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AN ECOLOGICAL INVESTIGATION OF WESTERN REDCEDAR SITES ON WESTERN VANCOUVER ISLAND

by

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ABSTRACT

A pilot study was conducted in which a wide range of sites, dominated by western redcedar, were sampled and described to provide background information on western redcedar sites on western Vancouver Island. A total of 40 sample plots, representing a wide range of environmental conditions, were sampled from 14 study sites in the Bamfield, Ucluelet, and Kennedy Lake areas.

Descriptive vegetation data were supplemented with additional environmental information and utilized for classification, interpretation and comparison of the study sites. The classical tabular method of comparing vegetation data was used to classify the sample plots into six associations. An ordination of the sample plots, by species composition, confirmed the classification scheme. The associations have been described and discussed, but must be considered tentative due to the small sample size.

The productivity of the study sites, as expressed by site index of western redcedar at age 100, was evaluated against a variety of soil parameters. No significant correlations were found between site index and the concentration of soil nutrients, which included total N (%), available P (ppm), organic C (%), and exchangeable Ca, Mg, Na, and K (meq/100g), in the effective and total rooting zones. A significant correlation was found between site index and soil depth, especially the depth to a restrictive layer. This relationship is not surprising since the volume of soil available for rooting integrates many soil factors important to tree growth.

The observations and findings based on the sites sampled for this study indicated that productivity of western redcedar is strongly related to edaphic conditions. The most productive of the 14 study sites was characterized by deep, well-drained soils, with a rich nutrient regime as reflected by indicator plant species. Other productive sites were situated either on seepage slopes, where they presumedly received inputs of nutrients through seepage water; or on fertile floodplains with rich nutrient regimes as reflected by indicator plant species. The poorest sites had very shallow soils with a restrictive layer, and poor nutrient conditions (as reflected by indicator plant species), and were situated on either flat depressional areas or rock outcroppings.

A new species of earthworm was observed in 11 of the 14 study sites. Results from a preliminary study (Spiers _et al_. 1983) indicated that these worms break down organic material and improve nutrient availability in west coast ecosystems. This may have important implications for management practices in this region.

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CHAPTER 1: INTRODUCTION

The forests of British Columbia are the province's most vast and valuable resource, providing a continual supply of amenities and products, and supporting numerous communities through forest-based industry (B.C. Ministry of Forests 1980b). The wealth of the resource lies partially in its diversity, as each species has unique properties and attributes. One very important component of British Columbia's forests is western redcedar, Thuja plicata Donn. ex D. Don in Lamb., which hereafter may be referred to as "redcedar".

Western redcedar has been valued by man for centuries. It was a favorite tree of west coast Indians and was utilized for a wide variety of purposes: planks were cut from redcedar logs to construct houses and other buildings; large logs were often carved into totem poles or hollowed-out to make ocean-going canoes; the bark was woven into baskets, mats, blankets, thatch, rope, fishing line and clothing (Sargent 1933; Bowers 1956; Dallimore and Jackson 1967; Bolsinger 1979); roots were made into fish hooks, and large twigs served as arrows (Dallimore and Jackson 1967; Edlin 1968).

Today, western redcedar is still prized for its beautiful, aromatic wood. Wood of old trees is fine and straight-grained, high in extractives but completely free from pitch, richly coloured, relatively free of knots, lightweight, with a small proportion of sapwood (COFI 1978; Bolsinger 1979). These characteristics enhance the workability of the wood and the durability and attractiveness of its products. Redcedar is well known for its superior insulation value, dimensional stability, attractive appearance, exceptional durability and resistance to weathering (COFI 1978).

This combination of properties makes redcedar a preferred species for many purposes. Redcedar is primarily cut into lumber, shakes and shingles. Other products include boats, canoes, exterior siding, sashes, doors, window frames, roof decking, caskets, crates, boxes, outdoor furniture, fences, clothes closets and chests, bee hives, rain-gutters, and fish-trap floats (Forest Products Lab 1955; Viereck and Little 1972; Sharpe 1974). Redcedar is unmatched as an exterior siding and is the most important species used in manufacturing wooden shingles and siding in both the United States and Canada (Panshin and de Zeeuw 1970; COFI 1978). Redcedar is also used for interior panelling, posts, poles, pilings, and to a limited extent, pulp. In addition, its leaf oil and extractives can be used in perfumes, room deodorants, insecticides, fungicides, antibiotics, pharmaceuticals, and shoepolishes (Wethern 1959; Barton 1973); although the market is very limited and extraction is marginally economical at best.

Because of its excellent properties and many uses, western redcedar is in constant demand and commands a high price. In the United States, both consumption rates and prices of western redcedar products increased rapidly between 1965 and 1979; more so than for any other west coast species (Bolsinger 1979). Similarly, in British Columbia, redcedar prices rose dramatically from 1975 and peaked in 1979 (Fig. 1). Western redcedar received the highest stumpage price of any species scaled on TFL cutting permits in B.C. in 1979 (B.C. Ministry of Forests 1980a). Although prices

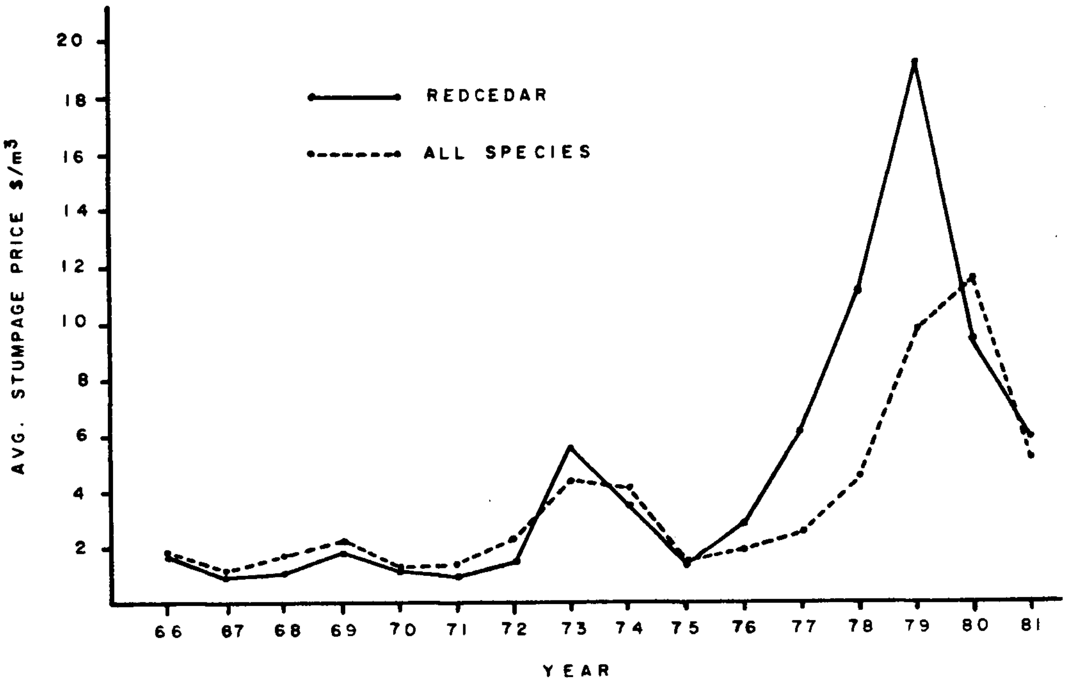


Figure 1: Comparison of average stumpage price received on redcedar with that on all species from TFL cutting permits between 1966 and 1981

(compiled from: B.C. Ministry of Forests Annual Reports, 1966 to 1981) have since declined, the stumpage price of redcedar in 1981 was still higher than the average stumpage price of all species (Fig. 1).

