Species such as Douglas-fir (*Pseudotsuga menziesii*), Oregon grape (*Mahonia nervosa*), salal (*Gaultheria shallon*), baldhip rose (*Rosa gymnocarpa*), bracken (*Pteridium aquilinum*), and Oregon beaked moss (*Kindbergia oregana*) are more common and more abundant on the east side. Western hemlock (*Tsuga heterophylla*), red huckleberry (*Vaccinium parvifolium*), salmonberry (*Rubus spectabilis*), sword fern (*Polystichum munitum*), and deer fern (*Blechnum spicant*) are more common and more abundant on the west side. Amabilis fir (*Abies amabilis*) is somewhat important in the west-side plots, but absent from the east. The east side is more diverse in graminoid indicator species; the west, in ferns and fern allies. On each side of the island, the leading tree species, and to a lesser extent shrub species, are present with some consistency among the chronosequences.

Generally the east–side chronosequences appear more diverse in indicator species, the diversity being mainly in the herbaceous (including graminoid) stratum, and somewhat less in the bryophyte stratum. The Koksilah plots, and to a lesser extent the Victoria Watershed South plots, contain numerous indicator species not found in the other chronosequences. Most of these species are found in only a single plot. Much of this floristic distinctiveness is accounted for by the Koksilah regeneration plot (herbaceous, including graminoid, species) and the Koksilah mature plot (bryophytes).

6.4.1 Comparison by site

Some differences stand out among the chronosequences (Table 10). Among the east–side chronosequences, only the Victoria Watershed South plots contain red alder, big-leaf maple, and sword fern, with sword fern being in every plot. These species are more widely distributed on the west side. Victoria Watershed South is also rich in grasses, which are mostly confined to the regeneration plot. The Victoria Watershed North chronosequence is distinguished mainly by a very high cover of salal. It is very poor in herbaceous indicator species. The Koksilah group, as mentioned above, is notably rich in herbaceous species, including grasses (mostly in the regeneration plot) and bryophytes (mostly in the mature plot). The Nanaimo chronosequence is the only one to contain western white pine (present in three of the plots) and arbutus (in one plot only). Like Victoria Watershed North, this plot is poor in herbaceous indicator species.

The Renfrew chronosequence is the only one to contain Sitka spruce, though only in one plot. Salal covers one plot almost totally, but is minor in the other plots. Red/Granite Creek has more alder and less salal than the other chronosequences. The Nitinat chronosequence has the highest average cover of salal on the west side. It also has western yew in every plot, the only chronosequence to have this species. Klanawa has the most amabilis fir of all the chronosequences, though only in two plots.

6.4.2 Comparison by sere

Table 11 shows changes in species composition along the chronosequence gradient. Coniferous tree species have low presence and cover in the regeneration (east) plots, then gain quickly. On the west side this trend is weak. Douglas-fir shows an increasing trend with seral stage on the east side, but a decreasing trend on the west side. On the east side, salal shows virtually constant presence and cover across all age classes. Herbaceous indicator species, including graminoids, are much more diverse in the regeneration plots; this trend is more apparent on the east side. On the east side, mosses and liverworts appear to increase in diversity with stand age (discounting the diversity peak in the mature plots that is largely due to the effect of a single plot). This trend is not apparent on the west side.

The regeneration (east) plots are characterized by low presence and cover of coniferous tree species, high diversity of herbaceous (including graminoid) indicator species, and low diversity and cover of mosses and liverworts. The immature (east) plots have higher presence and cover of conifers, far lower diversity of herbaceous species (including graminoids), and slightly more diversity and cover of mosses and liverworts, than the regeneration plots. Among the mosses and liverworts a more mature flora is becoming established. The mature (east) plots have the greatest diversity and cover of mosses and liverworts, due mainly to a single plot. The old-growth (east) plots have a group of herbaceous species not found in any other seral groups, but these species are not actually indicators of old–growth.

The regeneration (west) plots have generally more salal than the other west-side seres (except for a single old-growth plot). The herbaceous layer is much more diverse for indicator species in this sere. The immature (west) sere commences a trend of increasing western hemlock and sword fern, and has an almost completely different moss and liverwort flora from the regeneration plots. The mature (west) plots have the highest average cover of western hemlock and amabilis fir. The old-growth (west) sere shows a much greater dominance by western redcedar. It also has the highest cover of salal, mainly because of a single plot.

Table 10. Indicator vegetation species summary by chronosequence. Presence (P) of each vegetation type, and the percent cover (%C) of each vegetation type is given for each chronosequence. Four plots were examined in each chronosequence. Plant species are listed in order by presence class, from top to bottom and from left to right across the vegetation units, within each life form category. Presence classes: 1 = 0–20% of plots; 2 = 21–40%; 3 = 41–60%; 4 = 61–80; 5 = 81–100%. A blank space indicates that the vegetation type was absent or undetectable.

	East (CWHxm)								West (CWHvm)							
	VWS		VWN		KOK		NAN		REN		RGC		NIT		KLA	
	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C
Coniferous trees:																
Pseudotsuga menziesii	4	42	4	60	4	51	5	34	2	1	2	3	3	6	2	1
Thuja plicata	4	4	4	3	3	11	4	1	3	11	3	5	4	2	4	1
Tsuga heterophylla	4	16	2	2	4	1	5	10	5	32	5	42	5	28	5	21
Pinus monticola							4	1								
Abies amabilis									3	4			3	1	3	10
Picea sitchensis									2	1						
Taxus brevifolia													4	1		
Broad-leaved trees:																
Alnus rubra	5	2							2	1	4	10	2	1		
Acer macrophyllum	3	1									2	1			2	1
Populus sp.							2	1			2	1				
Arbutus menziesii							2	1								
Malus fusca													2	1		
Evergreen shrubs:																
Gaultheria shallon	5	33	5	78	5	43	5	32	4	23	3	1	5	30	5	16
Mahonia nervosa	4	5	4	6	3	3	5	1					2	1		
Chimaphila umbellata	2	2			2	1	3	1								
Deciduous shrubs:																
Rubus leucodermis	2	2	2	1												
Salix scouleriana	2	1			2	1										
Rosa gymnocarpa			2	1	3	1	3	1								
Vaccinium parvifolium					2	1			4	1	5	1	5	13	3	5
Holodiscus discolor					4	2										
Ribes lacustre					2	1										
Rubus spectabilis							2	1	2	5	4	2	4	1	5	2
Rubus parviflorus							2	1								
Menziesia ferruginea									2	1					2	1
Vaccinium alaskaense													4	8	3	1
Rubus ursinus													2	1		
Ferns and fern allies:																
Pteridium aquilinum	3	10	3	4	2	1	4	1					2	1		
Polystichum munitum	5	7							3	1	4	20	3	7	4	1
Blechnum spicant									5	10	4	10	5	2	5	2
Athyrium filix-femina									2	1			2	1	2	1
Lycopodium annotinum											2	1				
Dryopteris expansa													2	1		
Graminoids:																
Festuca occidentalis	2	1	2	4	3	2										
Aira praecox	2	1			2	1										
Bromus vulgaris	3	1			2	1										
Carex deweyana	2	1														
Danthonia spicata	2	1														
Holcus lanatus	2	1														
Poaceae					2	1			2	1	2	1				
Deschampsia elongata					2	1										
Elymus glaucus					2	1										
Festuca subulata					3	1										
Melica subulata					2	1										

Table 10. (Continued)

	-------------- East (CWHxm) --------------								--------------West (CWHvm) ---------------							
	VWS		VWN		KOK		NAN		REN		RGC		NIT		KLA	
	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C
Herbs:																
Linnaea borealis	3	7	2	1	2	1	2	1					2	1		
Hypochoeris radicata	2	7	2	1	2	2										
Lactuca muralis	2	1	2	1												
Anaphalis margaritacea	2	1							2	2	2	3			2	1
Tiarella trifoliata	2	1							2	1					4	1
Cerastium fontanum	2	1														
Digitalis purpurea	2	1														
Galium triflorum	2	2														
Viola sempervirens	2	1														
Achlys triphylla					2	1	3	1					4	1		
Epilobium angustifolium					2	1			2	3	2	5				
Achillea millefolium					2	1										
Campanula scouleri					2	1										
Collomia heterophylla					2	1										
Hieracium albiflorum					2	1										
Lupinus polycarpus					2	1										
Moehringia macrophylla					2	1										
Montia parvifolia					2	1										
Trifolium campestre					2	1										
Epilobium sp.							2	1					2	1		
Fragaria sp.							2	1								
Goodyera oblongifolia							2	1								
Cornus canadensis									2	1					2	2
Streptopus roseus									2	1					2	1
Ranunculus sp.											2	1				
Lysichitum americanum															2	1
Tolmiea menziesii															2	1
Mosses and liverworts:																
Kindbergia oregana	5	13	4	25	4	16	4	5	3	1	4	3	5	5	4	1
Polytrichum juniperinum	2	1	2	1	2	1	3	1	2	1	2	2			2	1
Hylocomium splendens	3	8	3	2	3	5	3	1					4	7	3	1
Rhytidiadelphus triquetrus		3	1	3	1											
Rhytidiadelphus loreus	3	1					3	1					3	1	3	1
Hypnum circinale	2	1														
Scapania bolanderi	2	1														
Ceratodon purpureus			2	1	2	1										
Trachybryum megaptilum				2	1	3	1									
Rhytidiopsis robusta			2	1	2	1										
Bryum miniatum			2	1												
Dicranum fuscescens					2	1										
Dicranum scoparium					2	1										
Isothecium myosuroides					2	1										
Mnium spinulosum					2	1										
Rhacomitrium canescens					3	1										
Dicranum sp.							3	1	2	1	2	1	3	1		
Plagiothecium undulatum							2	1	4	1			4	1	4	1
Plagiomnium insigne							2	1								
Rhizomnium glabrescens									2	1	2	1			4	2
Isothecium myosuroides											3	1				
Leucolepis menziesii															2	1
Lichens:																
Cladonia fimbriata			2	1												
Cladina sp.							2	1								
Letharia vulpina							2	5								
lichen sp.													2	1		

Table 11. Indicator vegetation species summary by seral stage and subzone. Presence (P) of each vegetation type, and the percent cover (%C) of each vegetation type is given for each seral stage and subzone. Four plots were examined in each seral stage and subzone. Plant species are listed in order by presence class, from top to bottom and from left to right across the vegetation units, within each life form category. Presence classes: 1 = 0–20% of plots; 2 = 21–40%; 3 = 41–60%; 4 = 61–80; 5 = 81–100%. A blank space indicates that the vegetation type was absent or undetectable.

	-------------- East (CWHxm) --------------								--------------West (CWHvm) ---------------							
	REG		IMM		MAT		OLG		REG		IMM		MAT		OLG	
	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C
Coniferous trees:																
Thuja plicata	2	1	4	12	5	3	4	5	4	1	3	1	2	1	5	18
Tsuga heterophylla	2	1	4	5	4	5	5	19	5	10	5	36	5	42	5	34
Pseudotsuga menziesii	2	5	5	64	5	59	5	59	3	4	4	7				
Pinus monticola	2	1			2	1	2	1								
Taxus brevifolia									2	1	2	1			2	1
Abies amabilis									2	1			3	13	4	2
Picea sitchensis									2	1						
Broad-leaved trees:																
Alnus rubra	2	1	2	1	2	1	2	1	3	1	3	10	2	1		
Populus sp.	2	1							2	1						
Arbutus menziesii	2	1														
Acer macrophyllum			2	1	2	1					2	1	2	1		
Malus fusca									2	1						
Evergreen shrubs:																
Gaultheria shallon	5	40	5	55	5	41	5	52	5	14	3	1	4	1	5	53
Mahonia nervosa	3	1	5	6	4	5	4	4			2	1				
Chimaphila umbellata					3	2	3	1								
Deciduous shrubs:																
Holodiscus discolor	2	1			2	1	2	1								
Rosa gymnocarpa	3	1			3	1	2	1								
Rubus leucodermis	3	2														
Rubus spectabilis			2	1					5	8	4	1	3	1	3	1
Salix scouleriana					2	1	2	1								
Vaccinium parvifolium					2	1			4	3	4	2	5	4	4	11
Ribes lacustre							2	1								
Rubus parviflorus							2	1								
Vaccinium alaskaense									2	2			3	1	3	7
Rubus ursinus											2	1				
Menziesia ferruginea															3	1
Ferns and fern allies:																
Polystichum munitum	2	1	2	2	2	3	2	1	2	1	4	4	5	11	3	12
Pteridium aquilinum	4	10	3	3	3	2	2	1			2	1				
Blechnum spicant									5	13	4	1	5	5	5	6
Lycopodium annotinum									2	1						
Athyrium filix-femina											2	1	3	1		
Dryopteris expansa													2	1		
Graminoids:																
Bromus vulgaris	3	1			2	1										
Festuca occidentalis	4	7					2	1								
Festuca subulata	2	1					2	1								
Aira praecox	3	1														
Carex deweyana	2	1														
Danthonia spicata	2	1														
Deschampsia elongata	2	1														
Elymus glaucus	2	1														
Holcus lanatus	2	1														
Melica subulata	2	1														
Poaceae			2	1					3	1						

Table 11. (Continued)

	East (CWHxm)								West (CWHvm)							
	REG		IMM		MAT		OLG		REG		IMM		MAT		OLG	
	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C	P	%C
Herbs:																
Achlys triphylla	2	1	2	1	2	1			2	1	2	1	2	1		
Linnaea borealis	2	1			3	7	3	1			2	1				
Lactuca muralis	2	1			2	1										
Anaphalis margaritacea	2	1							4	6						
Epilobium angustifolium	2	1							3	8						
Epilobium sp.	2	1							2	1						
Achillea millefolium	2	1														
Cerastium fontanum	2	1														
Digitalis purpurea	2	1														
Hieracium albiflorum	2	1														
Hypochoeris radicata	4	11														
Lupinus polycarpus	2	1														
Montia parvifolia	2	1														
Trifolium campestre	2	1														
Fragaria sp.			2	1												
Tiarella trifoliata					2	1					2	1	3	1	2	1
Galium triflorum					2	2										
Campanula scouleri							2	1								
Collomia heterophylla							2	1								
Goodyera oblongifolia							2	1								
Moehringia macrophylla							2	1								
Viola sempervirens							2	1								
Cornus canadensis									2	2					2	1
Lysichitum americanum									2	1						
Ranunculus sp.									2	1						
Tolmiea menziesii									2	1						
Streptopus roseus											2	1	2	1		
Mosses and liverworts:																
Kindbergia oregana	2	1	5	12	5	35	5	11	2	1	5	4	4	3	5	3
Polytrichum juniperinum	4	2	2	1	2	1			4	3						
Bryum miniatum	2	1														
Ceratodon purpureus	3	1														
Hylocomium splendens			2	1	4	7	5	9	2	1			3	1	3	6
Rhacomitrium canescens			2	1	2	1										
Plagiomnium insigne			2	1												
Rhytidiadelphus loreus					3	1	3	1	2	1			2	1	3	1
Dicranum sp.					2	1	2	1	4	1					2	1
Trachybryum megaptilum					2	1	3	1								
Rhytidiopsis robusta					2	1	2	1								
Rhytidiadelphus triquetrus					3	1	3	1								
Plagiothecium undulatum					2	1					4	1	4	1	4	1
Dicranum fuscescens					2	1										
Dicranum scoparium					2	1										
Isothecium myosuroides					2	1										
Mnium spinulosum					2	1										
Scapania bolanderi					2	1										
Hypnum circinale							2	1								
Rhizomnium glabrescens											3	1	2	1	3	1
Isothecium myosuroides											2	1	2	1		
Leucolepis menziesii											2	1				
Lichens:																
Cladonia fimbriata	2	1														
Cladina sp.							2	1								
Letharia vulpina							2	5								
lichen sp.															2	1

6.4.3 Similarity matrices

PC VTAB, a program developed by the Research Branch, B.C. Ministry of Forests, (Emanuel 1990) for the tabular analysis of vegetation data, can produce a matrix of similarity coefficients based on the percentage of species that are common to each pair of vegetation units (Kayahara 1992)[1]. Similarity matrices were calculated with this program for both chronosequence and seral stage units, using both percent cover and presence/absence data.

Looking first at the similarity matrices for the chronosequences (Table 12), two points are evident. First, there is an overall dissimilarity between the west-side units and the east-side units, whereas the chronosequence units are relatively similar on each side of the island. This result reinforces the data in Table 10 (vegetation summary by chronosequence). Second, the results are very similar whether cover or presence/absence data are used, suggesting that these results derive more from differences in species presence than from differences in species abundance.

The similarity matrices for the seral stages (Table 13) show a different pattern than those mentioned above, in that the similarities are distinctly greater when presence/absence data are examined. This result suggests that differences among the seral stages are based less on differences in species presence than on differences in species abundance, that is, based more on the growth and development of plant communities than on species replacement. As with the comparison of chronosequences, the similarities are greatest within each side of the island, the greatest differences showing up between the west-side seral units and the east-side seral units. This can also be seen in Table 11 (vegetation summary by seral stage).

These results suggest that the greatest floristic differences in the plot data are biogeoclimatic: the west (wetter) side of southern Vancouver Island and the east (drier) side each has its distinctive flora. Within a chronosequence (i.e. between seral stages) dissimilarities are based more on quantitative than on qualitative floristic differences (i.e., on the relative abundance of each species rather than on which species are present).

[1] The PC VTAB hypertext documentation describes the matrix as "an identity matrix based on the formula: Matrix(vu1,vu2) = (Slow-val-common × 2) / (Sval-vu1 + Sval-vu2) × 100. The numerator is the sum over all species of the smaller val (vu1 or vu2) for species that exist in both vegetation units, multiplied by 2. The denominator is the sum over all species of all val in the vegetation unit. Values ("val") used were either presence or absence (1 or 0), or percent cover.

Table 12. Indicator vegetation species similarity matrices for chronosequences

Unit number	Unit	Number Of plots
1	VWS	4
2	VWN	4
3	KOK	4
4	NAN	4
5	REN	4
6	RGC	4
7	NIT	4
8	KLA	4

Similarity based on species percent cover:

	1	2	3	4	5	6	7
2	61.4						
3	65.5	74.0					
4	65.0	56.0	60.4				
5	35.4	21.8	28.2	37.6			
6	26.5	10.3	10.3	21.0	57.5		
7	52.5	33.2	37.8	52.3	58.6	45.2	
8	30.8	18.3	19.6	37.2	60.5	34.9	60.4

Average similarity = 41.9

Similarity based on species presence/absence:

	1	2	3	4	5	6	7
2	54.5						
3	41.6	50.0					
4	39.3	45.8	37.1				
5	34.5	26.7	26.9	35.3			
6	36.4	28.6	28.1	37.5	71.1		
7	39.3	37.5	31.4	55.6	54.9	45.8	
8	40.0	29.8	23.2	37.7	76.0	55.3	56.6

Average similarity = 42.0

Table 13. Indicator vegetation species similarity matrices for seral stages.

Unit number	Unit		Number Of plots
1	Regen.	East	4
2	Immat.	East	4
3	Mature	East	4
4	Old	East	4
5	Regen.	West	4
6	Immat.	West	4
7	Mature	West	4
8	Old	West	4

Similarity based on species percent cover:

	1	2	3	4	5	6	7
2	39.5						
3	37.9	76.9					
4	36.5	82.9	75.1				
5	24.0	22.0	20.7	27.2			
6	10.7	20.9	19.5	28.8	27.7		
7	2.2	9.5	10.4	18.3	26.7	61.1	
8	32.6	47.4	37.6	52.4	34.5	41.9	51.8

Average similarity = 34.9

Similarity based on species presence/absence:

	1	2	3	4	5	6	7
2	36.1						
3	43.0	51.9					
4	39.5	39.2	60.9				
5	35.6	50.0	39.4	31.7			
6	32.8	57.1	50.0	35.1	44.4		
7	21.5	50.0	44.8	29.1	53.8	73.9	
8	15.9	36.8	39.3	30.2	60.0	54.5	71.4

Average similarity = 43.9

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Appendices

Appendix I. Chronosequence names, plot numbers, UTM coordinates, and plot orientations

Chronosequence Name	Chr. No.	Plot Est. No.	Plot No.	Zone	East	North	Sere	Age	Orientation Degrees
Victoria Watershed	1	1	1	10	452160	5379040	R	4	0
South		2	2	10	452340	5378800	I	32	21
VWS		2a	3	10	452780	5378780	I-M	-	-
		3	4	10	452120	5380260	M	-	-
		3a	5	10	451100	5379660	M	99	0
		4	6	10	452560	5378220	O	245	0
		5	7	10	450500	5378640	O	-	-
		1a	8	10	450540	5378920	R	-	-
Victoria Watershed	2	1	11	10	446920	5384860	R	6	0
North		2	12	10	447259	5387002	I	42	0
VWN		3	13	10	446402	5387257	M	93	0
		3a	14	10	446600	5385120	M	-	-
		4	15	10	446920	5384640	O	316	-
		5	16	10	446440	5385000	O	-	-
Koksilah	3	1	21	10	443170	5389420	R	5	0
KOK		2	22	10	443951	5389752	I	43	0
		3	23	10	444927	5389217	M	77	0
		4	24	10	444684	5389466	O	288	0
		5	25	10	443746	5389754	O	-	-
Nanaimo River	4	1	31	10	414443	5433270	R	10	40
NAN		2	32	10	415118	5433599	I-M	60	20
		3	33	10	414703	5433049	M	68	350
		4	34	10	414277	5433330	O	330	0
		-	35	10	415957	5434049	I	39	120
Loon Lake	5	1	41	10	375811	5458067	R	-	-
LOON		2	42	10	375591	5459060	I	-	-
		3	43	10	375841	5458499	M	-	-
		4	44	10	375561	5458629	O	-	-
Renfrew	6	1	51	10	397669	5378482	R	4	10
REN		2	52	10	399387	5379377	I	42	20
		3	53	10	397570	5378700	M	66	350
		4	54	10	397642	5377031	O	255	50
Red/Granite Creek	7	1	61	10	410645	5380886	R	9	20
RGC		2	62	10	404265	5380528	I	43	0
		3	63	10	404804	5383329	M	76	330
		5	64	10	409891	5381146	O	176	0
Nitinat	8	1	71	10	379745	5409942	R	9	0
NIT		2	72	10	379914	5411143	I	39	340
		3	73	10	379268	5410539	M	70	30
		4	74	10	379740	5409726	O	270	40
Klanawa	9	1	81	10	364518	5409456	R	3	0
KLA		2	82	10	364574	5413471	I	32	0
		3	83	10	363984	5409315	M	69	46
		4	84	10	364181	5409032	O	445	0
		5	85	10	364396	5413661	O	-	-
Mt.Ozzard	10	1	91	10	316871	5425621	R	-	-
OZZ		2	92	10	316379	5427368	I	-	-
		2a	93	10	319234	5425698	I	-	-
		3	94	10	317576	5425412	M	-	-
		4	95	10	317844	5425496	O	-	-

Appendix I. (Continued)

Field specifications for plot location table for Canadian Forest Service Coastal Forest Chronosequence plots.

Field	Information
Chronosequence name	Full name used for site and abbreviation.
Chr. No.	Site number, no longer used in further reports.
Plot Est. No.	Number assigned to plot when first established. Used to indicate plot position on initial 1:20 000 forest cover maps, descriptions and sketch maps in Trofymow 1991 site selection file report; Blackwell 1992a plot location contract report.
Plot No.	Unique plot number used in all subsequent reports and in final maps in the CFC establishment (this) report.
Zone East North	UTM coordinates, 1927 datum. Derived from 1:20 000 forest cover maps from various companies. MB and GVWD forest cover maps were used. Plot coordinates at REN and RGC sites were determined by overlaying MB map for the area over TimberWest forest cover maps. Coordinates were read to give an accuracy of 50 m.
Sere	Phase of seral development of stand within which plot is located: regeneration, immature, mature, old-growth.
Age	Total stand age in 1991 for old-growth and some mature plots was determined from breast height increment cores of 4–6 codominant trees in the plot and adding 10 years. Regeneration immature and some mature plot ages were calculated from year of regeneration on forest cover map.
Orientation Degrees	Orientation of triangular plots, subplot 1 in relation to plot centre, subplot 4.

Appendix II. Plot locator maps, driving instructions, and forest cover maps for chronosequence plots

DISTANCE to Victoria Watershed South plots 1,2,3,4,5,6,7,8 (kilometres):

Take exit west off of Trans-Canada on Malahat onto "South end Shawnigan Lake" turnoff: this is Shawnigan Lake Road, km 0.0.

1.4	RR track crossing
5.7	turn L onto Sooke Lake Road
6.1	bridge
7.1	stay straight
8.0	watershed sign
8.9	L to Vic. Watershed S plots, but go straight to sign in.
9.1	small parking lot on R just before first aid trailer - get information for access here - have your own radio for watershed North plots. This is new 0.0.