To meet the continuous demand for redcedar products there must be a constant supply. What is the extent of the redcedar resource in the Pacific Northwest? In the United States, the total volume of western redcedar, in live trees that are at least 25 percent sound, was estimated to be 255 million m^3 in 1977 (Bolsinger 1979). Almost half of this resource is found in Washington; particularly on the Olympic Peninsula. Most of the volume is in very large, old trees.

British Columbia's supply of western redcedar is over three times that of the United States. In 1979, the total standing volume of mature western redcedar was estimated to be almost 800 million m^3 (B.C. Ministry of Forests 1980b). Redcedar constitutes 12 percent of the total volume of mature timber for all species in the province (Fig. 2). Most of British Columbia's redcedar is found in coastal areas, with over 80 percent of the total volume of mature redcedar contained in the Vancouver and Prince Rupert Forest Regions (Table 1). Redcedar is a very important component of the forests in these regions. It comprises 17 percent of the total volume of mature timber in the Prince Rupert Region, and 26 percent in the Vancouver Region. Like the United States, most of the redcedar in B.C. is old growth. In fact, 93 percent of British Columbia's redcedar is in age class 7; greater than 129 years (B.C. Ministry of Forests 1980b).

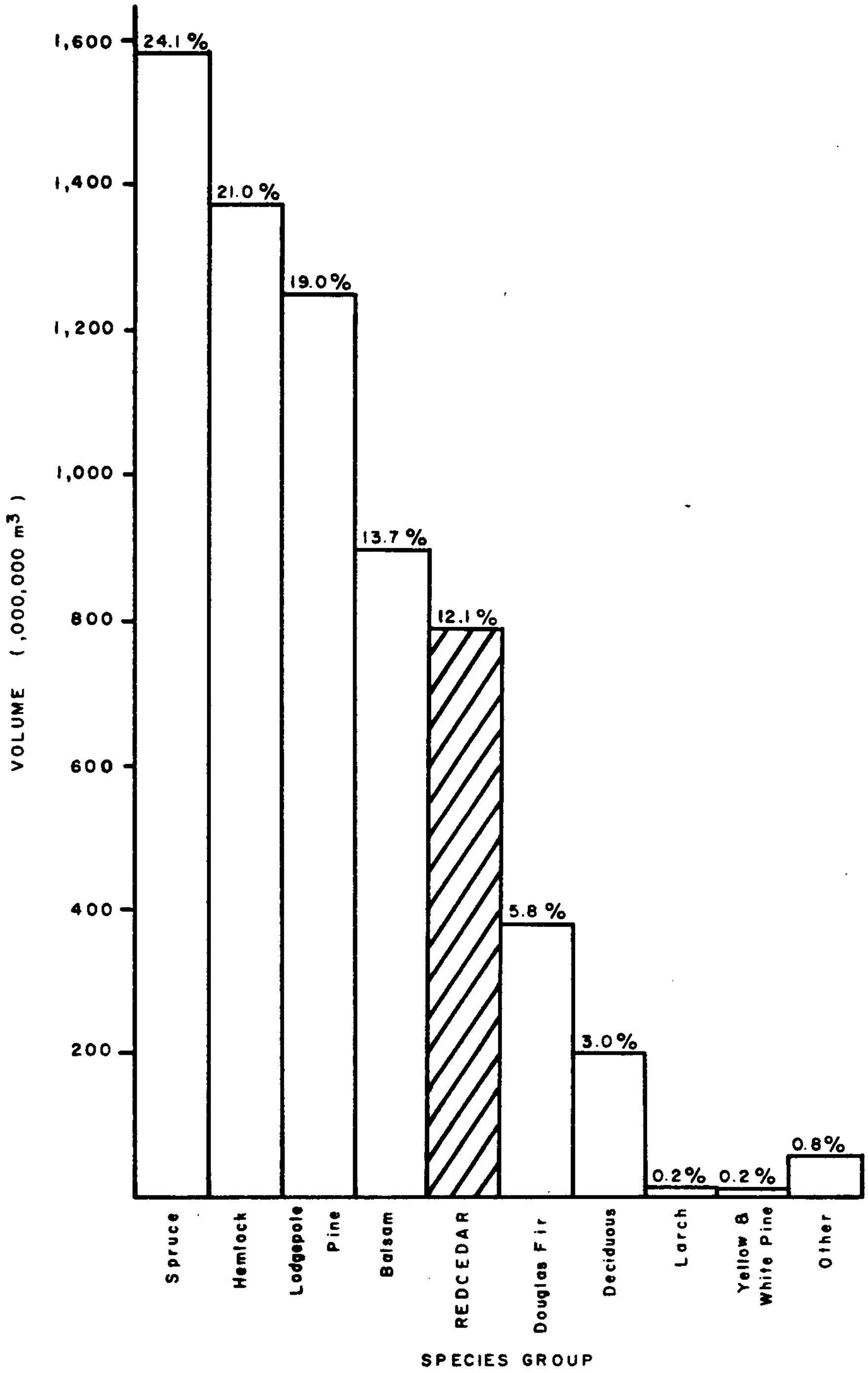


Figure 2: Volume of mature timber in British Columbia, by species or species group

(from: BC Ministry of Forests, Forest and Range Resource Analysis Technical Report, 1980)

Table 1: Distribution of mature western redcedar in British Columlbia

Forest region	Volume of mature redcedar (,000 m^3)	Total volume of mature timber (,000 m^3)	Percentage redcedar	Percentage of total BC redcedar resource
Vancouver	245,717	930,808	26.4	31.2
Cariboo	24,122	593,513	4.1	3.1
Prince Rupert	412,173	2,467,355	16.7	52.3
Prince George	34,058	1,687,419	2.0	4.3
Nelson	31,568	340,120	9.3	4.0
Kamloops	40,867	526,468	7.8	5.2
Total	788,505	6,545,683	12.0	100.1

* values for the Bulkley-Northwest Forest Region are included in those given for the Prince Rupert Region, and values for the Peace River Region were added to those for the Prince George Region.

(from: BC Ministry of Forests, 1980, Forest and Range Resource Analysis Technical Report)

Western redcedar has continuously been an important component of British Columbia's annual timber harvest. From 1965 to 1980, redcedar averaged 12.4 percent of the total annual cut (Fig. 3). Unfortunately, redcedar has not figured as prominently in the province's annual planting regime. As Table 2 illustrates, only 3.2 percent of the total number of trees sown in 1979 and 1980 were western redcedar. Since there is very little redcedar in young age classes, the combined effect of this continual harvesting without renewal, means a depletion of the redcedar resource. Although redcedar is naturally restocking some logged areas (Bolsinger 1979), it has become scarce where extensive areas have been clearcut, burned, and artifically reforested (Minore 1979a). As the area of intensively managed forest increases, the amount of western redcedar is likely to decrease.

Estimates indicate that at current rates of use, British Columbia's supply of mature redcedar will last approximately 100 years (Muller 1980). However, predictions for the United States are far more glum. Washington's redcedar is expected to last for little more than 30 years, and Oregon's supply should be gone in about 50 years (Bolsinger 1979). This dwindling supply is going to have a widespread economic effect. As redcedar production drops in Washington and Oregon, the States will be looking to Canada for their supply, putting increased pressure on British Columbia's redcedar resource and forcing its price up.

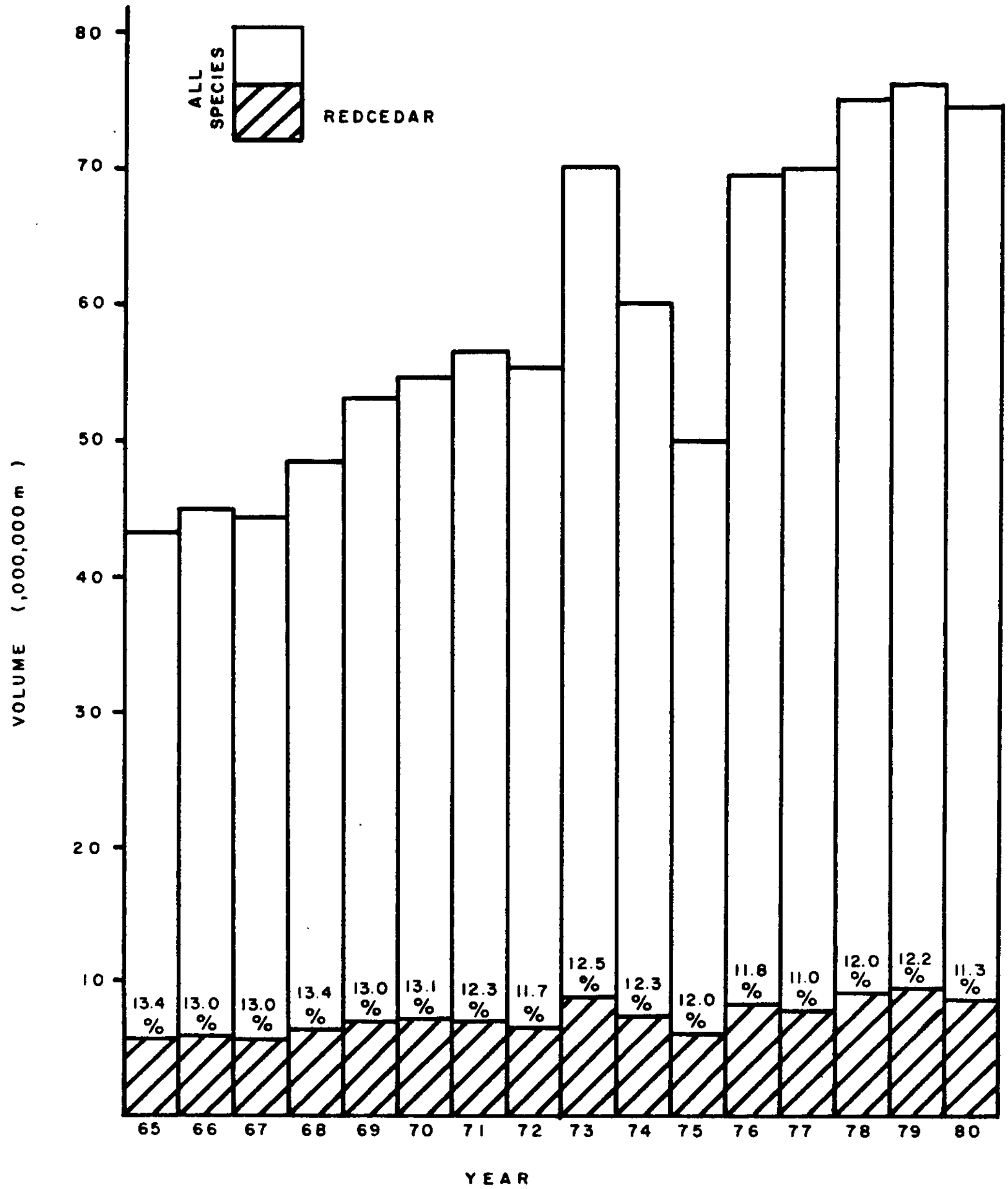


Figure 3: Annual total cut of western redcedar and all species in British Columbia from 1965 to 1980

(compiled from: BC Ministry of Forests Annual Reports, 1965 to 1980)

Table 2: Annual spring sowing of western redcedar in British Columbia

Year	Number of w. redcedar trees planted (,000s)	Total number of trees planted (,000s)	Percentage western redcedar
1978	1,420	96,848	1.5
1979	3,200	99,022	3.2
1980	3,475	110,583	3.2

(compiled from: B.C. Ministry of Forests Annual Reports, 1978 to 1980)

Why is this highly-valued, sought-after tree species not being replanted and managed? The response of timber growers is widespread and clear, "It just isn't economical". Western redcedar is considered to be a relatively slow-growing species and, it is argued that, on many sites, two or even three rotations of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) can be grown in the same time period as one crop of redcedar (Bolsinger 1979; Muller 1980). However, this argument may not be valid. Since redcedar has largely been ignored, very little is known about its capabilities. Consequently, the risks and uncertainties associated with managing redcedar are greater than those for species with which there has been more experience. Sound management practices must be based on a thorough understanding of ecology, physiology, mensuration, and silviculture. Unfortunately, knowledge of western redcedar is seriously lacking in all these areas. It is this lack of knowledge that poses the greatest hindrance to redcedar management. With additional information and experience, the problems associated with managing redcedar could be overcome or avoided.

Rationale and Objectives for Present Study

In the spring of 1980, Dr. E. Packee of MacMillan-Bloedel Ltd. proposed a pilot study to define the characteristics of productive sites for western redcedar on western Vancouver Island. Information for this region was very limited, but observations seemed to suggest that the region contained ideal habitat for growing western redcedar.

The objectives of this thesis are:

1- to review briefly the current literature on the ecology and silvics of western redcedar, and

2- to describe quantitatively and qualitatively a sample of sites, representing a wide range of habitats, in which western redcedar is a major or dominant species on western Vancouver Island.

Literature Review

General Description

Nomenclature

Western redcedar is the only *Thuja* species native to western North America. Contrary to what its name suggests, redcedar is not a true cedar, but actually a member of the cypress (Cupressaceae) family. The words red and cedar are combined into one word, redcedar, to distinguish it from true cedars (Muller 1980). Other common names for western redcedar include giant arborvitae, giant cedar, Pacific redcedar, canoe cedar, shinglewood, and cedar.

Form

Western redcedar typically has a conical form with drooping branches that turn upwards at the ends. Old trees tend to be flared or swollen at the base and are often conspicuously fluted, with frequent bark seams (Sudworth 1908; McBride 1959). Many old trees have hollow bases and dead, broken "spiked" tops (Daubenmire and Daubenmire 1968; Sharpe 1974), or "candellabra" tops when several leaders are present (Bowers 1956). Although no-one has determined what causes the candellabra shaped tops of redcedar, Eis (1962) suggested that they are caused by periodic drought and subsequent regeneration of the crown during more favourable years.

Ecological Characteristics

Geographic Range

Western redcedar grows along the Pacific coast from southeastern Alaska, with a northern limit of Sumner Strait (Andersen 1953); southward through the coast ranges of British Columbia, Washington, and Oregon where it is most abundant and attains its largest size; to Humboldt County in northern California (Sudworth 1908; Sargent 1933; Eliot 1948; Boyd 1959; Fowells 1965; Dallimore and Jackson 1967). The range of *Thuja plicata* is made up of two regions: the west coast region, outlined above; and the Inland Empire or northern Rocky Mountain region (Boyd 1959). The inland region of redcedar extends from the interior ranges in southeastern British Columbia, through northeastern Washington, northern Idaho to the mountains of northwestern Montana (Sudworth 1908; Hanzlik 1928; Sargent 1933; Soos and Walters 1963; Dallimore and Jackson 1967; Hitchcock *et al*. 1969; Sharpe 1974). The easternmost limit of redcedar is the western slope of the Rocky Mountains in northern Montana (Boyd 1959; Fowells 1965).