From 9.1 kilometres to watershed South plots:

0.0	parking lot at first aid trailer - head east towards Shawnigan
0.1	go R onto Leechtown Main
0.3	plot 4 (3) - tag is on L but trail and plot is on R
0.9	L onto Access Road - require gate key
1.0	T junction - go L for plots 1,2,3,6; R for plots 5,7,8

To plots 1,2,3,6

1.0	T-junction - go L
1.05	go L onto 2A
2.4	R on spur road to plot 1 - go 120 m. to end of road, park. Straight ahead for plots 2,3 and 6.
2.6	plot 2 tag on right
2.9	plot 3 (2a) on left
3.2	plot 6 (4) on right old skid road

To plots 5,7,8

1.0	T junction - go R
3.6	flagging and tag on R park for plot 8(3a), trail to plot starts below road bank
5.4	tag on left for plots 8(1a) and 7(5)

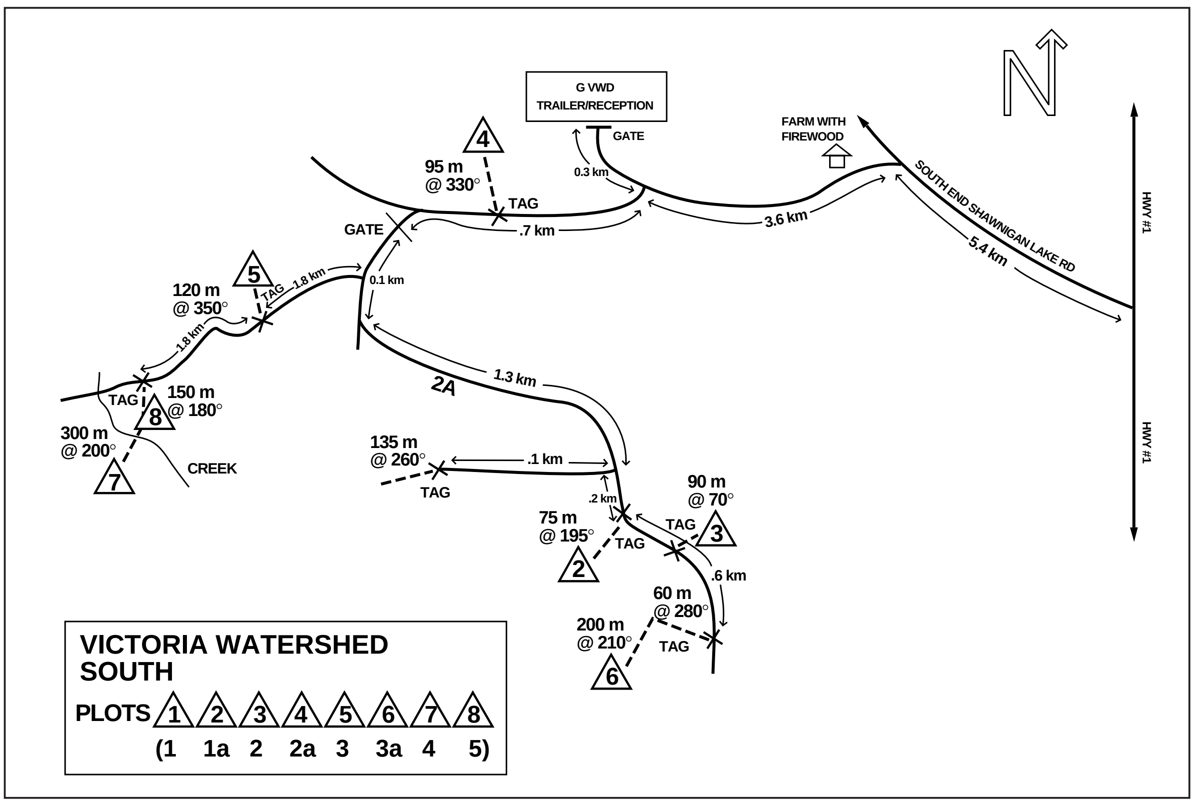
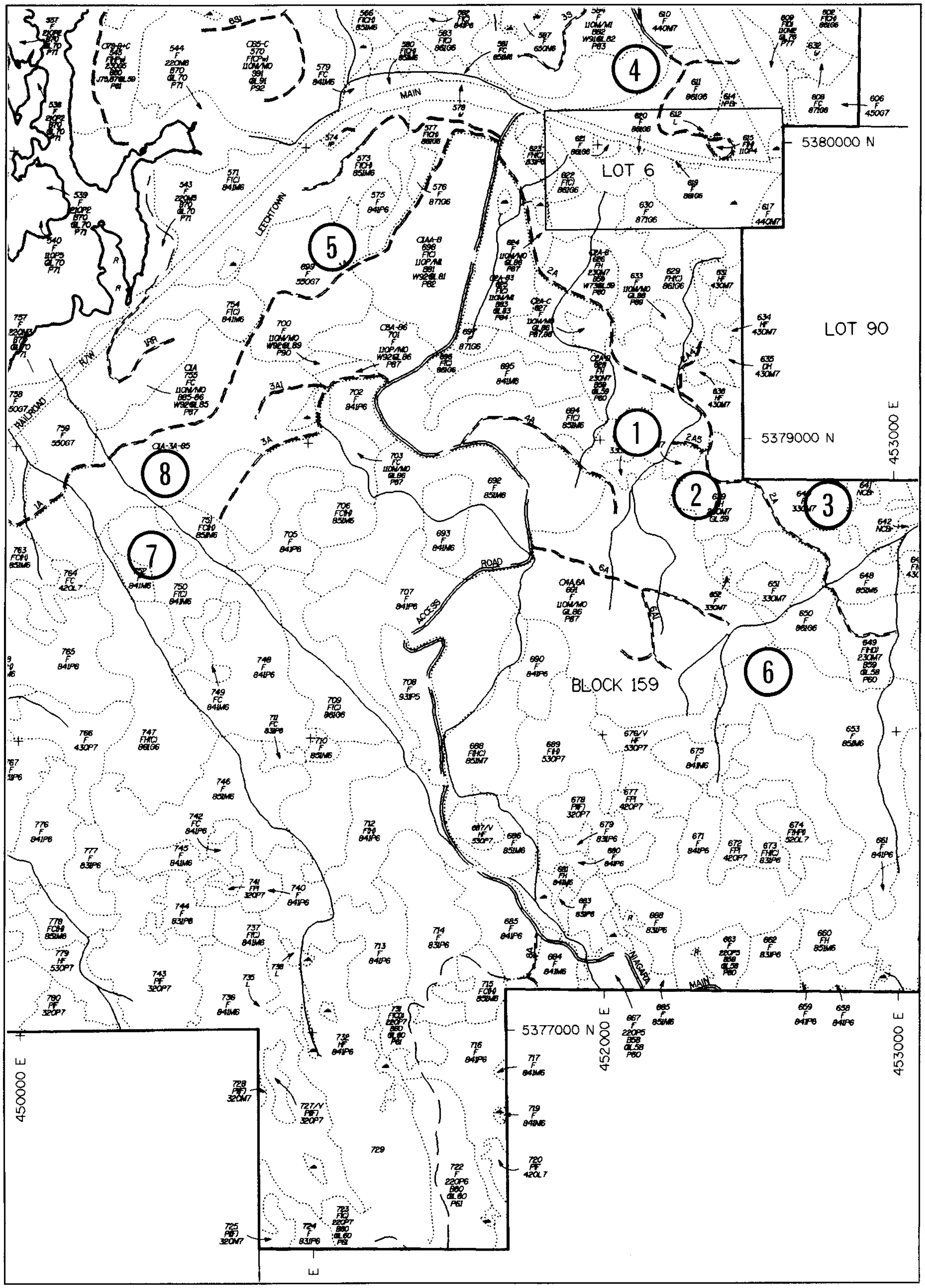


Figure II-1. Locator information for Victoria Watershed South (VWS) plots



1:20 000 forest cover map for Victoria Watershed South plots 1,2,3,4,5,6,7,8

Appendix II. (Continued)

DISTANCE to Victoria Watershed North plots 11,15 (kilometres):

Take exit west off of trans-Canada on Malahat onto "South end Shawnigan Lake" turnoff - this is Shawnigan Lake Road, km 0.0.

0.0	first aid trailer - head W on Sooke Lake Rd.
2.5	9S - stay on Main
7.8	go R onto Rithet East Main - follow it straight ahead at 11.5 km
14.2	go R onto 4RE, stay R at 14.3 km
15.3	4RE3/2RE1 junction - go straight
15.4	Plot 11 (1) on left
15.5	Plot 15 (4) on right

DISTANCE to Victoria Watershed North Plots 12,13 (kilometres):

Drive west along the north shore of Shawnigan Lake until you reach a Y junction: left is a dirt FCC road (TFL 68) and right is a paved road going quickly to dirt that goes down to the Koksilah River bridge.

0.0	L onto FCC road
1.8	L on small road to pipe gate - you need a key.
2.9	junction - go L to plot 12 - park here for plot 13 (3), walk 220 m along overgrown road
3.6	small parking lot, Forestry Canada sign and "green shed." Park here and walk in on West Trail, L on South, R onto East (signed).

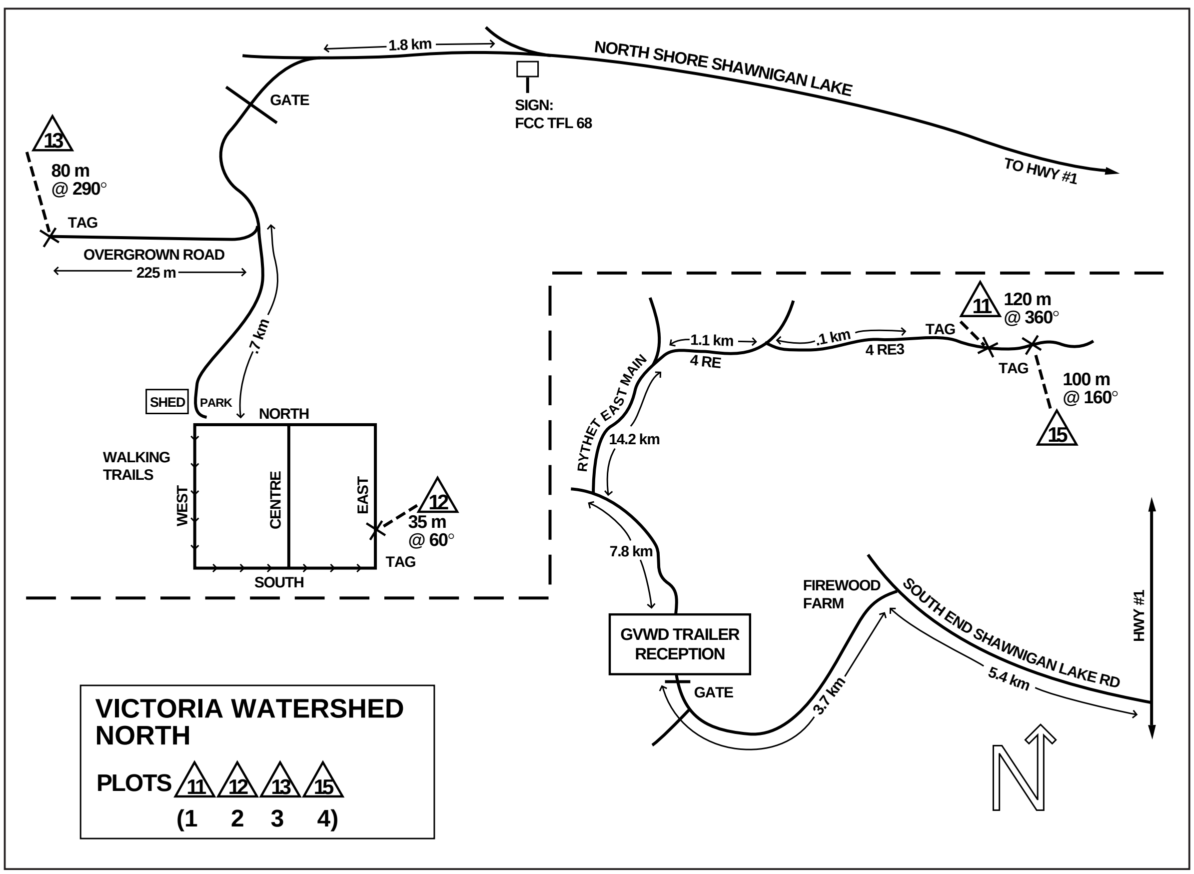
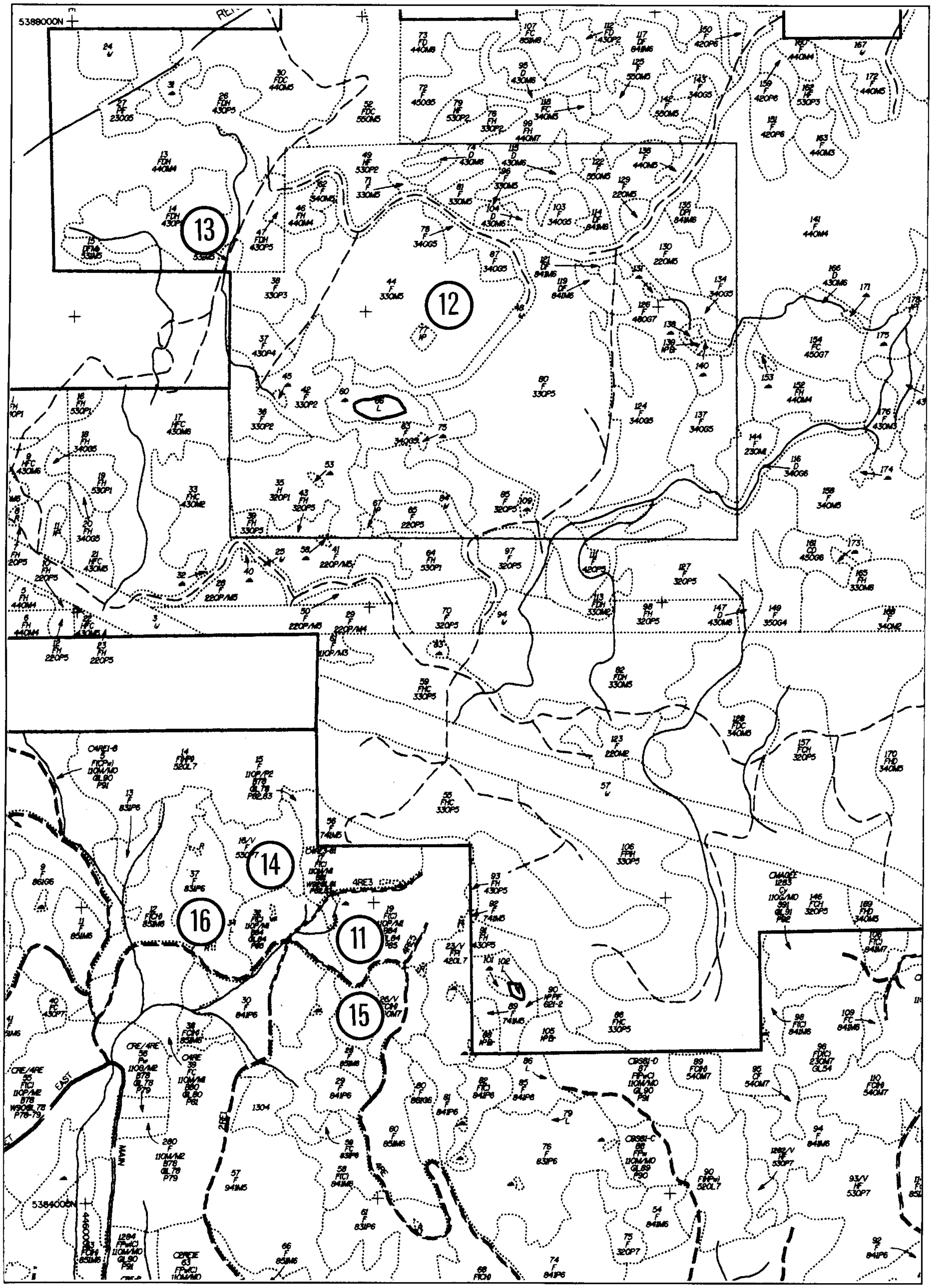


Figure II-2. Locator information for Victoria Watershed North (VWN) plots



1:20 000 forest cover map for Victoria Watershed North plots 11, 12, 13, 15

Appendix II. (Continued)

DISTANCE to Koksilah plots 21,22,23,24,25 (kilometres):

From downtown Duncan, find bridge on Allenby Road heading across Cowichan River towards Deerholme. This bridge is km 0.0

0.0	go straight on Indian Road
3.5	Glenora intersection - go straight
4.5	go R
5.1	continue straight through stop signs to M&B shop on R at 5.8 km - stop and check in.
6.2	go L around sort - follow mainline for several km to junction.
15.4	go L towards Wild Deer Lake - follow this Mainline past turnoffs up H700, 800, 9000
19.6	W1 goes L - stay R
19.7	W2 goes L - follow this or Alternate route below
21.0	R onto W2000
21.8	L onto W2300
22.7	L onto W3400
25.6	L for plots 21,22,25; R for 23,24.

To plots 21,22,25

25.6	go L onto W3426
25.7	Park for plot 21(1)
26.8	L on W3426A, follow this to the end for plot 22 (2), 50 m. before the end for plot 25 (5).

To plots 23,24

25.6	R downhill
26.5	L onto W3424
27.7	end of road - park for plots. Plot 23 (3) is below road, 24 (4) above.

ALTERNATE ROUTE

19.7	W2 goes L - stay R
22.8	Wild Deer Lake on R
22.6	L onto W3000
23.7	W3300 on L keep straight
24.8	L onto W3400, keep straight past W3430, W3422
27.0	Straight onto W3424 for plots 23, 24; L uphill to plots 21, 22, 25.

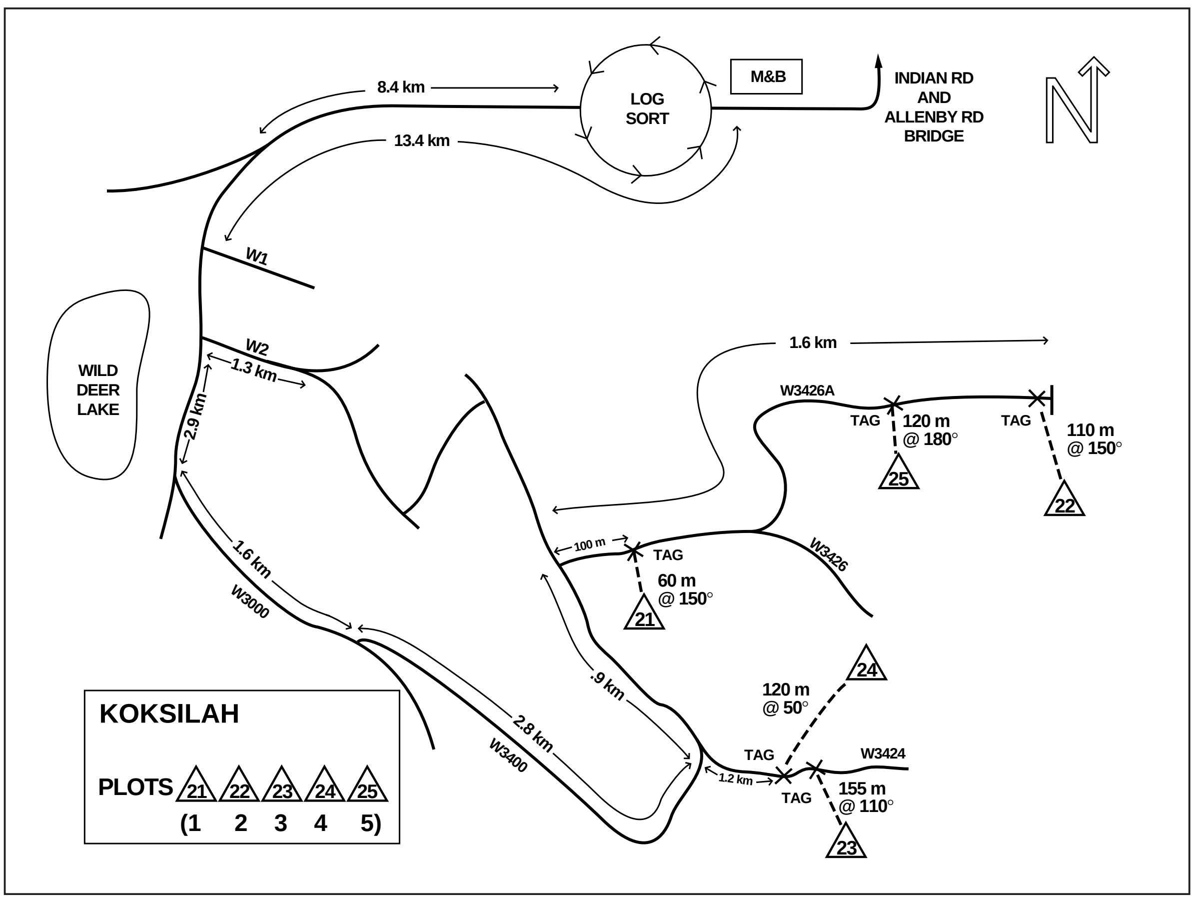
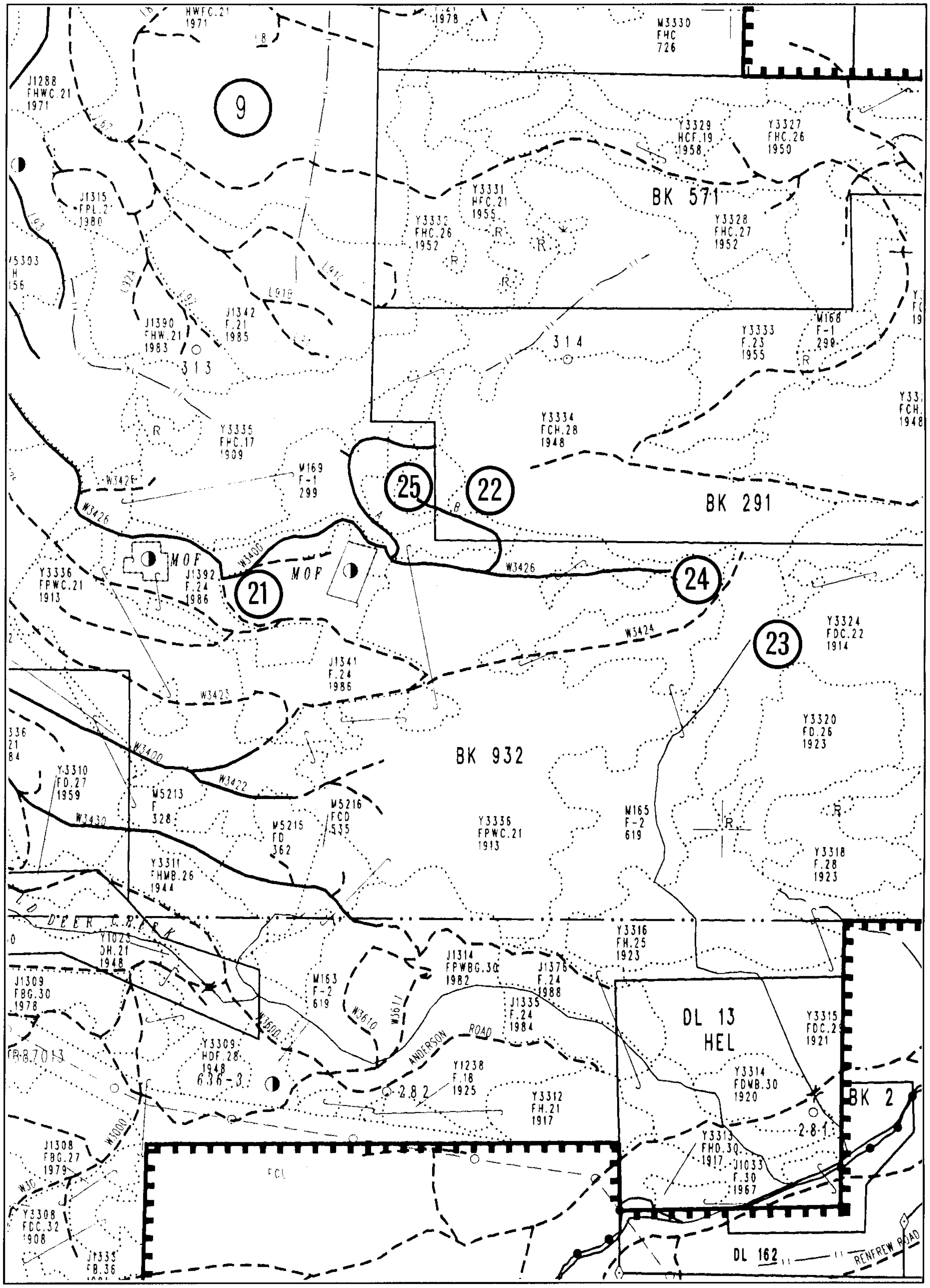


Figure II-3. Locator information for Koksilah (KOK) plots



1:20 000 forest cover map for Koksilah plots 21,22,23,24,25

Appendix II. (Continued)

DISTANCE to Nanaimo River plots 31,32,33,34,35 (kilometres):

Leave Island Highway onto Nanaimo River Road, go up towards TimberWest land for 17.2 km to MB road cutting off downhill to left. This is 0.0 km.

0.0	MB road
1.0	bridge over Nanaimo River, gate (open 0630 - 0730).
1.2	stay R (on mainline)
1.6	enter MB yard - check in
1.7	exit yard on R (west) side
2.0	gate
5.8	J2 branches off to R - stay L on mainline
9.1	go R onto J3 towards Peacock
10.6	explosive shed - go R uphill on P road
11.5	junction L to 34; R to 31,32,33,35

To plot 34

11.5	junction - park walk L 175 m to tag, plot 34(4)

To plots 31,32,33,35

11.5	junction R
11.6	tag L uphill plot 31(1)
11.7	tag R downhill plot 33(3)
12.4	tag L uphill plot 32(2)
13.3	tag L uphill plot 35

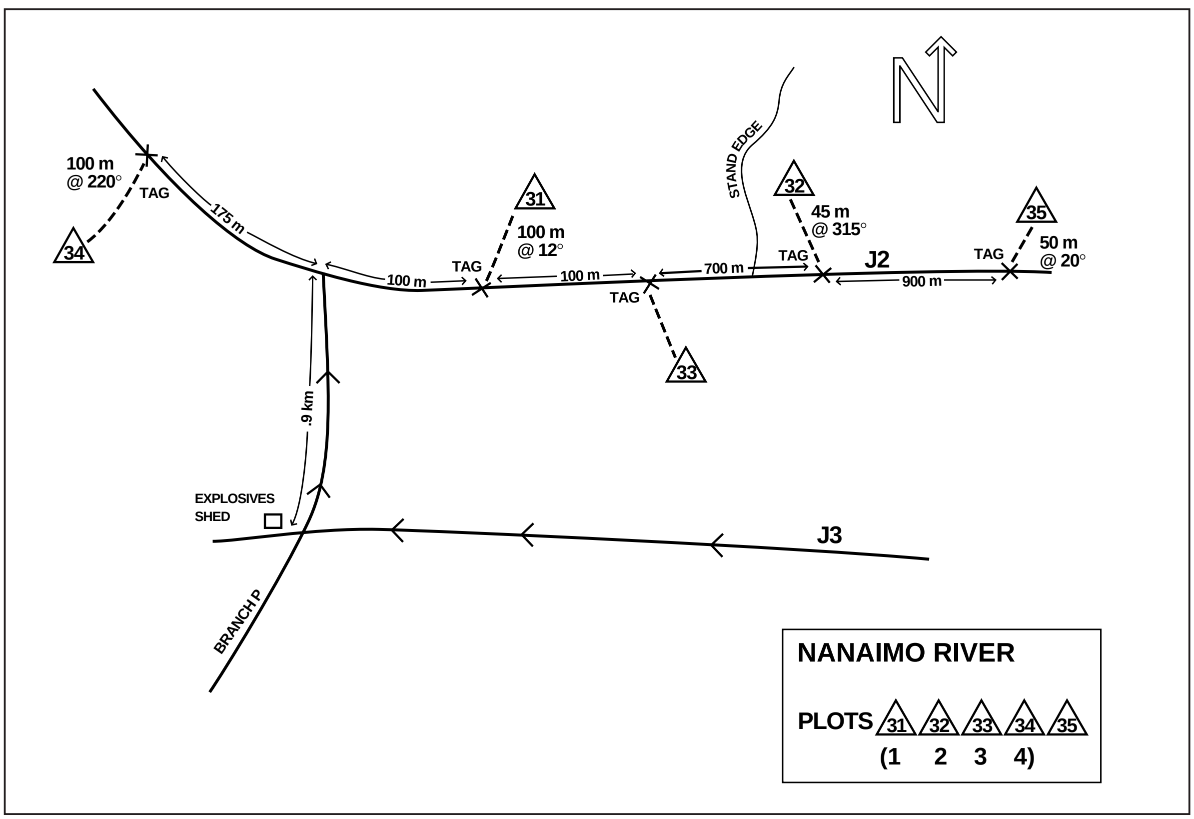
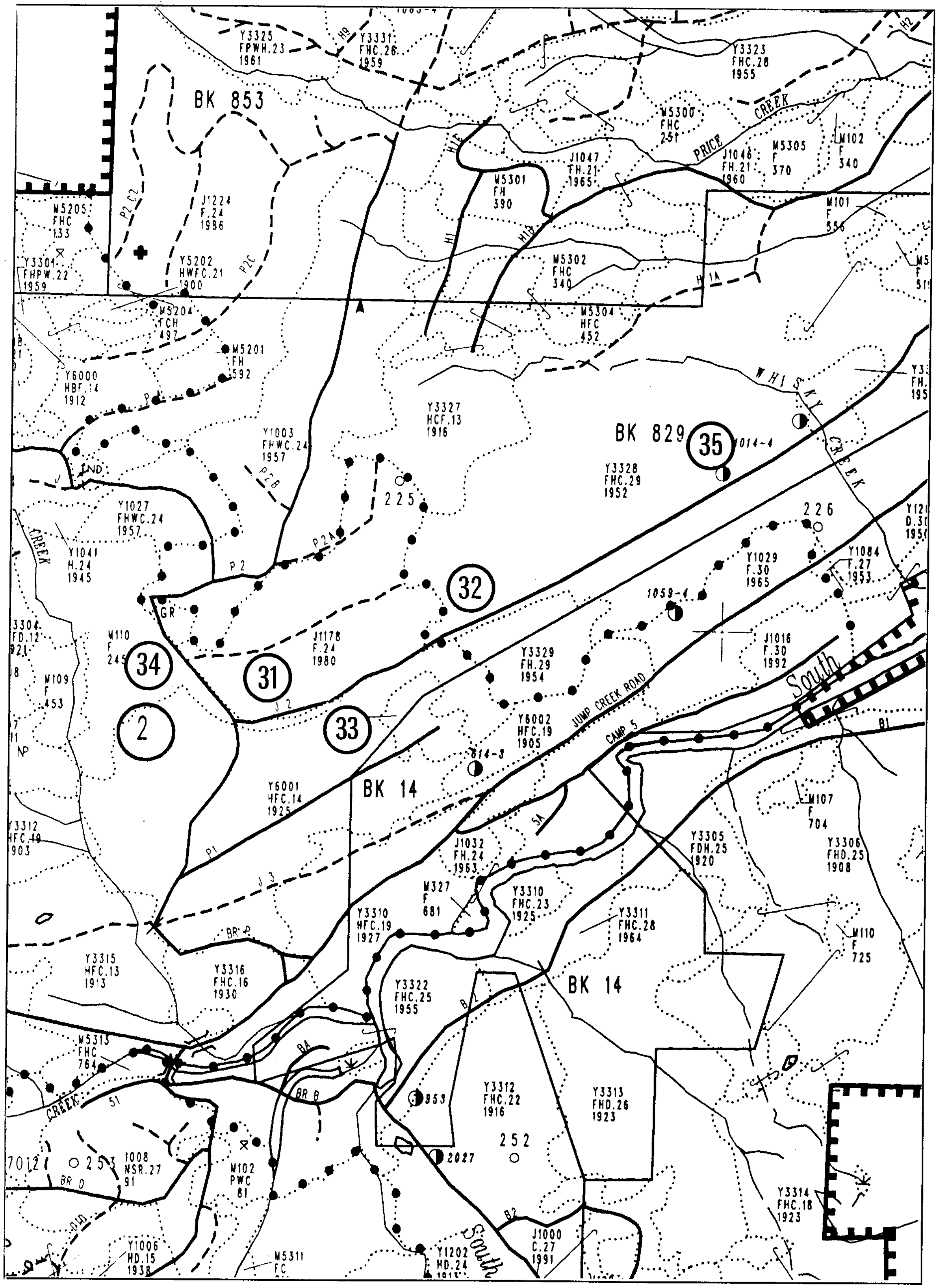


Figure II-4. Locator information for Nanaimo River (NAN) plots



1:20 000 forest cover map for Nanaimo River plots 31,32,33,34,35

Appendix II. (Continued)

DISTANCE to Loon Lake plots 41,42,43,44 (kilometres):

Head towards Port Alberni on Highway #4. Look for intersection where the road to Loon Lake is on the right, and Summit Main (to Mt. Arrowsmith) is on the left. Turn right up towards Loon Lake, this is 0.0 km.