Elevational Range

Western redcedar is a relatively low elevation species. On the coast it grows from sea level to 915 m in Alaska (Viereck and Little 1972), from sea level to about 1200 m in British Columbia (Andersen 1961), and from sea level to 1500 m in Washington and Oregon (Eliot 1948; Fowells 1965).
In the interior, redcedar may be found from 600 to 2,100 m in the mountains

(Boyd 1959; Harlow and Harrar 1969). However, at elevations abvove 1,350 m it is reduced to a shrub, being twisted and stunted by the severe storms and adverse growing conditions (Eliot 1948; Hosie 1979). Its commercial range is limited to about 900 m in the coastal region, and to 1,500 m in the Inland Empire (Sudworth 1908; Hanzlik 1928).

Climatic Range

Throughout its range, western redcedar is confined almost entirely to areas having abundant precipitation and atmospheric humidity (Sudworth 1908; Hanzlik 1928). Redcedar thrives in the fog belt region of British Columbia and Washington, which extends 48 km inland from the coast (Peavey 1929). Within the fog belt, precipitation varies from 150 to 325 cm per year, with frequent summer rains (Boyd 1959; Fowells 1965). In the inland region, where summers are dry, the distribution of redcedar is often limited to northern slopes and moist valley bottoms (Soos and Walters 1963).

Where sufficient precipitation is present, the range of redcedar is apparently restricted by temperature (Minore 1979a). The length of the frost-free period may be another climatic constraint for redcedar, since it is not very frost resistant (Schmidt 1955; Daubenmire and Daubenmire 1968). The optimum growing conditions for redcedar are found in regions with abundant precipitation, cool summers and mild winters; such as the Olympic Peninsula, Puget Sound area, and parts of Vancouver Island (Boyd 1959; Fowells 1965; Sharpe 1974).

Habitats

Because of its requirements for abundant moisture and moderate temperatures, redcedar is typically found growing on stream bottoms, river banks, alluvial floodplains, moist flats, terraces, ravines and gulches, and gentle lower slopes (Sudworth 1918; Miller 1927; Sargent 1933; Dallimore and Jackson 1967; Krajina 1969). It is also common in forested swamps and may even be found in shallow sphagnum bogs (Soos and Walters 1963; Harlow and Harrar 1969; Hosie 1979; Minore 1979a). Occasionally redcedar grows on dry slopes and warm sites, but there growth is usually poor and often stunted (Sudworth 1908; Eliot 1948; Harlow and Harrar 1969; Sharpe 1974). It has also been noted that a north aspect is more suitable for redcedar than the relatively drier southern aspect (Boyd 1959; Fowells 1965).

Root System

In order to understand better the types of sites and soils which redcedar prefers, it is important to consider the root system of this species. Western redcedar is generally reported to have an extensive, wide-spreading root system (Harlow and Harrar 1969; Leaphart and Grismer 1974; Hosie 1979), with a well-developed network of fine roots and a poorly-developed taproot (Leaphart and Wicker 1966; Eis 1974). Redcedar is considered to be a shallow-rooted species, for its system of fine roots is usually concentrated in upper, organic horizons of the soil profile (Ross 1932; Haig *et al*. 1941; McMinn 1960). Apparently, the rooting depth of redcedar is limited on shallow and wet sites, and in soils of high bulk density, since redcedar has been reported to form deep root systems on deep, moderately dry soils (Forristall and Gessel 1955; Day 1957; McMinn 1960; Minore *et al*. 1969).

Soils

Only limited information is available about the optimum soil conditions for redcedar. It is apparently able to tolerate a wide range of soil types, from deep rich loams, wet clayey soils, and peat; to shallow gravelly sands (Knapp and Jackson 1914; Dallimore and Jackson 1967). Packee (1976) reports that redcedar is found on all landforms, soil textures and parent materials on Vancouver Island. The optimal soil conditions reported for redcedar are largely based on observation and speculation.

It is generally reported that western redcedar prefers neutral to moderately acidic sites, with high levels of available nutrients; particularly nitrogen, calcium and magnesium (Daubenmire 1952; UBC Forestry Club 1959; Krajina 1969). Nevertheless, redcedar does survive and grow, though less productively, on nutritionally-poor soils throughout its range (Krajina et al. 1982). Reports of redcedar's nutrient requirements are primarily based on findings from controlled greenhouse experiments in which seedlings have been grown in sand cultures to test the effects of a variety of nutrient deficient solutions on the growth of seeedlings (Gessel et al. 1951; Walker et al. 1955; Krajina 1969; Krajina et al. 1973, 1982). It is questionable whether results from such studies provide meaningful information about the nutrient requirements of trees growing in natural forest ecosystems.

For western redcedar, the amount of available soil moisture is probably more important than soil depth, texture, or fertility (Sudworth 1908; Knapp and Jackson 1914). However, fertile soils and abundant moisture are reported to be both necessary for best development (Boyd 1959; Sharpe 1974; Krajina 1969).

Redcedar is able to tolerate a wide range of soil moisture conditions, from dry rock bluffs to swamps and bogs (Handley 1979). Although redcedar is relatively drought tolerant (Minore 1979b), its growth is restricted in dry soils (McMinn 1960), and adequate soil moisture during the growing season is essential for good growth (Handley 1979; Minore 1979a). At the opposite end of the moisture spectrum, western redcedar is very tolerant of excess soil moisture. It can grow over shallow water tables, in stagnant sites, and in sites subjected to flooding; where other coniferous species often cannot survive (Brink 1954; Minore 1968, 1970; Minore and Smith 1971; Krajina et al. 1982). Although redcedar is well-adapted to such wet conditions, its growth is better on deep soils with better drainage (McMinn 1960; Sharpe 1974; Hosie 1979).

Shade Tolerance

Western redcedar is considered to be a shade tolerant species because it can germinate, grow and reach maturity in shade (Boyd 1959; Sharpe 1974). Tolerance varies with age, altitude, latitude, soil moisture and climatic conditions (Sudworth 1908). However, growth of redcedar is retarded in proportion to the density of the shade (Boyd 1959), for although shade is tolerated to a high degree, it is not necessarily required (Sudworth 1908). One exception to this might be relatively dry habitats, where redcedar is a shade-requiring tree (Krajina et al. 1982).

Small redcedar trees can endure suppression for a considerable length of time and respond well in growth rate after release (Schmidt 1955; Boyd

1959; Handley 1979). Redcedar's ability to survive long periods of suppression may be related to its ability to produce new root growth in full-shade (Haig 1936), or to root-grafting (Eis 1972). The response of suppressed redcedar trees to an overstory removal is probably also related to redcedar's extensive root systyem (Leaphart and Grismer 1974). The function of the roots in this response is however, unclear.