0.0	junction of Hwy #4 and Summit Main
0.4	cross over old railway tracks
1.5	fork - stay L for plots 41, 43; R for 42, 44

To plots 41,43

1.5	go L
1.8	park - road tag location for 41(1), 43(3)

To plots 42,44

1.5	fork - stay R
2.1	fork - stay left
2.5	keep left
3.2	fork - L for 44(4) park; R for 42(2) park

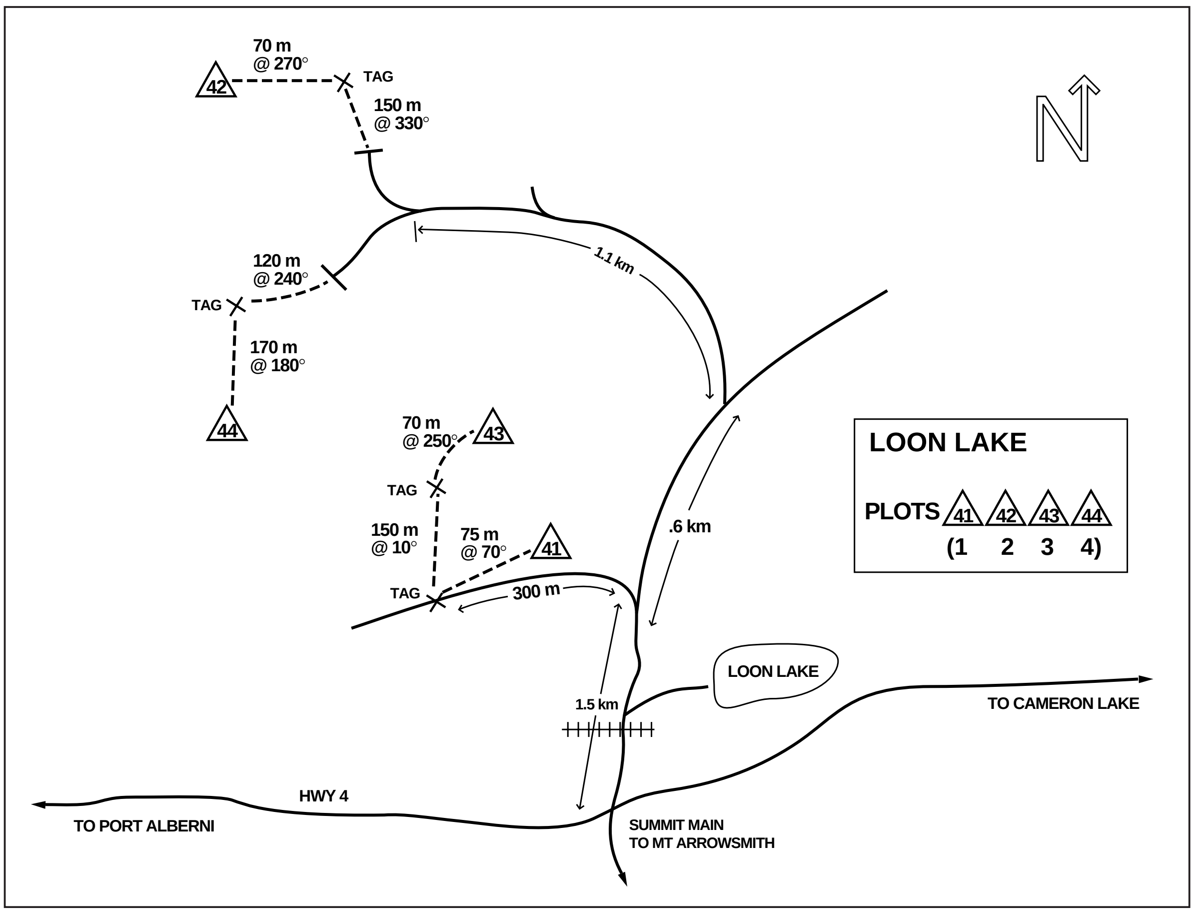
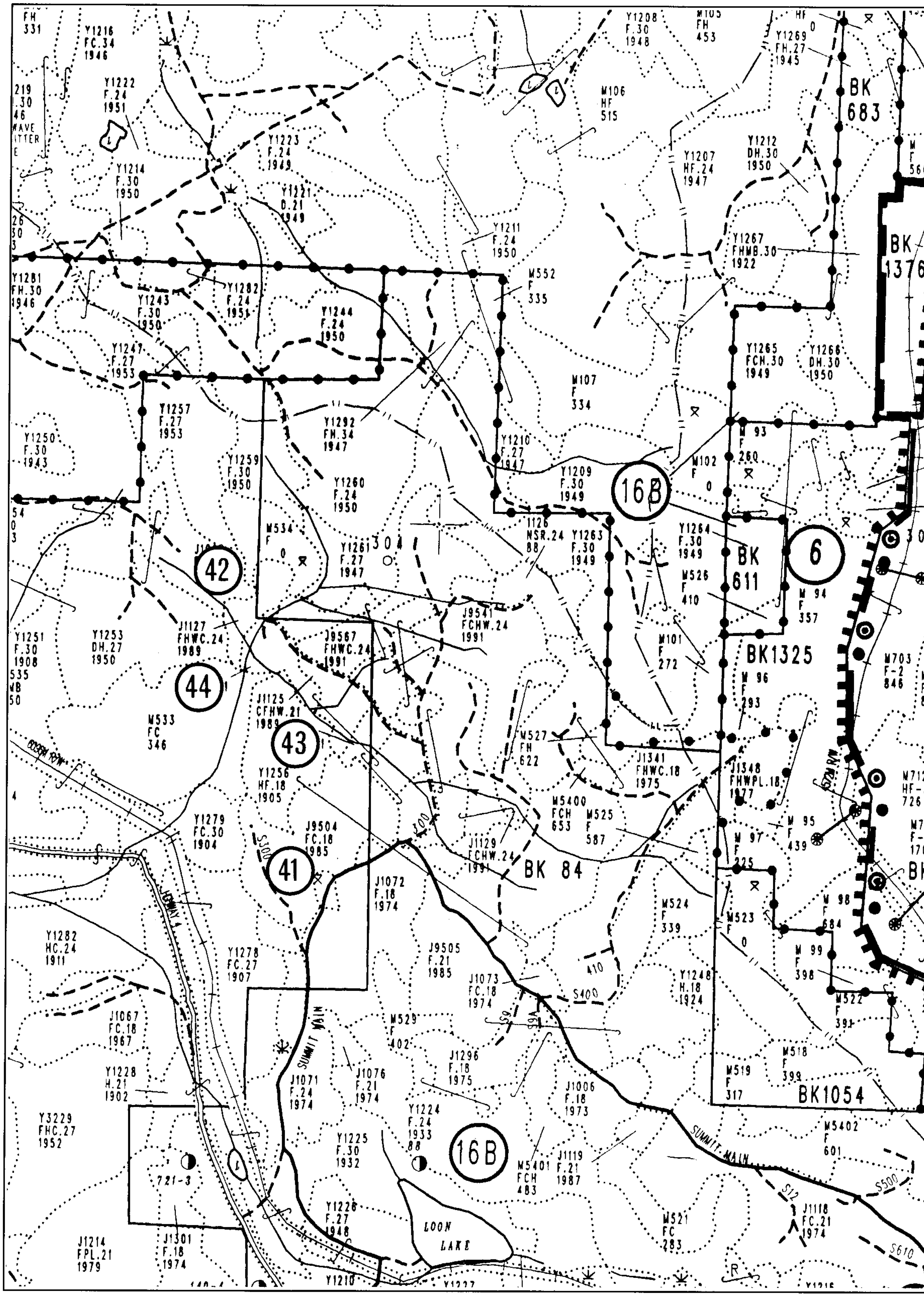


Figure II-5. Locator information for Loon Lake (LOON) plots



1:20 000 forest cover map for Loon Lake plots 41,42,43,44

Appendix II. (Continued)

DISTANCE to Renfrew plots 51,52,53,54 (kilometres):

0.0 Port Renfrew Rec. Centre - head E on pavement toward Jordan River and Victoria

1.2 Salmncum Road heads off to the R - take this to plots 51 and 53

- 0.0 junction Salmncum Rd. - highway
- 0.2 stay R at fork
- 0.7 road curves up to the L - park on this corner for plot 53 (3) - tag visible on stand edge 50 m at 210˚
- 1.7 end of road at landing - park here for plot 51 (1)

2.4 Elliot Mainline on R - go up here for plot 54

- 0.0 junction Elliot M/L - highway
- 2.0 stay L at fork to 54
- 2.2 stay R
- 2.4 road in trouble - park here
- 2.5 fork R - stay L
- 2.6 plot 54 (4)

2.7 Park for plot 52 (2), just up the hill on the R

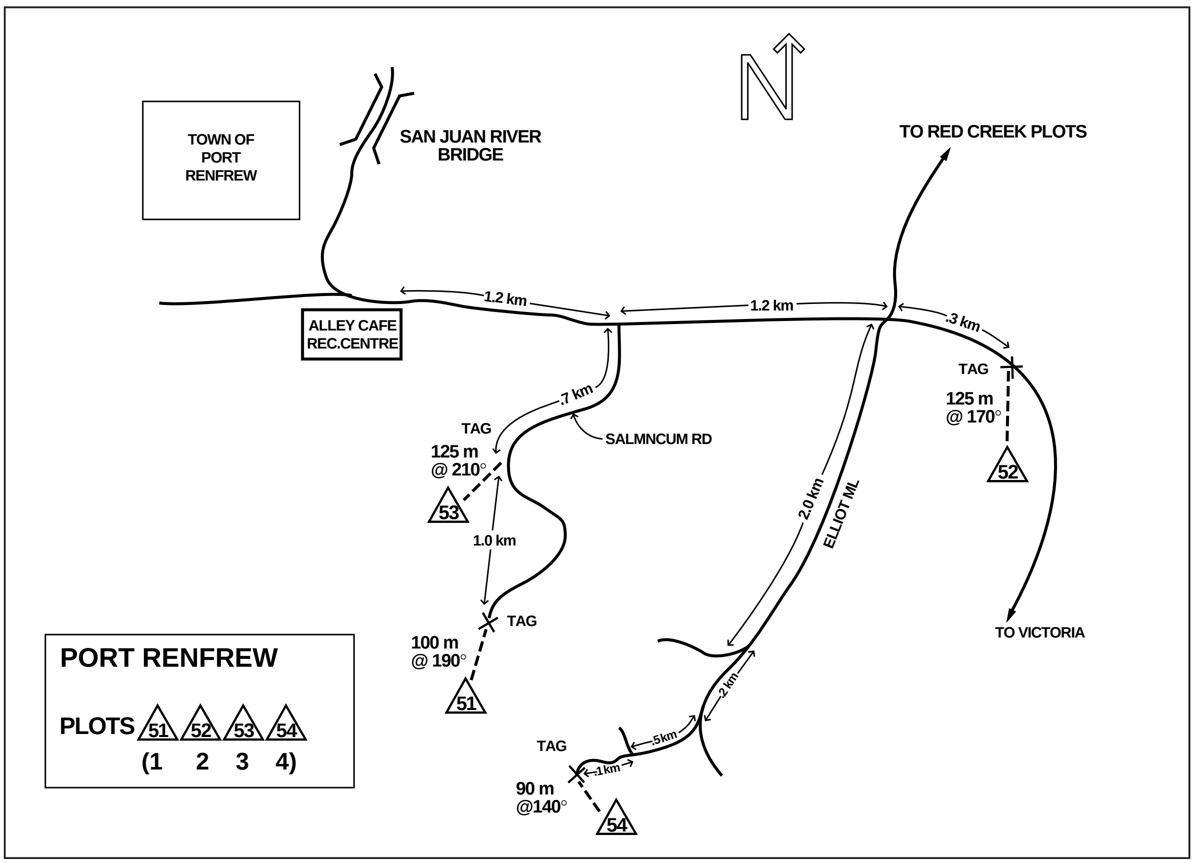
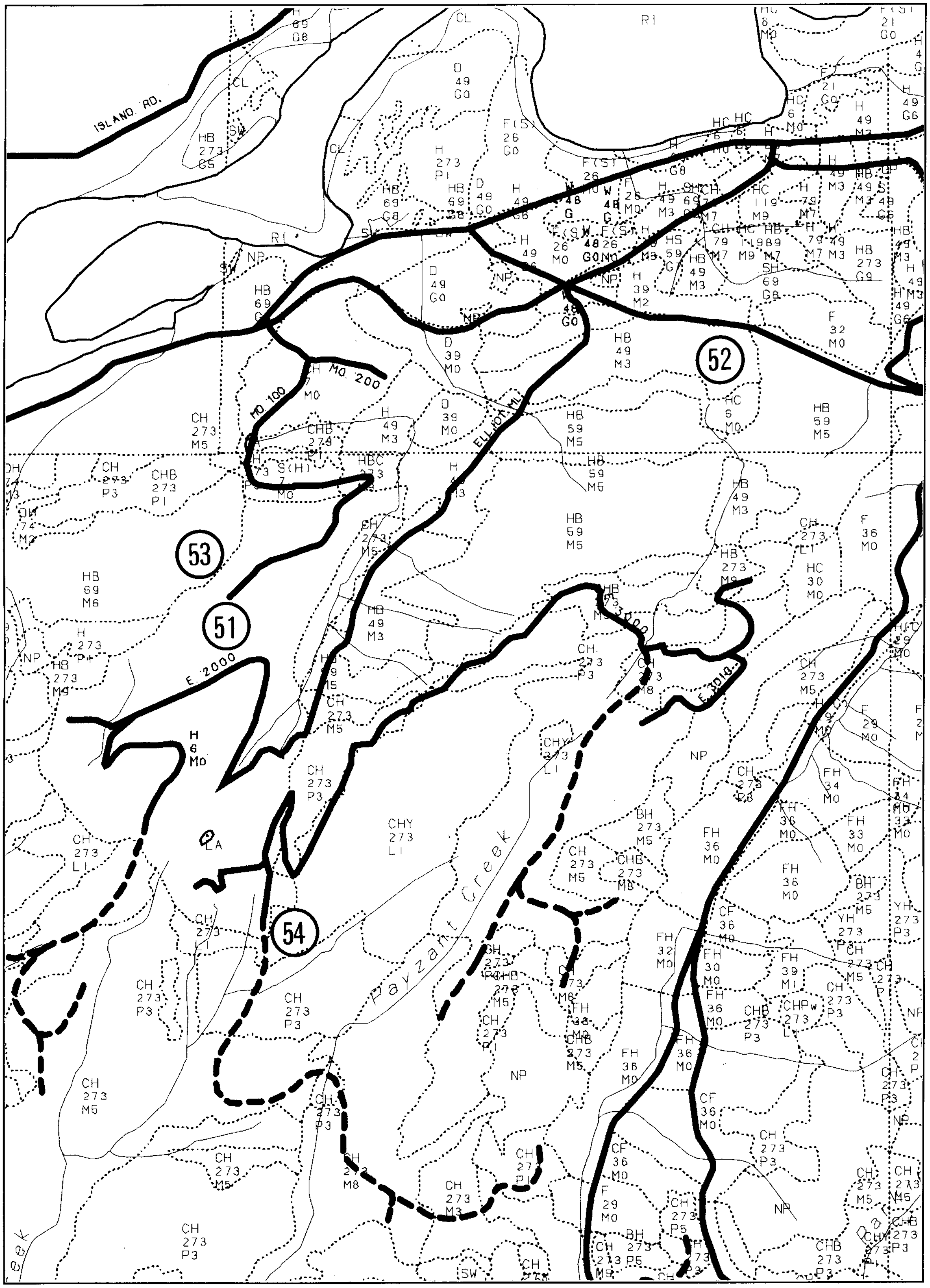


Figure II-6. Locator information for Renfrew (REN) plots



1:20 000 forest cover map for Port Renfrew plots 51,52,53,54

Appendix II. (Continued)

DISTANCE to Red/Granite Creek plots 61,62,63,64 (kilometres):

0.0	Port Renfrew Rec Centre - east to 61,62,64; north to 63.

To Red Creek plots 61,62,64

0.0		Port Renfrew Rec Centre - Head east towards Jordan River
2.4		Where Elliot Main goes up R (km 2.4) go down L following signs towards the Red Creek Fir.
	0.0	junction Elliot M/L - highway
	0.4	stay R
	6.8	old road on left, park walk road uphill to tag for plot 62(2)
	8.8	creek
	11.3	junction - up R to Red 61, straight ahead to Red 64
	13.4	up right park for Red 61(1) - tag is below road, plot is uphill
	12.6	straight to parking area for Red Creek Fir
	12.8	trail up to Red Creek Fir
	12.9	tag for Red 64(5)

To Granite Creek plot 63

0.0	Port Renfrew Rec Centre - Head north across San Juan River
2.7	T junction, R towards Lake Cowichan
10.5	bridge over Granite Crk. park before bridge follow overgrown spur road on N uphill side, to plot 63(3)

DISTANCE to Granite Creek plot 63 from Lake Cowichan (kilometres):

0.0	bridge in Cowichan Lake
6.6	turnoff S in Mesachie Lake - a traffic light (not operating January 1992) just before (E of) CPFP yard onto Hillcrest Mainline
15.1	stay R onto Harris Creek Mainline
27.9	stay L
38.6	Gordon Mainline comes in on R - cross Harris Creek bridge at 38.7
43.2	Lizard Lake Rec. Site
45.0	join San Juan River Mainline
49.4	Granite Creek Mainline goes N, cross bridge
49.6	overgrown spur road on N, uphill side, follow to plot 63(3)

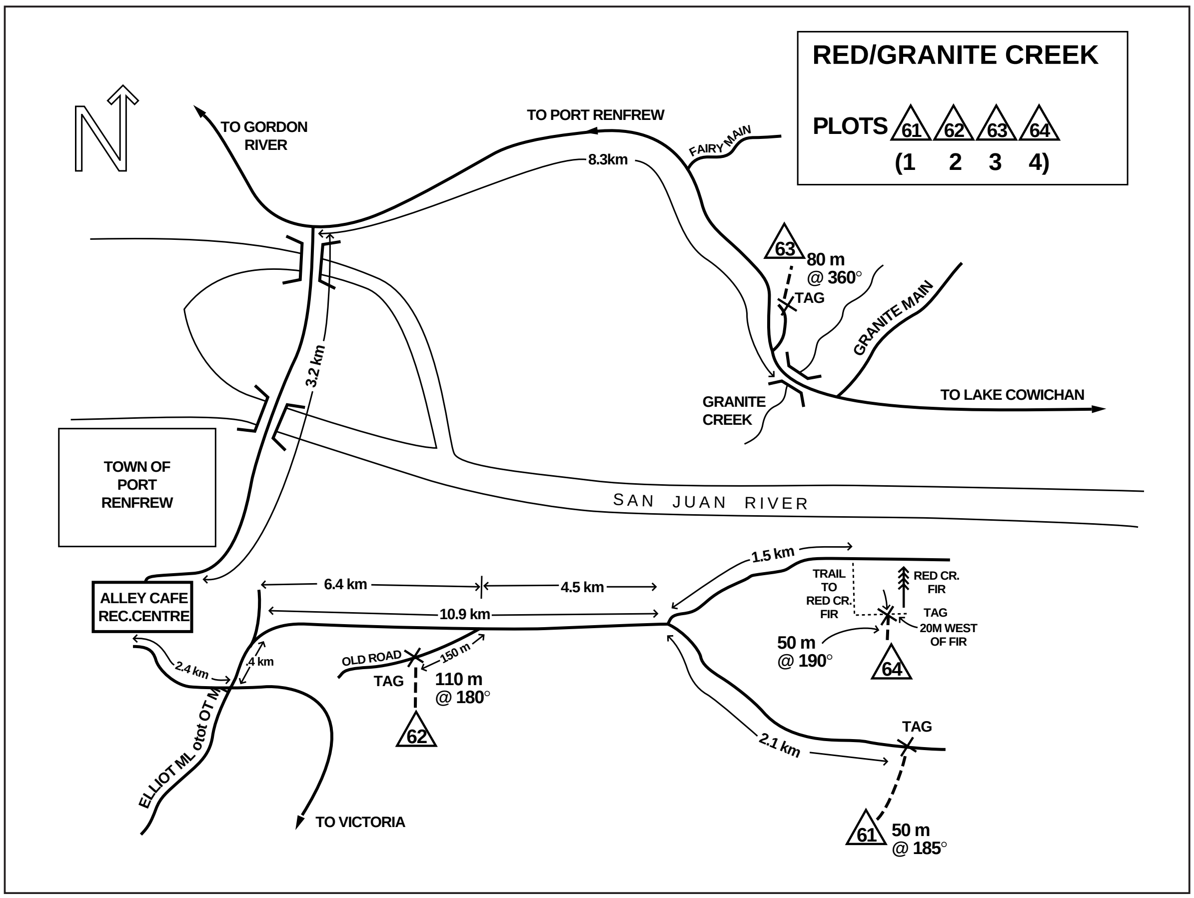
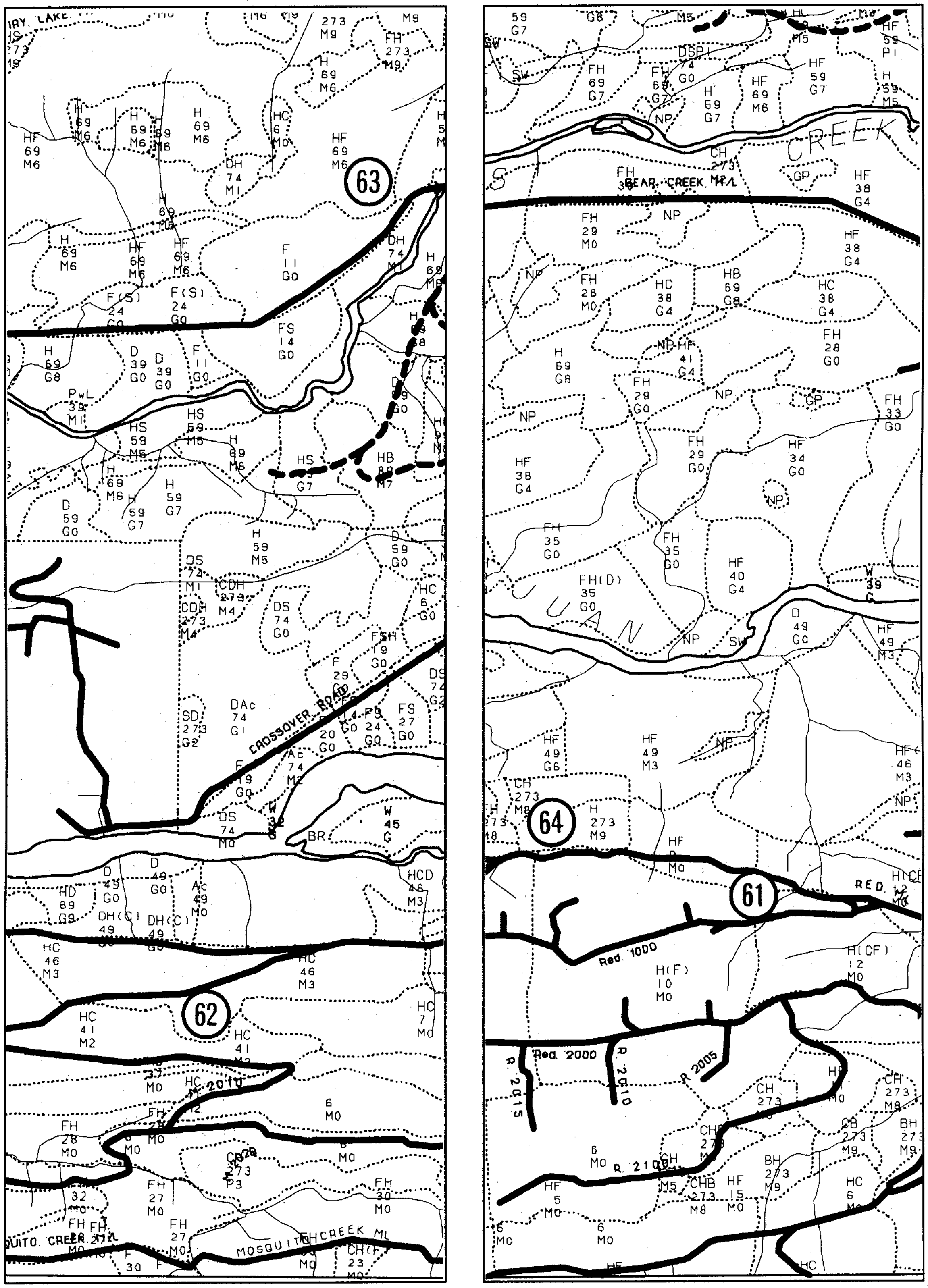