Associates

Western redcedar rarely grows in pure stands to any great extent, but usually occurs in mixed stands of coniferous and broadleaf species (Sudworth 1908; Eliot 1948; Boyd 1959; Fowells 1965; Edlin 1968; Sharpe 1974; Hosie 1979; Eyre 1980). In mixed forests, redcedar may form up to 50 percent of the stand (Hanzlik 1928; Harlow and Harrar 1969). Tree species associated with western redcedar vary a great deal according to the local environmental conditions (Sharpe 1974). In Alaska and northern regions, redcedar grows with *Tsuga heterophylla* (Raf.) Sarg., *Picea sitchensis* (Bong.) Carr., and *Chamaecyparis nootkatensis* (D. Don) Spach (Eliot 1948; Fowells 1965). Redcedar has numerous associates along the Pacific Coast including *Tsuga heterophylla*, *Pseudotsuga menziesii* (Mirb.) Franco, *Picea sitchensis*, *Abies amabilis* (Dougl.) Forbes, *A. grandis* (Dougl.) Lindl., *Chamaecyparis nootkatensis*, *C. lawsoniana* (A.Murr.) Parl., *Taxus brevifolia* Nutt., *Alnus rubra* Bong., *Acer circinatum* Pursh., *A. macrophyllum* Pursh, *Populus trichocarpa* Torr. & Gray, and *Arbutus menziesii* Pursh (Hanzlik 1928; Schmidt 1955; Boyd 1959; Andersen 1961; Orloci 1965; Fowells 1965; Harlow and Harrar 1969; Krajina 1969; Franklin and Dyrness 1973; Sharpe 1974; Packee 1976; Hosie 1979). In California its associates are *Tsuga heterophylla* and *Sequoia sempervirens* (D. Don) Endl. (Fowells

1965; Sharpe 1974). In the interior of British Columbia and mountainous regions of the Inland Empire, associates of western redcedar include *Chamaecyparis nootkatensis*, *Tsuga mertensiana* (Bong.) Carr., *T. heterophylla*, *Abies amabilis*, *A. procera* Rehd., *A. lasiocarpa* (Hook.) Nutt., *Picea engelmannii* Parry, *Pinus monticola* Dougl., *P. contorta* Dougl., *Pseudotsuga menziesii*, *Larix occidentalis* Nutt., *Populus trichocarpa*, *P. tremuloides* Michx., and *Betula papyrifera* Marsh. (Sudworth 1908; Hanzlik 1928; Haig *et al*. 1941; McLean and Holland 1958; Boyd 1959; Harlow and Harrar 1969; Clark 1970; Sharpe 1974; Hosie 1979).

Because of its wide ecological amplitude, redcedar exists in a variety of plant communities with a number of associated shrubs, herbs, ferns, and mosses. The reader is referred to Minore (1979a, 1983) for a detailed account of the major western redcedar communities which have been described in the literature, and their associated understory species.

Successional Status

Western redcedar is generally regarded as being a climax or near-climax species (Schmidt 1955; McLean and Holland 1958). Most of redcedar's associates are more prone to insect and disease attack which tends to hasten the succession of redcedar to climax position (Schmidt 1955; Boyd 1959; Sharpe 1974).

Moisture and soil conditions strongly influence the successional status of western redcedar (BC Forest Service 1947; Habeck 1968; Krajina 1969; Franklin and Dyrness 1973); consequently, redcedar is often present in all stages of forest succession (Packee 1976; Minore 1979a, 1983). Minore (1979a, 1983) suggests that redcedar should probably be considered an edaphic climax species rather than a climatic climax tree.

Life History

Reproduction

Western redcedar is known to produce prodigious amounts of seed (Sudworth 1908; Schmidt 1955; Harlow and Harrar 1969), and is capable of bearing seed at a young age (Bolsinger 1979). Unfortunately, large seed crops for redcedar do not occur every year. The frequency of good seed crops tends to be somewhat erratic (Gashwiler 1969), occurring approximately once every 3 or 4 years (Hanzlik 1928; Haig *et al*. 1941; Hetherington 1965; Clark 1970).

The seeds of western redcedar are light and small and are dispersed by wind (Hanzlik 1928). However, the small wing surface of the seed allows it to fall fairly rapidly, thus limiting the distance of dispersal (Isaac 1930; Boyd 1959; Stewart 1962; Hetherington 1965; Fowells 1965; Clark 1970; Sharpe 1974). On the positive side, the small seeds of redcedar are rarely eaten by small mammals and birds, since larger seeds of associated species are preferred (Isaac 1939; Schopmeyer 1940; Gashwiler 1967, 1970; Sharpe 1974).

Seed of western redcedar is reported to have a high rate of germination (Sudworth 1908; Haig *et al*. 1941; Schmidt 1955; Boyd 1959; Fowells 1965; Bolsinger 1979). The major requirement for successful germination is an abundance of soil moisture (Sharpe 1974). For this reason, redcedar reproduces best where protection from drying winds and sunlight is provided (Hanzlik 1928; Schmidt 1955).

Researchers cannot seem to agree on the optimal seedbed conditions for germination of western redcedar. Discrepancies may exist due to differences in moisture conditions. Redcedar is reported to germinate on any natural surface if adequate seedbed moisture is available (Knapp and Jackson 1914; Fischer 1935; Soos and Walters 1963; Harlow and Harrar 1969).

Disturbance of the forest floor is reported to be beneficial for the establishment of redcedar (Schmidt 1955; Clark 1970; Minore 1979a). Such disturbance is probably especially critical following logging, when a mineral seedbed would be preferable for redcedar over a potentially droughty organic seedbed. Slashburning after logging may also favour the establishment of redcedar (B.C. Forest Service 1947), since it probably exposes more mineral soil surfaces (Clark 1970; Minore 1979a). However, slashburning is evidently not a requirement, since redcedar can become established after logging with or without slashburning. Soos and Walters (1963) reported unburned mineral soil to be most favorable for germination of redcedar.

The optimal conditions for good growth of western redcedar seedlings are similar to those for germination. The key is, once again, moisture availability. Western redcedar seedlings require a continuous supply of accessible moisture for their survival and growth (Haig et al. 1941). Consequently, seedlings prefer conditions which maintain adequate moisture levels. Such conditions are usually well met on unburned mineral soils, under partial shade (Larsen 1940; Boyd 1959).

Unfortunately, even when all the requirements for germination and seedling growth are met, very few redcedar trees become established in spite of the tremendous number of seeds released. Reproduction failure is primarily due to excessive mortality during germination and early stages of seedling development (Haig et al. 1941; Boyd 1959; Fowells 1965; Harlow and Harrar 1969). Causes of mortality include fungal attack, drought and insolation injury, frost-heaving, and browse by deer, elk, and rabbits (Cowan 1945; Worthington 1955; Boyd 1959; Soos and Walters 1963; Fowells 1965; Gockerell 1966; Packee 1975). In large portions of the Queen Charlotte Islands, BC, introduced Sitka blacktail deer have greatly reduced redcedar regeneration (Minore 1983).

Although redcedar has the capability of successfully reproducing from seed on open areas, it is rarely relied upon to restock logged areas. The problems of infrequent seed crops, limited seed dispersal, and seedling mortality, are very real.

In established stands, the situation is not much better. Advanced regeneration of redcedar is often erratic and absent in undisturbed, commercial forests; even when redcedar is a major component of the stand (Schmidt 1955). Germination failure and seedling mortality are thought to be the major causes (Schmidt 1955; Fowells 1965). Interestingly, however, redcedar has been observed to reproduce in young pioneer stands of redcedar scrub (Schmidt 1955). Why redcedar is able to reproduce in these stands is unclear.

In many stands, redcedar is able to reproduce vegetatively; adventitious roots may develop from low-hanging limbs, broken-off branches, and fallen tree trunks that remain alive (Schmidt 1955; Boyd 1959; Fowells

1965). A wet soil surface is necessary for this form of reproduction (Habeck 1968), and growth is usually very slow (Sharpe 1974).

Maximum Size and Age

Once established, western redcedar has few natural enemies, so it can live for several hundred years and attain large sizes. Under favorable growing conditions, individual redcedars may reach heights of 45 to 60 m, with diameters above the swelled base of 2.5 to 5 m (Hanzlik 1928; Fowells 1965; Dallimore and Jackson 1967; Edlin 1968; Harlow and Harrar 1969; Hosie 1979). This species is known for its longevity: 500 to 1,000 year old individuals are common (Hanzlik 1928). In eastern Washington, some redcedars have been reported to be 2,000 years old (Sharpe 1974).