Figure II-7. Locator information for Red/Granite Creek (RGC) plots



1:20 000 forest cover map for Red/Granite Creek plots 61,62,63,64

Appendix II. (Continued)

DISTANCE to Nitinat plots 71,72,73,74 (kilometres):

Description for Nitinat plots begins at Nitinat River Bridge - 28.1 km from W. end Lake Cowichan to Nitinat River Bridge

0.0	Nitinat River Bridge - head towards Cowichan and Nitinat
0.2	T-junction - R towards 73; L to 71,72,74

To plot 73

0.2	go R
3.7	plot 73(3) on L - go 50 m further to park off of road on R

To plots 71,72,74

0.2	T-junction L towards Cowichan
0.9	turn R uphill onto Jasper M/L
1.4	go R again, continue up possible washouts beyond here
4.0	plot 72(2) uphill on L
4.5	turn R onto 70B
5.5	keep L
6.5	turn R
6.6	trail to 71(1); 74(4) is on downhill side

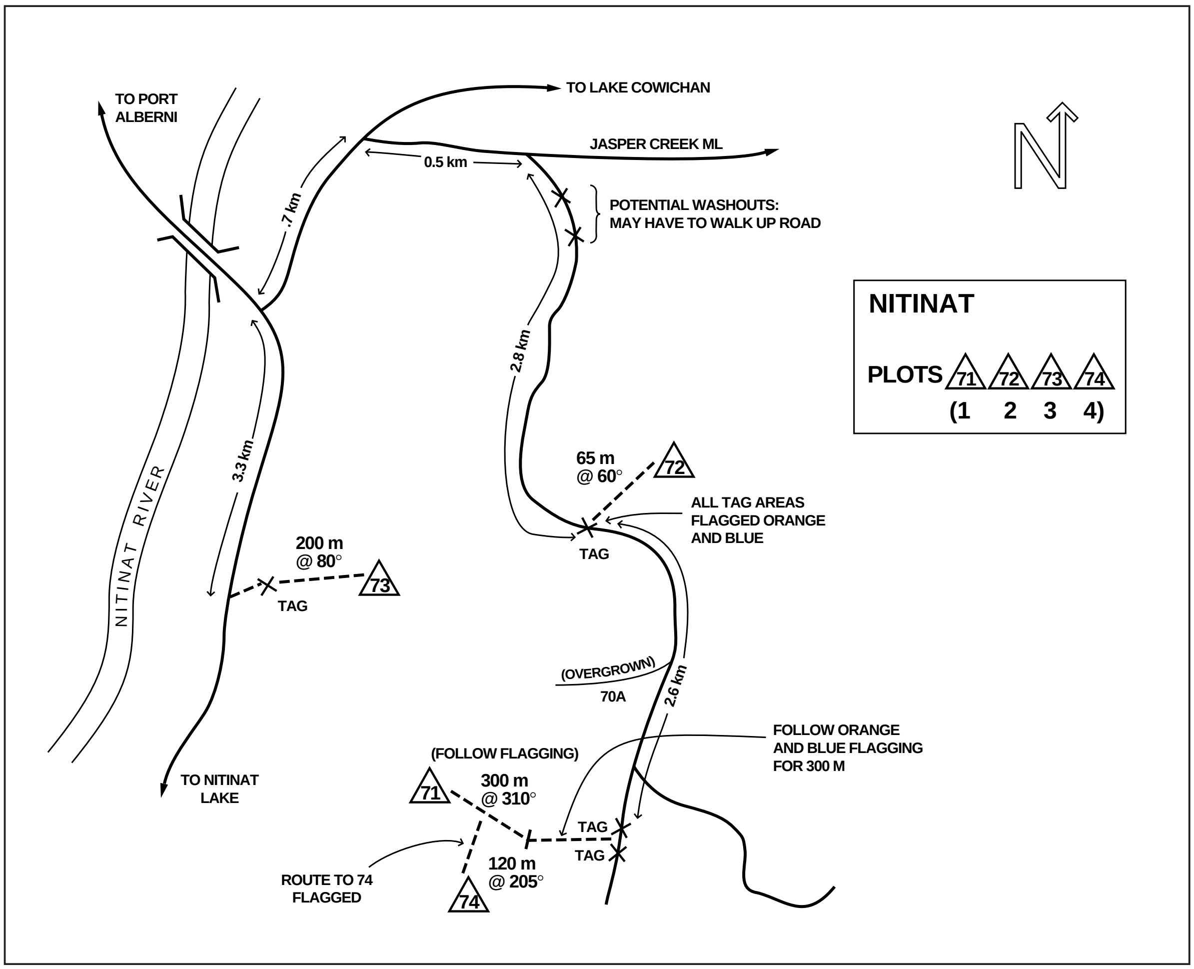
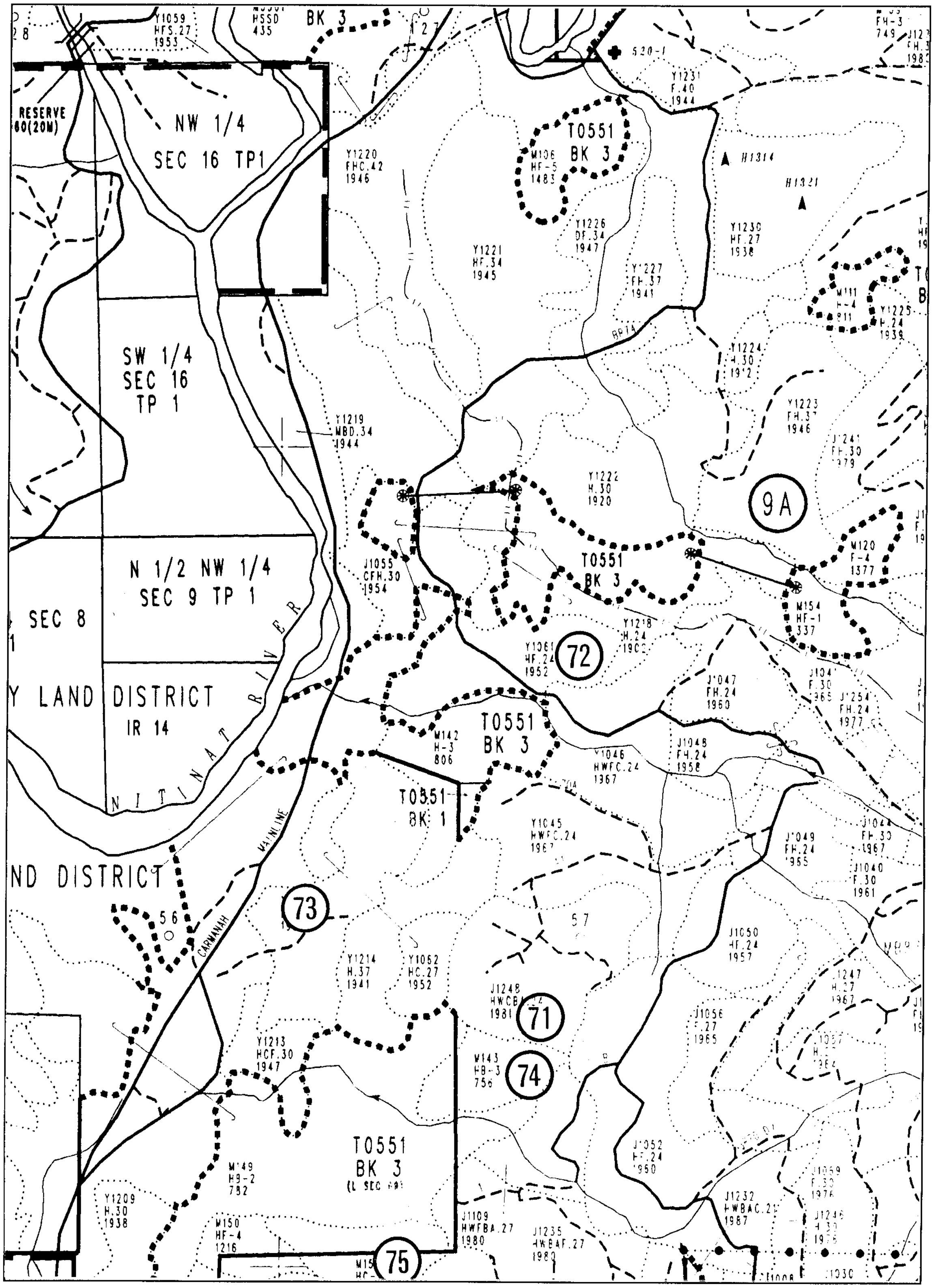


Figure II-8. Locator information for Nitinat (NIT) plots



1:20 000 forest cover map for Nitinat plots 71,72,73,74

Appendix II. (Continued)

DISTANCE to Klanawa plots 81,82,83,84,85 (kilometres):

0.0	Coleman Cr. bridge (200 m NW Franklin Camp turnoff) - NW goes to Pt. Alberni; SE to Franklin Camp and Lk Cowichan; SW to Bamfield. Check in with dispatch at Franklin to find out where hauling is occurring.
0.2	junction go SW to Bamfield. Stay straight on M/L at 1.3, 3.0, 11.2 (bridge), and 12.1
13.3	Bridge - take immediate L onto Central North M/L. Stay straight on M/L at 17.6, 18.9, and 19.2.
22.0	T junction - go R on Central South M/L (L is Flora Lake M/L).
23.6	junction - L to plots 81,83,84; R to 82,85

To plots 81, 83, and 84

0.0	L onto Branch 265
1.4	stay straight
1.7	bridge
1.8	stay R on 265
5.4	junction with North Fork, turn onto North Fork
5.5	gate - closes (Jan 1992) at 15:45
5.6	stay straight on NF ML at 5.6, 5.8, 6.1
6.2	junction with NF 400; R 300 m to tag for plot 81(1); straight for 83,84
6.9	stand boundary; 80 m for tag 84(4), 160 m for 83(3)

To plots 82 and 85

23.6	stay R on Central South M/L toward Bamfield.
24.1	creek with culvert.
24.4	pullout on L, watertank on R. Park here. Plot 85(5) tag further on uphill side; 82(2) back on downhill side.

DISTANCE from Klanawa to Cowichan Lake from plots 82,85 (kilometres):

0.0	pullout for Klanawa 82 and 85
0.8	265 goes R - stay straight
2.5	Central North goes L - stay R on Flora Lake M/L. Stay straight at 4.1, 5.5, 7.5
8.5	E junction of 265 on R - stay straight
15.7	bridge over Little Nitinat Rvr. - go R onto S M/L
24.3	Nitinat Riv. bridge - L at T - junction to Lk. Cowichan

DISTANCE from Klanawa to Cowichan Lake from plots 81,83,84 (kilometres):

0.0	from plots 81,83,84 start gate junction of North Fork and Branch 265
0.1	R onto Branch 265
5.0	bridge start of Upper Klanawa M/L
7.5	continue straight
14.9	R onto Flora Lake M/L
22.1	bridge over Little Nitinat Riv. - go R.
30.7	Nitinat Riv. bridge - L at T junction to Lk. Cowichan.

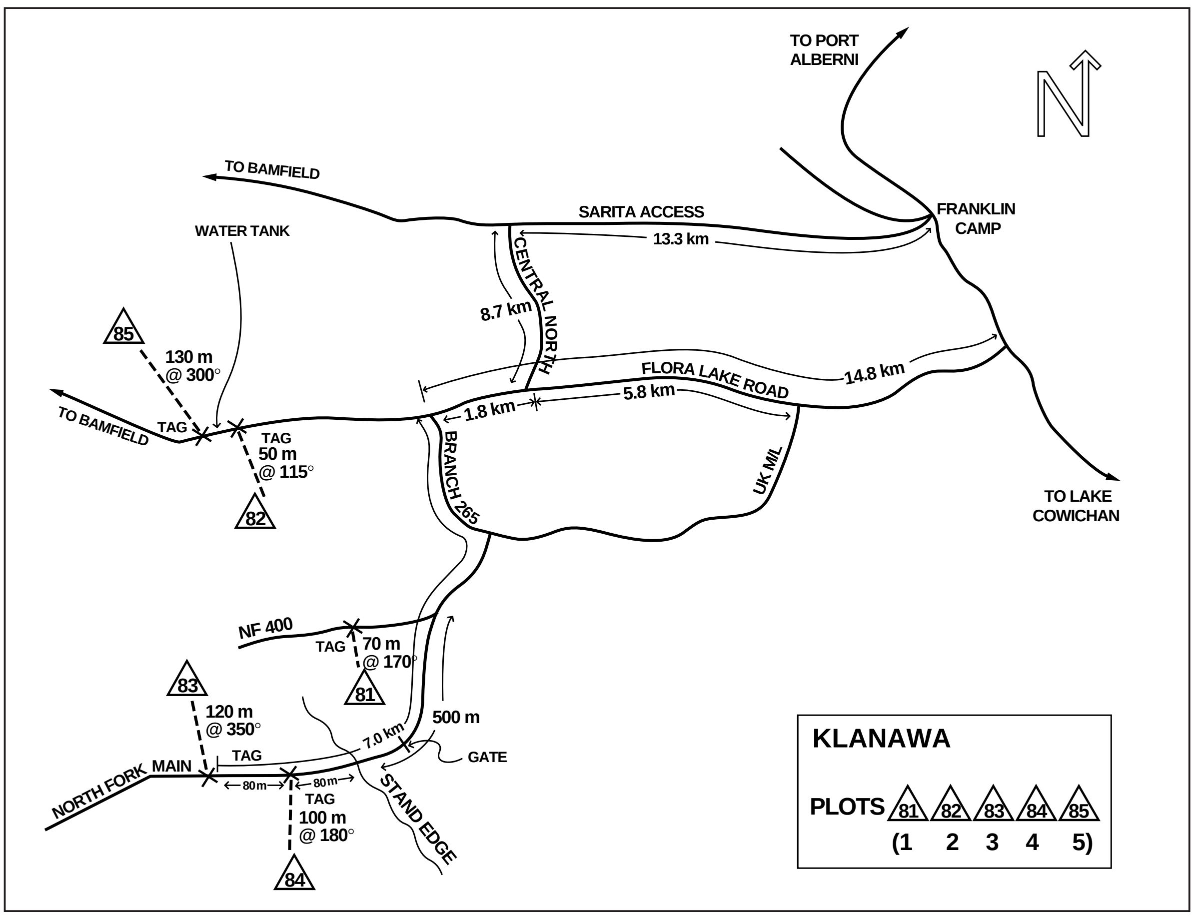
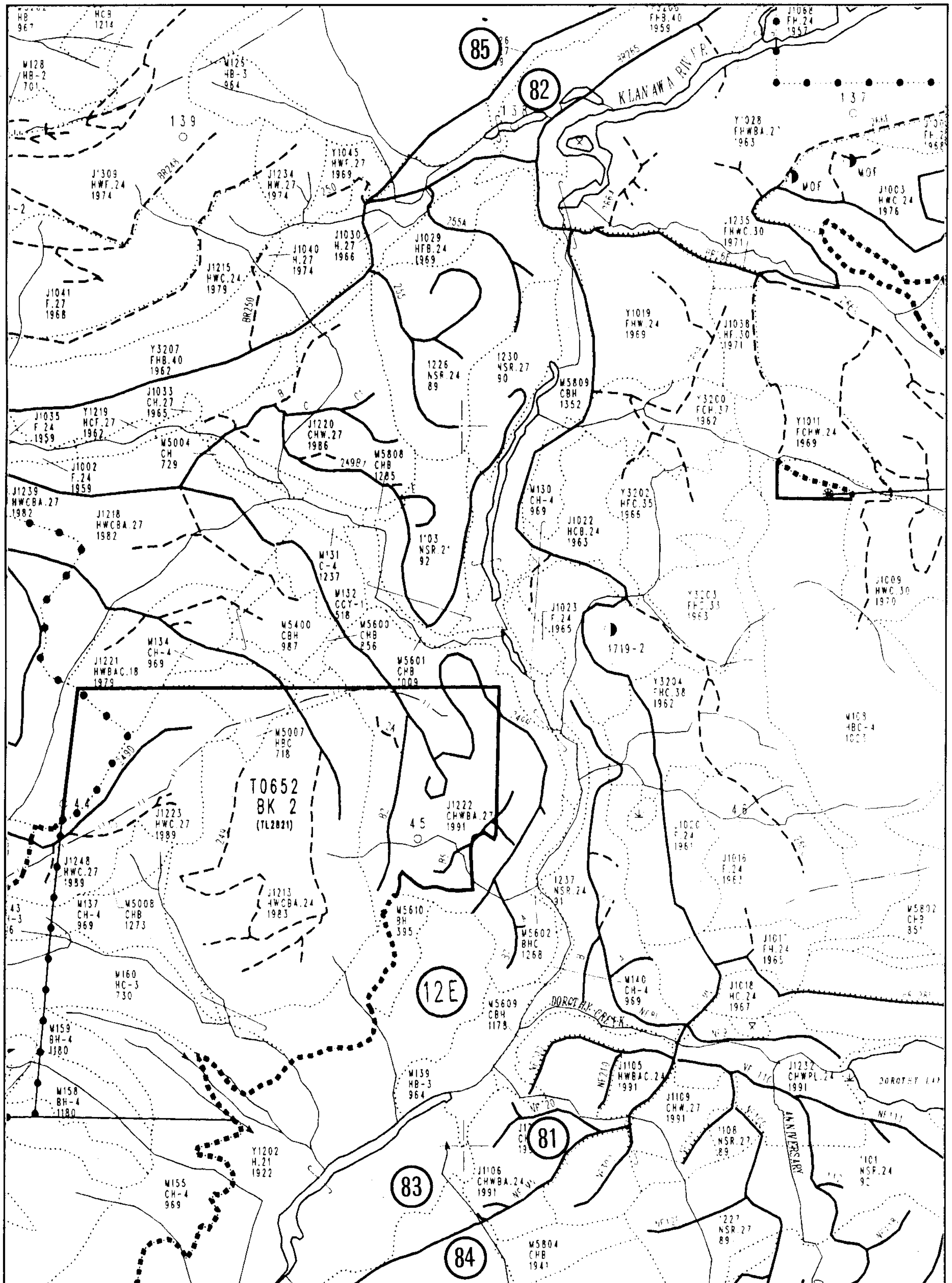


Figure II-9. Locator information for Klanawa (KLA) plots



1:23 250 forest cover map for Klanawa plots 81,82,83,84,85

Appendix II. (Continued)

DISTANCE to Mount Ozzard plots 91,92,93,94,95 (kilometres):

About 5.1 km west of Ucluelet is a paved road heading toward Port Albion. Take this road, the junction is km 0.0.

0.0	Port Albion cutoff
1.2	logging mainline crosses road. Can turn R to visit Kennedy Lake Division office if necessary (0.6 km).
4.1	pavement ends - go L up Mercantile Crk. Rd.
5.3	junction to L - stay straight (right)
5.9	junction - go L to 91,92,94,95; R to 93
6.7	junction - go L to 92; R to 94 and 95

To plot 92

5.9	go L onto Mercantile Crk. Rd.
6.7	go L
7.9	junction - stay straight ahead
8.1	L onto MCR 70
8.2	bridge over Mercantile Creek - can drive a bit further (stay R at fork in 100 m) but measurement to plot 92(2) road tag is from this point.

To plots 91, 94 and 95

5.9	go L onto Mercantile Crk. Rd.
6.7	go R
7.7	stay R
8.5	stay R for 94 and 95 - go L 200 m. to 91(1)
8.7	junction - road to R is the route to plots. Road is blocked in 200 m, so measurements to plots 94(3), 95(4) are from this junction.

To plot 93

5.9	go R onto Barclay Main
8.7	BM 28 goes R - stay L
10.9	plot 93 (2A) on L
11.0	BM 51 goes L - park and walk back to plot

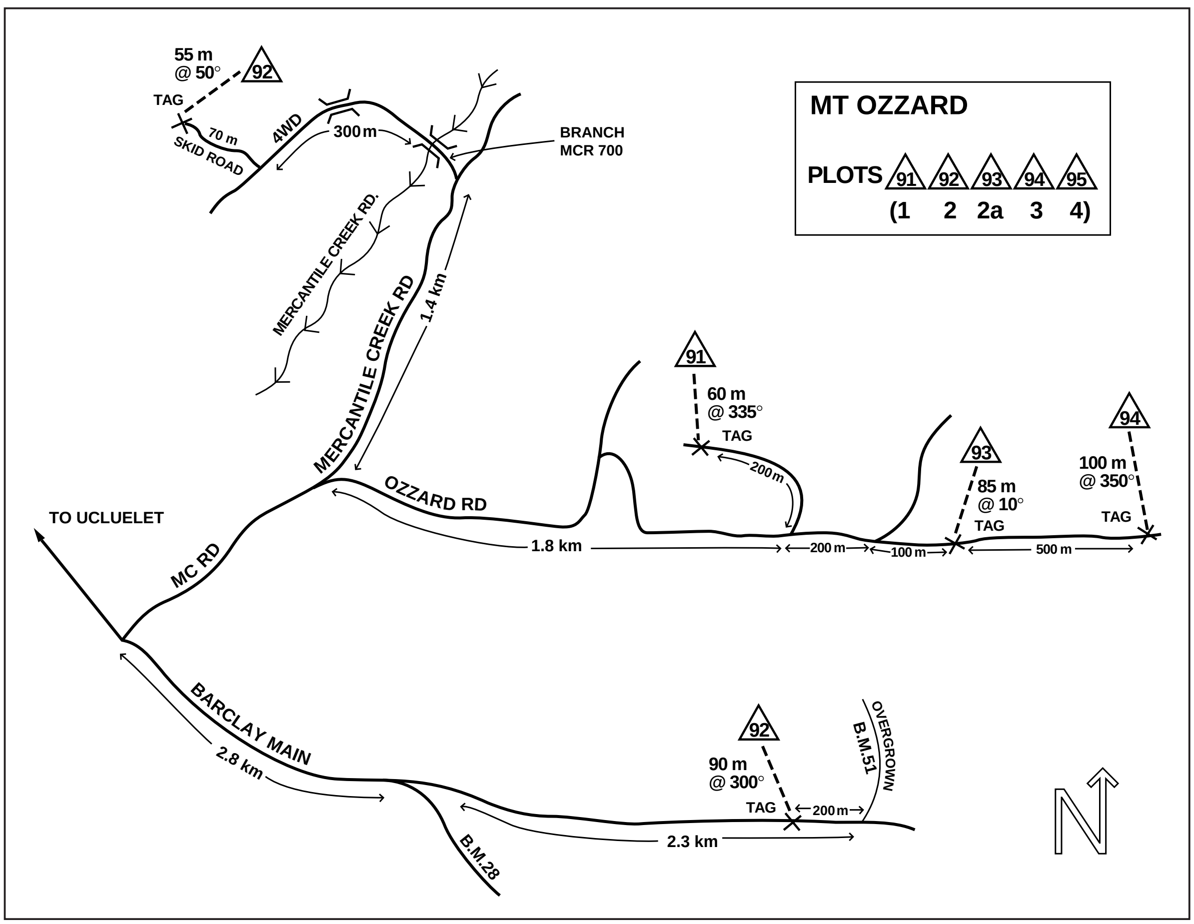
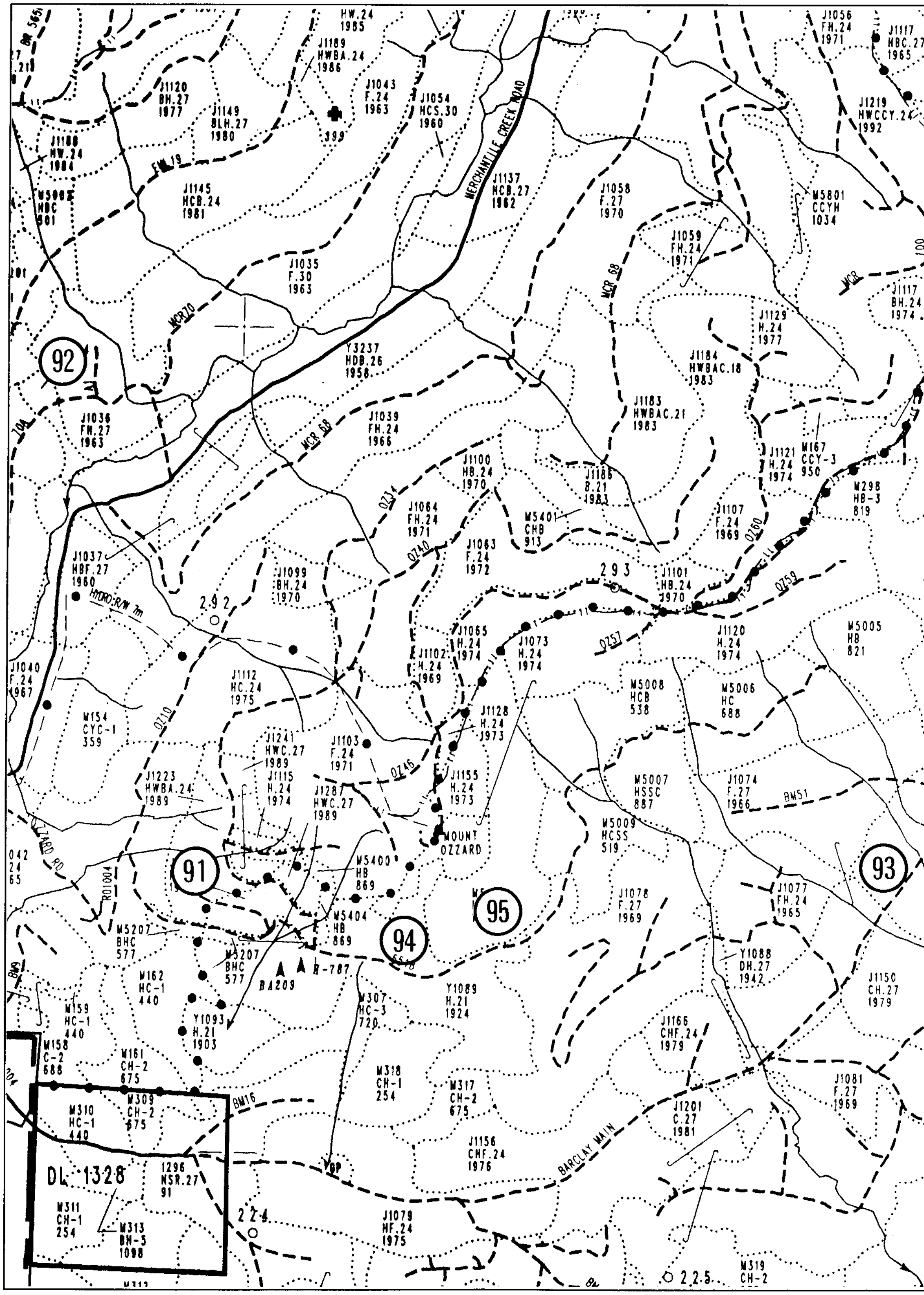


Figure II-10. Locator information for Mt. Ozzard (OZZ) plots



1:20 000 forest cover map for Mt. Ozzard plots 91, 92, 93, 94, 95.

Appendix III. Environmental characteristics for each plot by chronosequence

Table III-1. Environmental characteristics for Victoria Watershed South (VWS) plots

Plot -->	Mean	01	02	05	06
Biogeoclimatic Zone		CWH	CWH	CWH	CWH
Subzone/Variant/Phase		xm1	xm1	xm1	xm1
Site Series		01	01	01-07	01
*** Location ***					
Physiographic location		GVWSOUTH	GVWSOUTH	GVWSOUTH	GVWSOUTH
NTS Map Sheet		92B/12	92B/12	92B/12	92B/12
Longitude		1233855	1233855	1233945	1233853
Latitude		483351	483351	48347	483344
*** Environment ***					
Elevation (m)	303	280	305	240	390
Slope gradient (%)	26	15	40	11	40
Aspect (degrees)		50	20	315	30
Meso slope position		UP	MD	LW	MD
Exposure		NA	NA	NA	NA
Surface shape		CC	ST	ST	ST
Hygrotope		M	M	SHG	SM
Trophotope		M	M	PM	M
Terrain		gsMIj	gsMIj	gsFIj	gsMIk
Soil		O	O	DU	O
Subgroup (CSSC 1978)		DYB	DYB	DYB	DYB
Family Particle size		FSI CL	FSI CL	FSILCL	FSI CL
Rooting depth (cm)	37	23	44	37	46
Root restricting depth (cm)	63	83	44	——	——
Soil drainage		W	W	MW	W
Humus form		MLMD	CTMD	CZMU	MLMD
Successional Stage		PS	YS	MS	OS

Table III-2. Environmental characteristics for Victoria Watershed North (VWN) plots

Plot -->	Mean	11	12	13	15
Biogeoclimatic Zone		CWH	CWH	CWH	CWH
Subzone/Variant/Phase		xm2	xm2	xm1	xm2
Site Series		01	01	01	01
*** Location ***					
Physiographic location		GVWNORTH	GVWNORTH	GVWNORTH	GVWNORTH
NTS Map Sheet		92B/12	92B/12	92B/12	92B/12
Longitude		1234317	1234240	1234409	1234317
Latitude		483659	483808	483819	483659
*** Environment ***					
Elevation (m)	382	450	355	260	465
Slope gradient (%)	21	25	5	15	40
Aspect (degrees)		260	360	55	250
Meso slope position		MD	MD	MD	MD
Exposure		NA	NA	NA	NA
Surface shape		CC	CV	ST	ST
Hygrotope		M	M	M	M
Trophotope		M	M	M	M
Terrain		gsMI	gsMIj	gsMIj	xsDIj
Soil		O	DU	DU	O
Subgroup (CSSC 1978)		HFP	DYB	DYB	HFP
Family Particle size		L FSI	L S	FSI CL	FSI L
Rooting depth (cm)	65	45	74	78	45
Root restricting depth (cm)	71	—	74	95	45
Soil drainage		W	W	W	W
Humus form		HFMR	HFMR	HFMR	HFMR
Successional Stage		PS	YS	MS	OS

Table III-3. Environmental characteristics for Koksilah (KOK) plots

Plot -->	Mean	21	22	23	24
Biogeoclimatic Zone		CWH	CWH	CWH	CWH
Subzone/Variant/Phase		xm2	xm2	xm2	xm2
Site Series		01	01	03	03
*** Location ***					
Physiographic location		KOKSILAH	KOKSILAH	KOKSILAH	KOKSILAH
NTS Map Sheet		92B/12	92B/12	92B/12	92B/12
Longitude		1234610	1234610	1234450	1234550
Latitude		483925	483930	483920	483930
*** Environment ***					
Elevation (m)	631	595	710	590	630
Slope gradient (%)	20	15	15	35	15
Aspect (degrees)		170	170	210	180
Meso slope position		MD	MD	MD	MD
Exposure		WI	WI	WI	WI
Surface shape		ST	ST	ST	CV
Hygrotope		M	M	SX	SM
Trophotope		M	M	M	SM
Terrain		g$CIj	g$CIj	g$CIj	g$CIj
Soil		O	O	O	O
Subgroup (CSSC 1978)		HFP	HFP	HFP	HFP
Family Particle size		FSI L	FSI L	FSI L	FSI L
Rooting depth (cm)	47	50	50	50	40
Root restricting depth (cm)					
Soil drainage		R	R	R	R
Humus form		HUR	HUR	HUR	HUR
Successional Stage		PS	YS	MS	OS

Table III-4. Environmental characteristics for Nanaimo River (NAN) plots

Plot -->	Mean	31	35	33	34
Biogeoclimatic Zone		CWH	CWH	CWH	CWH
Subzone/Variant/Phase		xm1	xm1	xm1	xm1
Site Series		01	01	01	01
*** Location ***					
Physiographic location		NANAIMO	NANAIMO	NANAIMO	NANAIMO
NTS Map Sheet		92F/1	92F/1	92F/1	92F/1
Longitude		1241020	1241020	1240945	1241040
Latitude		490255	490255	490310	490250
*** Environment ***					
Elevation (m)	447	460	440	430	430
Slope gradient (%)	21	20	20	20	25
Aspect (degrees)		190	138	180	220
Meso slope position		UP	MD	MD	MD
Exposure		WI	NA	NA	NA
Surface shape		ST	ST	ST	CV
Hygrotope		SM	SM	SM	SM
Trophotope		SM	SM	SM	SM
Terrain		gsMIj	gsMIj	$gMIj	$gMIj
Soil		DU	DU	DU	DU
Subgroup (CSSC 1978)		HFP	HFP	HFP	HFP
Family Particle size		L FSI	L FSI	FSI L	FSI L
Rooting depth (cm)	54	60	30	60	60
Root restricting depth (cm)	35		35		
Soil drainage		W	W	W	W
Humus form		HUR	HUR	HUR	HUR
Successional Stage		PS	YS	YS	OS

Table III-5. Environmental characteristics for Renfrew (REN) plots

Plot -->	Mean	51	52	53	54
Biogeoclimatic Zone		CWH	CWH	CWH	CWH
Subzone/Variant/Phase		vm1	vm1	vm1	vm1
Site Series		01	01	01	06s
*** Location ***					
Physiographic location		RENFREW	RENFREW	RENFREW	RENFREW
NTS Map Sheet		92C/9	92C/9	92C/9	92C/9
Longitude		1243330	1242222	1242326	1242321
Latitude		483315	483328	433321	483250
*** Environment ***					
Elevation (m)	206	240	135	130	320
Slope gradient (%)	38	50	45	25	35
Aspect (degrees)		340	350	340	270
Meso slope position		MD	MD	MD	MD
Exposure		WI	WI	NA	WI
Surface shape		ST	CV	CC	ST
Hygrotope		M	M	M	SHG
Trophotope		M	M	M	SM
Terrain		sxCIk	sxCIa	$xCIj	$xCIj
Soil		O	O	O	GL
Subgroup (CSSC 1978)		HFP	HFP	HFP	HFP
Family Particle size		LS S	S L	FSI L	FSI L
Rooting depth (cm)	38	50	50	30	25
Root restricting depth (cm)	61	60		100	25
Soil drainage		W	W	W	P
Humus form		OHR	OHR	OHR	OHR
Successional Stage		PS	YCC	MCC	

Table III-6. Environmental characteristics for Red/Granite Creek (RGC) plots

Plot -->	Mean	61	62	63	64
Biogeoclimatic Zone		CWH	CWH	CWH	CWH
Subzone/Variant/Phase		vm1	vm1	vm1	vm1
Site Series		01	01	05	05
*** Location ***					
Physiographic location		REDGR.CR	REDGR.CR	REDGR.CK	REDGR.CR
NTS Map Sheet		92C/9	92C/9	92C/9	92C/9
Longitude		1241311	1241743	1241720	1241307
Latitude		483434	483414	483675	483435
*** Environment ***					
Elevation (m)	172	300	130	80	180
Slope gradient (%)	47	45	35	10	100
Aspect (degrees)		5	360	85	360
Meso slope position		MD	MD	LV	MD
Exposure		WI	WI	WI	WI
Surface shape		CV	ST	ST	ST
Hygrotope		M	M	M	M
Trophotope		M	E	M	PM
Terrain		x$CIk	x$CIj	$MIj	x$CIs
Soil		O	O	DU	O
Subgroup (CSSC 1978)		HFP	HFP	FHP	HFP
Family Particle size		FSI L	FSI L	FSI L	S L
Rooting depth (cm)	57	60	60	60	50
Root restricting depth (cm)	60				60
Soil drainage		W	W	W	W
Humus form		OHR	ORD	OHR	OWD
Successional Stage		PS	YS	YCC	

Table III-7. Environmental characteristics for Nitinat (NIT) plots

Plot -->	Mean	71	72	73	74
Biogeoclimatic Zone	|	CWH|	CWH|	CWH|	CWH|
Subzone/Variant/Phase	|	vm1|	vm1|	vm1|	vm1|
Site Series	|	01s|	04|	05|	01s|
*** Location ***					
Physiographic location	|	NITINAT|	NITINAT|	NITINAT|	NITINAT|
NTS Map Sheet	|	92C/15|	92C/15|	92C/15|	92C/15|
Longitude	|	1243824|	1243810|	1243839|	1243822|
Latitude	|	485004|	485042|	485016|	485003|
*** Environment ***					
Elevation (m)	227|	315|	185|	85|	325|
Slope gradient (%)	31|	30|	45|	30|	22|
Aspect (degrees)	|	240|	225|	280|	245|
Meso slope position	|	MD|	MD|	LO|	MD|
Exposure	|	WI|	WI|	NA|	WI|
Surface shape	|	CC|	ST|	CC|	ST|
Hygrotope	|	SM|	M|	M|	M|
Trophotope	|	SM|	M|	PM|	SM|
Terrain	|	gsCIa|	g$CIa|	g$CIj|	g$CIj|
Soil	|	O|	O|	O|	O|
Subgroup (CSSC 1978)	|	HFP|	HFP|	HFP|	HFP|
Family Particle size	|	FSI L|	L FSI|	FSI L|	FSI L|
Rooting depth (cm)	40|	26|	50|	75|	10|
Root restricting depth (cm)	30|	26|	|	|	35|
Soil drainage	|	R|	R|	R|	R|
Humus form	|	HUR|	HUR|	HWD|	HUR|
Successional Stage	|	PS|	YS|	MCC|	|

Table III-8. Environmental characteristics for Klanawa (KLA) plots

Plot -->	Mean	81	82	83	84
Biogeoclimatic Zone		CWH	CWH	CWH	CWH
Subzone/Variant/Phase		vm1	vm1	vm1	vm1
Site Series		06	01	06	01s
*** Location ***					
Physiographic location		KLANAWA	KLANAWA	KLANAWA	KLANAWA
NTS Map Sheet		92C/15	92C/15	92C/15	92C/15
Longitude		1245027	1245009	1245027	1245027
Latitude		484922	485145	484922	484922
*** Environment ***					
Elevation (m)	155	120	230	120	150
Slope gradient (%)	23	15	35	15	27
Aspect (degrees)		300	135	330	340
Meso slope position		LO	MD	LO	MD
Exposure		WI CO	WI	WI	WI
Surface shape		ST	CC	CV	CV
Hygrotope		SHG	SM	SHG	M
Trophotope		M	M	M	M
Terrain		gsCIj		gsCIj	gsCIa
Soil		O	O	O	O
Subgroup (CSSC 1978)		FHP	HFP	HFP	FHP
Family Particle size		FSI L	FSI L	L	S L
Rooting depth (cm)	45	40	60	40	40
Root restricting depth (cm)	130	130			
Soil drainage		MW	W	MW	MW
Humus form		OUR	OHR	LUR	OUR
Successional Stage		PS	YS	MCC	

Appendix IV. Selected soil chemistries and soil horizon descriptions for each plot by chronosequence

Table IV-1. Selected soil chemical properties for each plot by chronosequence, meaned for all four samples taken per plot

		LFH				Mineral Soil (0–30 cm)							
Sere	Plot	pH	C/N ratio	%C	N (kg/ha)	pH	CEC	C/N ratio	%C	%Fe+Al	Total N (kg/ha) 0–30	Ca+Mg+K (kg/ha) 0–30	Total N (kg/ha) LFH+Min 0–30
VICTORIA WATERSHED SOUTH													
Regeneration	1	4.24	52.94	39.29	118.07	4.45	20.26	43.04	2.42	0.69	1310.19	516.76	1428.26
Immature	2	4.58	41.80	40.05	295.09	4.46	19.78	35.87	3.17	0.78	1270.32	755.62	1565.41
Mature	5	4.30	83.86	40.77	66.18	4.76	19.84	25.65	3.40	0.82	2146.37	1054.64	2212.55
Old Growth	6	4.60	46.32	41.75	447.38	4.50	11.97	129.10	1.73	0.52	313.70	1181.38	761.08
VICTORIA WATERSHED NORTH													
Regeneration	11	4.40	64.32	44.86	372.23	4.53	20.06	146.47	4.53	0.59	363.10	624.20	735.33
Immature	12	4.81	42.85	44.14	221.23	4.49	19.90	171.07	4.49	0.67	353.39	917.49	574.62
Mature	13	5.07	47.17	42.32	216.07	4.84	10.72	77.64	1.61	0.46	499.38	653.91	715.45
Old Growth	15	4.65	43.31	42.49	336.95	4.48	13.84	85.43	2.58	0.57	831.63	420.04	1168.58
KOKSILAH													
Regeneration	21	4.77	39.35	37.85	273.30	4.81	21.54	93.37	3.62	0.55	1297.00	2512.93	1570.30
Immature	22	5.28	60.03	42.05	103.60	4.85	11.93	59.61	1.90	0.35	1058.00	762.86	1161.60
Mature	23	4.81	42.74	37.81	210.96	5.02	16.99	134.13	3.24	0.52	652.00	1216.39	862.96
Old Growth	24	4.73	40.45	42.37	373.50	4.84	18.90	113.73	3.13	0.57	761.00	1268.69	1134.50
NANAIMO RIVER													
Regeneration	31	4.53	58.97	36.51	247.10	4.84	7.56	157.29	1.65	0.37	202.34	556.06	449.44
Immature	32	4.22	60.41	42.99	192.00	4.70	15.05	154.08	2.75	0.48	336.00	1247.91	528.00
Mature	33	4.51	57.97	47.09	247.22	4.68	8.25	127.46	1.79	0.32	342.00	680.21	589.22
Old Growth	34	4.20	51.87	45.34	153.70	4.54	7.15	113.98	1.40	0.41	850.00	407.99	1003.70
RENFREW													
Regeneration	51	3.73	53.57	44.30	284.20	4.65	28.99	18.22	5.06	1.73	2737.00	219.00	3020.20
Immature	52	3.26	50.06	45.01	303.60	3.83	30.94	23.00	4.80	2.35	2344.00	263.80	2647.60
Mature	53	3.21	43.85	45.13	1232.00	4.32	22.12	35.71	4.09	2.12	2473.00	206.44	3705.00
Old Growth	54	3.46	47.93	42.09	936.10	3.46	21.34	34.65	5.85	0.75	2640.0	408.70	3576.10
RED/GRANITE CREEK													
Regeneration	61	4.10	37.91	41.96	310.00	4.49	21.68	59.67	3.45	1.95	2117.00	189.08	2427.00
Immature	62	3.89	29.24	40.91	335.70	4.24	19.11	23.70	3.47	1.38	3329.00	628.62	3664.70
Mature	63	3.04	35.15	46.25	905.20	4.68	32.53	21.58	5.87	2.07	4907.00	246.35	5812.20
Old Growth	64	3.40	65.86	46.09	303.20	4.32	21.33	38.22	4.18	1.91	3053.00	417.72	3356.20
NITINAT													
Regeneration	71	3.39	80.59	42.85	266.30	4.08	24.56	51.94	4.08	1.52	1651.70	252.56	1918.00
Immature	72	3.60	65.85	46.91	241.80	3.98	33.59	36.99	7.17	1.27	1740.80	282.37	1982.60
Mature	73	3.54	48.53	43.43	400.80	4.64	34.47	19.81	6.79	3.31	3580.00	171.98	3980.80
Old Growth	74	3.19	85.40	49.01	578.20	3.63	54.98	31.55	11.92	3.04	1042.00	98.81	1620.20
KLANAWA													
Regeneration	81	3.74	36.68	40.22	972.10	4.27	34.77	33.38	5.92	3.08	2564.50	193.73	3536.60
Immature	82	3.39	45.61	46.79	296.10	4.47	24.77	50.16	5.58	2.11	2733.00	459.79	3029.10
Mature	83	3.24	52.42	40.87	422.10	4.38	31.79	29.88	7.35	3.19	3497.00	187.81	3919.10
Old Growth	84	3.51	44.34	39.53	1203.00	4.35	26.57	35.13	5.91	2.65	2572.00	160.88	3775.00

C = carbon; N = nitrogen; CEC = cation exchange capacity; Fe = iron; Al = aluminium; Ca - calcium; Mg = magnesium; K = potassium

Table IV-2. Soil horizon descriptions for the Victoria Watershed South (VWS) plots

Horizon	Depth (cm)	Description
REGENERATION Plot 1		
LH	2–0	Abundant very fine oblique roots; old H weak; 0–2 cm thick.
Ah	0–8	Grayish brown (10YR 5/2) to light gray (10YR 7/2); loam; weak massive structure; plentiful, very fine roots with horizontal orientation, and plentiful medium roots with oblique orientation; no cementation; pH 4.67; Fe+Al 0.579%; 7–10 cm thick.
B1	8–23	Very pale brown (10YR 7/4) to light brown (7.5YR 6/4); silt loam; weak to moderate, fine, angular blocky structure; plentiful fine and medium roots with oblique orientation; no cementation; pH 4.58; Fe+Al 0.744%; 12–17 cm thick.
B2	23–41	5% cobbles; silt loam; weak to moderate, fine, angular blocky structure; few fine and medium roots with oblique orientation; no cementation; pH 4.677; Fe+Al 0.597%; 16–20 cm thick.
BC	41–84	5% cobbles; silt loam; few fine and medium roots with oblique orientation; moderate, discontinuous cementation; 40–45 cm thick.
C	84+	Few coarse roots with horizontal orientation; moderate continuous cementation.
IMMATURE Plot 2		
LFH	5–0	Plentiful fine roots with oblique orientation, few coarse roots with horizontal orientation; 2–8 cm thick.
Ae	0–11	Reddish brown (5YR 5/3) to dark reddish gray (5YR 4/2); 20% cobbles and 5% stones all sub-rounded and sub-angular; silt loam; weak massive structure; abundant fine roots and plentiful medium roots both with oblique orientation; no cementation; pH 4.47; Fe+Al 0.794%; 8–14 cm thick.
Bf1	11–28	Light brown (7.5YR 6/4) to reddish yellow (7.5YR 6/6); 30% cobbles sub-rounded and sub-angular; silt loam; weak massive structure; plentiful fine roots and few medium roots both with oblique orientation; no cementation; pH 4.48; Fe+Al 0.787%; 16–19 cm thick.
B2	28–42	Silt loam; weak massive structure; plentiful fine roots and few medium roots both with oblique orientation; plentiful, medium, oblique pores; no cementation; pH 4.62; Fe+Al 0.844%; 14–16 cm thick.
BC	42–44	Silt loam; weak massive structure; abundant fine roots and plentiful medium roots both with horizontal orientation; discontinuous cementation; 2–4 cm thick.
R	44+	Tight bedrock; no fracture.
MATURE Plot 5		
L	2–0	Many fine, oblong worm casts throughout matrix; 1–2 cm thick.
Ah	0–6	Brown (7.5YR 4/2) to dark reddish gray (5YR 4/2); loam; plentiful fine roots with oblique orientation and few medium roots with horizontal orientation; common, fine, oblong worm casts throughout matrix; pH 4.65; Fe+Al 0.856%; 5–7 cm thick.
Bfh1	6–22	Reddish yellow (7.5YR 6/6) to very pale brown (10YR 7/4); loam; weak to moderate, fine, sub-angular blocky structure; plentiful fine and medium roots with oblique orientation; 16–17 cm thick.
B2	22–38	Very pale brown (10YR 7/4) to reddish yellow (5YR 6/6); silt loam; 15% rounded cobbles; weak to moderate, fine, sub-angular blocky structure; plentiful fine roots and few medium roots both with oblique orientation; pH 4.79; Fe+Al 0.810%; 12–19 cm thick.
BC	38–86+	Weak massive structure, 15% rounded cobbles, few fine and medium roots with oblique orientation; pH 4.86; Fe+Al 0.585% , stopped digging at 86 cm.
OLD GROWTH Plot 6		
LFH	6–0	4–7 cm thick.
Ae	0–6	Reddish yellow (7.5YR 6/6) to pale brown (10YR 6/3); silty clay loam; massive structure; plentiful fine and few coarse roots both with horizontal orientation and a matrix distribution; abundant, fine, oblique pores within the soil matrix; 2–10 cm thick.
Bf1	6–19	Very pale brown (10YR 7/4) to reddish yellow (5YR 6/6); silty clay loam; weak, granular, fine structure; plentiful fine and few medium roots with horizontal orientation and a matrix distribution; abundant, medium, oblique pores dominantly along ped surfaces; pH 4.51; Fe+Al 0.565%; 5–22 cm thick.
B2	19–46	Yellowish red (5YR 5/6); silty clay loam; weak, granular, fine structure; plentiful fine and few medium roots with horizontal orientation and a matrix distribution; abundant, medium, oblique pores dominantly along the ped surfaces; pH 4.49; Fe+Al 0.498%; 24–32 cm thick.
BC	46+	5% gravel, 60% cobbles, 35% stones all sub-rounded, sub-angular; massive structure; few fine and medium roots with oblique orientation and a matrix distribution; pH 4.60; Fe+Al 0.427%.

Fe = iron; Al = aluminum; YR = Munsel colour chart designation

Table IV-3. Soil horizon descriptions for the Victoria Watershed North (VWN) plots

Horizon	Depth (cm)	Description
REGENERATION Plot 11		
LFH	3–0	Abrupt wavy horizon boundary; abundant medium roots with horizontal orientation, plentiful fine roots with oblique orientation; 0–6 cm thick.
Ah	0–3	Light brown (7.5YR 6/4) to brown (7.5YR 5/4); diffuse, irregular horizon boundary; 15% sub - rounded, sub-angular cobbles; loam; weak, fine granular structure; plentiful medium and fine roots; weak horizon; pH 4.48; Fe+Al 0.650%; 0–6 cm thick.
B1	3–30	Light brown (7.5YR 6/4); diffuse irregular horizon boundary; 30% sub-rounded cobbles; loam; weak, fine, granular structure; plentiful medium and fine roots; pH 4.53; Fe+Al 0.558%; 26–28 cm thick.
B2	30–63	Diffuse, irregular horizon boundary; 25% sub-rounded, sub-angular cobbles; loam; weak, fine, granular structure; few medium and plentiful fine roots; pH 4.51; Fe+Al 0.490%; 31–35 cm thick.
B3	63–85	Gradual, wavy horizon boundary; 30% sub-rounded, sub-angular cobbles; loam; weak, fine, granular structure, few medium and fine roots; 22–23 cm thick.
BC	85+	Few medium and fine roots.
IMMATURE Plot 12		
LFH	3–0	Plentiful fine roots with horizontal orientation; 2–3 cm thick.
Ahe	0–2	Yellowish red (5YR 5/6); loam; weak to moderate, medium to fine, sub-angular blocky structure; plentiful fine and medium roots with oblique orientation; 2–3 cm thick.
Bh	2–16	Reddish yellow (5.0YR 6/6); horizon surface broken; loam; weak to moderate, medium to fine sub - angular blocky structure; 5% sub-rounded, sub-angular cobbles; plentiful fine and medium roots with oblique orientation; pH 4.47; Fe+Al 0.560%; 9–19 cm thick.
B1	16–22	Loam; 5% sub-rounded, sub-angular cobbles; plentiful fine and medium roots with oblique orientation; pH 4.48; Fe+Al 0.725%; pocket inclusion of gray Ae? clay; 0–10 cm thick.
B2	22–50	Weak to moderate, medium to fine, sub-angular blocky structure; loam; 2% sub-rounded, sub-angular cobbles; plentiful fine and medium roots with oblique orientation; pH 4.35; Fe+Al 0.494%; 27–30 cm thick.
B3	50–65	Weak medium to weak moderate, fine, sub-angular blocky structure; loam; 2% sub-rounded, sub - angular cobbles; few fine and plentiful medium roots with oblique orientation; 14–17 cm thick.
BC	65–74	2% sub-rounded, sub-angular cobbles; continuous, moderately cemented; roots restricted at bottom; 9 cm thick.
MATURE Plot 13		
LFH	4–0	Plentiful fine roots with oblique orientation, few medium roots with horizontal orientation; 2–5 cm thick.
Ae	0–6	Pink (7.5YR 7/4) to brown (7.5YR 5/4); weak, medium to fine, granular structure; plentiful fine and medium roots with oblique orientation; weak e, ash and charcoal bits; pH 4.87; Fe+Al 0.608%; 6–7 cm thick.
B1	6–34	Silt loam; 10% cobbles and 2% stones both sub-rounded, sub-angular; weak, medium to fine granular structure; plentiful fine and medium roots with oblique orientation; lots of very fine roots; pH 4.82; Fe+Al 0.402%; 22–33 cm thick.
B2	34–78	Silt loam; 5% sub-rounded, sub-angular cobbles; weak, medium to fine granular structure; few fine and medium roots with oblique orientation; pH 4.92; Fe+Al 0.264%; 32–53 cm thick.
BC	78–96	Silt loam; 5% sub-rounded, sub-angular cobbles; massive structure; few fine and plentiful medium roots with oblique orientation; bottom of hole very sandy; 15–19 cm thick.
OLD GROWTH Plot 15		
LFH	2–0	Plentiful fine roots with oblique orientation and plentiful medium roots with horizontal orientation; 0–4 cm thick.
Ae	0–1	Light brown (7.5YR 6/4) to reddish yellow (7.5YR 6/6); plentiful fine and medium roots with oblique orientation; 0–2 cm thick.
Bh	1–8	Silt loam; plentiful fine and medium roots with oblique orientation; pH 4.37; Fe+Al 0.575%; 6–9 cm thick.
B1	8–24	Light reddish brown (5YR 6/4) to reddish yellow (5YR 6/6); silt loam; plentiful fine and medium roots with oblique orientation; 13–19 cm thick.
B2	24–38	Silt loam; weak, fine, granular structure; plentiful fine and few medium roots with oblique orientation; pH 4.50; Fe+Al 0.531%; 0–15 cm thick.
BC	38+	65% thin flat cobbles and 5% angular stones; weak, fine, granular structure; few fine and medium roots with oblique orientation; pH 4.67; Fe+Al 0.350%; 41–47 cm thick.