Natural Enemies

Redcedar is highly resistant to, or undamaged by, most insects and diseases. Healthy trees are rarely attacked by insects. Hanzlik (1928) suggested that this may be due to the strong aromatic character of the wood, which may be disagreeable to most insects. More recent studies have shown that redcedar extractives have insecticidal properties (MacLean 1970; Barton et al. 1972). Redcedar is rarely killed by pathological attacks; however, root, butt, and trunk rots can cause considerable damage (Hubert 1931; Buckland 1946; US Forest Service 1961; Wallis and Reynolds 1967; Koenings 1969; Hepting 1971; Aldhous and Low 1974).

Redcedar is not very frost resistant. Consequently, early and late spring frosts may be very damaging; especially in coastal areas (Krajina 1969; Handley 1979; Minore 1979a; Krajina et al. 1982). Windthrow may also be a problem for redcedar, especially on wet sites where the soil is shallow (Knapp and Jackson 1914; Sharpe 1974). However, on dry sites, where good anchorage is established, redcedar is quite windfirm (Boyd 1959; Minore 1979a; Steinblums et al. 1984).

The most serious enemy of western redcedar is fire (Boyd 1959). Redcedar has thin fibrous bark which burns easily (Sudworth 1908; Dallimore and Jackson 1967; Hitchcock et al. 1969; Sharpe 1974; Handley 1979); and its shallow roots are often scorched and killed by fire (Knapp and Jackson 1914; Harlow and Harrar 1969). One definite advantage for redcedar is that it usually grows on moist sites which tend not to be flammable; thus reducing both the frequency and severity of fires (Hanzlik 1928; Boyd 1959; Sharpe 1974; Habeck 1978).

Growth and Productivity

Growth Rate

Western redcedar is considered to be a relatively slow-growing species, especially when compared with its associates. However, this generalization should not be universally applied since growth rates of redcedar are strongly influenced by soil and moisture conditions, stand density and the age of the trees. On moist fertile sites, redcedar has been reported to grow more rapidly than other conifers (Bolsinger 1979). Packee (1976) studied conifers on Vancouver Island and observed that height growth of redcedar was equal to, and often exceeded, that of western hemlock and Sitka spruce - particularly on wet sites, where it frequently was greater in size than any of its associates.

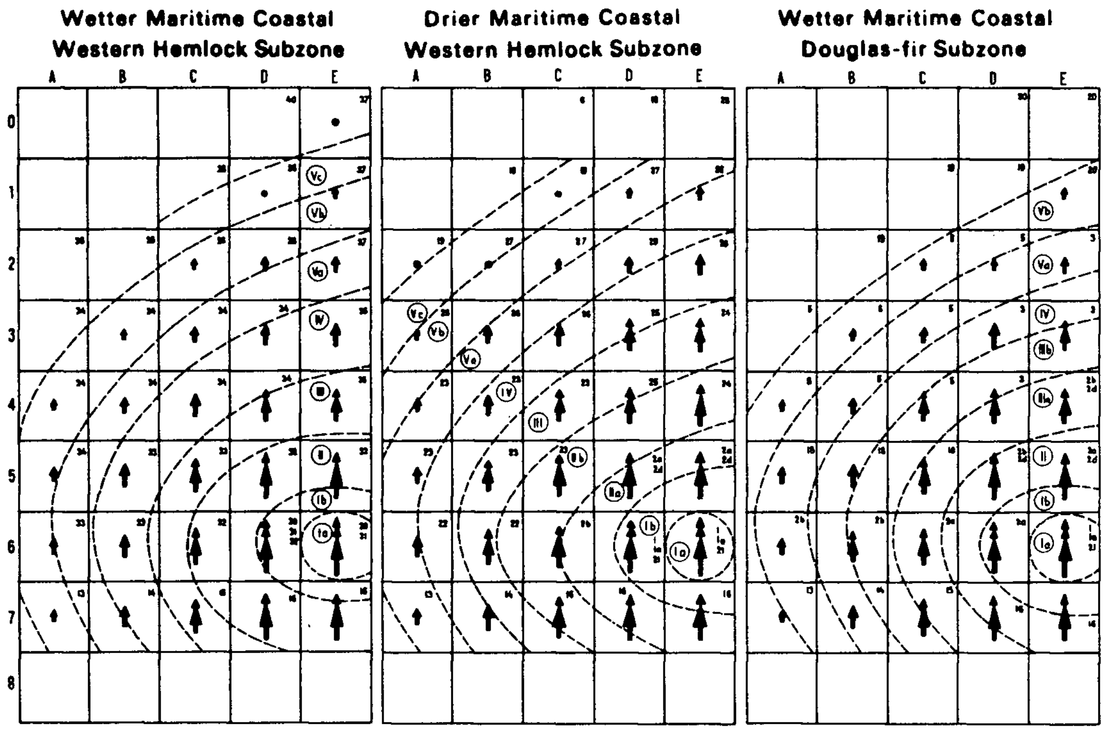
Walters et al. (1961) observed that western redcedar seedlings reached breast height faster than Douglas-fir seedlings on good sites in British Columbia. On poor sites, however, the species ranking was reversed. Packee (1976) cited annual radial increments of one to two cm for redcedar on the best moist sites. Hanzlik (1928) reports that under favorable conditions, redcedar makes fairly good growth, attaining a diameter of 48 cm and a height of 30 m in 80 years. On less suitable sites, such as poorer soils and steeper slopes, redcedar may take 100 to 150 years to reach such a size (Hanzlik 1928). McMinn (1960) also observed that growth rates of redcedar were impaired by inadequate moisture, or by highly leached soils.

As redcedar matures, its growth rate slows (Sharpe 1974). Maximum diameter and height growth occur during the first 30 years. On good sites, western redcedar has been observed to outgrow Douglas-fir and western hemlock in height during the first 5 years (Smith and DeBell 1973). However, by age 10, Douglas-fir tended to overtake redcedar; and hemlock was able to overtake redcedar by age 15 (Smith and DeBell 1973). Associated conifers tend to hold redcedar in an intermediate position for many years. Although growth of suppressed redcedar stands is not rapid or vigorous, it is quite uniform and well-sustained for at least two centuries. As mentioned, redcedar is able to outlive most of its associates and responds well to release, even after long periods of suppression.

Western Redcedar Site-Productivity

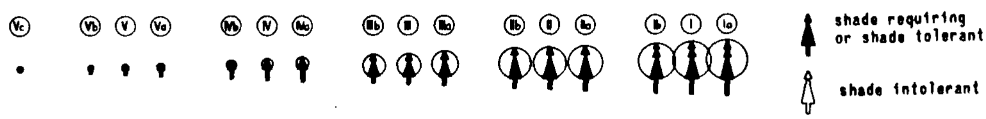
Many authors have commented on the type of sites where growth of western redcedar is most vigorous. Eliot (1948) mentioned that redcedar reaches its largest size on bottoms near the coast on Vancouver Island in British Columbia and in the Puget Sound area of northwestern Washington. McMinn (1960) reported that, in the Douglas-fir region on Vancouver Island, growth of western redcedar is near optimum on the fertile, occasionally-flooded soils of the *Pseudotsuga-Thuja Adiantum* association. At the UBC research forest near Haney, BC, Eis (1962) reported that productivity of redcedar (as measured by site index) was highest in the wetter subzone communities on the transition between the *Vaccinium-Moss* and the *Blechnum* association, in sites with the best vigor of *Polystichum*. From his biomass estimates in northern Idaho, Hanley (1976) reported that the *Thuja plicata-Pachistima myrsinites* community identified by Daubenmire and Daubenmire (1968) is very productive for western redcedar. One serious limitation to the findings from the above studies is that they probably should not be extrapolated to sites outside the experimental areas.

Krajina (1969) (and more recently) Krajina *et al.* (1982), have reported on the silvics and productivity of tree species native to British Columbia. An edaphic grid technique was applied as an aid to express productivity of each tree species in different forest ecosystems for each biogeoclimatic subzone. The grid is composed of two gradients: a moisture gradient and a nutrient gradient. The moisture gradient is projected on the vertical axis and consists of 9 hygrotopes (0-8). The nutrient gradient is expressed on the horizontal axis and is made up of 5 trophotopes (A-E) (Fig. 4). Thus there are 45 possible combinations of soil nutrient and soil moisture regimes, which are referred to as edatopes. Within a given edatope, a variety of forest ecosystems can exist. These



Explanatory notes

Tree symbols and their sizes according to growth classes (site indices m/100 yrs) and tolerance to shade:



Hygrotopes (vertical axis):

0 - very xeric.	4 - mesic.
1 - xeric.	5 - subhygric.
2 - subxeric.	6 - hygric.
3 - submesic.	7 - subhydric

Trophotopes (horizontal axis):

A - oligotrophic.
B - submesotrophic.
C - mesotrophic.
D - permesotrophic.
E - subeutrophic to eutrophic

Site index (SI_{100}) for *Thuja plicata* is as follows:

growth class	meters	feet
Ia	45 - 51	150 - 170
b	42	140
IIa	39	130
b	36	120
IIIa	33	110
b	30	100
IVa	27	90
b	24	80
Va	21	70
b	18	60
c	<15	< 50

Figure 4: Edaphic grids showing isolines of site indices for western redcedar in the biogeocoenotic associations of three biogeoclimatic subzones

(reproduced from Krajina 1969)

ecosystems are differentiated primarily on the basis of their floristic composition, and are termed "biogeocoenoses". The productivity of a tree species in each edatope is expressed by site index. Similar site indices are connected by isolines of productivity.

Krajina (1969) reported that maximum growth of western redcedar in British Columbia occurs on the edatope 6/E (hygric/subeutrophic) in three biogeoclimatic units: the Wetter Maritime Coastal Douglas-fir Subzone (CDFb), the Drier Maritime Coastal Western Hemlock Subzone (CWHa), and the Wetter Maritime Coastal Hemlock Subzone (CWHb) (Fig. 4). On such sites, redcedar's growth class is Ia (SI_{100}=45-51 m). In the Wetter Maritime Coastal Western Hemlock Subzone (CWHb) on the edatope 6/E , growth of western redcedar is best with the biogeocoenoses 30 and 31:

<u>30</u>: Mnio (insignis)-Leucolepido (menziesii)-Eurhynchio (stokesii)-Polysticho (muniti)-Pseudotsugo-Abieto (amabilis)-Piceo (sitchensis)-Thujetum plicatae on weakly podzolized and strongly gleyed brown wooded soils with accumulation of moder humus (overlain by mor humus). (Gleyed Sombric-Humo-Ferric Podzols).

<u>31</u>: Mnio (insignis)-Leucolepido (menziesii)-Polysticho-Rubo (spectabilis)-Ribeso (bracteosi)-Oplopanaco (horridi)-Abieto (amabilis)-Piceo (sitchensis)-Thujetum plicatae on alluvial floodplain regosols.

In both the Coastal Western Hemlock dry subzone and the Coastal Douglas-fir wet subzone, on the edatope 6/E, growth of redcedar is best with the biogeocoenoses 1, la, and 21:

<u>1</u>: Mnio (insignis)-Eurhynchio (stokesii)-Polysticho (muniti)-Tiarello (trifoliatae)-Pseudotsuga (menziesii)-Abieto (grandis)-Thujetum plicatae with gleyed reddish brown soils (Gleyed Dystric Brunisols).

1a: Mnio (insignis)-Eurhynchio (stokesii)-Polysticho (muniti)-Tiarello (trifoliatae)-Symphoricarpo (albi)-Pseudotsuga (menziesii)-Abieto (grandis)-Thujetum plicatae with alluvial terrace regosols (sand-silt-loam) affected by seepage water.

21: Adianto (pedati)-Symphoricarpo (albi)-Abieto (grandis)-Thujetum plicatae on silty loams of alluvial floodplain regosols.

However, within these biogeocoenoses, redcedar is more productive in the CWHa than in the CDFb due to the greater precipitation in the CWHa.

While Krajina's work is a major advancement in understanding the productivity of native species in British Columbia, it should probably be viewed as a series of hypotheses, or a framework for future studies since little concrete evidence is offered to support his findings. Krajina (1969) points out that the growth class curves of the edaphic grids are "idealized and smoothened" and need to be "checked and rechecked to provide more accurate knowledge in this research field".

The Study Area

Sites were sampled on western Vancouver Island in the Bamfield, Ucluelet and Kennedy Lake areas (Fig. 5). All sites were contained in the wet subzone of the Western Hemlock Zone, known as the Wetter Maritime Coastal Western Hemlock Subzone (CWHb) (Krajina 1969). This subzone covers much of Vancouver Island and the Coast Mountains, and extends along the Pacific Coast into Washington and Oregon (Klinka et al. 1979). The upper elevational limits are 900 m on the windward side of the mountains, and 1100 m on the leeward side. The subzone extends to sea level outside of the rainshadow area (Klinka et al. 1979).

Based on climatic characteristics, Klinka et al. (1979) have subdivided the Wetter Maritime Coastal Western Hemlock Subzone into variants. The sites that were sampled for this study were located in the Estevan and West Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock biogeoclimatic variants. Descriptions of these variants have been detailed in Klinka et al. (1979). Climatic characteristics have been tabulated in Table 3.

The west coast of Vancouver Island is characterized by a perhumid climate, with mild winters, cool summers, abundant precipitation, especially in the winter, and low snowfall (Valentine 1971; Jungen and Lewis 1978; Schaefer 1978). The relative humidity is high year round; especially in the winter, when sea fogs and haze are common. Since precipitation is so plentiful, the soils are constantly moist, and lack of moisture is seldom a limitation to plant growth (Jungen and Lewis 1978;