Fe = iron; Al = aluminum; YR = Munsel colour chart designation

Table IV-4. Soil horizon descriptions for the Koksilah (KOK) plots

Horizon	Depth (cm)	Description
REGENERATION Plot 21		
LFH	2–0	Plentiful medium and abundant very fine roots with horizontal orientation; little L, no F, H probably from old forest floor; 1–2 cm thick.
Ah	0–2	Reddish brown (5YR 4/4) to dark reddish brown (5YR 3/4); silt loam; weak, fine sub-angular blocky structure; plentiful medium and abundant very fine roots with horizontal orientation; very thin Ah, hard to distinguish from H; pH 4.74; Fe+Al 0.665%; 1–2 cm thick.
B1	2–54	Yellowish red (5YR 5/6) to yellowish brown (10YR 5/6); silt loam; weak, medium, sub-angular blocky structure; 5% sub-rounded, sub-angular cobbles; plentiful fine roots with oblique orientation and plentiful very fine roots with horizontal orientation; pH 4.85 (30 cm); Fe+Al 0.515% (30 cm); pH 4.84 (50 cm); Fe+Al 0.583% (50 cm); 48–57 cm thick.
B2	54–72	5% sub-rounded, sub-angular cobbles; weak, medium, sub-angular blocky structure; plentiful fine and very fine roots with oblique orientation; 15–20 cm thick.
BC	72–86	30% angular gravel; weak sub-angular blocky structure; few very fine roots with horizontal orientation; brownish colour, high gravel content as fractured bedrock; 13–17 cm thick.
C	86+	Fractured bedrock.
IMMATURE Plot 22		
LFH	2–0	Abundant fine and plentiful medium roots with horizontal orientation and a matrix distribution; 0–3 cm thick.
Ah	0–3	Strong brown (7.5YR 5/6); gradual smooth horizon boundary; silt loam; weak single grained structure; abundant medium and plentiful fine roots with horizontal orientation and a matrix distribution; pH 4.72; Fe+Al 0.460%; 2–7 cm thick.
Bf	3–22	Yellowish red (5YR 4/6) to strong brown (7.5YR 5/8); gradual smooth horizon boundary; silt loam; weak, single grained structure; abundant fine and plentiful medium roots with horizontal orientation and a matrix distribution; pH 4.89; Fe+Al 0.325%; 19–23 cm thick.
BC	22–60	Red (2.5YR 4/8) to strong brown (7.5YR 5/8); abrupt smooth horizon boundary; silt loam; weak single grained structure; plentiful fine and medium roots with horizontal orientation and a matrix distribution; pH 4.95; Fe+Al 0.350%; 30–40 cm thick.
MATURE Plot 23		
LFH	3–0	Weak H development; 2–3 cm thick.
Ah	0–4	Strong brown (7.5YR 5/6); silt loam; weak, medium, sub-angular blocky structure; plentiful medium roots with horizontal orientation; brown/black, some charcoal fragments; pH 5.05; Fe+Al 0.585%; 4–5 cm thick.
B	4–38	Red (2.5YR 4/8) to reddish yellow (7.5YR 6/6); silt loam; weak, single grained structure; plentiful medium roots with horizontal orientation and few coarse roots with oblique orientation; pH 4.97; Fe+Al 0.500%; 26–40 cm thick.
BC	38–88	Red (2.5YR 4/8) to strong brown (7.5YR 5/6); silt loam; weak, single grained structure; plentiful medium roots with horizontal orientation and very few coarse roots with oblique orientation; abrupt transition to bedrock; pH 4.89; Fe+Al 0.565%; 41–61 cm thick.
C	88+	Unbroken bedrock.
OLD GROWTH Plot 24		
LFH	4–0	Plentiful medium and fine roots with horizontal orientation; 50% of LFH is H; 3–4 cm thick.
Ah	0–4	Silt loam; weak medium, sub-angular blocky structure; few medium and plentiful fine roots with horizontal orientation; thin, not as dark or distinct (discontinuous); pH 4.93; Fe+Al 0.623%; 3–4 cm thick.
B	4–28	Yellowish red (5.0YR 5/8) to red (2.5YR 4/8); silt loam; weak, fine, granular structure; plentiful medium roots with oblique orientation; plentiful fine roots with horizontal orientation; pH 4.80; Fe+Al 0.577%; 20–28 cm thick.
BC	28–82	Yellowish red (5YR 5/8 to 5YR 5/6) silt loam; weak, single grained structure; plentiful medium and few coarse roots with oblique orientation; distinct boundary between B and BC; pH 4.86; Fe+Al 0.498%; 46–62 cm thick.
C	82+	Compact basal till, no root penetration, lots of medium roots growing along the surface.

Fe = iron; Al = aluminum; YR = Munsel colour chart designation

Table IV-5. Soil horizon descriptions for the Nanaimo River (NAN) plots

Horizon	Depth cm	Description
REGENERATION Plot 31		
LFH	3–0	Abundant very fine roots with horizontal orientation and a matrix distribution; 1–5 cm thick.
Ae	0–5	Silt loam, abrupt smooth horizon boundary; weak single grained structure; abundant very fine roots with horizontal orientation and a matrix distribution; pH 4.78; Fe+Al 0.365%; 2–7 cm thick.
Bf	5–27	Pale brown (10YR 6/3) to light yellowish brown (10YR 6/4); loam; clear smooth horizon boundary; weak, single grained structure; abundant very fine roots with horizontal orientation and a matrix distribution; pH 4.87; Fe+Al 0.373%; 20–28 cm thick.
BC	27–57	Pale brown (10YR 6/3); loam; abrupt smooth horizon boundary; weak, single grained structure; no roots; pH 5.00; Fe+Al 0.202%; 30–35 cm thick.
C	57+	Silt loam; abrupt smooth horizon boundary; weak, single grained structure; no roots.
IMMATURE Plot 35		
LFH	0–2	Abundant very fine and plentiful medium roots with horizontal orientation through the matrix; 1–3 cm thick.
Bf	0–15	Pale brown (10YR 6/3) to brownish yellow (10YR 6/6); loam; weak single grain structure; abundant very fine and plentiful fine roots with horizontal orientation through the matrix; 10–17 cm thick.
BC	15–35	Pale brown (10YR 6/3) to red (2.5YR 4/7); loam; weak single grain structure; plentiful medium roots with horizontal orientation through the matrix; 22–27 cm thick.
C	35+	Silty loam; weak single grain structure; no roots.
MATURE Plot 33		
LFH	5–0	Plentiful fine and medium roots with horizontal orientation and a matrix distribution; 1–9 cm thick.
Ae	0–3	Light yellowish brown (10YR 6/4) to light gray (10YR 6/1); abrupt smooth horizon boundary; silt loam; weak, single grained structure; few fine and medium roots with horizontal orientation and a matrix distribution; pH 4.47; Fe+Al 0.317%; 2–4 cm thick.
Bf	3–25	Brownish yellow (10YR 6/6) to yellowish brown (10YR 5/4); clear smooth horizon boundary; silt loam; weak, single grained structure; plentiful medium and fine roots with horizontal orientation and a matrix distribution; pH 4.77; Fe+Al 0.329%; 20–27 cm thick.
BC	25–55	Strong brown (7.5YR 5/6); abrupt smooth horizon boundary; silt loam; weak, single grained structure; few medium roots with horizontal orientation and a matrix distribution; pH 4.74; Fe+Al 0.279%; 25–35 cm thick.
C	55+	Silt loam; abrupt smooth horizon boundary; weak, single grained structure; no roots.
OLD GROWTH Plot 34		
LFH	6–0	Abundant medium and plentiful fine roots with horizontal orientation and a matrix distribution; 1–10 cm thick.
Ae	0–2	Light gray (10YR 7/2) to pale brown (10YR 6/3); silt loam; abrupt smooth horizon boundary; weak, single grained structure; few medium and fine roots with horizontal orientation and a matrix distribution; pH 4.38; Fe+Al 0.415%; 0–2 cm thick.
Bf	2–30	Light yellowish brown (10YR 6/4); silt loam; clear smooth horizon boundary; weak, single grained structure; abundant medium and plentiful fine roots with horizontal orientation and a matrix distribution; pH 4.56; Fe+Al 0.431; 15–30 cm thick.
BC	30–70	Pale brown (10YR 6/3); silt loam; gradual smooth horizon boundary; weak, single grained structure; few fine roots with horizontal orientation and a matrix distribution; pH 4.84; Fe+Al 0.250%; 30–50 cm thick.
C	70+	Silt loam; gradual smooth horizon boundary; weak, single grained structure; no roots.

Al = aluminum; Fe = iron; YR = Munsel colour chart designation

Table IV-6. Soil horizon descriptions for the Renfrew (REN) plots

Horizon	Depth cm	Description
REGENERATION Plot 51		
LFH	3–0	Abrupt smooth horizon boundary; abundant fine and plentiful coarse roots with horizontal orientation and inped distribution; 1–5 cm thick.
Bf	0–22	Yellowish brown (10YR 5/4) to reddish brown (2.5YR 5/4); loam; weak, fine, single grained structure; clear smooth horizon boundary; plentiful medium roots with exped distribution and few fine roots with inped distribution, both have horizontal orientation; pH 4.57 (10 cm); Fe+Al 2.239% (10 cm); pH 4.52 (30 cm); Fe+Al 1.581% (30 cm); 12–30 cm thick.
BC	22–80	Brown (7.5YR 4/4) to (10YR 4/3); loam; weak, fine, single grained structure; gradual smooth horizon boundary; few medium roots with horizontal orientation and inped distribution; pH 4.52; Fe+Al 2.58%; 45–60 cm thick.
C	80+	
IMMATURE Plot 52		
LFH	3–0	Abrupt smooth horizon boundary; abundant fine and plentiful coarse roots with horizontal orientation and inped distribution; 1–5 cm thick.
Bf	0–25	Yellowish brown (10YR 5/4) to brown (10YR 4/3); sandy loam; weak, fine, single grained structure; plentiful medium roots with exped distribution, few fine roots with inped distribution, both with horizontal orientation; pH 3.66; Fe+Al 2.296%; 15–30 cm thick.
BC	25–75	Yellowish brown (10YR 5/6) to reddish brown (10YR 4/4); sandy loam; weak, fine, single grained structure; few medium roots with horizontal orientation and inped distribution; pH 3.94 (30 cm); Fe+Al 2.350% (30 cm); pH 3.83 (50 cm); Fe+Al 2.035% (50 cm); 55–75 cm thick.
C	75+	
MATURE Plot 53		
LFH	15–0	Abrupt smooth horizon boundary; plentiful medium and abundant fine roots with horizontal orientation and inped distribution; 0–30 cm thick.
Bf	0–19	Yellowish brown (10YR 5/6) to (10YR 5/4); silt loam; weak, fine, single grained structure; clear smooth horizon boundary; plentiful coarse and fine roots with random orientation and inped distribution; pH 3.97; Fe+Al 2.229%; 13–19 cm thick.
BC	19–50	Brownish yellow (10YR 6/8); silt loam; abrupt smooth horizon boundary; weak, fine, single grained structure; few coarse roots with random orientation and inped distribution; pH 4.42 (30 cm); Fe+Al 2.219% (30 cm); pH 4.49 (50 cm); Fe+Al 2.392% (50 cm); 20–30 cm thick.
C	50+	
OLD GROWTH Plot 54		
LFH	8–0	Abundant fine roots with a matrix distribution and plentiful medium roots, both with horizontal orientation; 4–12 cm thick.
Bgf	0–30	Gray (10YR 5/1) to dark grayish brown (10YR 4/2); loam; abrupt smooth horizon boundary; weak, fine, massive structure; few medium roots with horizontal orientation and exped distribution; pH 3.34 (10 cm); Fe+Al 0.594% (10 cm); pH 3.48 (30 cm); Fe+Al 0.865% (30 cm); 15–30 cm thick.
C	30+	Rock.

Fe = iron; Al = aluminum; YR = Munsel colour chart designation

Table IV-7. Soil horizon descriptions for the Red/Granite Creek (RGC) plots

Horizon	Depth cm	Description
REGENERATION Plot 61		
LFH	4–0	Abundant very fine roots with horizontal orientation and a matrix distribution; 2–5 cm thick.
Bf	0–35	Yellowish brown (10YR 5/6) to brown (7.5YR 5/4); abrupt smooth horizon boundary; silt loam; weak, single grained structure; few coarse roots with horizontal orientation and a matrix distribution; pH 4.29 (10 cm); Fe+Al 2.853% (10 cm); pH 4.60 (30 cm); Fe+Al 1.797% (30 cm); 30–40 cm thick.
BC	35–65	Brownish yellow (10YR 6/6) to strong brown (7.5YR 5/6); silt loam; gradual smooth horizon boundary; weak, single grained structure; few fine roots with horizontal orientation and a matrix distribution; pH 4.35; Fe+Al 1.150%; 28–35 cm thick.
C	65–100+	Yellowish brown (10YR 5/6) to strong brown (7.5YR 5/6); silt loam; weak, single grained structure; abrupt smooth horizon boundary; few fine roots with horizontal orientation and a matrix distribution.
IMMATURE Plot 62		
LFH	4–0	Plentiful very fine roots with a horizontal orientation and a matrix distribution; 2–5 cm thick.
Ah	0–12	Brown (7.5YR 5/4) to yellowish brown (10YR 5/4); loam; abrupt smooth horizon boundary; weak, single grained structure; plentiful fine roots with horizontal orientation and a matrix distribution; pH 3.95; Fe+Al 1.429%; 10–20 cm thick.
Ae	12–16	Yellowish brown (10YR 5/4); loam; abrupt irregular horizon boundary; weak, single grained structure; few fine roots with horizontal orientation and a matrix distribution; 2–4 cm thick.
Bf	16–56	Yellowish brown (10YR 5/4); loam; abrupt smooth horizon boundary; weak, single grained structure; abundant medium roots with horizontal orientation and a matrix distribution; pH 3.95 (30 cm); Fe+Al 1.344% (30 cm); pH 4.27 (50 cm); Fe+Al 2.075% (50 cm); 30–45 cm thick.
C	56–100+	Yellowish brown (10YR 5/4); loam; clear smooth horizon boundary; weak, single grained structure; few fine roots with horizontal orientation and a matrix distribution.
MATURE Plot 63		
LFH	4–0	Abundant fine and plentiful medium roots with horizontal orientation and a matrix distribution; 3–5 cm thick.
Bf	0–27	Strong brown (7.5YR 5/6) to yellowish red (5YR 5/6); sandy loam; abrupt smooth horizon boundary; weak, single grained structure; abundant fine and plentiful medium roots with horizontal orientation and a matrix distribution; pH 4.28; Fe+Al 2.148%; 25–30 cm thick.
BC	27–60	Brownish yellow (10YR 6/6); sandy loam; clear smooth horizon boundary; weak, single grained structure; few fine and medium roots with horizontal orientation and a matrix distribution; pH 4.76 (30 cm); Fe+Al 2.127% (30 cm); pH 5.01 (50 cm); Fe+Al 0.877% (50 cm); 30–35 cm thick.
C	60+	Sandy loam; clear smooth horizon boundary; weak, single grained structure; no roots.
OLD GROWTH Plot 64		
LFH	2–0	Abundant medium roots with horizontal orientation and a matrix distribution; 1–3 cm thick.
Ah	0–12	Brown (7.5YR 5/4) to (10YR 5/3); loamy sand; clear smooth horizon boundary; weak, single grained structure; abundant medium roots with horizontal orientation and a matrix distribution; pH 4.387; Fe+Al 1.944%; 9–14 cm thick.
Bf	12–42	Brown (7.5YR 5/4) to light yellowish brown (10YR 6/4); loamy sand; abrupt smooth horizon boundary; weak, single grained structure; abundant fine roots with horizontal orientation and a matrix distribution; pH 4.26; Fe+Al 2.044%; 30–35 cm thick.
BC	42–72	Brown (7.5YR 4/4) to light yellowish brown (10YR 6/4); loamy sand; clear smooth horizon boundary; weak, single grained structure; no roots; pH 4.33; Fe+Al 1.944%; 28–32 cm thick.
C	72–100+	Loamy sand; abrupt, smooth horizon boundary; weak, single grained structure; no roots.

Fe = iron; Al = aluminum; YR = Munsel colour chart designation

Table IV-8. Soil horizon descriptions for the Nitinat (NIT) plots

Horizon	Depth cm	Description
REGENERATION Plot 71		
LFH	9–0	Abundant fine roots with horizontal orientation and a matrix distribution; 2–16 cm thick.
Ae	0–5	Reddish yellow (5YR 6/6) to strong brown (7.5YR 5/6); sandy loam; clear irregular horizon boundary; weak, single grained structure; plentiful fine roots with horizontal orientation and a matrix distribution; 0–5 cm thick.
Bf	5–26	Yellowish red (5YR 5/6); sandy loam; clear smooth horizon boundary; weak, single grained structure; plentiful fine roots with horizontal orientation and a matrix distribution; pH 3.99 (10 cm); Fe+Al% 1.632 (10 cm); pH 4.17 (30 cm); Fe+Al 1.621% (30 cm); 2–30 cm thick.
C	26+	Rock, abrupt smooth horizon boundary; no roots.
IMMATURE Plot 72		
LFH	4–0	Abundant coarse and plentiful fine roots with horizontal orientation and a matrix distribution; 2–7 cm thick.
Ah	0–8	Reddish brown (5YR 5/4) to strong brown (7.5YR 5/6); silt loam; gradual irregular horizon boundary; weak, single grained structure; abundant medium and plentiful fine roots with horizontal orientation and a matrix distribution; pH 4.03; Fe+Al 1.175%; 5–12 cm thick.
Bhf	8–18	Strong brown (7.5YR 5/6) to yellowish red (5YR 4/6); loam; gradual irregular horizon boundary; weak, single grained structure; plentiful medium and fine roots with horizontal orientation and a matrix distribution; pH 3.93; Fe+Al 1.350%; 10–25 cm thick.
Bf	18–55	Loam, clear smooth horizon boundary; weak, single grained structure; few fine roots with horizontal orientation and a matrix distribution; pH 4.58; Fe+Al 2.171%; 30–40 cm thick.
C	55+	
MATURE Plot 73		
LFH	8–0	Abundant medium and plentiful fine roots with horizontal orientation and a matrix distribution; 1–16 cm thick.
Ah	0–14	Reddish brown (5YR 4/4); silt loam; clear smooth horizon boundary; weak, single grained structure; abundant medium and plentiful fine roots with horizontal orientation and a matrix distribution; pH 4.55; Fe+Al 3.623%; 9–14 cm thick.
Bhf	14–44	Yellowish red (5YR 4/6) to strong brown (7.5YR 5/6); silt loam; clear smooth horizon boundary; weak, single grained structure; plentiful fine roots with a horizontal orientation and a matrix distribution; pH 4.70; Fe+Al 3.204%; 30–35 cm thick.
Bf	44–60	Brownish yellow (10YR 6/6); silt loam; abrupt smooth horizon boundary; weak, single grained structure; few fine roots with a horizontal orientation and a matrix distribution; pH 4.94; Fe+Al 1.523%; 15–25 cm thick.
C	60+	Weak, platy structure; no roots; restricting layer.
OLD GROWTH Plot 74		
LFH	8–0	Abundant medium and plentiful fine roots with horizontal orientation and a matrix distribution; 0–16 cm thick.
Ae	0–8	Dark reddish brown (5YR 3/3) to (5YR 3/4); silt loam; clear irregular horizon boundary; weak, single grained structure; abundant medium and plentiful fine roots with horizontal orientation and exped distribution; pH 3.64; Fe+Al 3.248%; 5–13 cm thick.
Bf	8–60	Strong brown (7.5YR 5/8); silt loam; clear irregular horizon boundary; weak, single grained structure; abundant coarse roots with horizontal orientation and a matrix distribution; few, fine, faint mottles; 10–50 cm thick.
C	60+	Rock; in most of area soils are less than 15 cm; no roots.

Fe = iron; Al = aluminum; YR = Munsel colour chart designation

Table IV-9. Soil horizon descriptions for the Klanawa (KLA) plots

Horizon	Depth cm	Description
REGENERATION Plot 81		
LFH	4–0	Abundant coarse roots with horizontal orientation and a matrix distribution; 0–8 cm thick.
Ah	0–13	Brown (7.5YR 5/4); silt loam; gradual smooth horizon boundary; weak, single grained structure; abundant coarse roots with horizontal orientation and a matrix distribution; pH 4.18; Fe+Al 2.508%; 6–13 cm thick.
Bhf	13–51	Pale brown (10YR 6/3) to yellowish brown (10YR 5/4); silt loam; gradual smooth horizon boundary; weak, single grained structure; few medium roots with horizontal orientation and a matrix distribution; many, medium, prominent mottles with sharp boundary distinctions; pH 4.39; Fe+Al 1.792%; 20–60 cm thick.
Bf	51–110	Silt loam; gradual smooth horizon boundary; medium, single grained structure; few medium roots with horizontal orientation and a matrix distribution; few, fine, prominent mottles with sharp boundary distinctions; pH 4.69; Fe+Al 1.560%; 30–70 cm thick.
C	110+	Silt loam; clear, smooth horizon boundary; medium, single grained structures.
IMMATURE Plot 82		
LFH	4–0	Abundant medium roots with horizontal orientation and a matrix distribution; 2–6 cm thick.
Ah	0–9	Strong brown (7.5YR 5/6) to yellowish brown (10YR 5/4); gradual smooth horizon boundary; weak, single grained structure; abundant medium roots with horizontal orientation and a matrix distribution; pH 4.34; Fe+Al 1.881%; 4–14 cm thick.
Bhf	9–25	Strong brown (7.5YR 5/6) to yellowish brown (10YR 5/6); clear smooth horizon boundary; weak, single grained structure; plentiful fine roots with an oblique orientation and a matrix distribution; pH 4.41; Fe+Al 2.465%; 8–24 cm thick.
Bf	25–55	Abrupt smooth horizon boundary; weak, single grained structure; few fine roots with oblique orientation and a matrix distribution; pH 4.50; Fe+Al 3.358%; 20–50 cm thick.
C	55+	Clear, smooth horizon boundary; weak to moderate platy structure; no roots; hard pan at 60 cm.
MATURE Plot 83		
LFH	35–0	Plentiful medium and fine roots with horizontal orientation and matrix distribution; 2–35 cm thick.
Ah	0–15	Plentiful medium and fine roots with horizontal orientation and a matrix distribution; pH 4.29; Fe+Al 3.313%; 9–15 cm thick.
Bf	15–75	Brown (7.5YR 4/4); loam; gradual smooth horizon boundary; weak, single grained structure; abundant medium and plentiful fine and few medium with a vertical orientation and a matrix distribution; pH 4.47 (30 cm); Fe+Al 3.208% (30 cm); pH 4.49 (50 cm); Fe+Al 3.198% (50 cm); 25–75 cm thick.
C	75+	Loam, abrupt smooth horizon boundary; moderate platy structure; no roots.
OLD GROWTH Plot 84		
LFH	18–0	Gradual smooth horizon boundary; plentiful medium roots with a matrix distribution, plentiful fine roots, both with horizontal orientation; 2–35 cm thick.
Ah	0–12	Strong brown (7.5YR 5/6) to reddish yellow (10YR 6/6); sandy loam; gradual smooth horizon boundary; weak, single grained structure; abundant medium roots with a matrix distribution and plentiful fine roots, both with horizontal orientation; pH 4.12; Fe+Al 2.854%; 0–30 cm thick.
Bhf	12–60	Strong brown (7.5YR 5/6) to light yellowish brown (10YR 6/4); loam; gradual smooth horizon boundary; weak, single grained structure; abundant fine roots with a matrix distribution, few medium roots, both have a vertical orientation; pH 4.45 (30 cm); Fe+Al 2.617% (30 cm); pH 4.76 (50 cm); Fe+Al 2.415% (50 cm); 25–75 cm thick.
Bf	60–100	Loam; gradual smooth horizon boundary; weak, single grained structure; few fine roots with vertical orientation and a matrix distribution; 20–60 cm thick.
C	100+	Abrupt horizon boundary; platy structure; no roots.

Fe = iron; Al = aluminum; YR = Munsel colour chart designation

Appendix V. Stand descriptions for each plot by chronosequence

Table V-1. Mensuration summary (with standard error) for Victoria Watershed South (VWS) plots

Plot	Form	Spp.	n	Mean density (#/ha)	Basal area (m^2/ha)		Mean DBH (cm)		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
01 (1)	tree	all	34	1443	0.3	(< 0.1)	1.4	(0.2)	0.9	(0.1)	3.7	4	
02 (2)	tree	FD	24	1019	22.7	(3.4)	13.2	(2.2)	11.9	(1.1)	22.6	18	(1)
		HW	29	1231	7.7	(1.4)	6.6	(1.1)	7.6	(0.8)	18.2		
			53	**2250**	**30.4**								
05 (3a)	tree	CW	7	99	4.8	(0.4)	23.1	(3.6)	16.9	(2.5)	28.3	89	(2)
		DR	1	14	1.5		36.2		37.4		37.4		
		FD	39	552	81.8	(9.1)	39.0	(3.1)	34.2	(1.5)	50.2		
		HW	1	14	0.6		22.5		20.5		20.5		
		PW	1	14	< 0.1		6.5		8.0		8.0		
			49	**693**	**88.7**								
06 (4)	tree	CW	4	42	2.9	(0.1)	26.9	(7.4)	16.7	(4.8)	27.6	235	(15)
		DR	1	11	0.9		32.5		16.9		16.9		
		FD	14	149	73.6	(6.4)	76.8	(5.6)	47.5	(2.0)	58.4		
		HW	32	340	5.7	(0.8)	12.4	(1.4)	10.4	(1.3)	34.0		
			51	**542**	**83.1**								
Stumps and snags													
01 (1)	stump	CW	30	318	45.9	(5.1)	38.1	(3.6)	0.4	(< 0.1)	0.7		
		FD	3	32	13.2		71.7	(9.0)	0.6	(0.3)	1.2		
			33	**350**	**59.1**								
02 (2)	stump	FD	3	127	67.1	(2.4)	81.7	(4.4)	0.7	(0.1)	0.8		
	snag	FD	14	594	0.4		2.7	(0.2)	3.9	(0.3)	5.8		
		HW	9	382	0.2		2.6	(0.4)	3.9	(0.5)	6.5		
			26	**1103**	**67.7**								
05 (3a)	snag	DR	4	57	3.9	(1.0)	29.3	(1.5)	15.5	(6.7)	31.2		
		FD	17	693	21.1	(6.4)	18.8	(2.7)	9.8	(2.0)	27.3		
			21	**750**	**25.0**								
06 (4)	snag	DR	1	11	0.6		26.6		4.9		4.9		
		FD	2	21	5.9		55.1	(22.6)	25.0	(22.6)	47.6		
		HW	33	467	8.1	(1.6)	7.9	(1.1)	4.4	(0.5)	10.6		
			36	**499**	**14.6**								

Notes:
Living tree data are derived from all living stems in regeneration plots and from all stems ≥ 3.0 m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer to variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, or that only one instance of the material was observed.
Plot numbers in brackets indicate the original chronosequence plot number in the plot location and establishment report (Blackwell 1992a).
CW = western redcedar; DR = red alder; FD = Douglas-fir; HW = western hemlock

Table V-2. Mensuration summary (with standard error) for Victoria Watershed North (VWN) plots

Plot	Form	Spp.	n	Mean density (#/ha)	Basal area (m^2/ha)		Mean DBH (cm)		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
11 (1)	tree	all	24	1019	0.5	(< 0.1)	2.2	(0.3)	1.2	(0.1)	2.6	6	
12 (2)	tree	FD	49	2080	48.6	(0.6)	16.4	(0.8)	18.2	(0.5)	23.5	32	(1)
13 (3)	tree	CW	3	64	1.6		15.2	(6.7)	9.2	(3.5)	16.0		
		FD	60	1273	65.1	(7.1)	20.8	(1.9)	19.1	(1.5)	37.6	83	(2)
			63	**1337**	**66.7**								
15 (4)	tree	CW	8	117	5.5	(2.6)	24.3	(5.7)	15.2	(3.4)	26.6	306	(3)
		FD	34	361	81.4	(1.2)	51.5	(2.6)	32.0	(1.1)	47.4		
		HW	16	233	3.1	(0.9)	10.9	(2.8)	7.7	(1.7)	29.0		
			58	**711**	**90.0**								
Stumps and snags													
11 (1)	stump	CW	5	53	15.1	(4.1)	53.2	(14.1)	0.4	(0.1)	0.7		
		FD	24	255	78.1	(2.0)	60.2	(3.5)	0.4	(< 0.1)	0.8		
		HW	3	32	0.5	(< 0.1)	13.3	(1.8)	0.3	(< 0.1)	0.3		
			32	**340**	**93.7**								
12 (12)	stump	FD	3	127	15.3		37.3	(8.4)	0.6	(0.1)	0.7		
	snag	FD	12	509	2.1	(0.3)	6.5	(1.0)	8.8	(1.3)	15.2		
			15	**636**	**17.4**								
13 (3)	stump	FD	1	21	7.0		65.0		0.5		0.5		
	snag	FD	32	679	3.1	(0.6)	6.3	(0.7)	6.7	(0.8)	16.4		
			33	**700**	**10.1**								
15 (4)	snag	CW	2	21	0.7		19.8	(1.8)	12.9	(0.5)	13.4		
		FD	10	297	14.7	(1.0)	24.3	(3.3)	4.5	(1.7)	18.8		
		HW	2	85	< 0.1		2.2	(0.1)	1.9	(0.7)	2.6		
			14	**403**	**15.4**								

Notes:
Living tree data are derived from all living stems in regeneration plots, from all stems ≥ 3.0 m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer to variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, or that only one instance of the material was observed. Plot numbers in brackets indicate the original chronosequence plot number in the plot location and establishment report (Blackwell 1992a).
FD = Douglas-fir; HW = western hemlock; DR = red alder; PW = western white pine; CW = western redcedar

Table V-3. Mensuration summary (with standard error) for Koksilah (KOK) plots

Plot	Form	Spp.	n	Mean Density (#/ha)	Basal Area (m^2/ha)		Mean DBH (cm)		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
21 (1)	tree	all	18	764	0.1	(< 0.1)	1.0	(0.1)	0.4	(< 0.1)	0.6	3	
22 (2)	tree	CW	20	849	3.3	(0.9)	6.3	(0.7)	5.4	(0.6)	12.3		
		FD	64	2716	41.9	(2.4)	11.8	(1.0)	11.1	(0.6)	20.8	33	(2)
		HW	4	170	2.4	(1.1)	11.6	(3.8)	10.5	(3.5)	17.8		
			88	**3735**	**47.6**								
23 (3)	tree	FD	79	3353	63.0	(3.1)	13.7	(0.8)	12.8	(0.6)	27.3	76	(2)
24 (4)	tree	FD	44	467	87.2	(3.0)	41.7	(3.8)	21.4	(1.7)	35.9	278	(14)
		HW	1	11	0.5		24.5		15.4		15.4		
			45	**478**	**87.7**								
Stumps and snags													
21 (1)	stump	CW	2	21	7.4	(1.6)	65.0	(15.0)	0.5	(< 0.1)	0.5		
		FD	28	297	97.7	(7.3)	61.7	(3.8)	0.4	(< 0.1)	0.6		
			30	**318**	**105.1**								
22 (2)	snag	CW	1	42	< 0.1		2.0		1.7		1.7		
		FD	7	297	0.2	(0.1)	2.4	(0.7)	2.9	(1.1)	9.5		
			8	**339**	**0.2**								
23 (3)		FD	35	1485	4.6	(0.3)	5.8	(0.4)	7.3	(0.7)	23.0		
24 (4)	snag	FD	5	53	4.0	(1.7)	26.9	(7.6)	12.4	(3.9)	26.1		

Notes:
Living tree data are derived from all living stems in regeneration plots, from all stems ≥ 3.0 m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer to variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, or that only one instance of the material was observed. Plot numbers in brackets indicate the original chronosequence plot number in the plot location and establishment report (Blackwell 1992a).
FD = Douglas-fir; HW = western hemlock; DR = red alder; PW = western white pine; CW = western redcedar

Table V-4. Mensuration summary (with standard error) for Nanaimo River (NAN) plots

Plot	Form	Spp.	n	Mean density (#/ha)	Basal area (m^2/ha)		Mean DBH (cm)		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
31 (1)	tree	all	84	3565	1.5	(0.1)	1.8	(0.2)	1.0	(0.1)	4.3	4	
35 (2)	tree	CW	1	42	0.1		4.0		3.0		3.0		
		FD	44	1867	32.5	(3.1)	13.2	(1.0)	13.0	(0.8)	22.8	33	
			45	**1909**	**32.6**								
33 (3)	tree	CW	2	85	1.1		12.0	(5.3)	9.1	(4.1)	13.2	58	(3)
		FD	35	1485	67.3	(5.1)	16.6	(3.0)	12.7	(1.5)	41.5		
		HW	38	1613	27.5	(3.2)	12.9	(1.2)	10.6	(0.9)	30.0		
		PW	1	42	< 0.1		2.1		3.0		3.0		
			76	**3225**	**95.9**								
34 (4)	tree	CW	2	28	1.4		24.6	(4.2)	13.9	(2.5)	16.4	320	(8)
		FD	13	184	61.8	(9.2)	60.4	(7.2)	25.7	(2.9)	38.8		
		HW	18	424	5.7	(1.0)	12.1	(2.1)	8.6	(1.3)	21.6		
		PW	3	42	0.1	(< 0.1)	3.9	(0.2)	3.8	(0.3)	4.3		
			36	**678**	**69.0**								
Stumps and snags													
31 (1)	stump	FD	25	265	73.8	(3.8)	56.7	(3.7)	0.5	(< 0.1)	0.8		
35 (2)	stump	FD	1	42	8.3		50.0		0.8		0.8		
	snag	DR	2	85	0.2		5.1	(1.9)	6.8	(3.5)	10.2		
		FD	4	170	1.1	(0.5)	7.1	(3.2)	6.6	(2.1)	12.4		
		HW	1	42	0.2		6.9		1.8		1.8		
			8	**339**	**9.8**								
33 (3)	snag	FD	7	297	5.1	(0.7)	11.0	(4.0)	6.0	(2.4)	15.1		
		HW	8	340	0.7	(0.1)	4.9	(0.8)	3.8	(0.8)	8.6		
			15	**637**	**5.8**								
34 (4)	snag	FD	1	42	1.2		19.0		14.2		14.2		
		HW	9	212	0.2	(0.1)	3.7	(0.3)	2.1	(0.2)	3.1		
			10	**254**	**1.4**								

Notes:
Living tree data are derived from all living stems in regeneration plots, from all stems ≥ 3.0 m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer to variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, or that only one instance of the material was observed.
Plot numbers in brackets indicate the original chronosequence plot number in the plot location and establishment report (Blackwell 1992a).
FD = Douglas-fir; HW = western hemlock; DR = red alder; PW = western white pine; CW = western redcedar

Table V-5. Mensuration summary (with standard error) for Renfrew (REN) plots

Plot	Form	Spp.	n	Mean density (#/ha)	Basal area (m^2/ha)		Mean DBH (cm)		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
51 (1)	tree	all	52	2207	0.9	(0.1)	2.0	(0.2)	1.9	(0.1)	4.3	4	
52 (2)	tree	CW	7	297	3.0	(0.6)	11.1	(1.0)	12.2	(0.7)	13.6	30	(2)
		HW	28	1188	38.8	(1.3)	18.1	(1.8)	21.7	(1.5)	32.4		
		SS	1	42	4.1		35.0		17.6		17.6		
			36	**1527**	**45.9**								
53 (3)	tree	BA	10	106	14.5	(0.9)	39.9	(4.0)	37.1	(2.8)	44.3	55	(4)
		CW	1	11	0.5		25.6		20.2		20.2		
		HW	38	403	55.6	(2.3)	37.7	(3.0)	35.1	(1.0)	46.0		
			49	**520**	**70.6**								
54 (4)	tree	BA	1	14	0.7		25.8		23.8		23.8	244	(11)
		CW	23	325	62.9	(3.6)	40.3	(6.2)	19.2	(2.0)	33.1		
		HW	19	269	20.3	(2.6)	27.5	(3.4)	20.4	(2.0)	31.9		
			43	**608**	**83.9**								
Stumps and snags													
51 (1)	stump	HW	16	170	90.0	(7.9)	75.1	(8.6)	0.9	(0.1)	1.4		
52 (2)	snag	CW	8	340	1.7	(0.4)	7.8	(0.8)	8.3	(0.9)	13.9		
		HW	81	3438	16.6	(2.0)	6.2	(0.5)	7.2	(0.5)	34.1		
			89	**3778**	**18.3**								
53 (3)	stump	HW	14	149	43.4	(4.9)	54.6	(7.5)	1.4	(0.1)	2.2		
	snag	BA	6	64	1.5	(0.3)	15.4	(3.6)	12.2	(3.8)	23.4		
		CW	2	21	0.4		15.8	(3.5)	13.7	(1.1)	14.8		
		HW	46	488	6.6	(0.5)	12.4	(0.6)	7.3	(0.9)	25.8		
			68	**722**	**51.9**								
54 (4)	snag	CW	11	156	17.9	(2.1)	31.4	(6.9)	10.0	(2.3)	23.0		
		HW	13	184	13.7	(1.2)	25.0	(5.2)	7.2	(2.0)	24.0		
			24	**340**	**31.6**								

Notes:
Living tree data are derived from all living stems in regeneration plots, from all stems ≥ 3.0m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer to variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, or that only one instance of the material was observed. Plot numbers in brackets indicate the original chronosequence plot number in the plot location and establishment report (Blackwell 1992a).
CW = western redcedar; HW = western hemlock; SS = Sitka spruce; BA = amabilis fir

Table V-6. Mensuration summary (with standard error) for Red/Granite Creek (RGC) plots

Plot	Form	Spp.	n	Mean density (#/ha)	Basal area (m^2/ha)		Mean DBH (cm)		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
61 (1)	tree	all	43	1825	1.5	(0.1)	2.5	(0.3)	2.4	(0.2)	6.8	9	
62 (2)	tree	CW	9	382	2.8	(0.5)	9.3	(0.8)	9.6	(0.8)	13.2	41	(2)
		DR	6	255	28.6	(3.6)	37.1	(3.4)	26.9	(1.3)	31.4		
		FD	4	170	5.5	(2.4)	18.5	(5.0)	19.1	(4.2)	30.3		
		HW	24	1019	16.7	(2.5)	12.7	(1.4)	14.1	(1.3)	30.2		
			43	**1826**	**53.6**								
63 (3)	tree	HW	21	891	76.8	(2.1)	31.4	(2.4)	33.1	(1.8)	42.7	62	(3)
64 (4)	tree	CW	1	11	37.1		211.0		58.8		58.8	166	(34)
		HW	46	488	57.0	(7.1)	25.6	(4.3)	16.5	(2.2)	55.5		
			47	**499**	**94.1**								
Stumps and snags													
61 (1)	stump	HW	10	106	52.5	(8.2)	70.1	(12.4)	0.8	(0.2)	2.0		
62 (2)	stump	HW	1	42	21.3		80.0		1.3		1.3		
	snag	CW	6	255	0.6	(0.1)	5.4	(0.5)	6.4	(0.8)	8.8		
		DR	3	127	0.9		8.5	(2.8)	10.4	(3.4)	17.1		
		HW	14	594	1.9	(0.2)	5.9	(0.7)	6.5	(0.8)	12.8		
			24	**1018**	**24.7**								
63 (3)	stump	CW	1	42	< 0.1		< 0.1		0.8		0.8		
	snag	DR	3	127	10.9	(4.0)	32.1	(5.6)	12.5	(5.4)	18.4		
		HW	19	806	12.7	(2.8)	12.7	(1.5)	6.3	(1.7)	31.9		
			23	**975**	**23.6**								
64 (4)	snag	HW	3	32	8.2	(1.4)	49.3	(20.6)	5.1	(1.3)	6.8		

Notes:
Living tree data are derived from all living stems in regeneration plots, from all stems ≥ 3.0 m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer to variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, or that only one instance of the material was observed. Plot numbers in brackets indicate the original chronosequence plot number in the plot location and establishment report (Blackwell 1992a).
CW = western redcedar; DR = red alder; FD = Douglas-fir; HW = western hemlock

Table V-7. Mensuration summary (with standard error) for Nitinat (NIT) plots

Plot	Form	Spp.	n	Mean density (#/ha)	Basal area (m^2/ha)		Mean DBH (cm)		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
71 (1)	tree	all	42	1783	0.6	(< 0.1)	1.6	(0.2)	1.3	(0.2)	4.4	6	
72 (2)	tree	CW	10	424	4.6	(0.9)	9.5	(2.4)	7.2	(1.4)	18.1	34	(2)
		DR	2	85	0.5		8.8	(0.6)	14.7	(0.1)	14.8		
		FD	15	637	43.3	(1.3)	27.1	(3.1)	21.8	(2.1)	34.9		
		HW	17	722	18.5	(2.0)	15.7	(2.2)	14.2	(1.7)	25.1		
			44	**1868**	**66.9**								
73 (3)	tree	HW	43	456	63.1	(1.4)	36.8	(3.1)	29.8	(2.0)	44.7	89	(8)
74 (4)	tree	BA	18	223	7.1	(1.4)	16.5	(3.4)	13.4	(2.6)	41.8	260	(36)
		CW	10	106	19.4	(8.1)	40.2	(8.9)	21.0	(3.5)	36.2		
		HW	36	477	56.8	(4.2)	33.8	(4.6)	22.6	(2.8)	52.1		
			64	**806**	**83.3**								
Stumps and snags													
71 (1)	stump	BA	1	11	2.1		50.0		1.7		1.7		
		CW	6	64	34.3	(8.0)	62.0	(24.6)	1.1	(0.1)	1.6		
		HW	6	64	12.1	(1.2)	44.0	(9.7)	0.9	(0.1)	1.1		
			13	**139**	**48.5**								
72 (2)	stump	unknown	3	127	17.2		39.4	(9.1)	4.8	(1.7)	6.8		
		HW	1	42	0.3		10.2		3.6		3.6		
	snag	HW	1	42	< 0.1		2.8		3.7		3.7		
			5	**211**	**17.5**								
73 (3)	stump	unknown	2	21	2.5	(1.3)	28.0	(27.1)	2.8	(1.4)	4.2		
	snag	HW	11	117	1.9	(< 0.1)	13.0	(1.9)	7.4	(1.6)	20.7		
			13	**138**	**4.4**								
74 (4)	snag	CW	3	32	8.7		50.9	(21.3)	8.2	(2.9)	12.4		
		HW	5	53	6.1	(1.6)	37.3	(4.4)	10.2	(3.0)	18.9		
			8	**85**	**14.8**								

Notes:
Living tree data are derived from all living stems in regeneration plots, from all stems ≥ 3.0m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer to variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, that only one instance of the material was observed. Plot numbers in brackets indicate the original chronosequence plot number in the plot location and establishment report (Blackwell 1992a).
CW = western redcedar; DR = red alder; FD = Douglas-fir; HW = western hemlock; BA = amabilis fir

Table V-8. Mensuration summary (with standard error) for Klanawa (KLA) plots

Plot	Form	Spp.	n	Mean density (#/ha)	Basal Area (m^2/ha)		Mean DBH cm		Mean height (m)		Maximum height (m)	Mean Age BH (years)	
Living trees													
81 (1)	tree	all	63	2674	< 0.1	(< 0.1)	0.4	(< 0.1)	0.3	(< 0.1)	0.5	3	
82 (2)	tree	BA	4	170	8.3		23.5	(4.9)	19.6	(1.6)	23.5	27	(2)
		CW	2	85	0.3	(0.1)	6.2	(1.8)	6.8	(2.9)	9.7		
		HW	34	1443	53.2	(2.9)	18.9	(1.9)	17.3	(1.1)	26.2		
			40	**1698**	**61.8**								
83 (3)	tree	BA	29	1231	19.6	(1.6)	11.6	(1.6)	10.8	(1.5)	25.5	154	(3)
		HW	8	340	46.4	(7.9)	33.2	(9.5)	24.2	(4.9)	50.2		
			37	**1571**	**66.0**								
84 (4)	tree	BA	16	170	8.8	(1.0)	20.7	(3.9)	13.4	(2.9)	38.8	435	(99)
		CW	8	85	176.2	(21.0)	154.5	(19.1)	48.1	(1.5)	53.3		
		HW	23	244	65.0	(16.4)	28.6	(10.8)	13.6	(2.8)	39.2		
			47	**499**	**250.0**								
Stumps and snags													
81 (1)	stump	unknown	6	64	3.4	(0.1)	24.0	(4.8)	0.7	(0.2)	1.3		
		CW	11	117	204.0	(17.7)	135.5	(19.8)	1.3	(0.1)	1.9		
		HW	13	138	13.4	(0.7)	33.7	(2.9)	0.9	(0.1)	1.4		
			30	**319**	**220.8**								
82 (2)	snag	CW	4	170	0.9	(0.2)	7.2	(2.2)	7.0	(1.9)	10.9		
		HW	17	722	4.6	(2.1)	7.4	(1.3)	8.7	(1.2)	21.6		
			21	**892**	**5.5**								
83 (3)	snag	unknown	2	85	13.2	(4.9)	40.7	(18.1)	2.5	(0.4)	2.8		
		BA	18	764	1.7	(0.2)	4.1	(0.9)	2.2	(0.4)	7.7		
		HW	3	127	61.4	(30.6)	65.8	(30.1)	6.8	(2.5)	11.9		
			23	**976**	**76.3**								
84 (4)	snag	BA	2	21	1.8	(< 0.1)	32.6	(< 0.1)	13.9	(10.0)	23.9		
		HW	2	21	4.0	(1.2)	46.7	(15.2)	7.6	(4.3)	11.9		
			4	**42**	**5.8**								

Notes:
Living tree data are derived from all living stems in regeneration plots, from all stems ≥ 3.0 m in all other plots.
Data for snags and stumps are derived from all snag and stump data for all plots.
Bold numbers indicate plot totals of living and dead materials.
Standard error for basal area / hectare refers to variation between mensuration subplots; standard errors for diameter and height refer variation within plots. Missing values for standard error imply that either the material was observed in only one mensuration subplot, that only one instance of the material was observed. Plot numbers in brackets indicate the original chronosequence plot number the plot location and establishment report (Blackwell 1992a).
BA = amabilis fir; CW = western redcedar; HW = Western hemlock

Appendix VI. Indicator vegetation species list for each plot by chronosequence

(P = presence class; MC = mean percent cover; St = stratum)

Table VI-1. Indicator vegetation species for Victoria Watershed South (VWS) plots

St *Species*	P	MC	01	02	05	06	Common name
Dominant trees							
Pseudotsuga menziesii	75.0	21.8		7.0	30.0	50.0	Douglas-fir
Tsuga heterophylla	25.0	2.0		8.0			western hemlock
Thuja plicata	25.0	1.0		4.0			western redcedar
Main canopy trees							
Tsuga heterophylla	75.0	9.8		8.0	6.0	25.0	western hemlock
Pseudotsuga menziesii	50.0	21.3		35.0	50.0		Douglas-fir
Alnus rubra	50.0	2.0		5.0		3.0	red alder
Thuja plicata	50.0	1.1			0.5	4.0	western redcedar
Acer macrophyllum	25.0	1.0		4.0			bigleaf maple
Understory trees							
Tsuga heterophylla	75.0	8.3		8.0	10.0	15.0	western hemlock
Pseudotsuga menziesii	50.0	6.5		20.0	6.0		Douglas-fir
Thuja plicata	50.0	2.3			4.0	5.0	western redcedar
Acer macrophyllum	25.0	0.3			1.0		bigleaf maple
Tall shrubs							
Tsuga heterophylla	50.0	3.0		8.0	4.0		western hemlock
Alnus rubra	50.0	0.4	0.5		1.0		red alder
Pseudotsuga menziesii	25.0	2.3		9.0			Douglas-fir
Thuja plicata	25.0	1.0			4.0		western redcedar
Salix scouleriana	25.0	0.1				0.5	Scouler's willow
Low shrubs							
Gaultheria shallon	100.0	33.8	20.0	60.0	15.0	40.0	salal
Mahonia nervosa	75.0	5.0		3.0	10.0	7.0	dull Oregon-grape
Chimaphila umbellata	25.0	2.0			8.0		prince's pine
Rubus leucodermis	25.0	2.5	10.0				black raspberry
Thuja plicata	25.0	0.1				0.5	western redcedar
Herbs							
Polystichum munitum	100.0	7.3	1.0	10.0	15.0	3.0	sword fern
Pteridium aquilinum	50.0	10.8	40.0	3.0			bracken
Linnaea borealis	50.0	7.8			30.0	1.0	twinflower
Bromus vulgaris	50.0	0.4	0.5		1.0		Columbia brome
Hypochoeris radicata	25.0	7.5	30.0				hairy cat's-ear
Galium triflorum	25.0	2.5			10.0		sweet-scented bedstraw
Lactuca muralis	25.0	1.8			7.0		wall lettuce
Tiarella trifoliata	25.0	1.3			5.0		three-leaved foamflower
Aira praecox	25.0	0.3	1.0				early hairgrass
Anaphalis margaritacea	25.0	0.1	0.5				pearly everlasting
Carex deweyana	25.0	0.3	1.0				Dewey's sedge
Cerastium fontanum	25.0	0.3	1.0				mouse-ear chickweed
Danthonia spicata	25.0	0.1	0.5				poverty oatgrass
Digitalis purpurea	25.0	0.5	2.0				foxglove
Festuca occidentalis	25.0	0.5	2.0				western fescue
Holcus lanatus	25.0	0.1	0.5				Yorkshire fog
Viola sempervirens	25.0	0.3				1.0	trailing yellow violet
Mosses, liverworts & lichens							
Kindbergia oregana	100.0	13.0	2.0	5.0	25.0	20.0	Oregon beaked moss
Hylocomium splendens	50.0	8.5			25.0	9.0	step moss
Rhytidiadelphus loreus	50.0	0.3			0.5	0.5	lanky moss
Rhytidiadelphus triquetrus	50.0	0.3			0.5	0.5	electrified cat's tail moss
Polytrichum juniperinum	25.0	1.0	4.0				juniper haircap moss
Hypnum circinale	25.0	0.3				1.0	
Scapania bolanderi	25.0	0.1			0.5		

Table VI-2. Indicator vegetation species for Victoria Watershed North (VWN) plots

St *Species*	P	MC	11	12	13	15	Common name
Dominant trees							
Pseudotsuga menziesii	75.0	7.0		15.0	11.0	2.0	Douglas-fir
Main canopy trees							
Pseudotsuga menziesii	75.0	53.8		75.0	60.0	80.0	Douglas-fir
Understory trees							
Pseudotsuga menziesii	75.0	5.8		10.0	10.0	3.0	Douglas-fir
Thuja plicata	50.0	3.3			3.0	10.0	western redcedar
Tsuga heterophylla	25.0	1.8				7.0	western hemlock
Tall shrubs							
Thuja plicata	50.0	1.0			1.0	3.0	western redcedar
Tsuga heterophylla	25.0	1.8				7.0	western hemlock
Pseudotsuga menziesii	25.0	0.3			1.0		Douglas-fir
Low shrubs							
Gaultheria shallon	100.0	78.8	70.0	80.0	85.0	80.0	salal
Mahonia nervosa	75.0	6.4	0.5	15.0	10.0		dull Oregon-grape
Rosa gymnocarpa	25.0	0.1			0.5		baldhip rose
Rubus leucodermis	25.0	0.1	0.5				black raspberry
Thuja plicata	25.0	0.1	0.5				western redcedar
Herbs							
Pteridium aquilinum	50.0	4.3		12.0	5.0		bracken
Festuca occidentalis	25.0	4.3	17.0				western fescue
Hypochoeris radicata	25.0	1.0	4.0				hairy cat's-ear
Lactuca muralis	25.0	0.3	1.0				wall lettuce
Linnaea borealis	25.0	0.8	3.0				twinflower
Mosses, liverworts & lichens							
Kindbergia oregana	75.0	25.0		30.0	50.0	20.0	Oregon beaked moss
Hylocomium splendens	50.0	2.6			0.5	10.0	step moss
Rhytidiadelphus triquetrus	50.0	0.3			0.5	0.5	electrified cat's tail moss
Bryum miniatum	25.0	0.1	0.5				
Ceratodon purpureus	25.0	0.5	2.0				fire moss
Cladonia fimbriata	25.0	0.1	0.5				
Trachybryum megaptilum	25.0	0.1				0.5	
Polytrichum juniperinum	25.0	0.5	2.0				juniper haircap moss
Rhytidiopsis robusta	25.0	0.1				0.5	pipecleaner moss

Table VI-3. Indicator vegetation species for Koksilah (KOK) plots

St *Species*	P	MC	21	22	23	24	Common name
Dominant trees							
Pseudotsuga menziesii	50.0	4.8		15.0	4.0		Douglas-fir
Thuja plicata	25.0	0.5		2.0			western redcedar
Main canopy trees							
Pseudotsuga menziesii	75.0	36.3		50.0	30.0	65.0	Douglas-fir
Thuja plicata	25.0	1.3		5.0			western redcedar
Tsuga heterophylla	25.0	0.3		1.0			western hemlock
Understory trees							
Pseudotsuga menziesii	75.0	18.5		25.0	35.0	14.0	Douglas-fir
Thuja plicata	50.0	2.3		8.0	1.0		western redcedar
Tsuga heterophylla	25.0	0.3				1.0	western hemlock
Tall shrubs							
Pseudotsuga menziesii	75.0	5.5		7.0	10.0	5.0	Douglas-fir
Thuja plicata	50.0	9.0		35.0	1.0		western redcedar
Holodiscus discolor	50.0	1.5			1.0	5.0	ocean spray
Tsuga heterophylla	50.0	0.4		1.0	0.5		western hemlock
Salix scouleriana	25.0	0.5			2.0		Scouler's willow
Low shrubs							
Gaultheria shallon	100.0	43.8	40.0	30.0	35.0	70.0	salal
Mahonia nervosa	50.0	3.8		8.0		7.0	dull Oregon-grape
Rosa gymnocarpa	50.0	1.5	3.0			3.0	baldhip rose
Thuja plicata	50.0	1.3		4.0	1.0		western redcedar
Holodiscus discolor	50.0	0.6	2.0		0.5		ocean spray
Chimaphila umbellata	25.0	0.1				0.5	prince's pine
Pseudotsuga menziesii	25.0	0.1		0.5			Douglas-fir
Ribes lacustre	25.0	0.3				1.0	black gooseberry
Tsuga heterophylla	25.0	0.1			0.5		western hemlock
Vaccinium parvifolium	25.0	0.1			0.5		red huckleberry
Herbs							
Festuca occidentalis	50.0	2.8	10.0			1.0	western fescue
Festuca subulata	50.0	0.4	0.5			1.0	bearded fescue
Hypochoeris radicata	25.0	2.8	11.0				hairy cat's-ear
Elymus glaucus	25.0	1.3	5.0				blue wildrye
Poaceae	25.0	0.3		1.0			grass family
Achillea millefolium	25.0	0.1	0.5				yarrow
Achlys triphylla	25.0	0.5	2.0				vanilla leaf
Aira praecox	25.0	0.3	1.0				early hairgrass
Bromus vulgaris	25.0	0.8	3.0				Columbia brome
Campanula scouleri	25.0	0.1				0.5	Scouler's harebell
Collomia heterophylla	25.0	0.1				0.5	vari-leaved collomia
Deschampsia elongata	25.0	0.8	3.0				slender hairgrass
Epilobium angustifolium	25.0	0.1	0.5				fireweed
Hieracium albiflorum	25.0	0.1	0.5				white-flowered hawkweed
Linnaea borealis	25.0	0.1				0.5	twinflower
Lupinus polycarpus	25.0	0.3	1.0				small-flowered lupine
Melica subulata	25.0	0.1	0.5				Alaska oniongrass
Moehringia macrophylla	25.0	0.5				2.0	big-leaved sandwort
Montia parvifolia	25.0	0.5	2.0				small-leaved montia
Pteridium aquilinum	25.0	0.1	0.5				bracken
Trifolium campestre	25.0	0.5	2.0				low hop-clover
Mosses, liverworts & lichens							
Kindbergia oregana	75.0	16.8		10.0	50.0	7.0	Oregon beaked moss
Hylocomium splendens	50.0	5.0			5.0	15.0	step moss
Trachybryum megaptilum	50.0	0.6			0.5	2.0	
Rhacomitrium canescens	50.0	0.6		2.0	0.5		grey frayed-cap moss
Ceratodon purpureus	25.0	0.1	0.5				fire moss
Dicranum fuscescens	25.0	0.3			1.0		curly heron's-bill moss
Dicranum scoparium	25.0	0.3			1.0		broom moss
Isothecium myosuroides	25.0	0.3			1.0		
Mnium spinulosum	25.0	0.1			0.5		red-mouthed leafy moss
Polytrichum juniperinum	25.0	0.3		1.0			juniper haircap moss
Rhytidiopsis robusta	25.0	0.1			0.5		pipecleaner moss

Table VI-4. Indicator vegetation species for Nanaimo River (NAN) plots

St *Species*	P	MC	31	35	33	34	Common name
Dominant trees							
Pseudotsuga menziesii	75.0	24.5		35.0	33.0	30.0	Douglas-fir
Main canopy trees							
Pseudotsuga menziesii	75.0	4.5		10.0	5.0	3.0	Douglas-fir
Tsuga heterophylla	50.0	1.3			3.0	2.0	western hemlock
Thuja plicata	25.0	0.3			1.0		western redcedar
Understory trees							
Tsuga heterophylla	50.0	5.5			2.0	20.0	western hemlock
Pseudotsuga menziesii	50.0	2.5		5.0	5.0		Douglas-fir
Thuja plicata	50.0	1.0			2.0	2.0	western redcedar
Tall shrubs							
Tsuga heterophylla	50.0	4.5			3.0	15.0	western hemlock
Pseudotsuga menziesii	25.0	2.0			8.0		Douglas-fir
Pinus monticola	25.0	0.1				0.5	western white pine
Thuja plicata	25.0	0.5				2.0	western redcedar
Low shrubs							
Gaultheria shallon	100.0	32.5	30.0	50.0	30.0	20.0	salal
Tsuga heterophylla	100.0	3.6	2.0	0.5	2.0	10.0	western hemlock
Mahonia nervosa	100.0	1.3	2.0	0.5	0.5	2.0	dull Oregon-grape
Pinus monticola	75.0	1.1	2.0		2.0	0.5	western white pine
Chimaphila umbellata	50.0	0.3			0.5	0.5	prince's pine
Rosa gymnocarpa	50.0	0.3	0.5		0.5		baldhip rose
Thuja plicata	50.0	0.3		0.5		0.5	western redcedar
Pseudotsuga menziesii	25.0	5.0	20.0				Douglas-fir
Rubus parviflorus	25.0	1.8				7.0	thimbleberry
Arbutus menziesii	25.0	0.8	3.0				arbutus
Populus sp.	25.0	0.1	0.5				poplar
Rubus spectabilis	25.0	0.1		0.5			salmonberry
Herbs							
Pteridium aquilinum	75.0	1.9	2.0		5.0	0.5	bracken
Achlys triphylla	50.0	0.4		1.0	0.5		vanilla leaf
Epilobium sp.	25.0	0.1	0.5				willowherb
Fragaria sp.	25.0	0.1		0.5			strawberry
Goodyera oblongifolia	25.0	0.1				0.5	rattlesnake-plantain
Linnaea borealis	25.0	0.1			0.5		twinflower
Mosses, liverworts & lichens							
Kindbergia oregana	75.0	5.1		5.0	15.0	0.5	Oregon beaked moss
Dicranum sp.	50.0	1.4			0.5	5.0	dicranum moss
Rhytidiadelphus loreus	50.0	1.0			1.0	3.0	lanky moss
Hylocomium splendens	50.0	0.9		0.5		3.0	step moss
Polytrichum juniperinum	50.0	0.6	2.0		0.5		juniper haircap moss
Letharia vulpina	25.0	5.0				20.0	wolf lichen
Cladina sp.	25.0	0.1				0.5	cladina lichen
Plagiomnium insigne	25.0	0.1		0.5			sign moss
Plagiothecium undulatum	25.0	0.1			0.5		flat moss

Table VI-5. Indicator vegetation species for Renfrew (REN) plots

St *Species*	P	MC	51	52	53	54	Common name
Dominant trees							
Tsuga heterophylla	75.0	11.3		5.0	15.0	25.0	western hemlock
Thuja plicata	25.0	8.8				35.0	western redcedar
Abies amabilis	25.0	1.3			5.0		amabilis fir
Pseudotsuga menziesii	25.0	0.1		0.5			Douglas-fir
Main canopy trees							
Tsuga heterophylla	75.0	16.3		30.0	30.0	5.0	western hemlock
Abies amabilis	50.0	4.0			15.0	1.0	amabilis fir
Thuja plicata	25.0	5.0				20.0	western redcedar
Understory trees							
Tsuga heterophylla	50.0	5.3		20.0	1.0		western hemlock
Low shrubs							
Gaultheria shallon	75.0	23.1	2.0		0.5	90.0	salal
Vaccinium parvifolium	75.0	0.8	2.0	0.5	0.5		red huckleberry
Rubus spectabilis	25.0	5.0	20.0				salmonberry
Tsuga heterophylla	25.0	5.0	20.0				western hemlock
Alnus rubra	25.0	1.3	5.0				red alder
Menziesia ferruginea	25.0	0.5				2.0	false azalea
Picea sitchensis	25.0	0.1	0.5				Sitka spruce
Thuja plicata	25.0	0.1	0.5				western redcedar
Herbs							
Blechnum spicant	100.0	10.6	30.0	0.5	2.0	10.0	deer fern
Polystichum munitum	50.0	1.8		3.0	4.0		sword fern
Epilobium angustifolium	25.0	3.8	15.0				fireweed
Anaphalis margaritacea	25.0	2.5	10.0				pearly everlasting
Poaceae	25.0	0.1	0.5				grass family
Athyrium filix-femina	25.0	0.1			0.5		lady fern
Cornus canadensis	25.0	0.1				0.5	bunchberry
Streptopus roseus	25.0	0.1		0.5			rosy twistedstalk
Tiarella trifoliata	25.0	0.1			0.5		three-leaved foamflower
Mosses, liverworts & lichens							
Plagiothecium undulatum	75.0	0.4		0.5	0.5	0.5	flat moss
Kindbergia oregana	50.0	0.9		0.5		3.0	Oregon beaked moss
Dicranum sp.	25.0	0.1	0.5				dicranum moss
Polytrichum juniperinum	25.0	0.8	3.0				juniper haircap moss
Rhizomnium glabrescens	25.0	0.1		0.5			

Table VI-6. Indicator vegetation species for Red/Granite Creek (RGC) plots

St *Species*	P	MC	61	62	63	64	Common name
Dominant trees							
Tsuga heterophylla	75.0	28.8		30.0	45.0	40.0	western hemlock
Alnus rubra	25.0	8.8		35.0			red alder
Thuja plicata	25.0	5.0				20.0	western redcedar
Main canopy trees							
Tsuga heterophylla	75.0	13.3		8.0	25.0	20.0	western hemlock
Alnus rubra	50.0	2.8		10.0	1.0		red alder
Thuja plicata	25.0	0.3			1.0		western redcedar
Understory trees							
Tsuga heterophylla	75.0	6.3		5.0	15.0	5.0	western hemlock
Tall shrubs							
Pseudotsuga menziesii	25.0	3.8	15.0				Douglas-fir
Tsuga heterophylla	25.0	3.8	15.0				western hemlock
Acer macrophyllum	25.0	0.1		0.5			bigleaf maple
Low shrubs							
Vaccinium parvifolium	100.0	1.9	3.0	0.5	2.0	2.0	red huckleberry
Rubus spectabilis	75.0	2.6	8.0	0.5		2.0	salmonberry
Gaultheria shallon	50.0	0.3	0.5			0.5	salal
Alnus rubra	25.0	0.1	0.5				red alder
Populus sp.	25.0	0.5	2.0				poplar
Herbs							
Polystichum munitum	75.0	20.0	5.0		25.0	50.0	sword fern
Blechnum spicant	75.0	10.0	20.0		10.0	10.0	deer fern
Epilobium angustifolium	25.0	5.0	20.0				fireweed
Anaphalis margaritacea	25.0	3.8	15.0				pearly everlasting
Poaceae	25.0	1.3	5.0				grass family
Lycopodium annotinum	25.0	0.1	0.5				stiff clubmoss
Ranunculus sp.	25.0	0.8	3.0				buttercup
Mosses, liverworts & lichens							
Kindbergia oregana	75.0	3.8		5.0	5.0	5.0	Oregon beaked moss
Isothecium myosuroides	50.0	1.5		5.0	1.0		
Polytrichum juniperinum	25.0	2.5	10.0				juniper haircap moss
Dicranum sp.	25.0	0.5	2.0				dicranum moss
Rhizomnium glabrescens	25.0	0.1				0.5	

Table VI-7. Indicator vegetation species for Nitinat (NIT) plots

St *Species*	P	MC	71	72	73	74	Common name
Dominant trees							
Tsuga heterophylla	75.0	17.5		15.0	15.0	40.0	western hemlock
Pseudotsuga menziesii	25.0	6.3		25.0			Douglas-fir
Thuja plicata	25.0	1.3				5.0	western redcedar
Main canopy trees							
Tsuga heterophylla	50.0	10.5			35.0	7.0	western hemlock
Abies amabilis	25.0	1.3				5.0	amabilis fir
Thuja plicata	25.0	0.5		2.0			western redcedar
Understory trees							
Tsuga heterophylla	50.0	1.0			2.0	2.0	western hemlock
Abies amabilis	25.0	0.5				2.0	amabilis fir
Alnus rubra	25.0	0.5		2.0			red alder
Thuja plicata	25.0	0.8		3.0			western redcedar
Tall shrubs							
Vaccinium parvifolium	25.0	7.5				30.0	red huckleberry
Vaccinium alaskaense	25.0	6.3				25.0	Alaskan blueberry
Pseudotsuga menziesii	25.0	0.5	2.0				Douglas-fir
Taxus brevifolia	25.0	0.1				0.5	western yew
Thuja plicata	25.0	0.1	0.5				western redcedar
Tsuga heterophylla	25.0	0.8	3.0				western hemlock
Low shrubs							
Gaultheria shallon	100.0	30.1	55.0	5.0	0.5	60.0	salal
Vaccinium parvifolium	100.0	5.9	8.0	8.0	7.0	0.5	red huckleberry
Tsuga heterophylla	75.0	2.6	5.0		0.5	5.0	western hemlock
Vaccinium alaskaense	75.0	2.8	10.0		0.5	0.5	Alaskan blueberry
Rubus spectabilis	75.0	0.8	0.5	2.0	0.5		salmonberry
Taxus brevifolia	50.0	0.3	0.5	0.5			western yew
Abies amabilis	25.0	0.1	0.5				amabilis fir
Mahonia nervosa	25.0	0.8		3.0			dull Oregon-grape
Malus fusca	25.0	0.1	0.5				Pacific crab apple
Pseudotsuga menziesii	25.0	0.1	0.5				Douglas-fir
Rubus ursinus	25.0	0.1		0.5			trailing blackberry
Thuja plicata	25.0	0.5	2.0				western redcedar
Herbs							
Blechnum spicant	100.0	2.6	3.0	0.5	5.0	2.0	deer fern
Achlys triphylla	75.0	0.4	0.5	0.5	0.5		vanilla leaf
Polystichum munitum	50.0	7.5		15.0	15.0		sword fern
Athyrium filix-femina	25.0	0.1			0.5		lady fern
Dryopteris expansa	25.0	0.1			0.5		spiny wood fern
Epilobium sp.	25.0	0.5	2.0				willowherb
Linnaea borealis	25.0	0.1		0.5			twinflower
Pteridium aquilinum	25.0	0.1		0.5			bracken
Mosses, liverworts & lichens							
Kindbergia oregana	100.0	5.3	1.0	10.0	5.0	5.0	Oregon beaked moss
Hylocomium splendens	75.0	7.1	3.0		0.5	25.0	step moss
Plagiothecium undulatum	75.0	0.8		0.5	2.0	0.5	flat moss
Dicranum sp.	50.0	0.4	1.0			0.5	dicranum moss
Rhytidiadelphus loreus	50.0	0.8	2.0			1.0	lanky moss
lichen	25.0	0.1				0.5	lichen

Table VI-8. Indicator vegetation species for Klanawa (KLA) plots

St *Species*	P	MC	81	82	83	84	Common name
Dominant trees							
Tsuga heterophylla	75.0	11.3		20.0	20.0	5.0	western hemlock
Abies amabilis	50.0	8.3			30.0	3.0	amabilis fir
Thuja plicata	25.0	1.3				5.0	western redcedar
Main canopy trees							
Tsuga heterophylla	75.0	11.3		40.0	2.0	3.0	western hemlock
Abies amabilis	25.0	2.5			10.0		amabilis fir
Pseudotsuga menziesii	25.0	0.8		3.0			Douglas-fir
Understory trees							
Tsuga heterophylla	75.0	2.5		5.0	2.0	3.0	western hemlock
Abies amabilis	50.0	1.5			5.0	1.0	amabilis fir
Acer macrophyllum	25.0	0.1			0.5		bigleaf maple
Thuja plicata	25.0	0.5		2.0			western redcedar
Tall shrubs							
Vaccinium parvifolium	50.0	5.0			10.0	10.0	red huckleberry
Tsuga heterophylla	50.0	1.5			3.0	3.0	western hemlock
Vaccinium alaskaense	50.0	1.4			0.5	5.0	Alaskan blueberry
Rubus spectabilis	50.0	0.6			2.0	0.5	salmonberry
Gaultheria shallon	25.0	15.0				60.0	salal
Abies amabilis	25.0	0.1				0.5	amabilis fir
Menziesia ferruginea	25.0	0.1				0.5	false azalea
Low shrubs							
Gaultheria shallon	100.0	2.0	2.0	0.5	0.5	5.0	salal
Rubus spectabilis	75.0	1.5	5.0	0.5	0.5		salmonberry
Tsuga heterophylla	50.0	0.3	0.5			0.5	western hemlock
Vaccinium alaskaense	50.0	0.6			0.5	2.0	Alaskan blueberry
Vaccinium parvifolium	25.0	1.3				5.0	red huckleberry
Abies amabilis	25.0	0.1				0.5	amabilis fir
Thuja plicata	25.0	0.1	0.5				western redcedar
Herbs							
Blechnum spicant	100.0	2.8	0.5	0.5	5.0	5.0	deer fern
Polystichum munitum	75.0	0.4		0.5	0.5	0.5	sword fern
Tiarella trifoliata	75.0	0.4		0.5	0.5	0.5	three-leaved foamflower
Cornus canadensis	25.0	2.0	8.0				bunchberry
Anaphalis margaritacea	25.0	0.1	0.5				pearly everlasting
Athyrium filix-femina	25.0	0.1		0.5			lady fern
Lysichitum americanum	25.0	0.1	0.5				skunk cabbage
Streptopus roseus	25.0	0.1			0.5		rosy twistedstalk
Tolmiea menziesii	25.0	0.1	0.5				piggy-back plant
Mosses, liverworts & lichens							
Rhizomnium glabrescens	75.0	2.0		0.5	0.5	7.0	
Kindbergia oregana	75.0	1.1		0.5	2.0	2.0	Oregon beaked moss
Plagiothecium undulatum	75.0	1.0		0.5	3.0	0.5	flat moss
Hylocomium splendens	50.0	0.9			3.0	0.5	step moss
Rhytidiadelphus loreus	50.0	0.3			0.5	0.5	lanky moss
Leucolepis menziesii	25.0	0.1		0.5			palm tree moss
Polytrichum juniperinum	25.0	0.1	0.5				juniper haircap moss

Appendix VII. Combined indicator vegetation species list for all chronosequence plots

Scientific name	Common name	Code
Coniferous trees		
Abies amabilis (Dougl. *ex* Loud.) Forbes	amabilis fir	ABIEAMA
Picea sitchensis (Bong.) Carr.	Sitka spruce	PICESIT
Pinus monticola Dougl. *ex* D. Don *in* Lamb.	western white pine	PINUMON
Pseudotsuga menziesii (Mirb.) Franco	Douglas-fir	PSEUMEN
Taxus brevifolia Nutt.	western yew	TAXUBRE
Thuja plicata Donn *ex* D. Don *in* Lamb.	western redcedar	THUJPLI
Tsuga heterophylla (Raf.) Sarg.	western hemlock	TSUGHET
Broad-leaved trees		
Acer macrophyllum Pursh	bigleaf maple	ACERMAC
Alnus rubra Bong.	red alder	ALNURUB
Arbutus menziesii Pursh	arbutus	ARBUMEN
Malus fusca (Raf.) Schneid.	Pacific crab apple	MALUFUS
Populus sp.	poplar	POPULUS
Evergreen shrubs		
Chimaphila umbellata (L.) Barton	prince's pine	CHIMUMB
Gaultheria shallon Pursh	salal	GAULSHA
Mahonia nervosa (Pursh) Nutt.	dull Oregon-grape	MAHONER
Deciduous shrubs		
Holodiscus discolor (Pursh) Maxim.	ocean spray	HOLODIC
Menziesia ferruginea Sm.	false azalea	MENZFER
Ribes lacustre (Pers.) Poir.	black gooseberry	RIBELAC
Rosa gymnocarpa Nutt. *in* Torr. & Gray	baldhip rose	ROSAGYM
Rubus leucodermis Dougl. *ex* Torr. & Gray	black raspberry	RUBULEU
Rubus parviflorus Nutt.	thimbleberry	RUBUPAR
Rubus spectabilis Pursh	salmonberry	RUBUSPE
Rubus ursinus Cham. & Schlecht.	trailing blackberry	RUBUURS
Salix scouleriana Barratt *in* Hook.	Scouler's willow	SALISCO
Vaccinium alaskaense How.	Alaskan blueberry	VACCALA
Vaccinium parvifolium Sm. *in* Rees	red huckleberry	VACCPAR
Ferns		
Athyrium filix-femina (L.) Roth	lady fern	ATHYFIL
Blechnum spicant (L.) Roth	deer fern	BLECSPI
Dryopteris expansa (Presl) Frsr.-Jenk. & Jermy	spiny wood fern	DRYOEXP
Lycopodium annotinum L.	stiff clubmoss	LYCOANN
Polystichum munitum (Kaulf.) Presl	sword fern	POLYMUN
Pteridium aquilinum (L.) Kuhn *in* Decken	bracken	PTERAQU

Appendix VII. (Continued)

Scientific name	Common name	Code
Graminoids		
Aira praecox L.	early hairgrass	AIRAPRA
Bromus vulgaris (Hook.) Shear	Columbia brome	BROMVUL
Carex deweyana Schwein.	Dewey's sedge	CAREDEW
Danthonia spicata (L.) Beauv. *ex* Roem. & Schult.	poverty oatgrass	DANTSPI
Deschampsia elongata (Hook.) Munro *ex* Benth.	slender hairgrass	DESCELO
Elymus glaucus Buckl.	blue wildrye	ELYMGLA
Festuca occidentalis Hook.	western fescue	FESTOCC
Festuca subulata Trin. *in* Bong.	bearded fescue	FESTSUB
Holcus lanatus L.	Yorkshire fog	HOLCLAN
Melica subulata (Griseb.) Scribn.	Alaska oniongrass	MELISUB
Herbs		
Achillea millefolium L.	yarrow	ACHIMIL
Achlys triphylla (Sm.) DC.	vanilla leaf	ACHLTRI
Anaphalis margaritacea (L.) Benth. & Hook.	pearly everlasting	ANAPMAR
Campanula scouleri Hook. *ex* A. DC.	Scouler's harebell	CAMPSCO
Cerastium fontanum Baumg.	mouse-ear chickweed	CERAFON
Collomia heterophylla Dougl. *ex* Hook.	vari-leaved collomia	COLLHET
Cornus canadensis L.	bunchberry	CORNCAN
Digitalis purpurea L.	foxglove	DIGIPUR
Epilobium sp.	willowherb	EPILOBI
Epilobium angustifolium L.	fireweed	EPILANG
Fragaria sp.	strawberry	FRAGARI
Galium trifidum L.	small bedstraw	GALITRI
Goodyera oblongifolia Raf.	rattlesnake-plantain	GOODOBL
Hieracium albiflorum Hook.	white-flowered hawkweed	HIERALB
Hypochoeris radicata L.	hairy cat's-ear	HYPORAD
Lactuca muralis (L.) Fresen.	wall lettuce	LACTMUR
Linnaea borealis L.	twinflower	LINNBOR
Lupinus polycarpus Greene	small-flowered lupine	LUPIPOL
Lysichitum americanum Hult. & St. John	skunk cabbage	LYSIAME
Moehringia macrophylla (Hook.) Fenzl	big-leaved sandwort	MOEHMAC
Montia parvifolia (Moc. *ex* DC.) Greene	small-leaved montia	MONTPAR
Ranunculus sp.	buttercup	RANUNCU
Streptopus roseus Michx.	rosy twistedstalk	STREROS
Tiarella trifoliata L.	three-leaved foamflower	TIARTRI
Tolmiea menziesii (Pursh) Torr. & Gray	piggy-back plant	TOLMMEN
Trifolium campestre Schreb.	low hop-clover	TRIFCAM
Viola sempervirens Greene	trailing yellow violet	VIOLSEM

Appendix VII. (Continued)

Scientific name	Common name	Code
Mosses		
Bryum miniatum Lesq.		BRYUMIN
Ceratodon purpureus (Hedw.) Brid.	fire moss	CERAPUR
Dicranum sp.	dicranum moss	DICRANU
Dicranum fuscescens Turn.	curly heron's-bill moss	DICRFUS
Dicranum scoparium Hedw.	broom moss	DICRSCO
Trachybryum megaptilum (Sull.) Schof.		TRACMEG
Hylocomium splendens (Hedw.) B.S.G.	step moss	HYLOSPL
Hypnum circinale Hook.	coiled-leaf moss	HYPNCIR
Isothecium myosuroides Brid.	cat-tail moss	ISOTMYO
Kindbergia oregana (Sull.) Ochyra	Oregon beaked moss	KINDORE
Leucolepis menziesii (Hook.) Steere *ex* L. Koch	palm tree moss	LEUCMEN
Mnium spinulosum B.S.G.	red-mouthed leafy moss	MNIUSPI
Plagiomnium insigne (Mitt.) T. Kop.	sign moss	PLAGINS
Plagiothecium undulatum (Hedw.) B.S.G.	flat moss	PLAGUND
Polytrichum juniperinum Hedw.	juniper haircap moss	POLYJUN
Rhacomitrium canescens (Hedw.) Brid.	grey frayed-cap moss	RHACCAN
Rhizomnium glabrescens (Kindb.) T. Kop.	large leafy moss	RHIZGLA
Rhytidiadelphus loreus (Hedw.) Warnst.	lanky moss	RHYTLOR
Rhytidiadelphus triquetrus (Hedw.) Warnst.	electrified cat's tail moss	RHTYTRI
Rhytidiopsis robusta (Hook.) Broth.	pipecleaner moss	RHYTROB
Liverworts		
Scapania bolanderi Aust.	yellow-ladle liverwort	SCAPBOL
Lichens		
Cladonia fimbriata (L.) Fr.		CLADFIM
Cladina sp. (Nyl.) Harm.	cladina lichen	CLADINA
Letharia vulpina (L.) Hue	wolf lichen	LETHVUL

NOTE: Vascular plant species are named according to Douglas, G.W.; Straley, G.B.; Meidinger, D. 1989 – 1991. The vascular plants of British Columbia, vols. 1 – 3. B.C. Ministry of Forests, Research Branch, Victoria, B.C. Non-vascular plant species common names are from the following sources: (1) Meidinger, D. 1987. Recommended vernacular names for common plants of British Columbia. B.C. Ministry of Forests, Research Branch, Victoria, B.C. Res. Rept. RR87002-HQ. (2) Pojar, J.; MacKinnon, A., editors. 1994. Plants of coastal British Columbia: including Washington, Oregon and Alaska. Lone Pine Publishing, Vancouver, B.C. (3) Vitt, D.H.; Marsh, J.E.; Bovey, R.B. 1988. Mosses, lichens and ferns of northwest North America. Lone Pine Publishing, Edmonton, Alta.