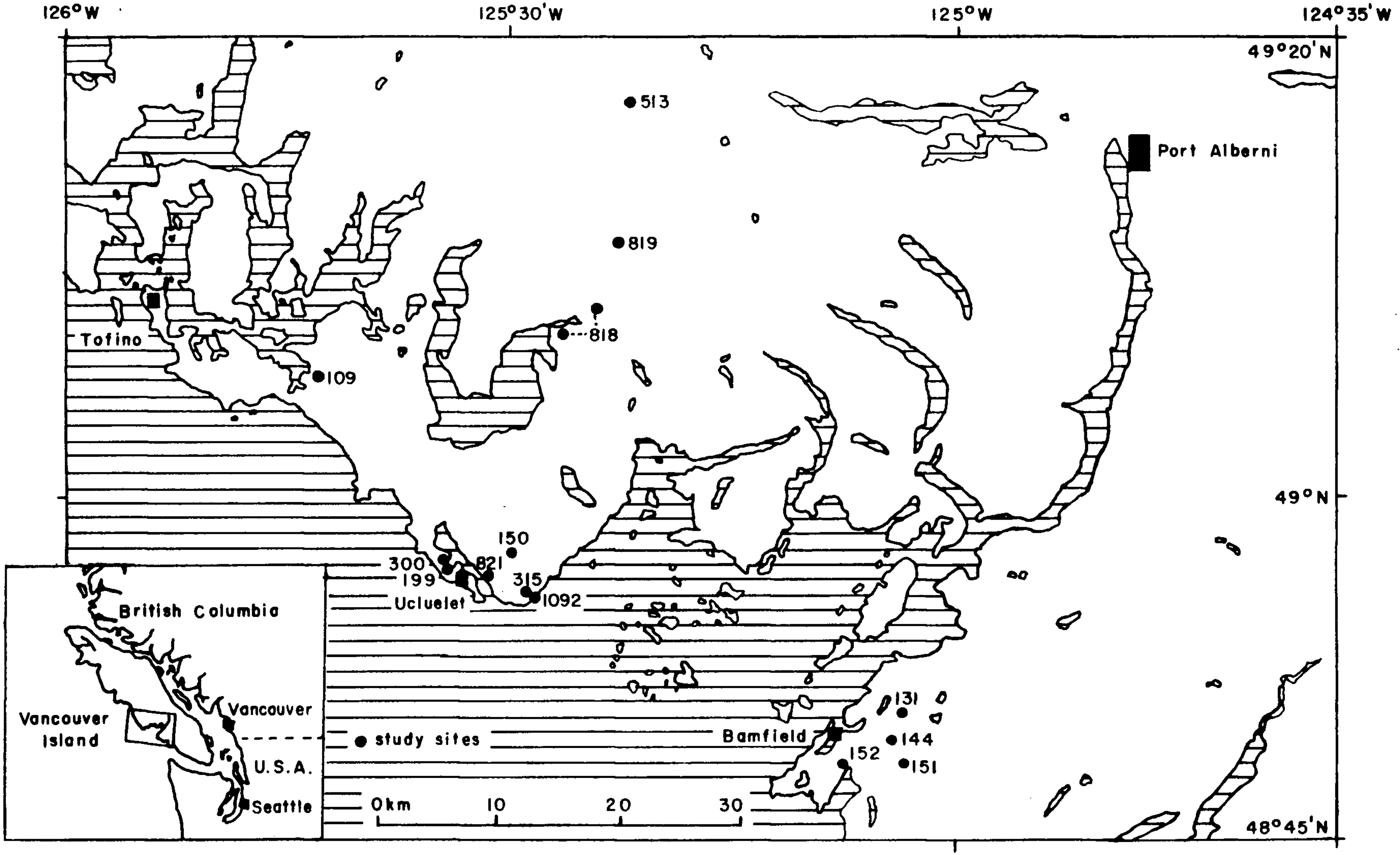


Figure 5: Location of study sites on western Vancouver Island. (Numbers indicate the stand number)

Table 3: Climatic characteristics of the Estevan and West Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock Biogeoclimatic Variants

Climatic Characteristics	Estevan Submontane	W. Van. Island Submontane
Climate (Koppen-Trewartha)	wetter Cfb/c	wetter Cfb/c
Mean annual precipitation (mm)	3016 (71)	3819 (853)
Mean precipitation April-September (mm)	774 (49)	876 (79)
Mean precipitation of driest month (mm)	83 (6)	91 (17)
Mean precipitation of wettest month (mm)	445 (20)	541 (19)
Mean annual temperature (°C)	9.2 (0.4)	7.1 (0.9)
Mean temperature of coldest month (°C)	4.6 (0.4)	2.1 (1.0)
Mean temperature of warmest month (°C)	14.2 (0.7)	12.4 (1.5)
No. of months with mean temperature >10°C	5.1 (0.9)	3.8 (0.9)
No. of months with mean temperature <10°C	0.0 (0.0)	0.1 (0.3)
Accumulated degree days over 5.6°C	1390 (145)	920 (242)
Frost free period (days)	263 (11)	206 (15)
Numbers of months with snow	0.0 (0.0)	2.5 (1.3)
Maximum snow depth (cm)	0.0 (0.0)	38 (32)
Number of months with water deficit	0.0 (0.0)	0.0 (0.0)
Water deficit (mm)	0.0 (0.0)	0.0 (0.0)
Water surplus (mm)	2485 (73)	3072 (138)
Mean radiation during growing season (Ly)	40,300 (310)	39,400 (940)
Potential evapotranspiration (mm)	531 (11)	502 (8)
Actual evapotranspiration (mm)	531 (11)	502 (8)
Actual/potential evapotranspiration (%)	100 (0.0)	100 (0.0)
Actual evapotranspiration April-Sept. (mm)	485 (9)	456 (10)
February (mm)	4 (1)	4 (1)
March (mm)	25 (1)	23 (1)
April (mm)	52 (2)	48 (2)
May (mm)	88 (2)	83 (3)
June (mm)	102 (1)	96 (3)
July (mm)	110 (1)	105 (2)
August (mm)	83 (1)	80 (3)
September (mm)	50 (1)	47 (1)
October (mm)	17 (1)	15 (1)

(from: Klinka *et al.* 1979)

(numbers in parentheses are standard deviations)

Schaefer 1978). In a study of the Tofino-Ucluelet lowlands, Valentine (1971) reported that actual and potential evapotranspiration values matched; and that plants did not suffer from any lack of water. In fact, he found the opposite to be true:

> The main problem for vegetation is to adjust to a moisture surplus....This is the most important single feature of the climate to be reckoned with when the interrelationships of climate, soil, and vegetation growth are considered.

Klinka et al. (1979) have made some interpretaions from curves of calculated actual evapotranspiration for the Coastal Western Hemlock, Coastal Douglas-fir and Mountain Hemlock Zones. They concluded that in the humid climate of the Coastal Western Hemlock Zone, lack of heat limits vegetation growth since precipitation is more than adequate to cover potential evapotranspiration.

Most, if not all, of this region has been glaciated, resulting in a wide variety of glacial deposits. Surficial deposits are comprised of morainal, colluvial, fluvial and marine materials. The coastal areas were depressed 50 to 70 m below sea level by the weight of the ice. "They later rose by isostatic rebound, leaving behind a complex marine-influenced zone..." (Jungen and Lewis 1978). Outwash sands and gravels were deposited by a river network emanating from the mountains (Valentine 1971). Widespread areas in the valleys and lower mountain slopes are covered by morainal deposits.

The study sites are contained primarily within the Ferro-Humic Podzol soil landscape, and partially within the Humo-Ferric Podzol and Folisol soil landscapes described by Jungen and Lewis (1978). The large surplus of water and lack of heat in the coastal area contribute to the characteristic soil forming processes which are: mor formation, leaching, illuviation, eluviation, and gleization (Krajina 1959, 1965, 1969; Klinka et al. 1979). The soils typically have thick surface organic horizons (mor humus) derived from forest litter; thin eluvial (Ae) horizons; and exceptionally strong podzol B horizons, rich in iron, aluminum and organic matter, and dark reddish to yellowish brown in colour (Jungen and Lewis 1978). Many of the soils, particularly those which have developed from morainal or gravelly fluvial parent materials, have extremely compact or cemented horizons or pans in the subsoil.

> These may be at various depths, have varying thicknesses, and contain different cementing agents. They are given different names - ortstein, placic, duric, or fragic - according to their morphology and mode of origin. They have the common effect of restricting root penetration and permeability (Valentine and Lavkulich 1978).

As a result of the abundant precipitation and restricted permeability, the soils are commonly moist to wet over most of the year. Many soils experience temporary or permanent seepage of water through the lower humus or above a restrictive layer (Klinka et al. 1979). This excess moisture is often apparent in the soil by a higher organic matter content and duller profile colours (Jungen and Lewis 1978).

This region supports some of the most productive forest land in British Columbia. Mean annual increments of over 20 m^3/ha/yr are reported for some of the best sites (Jungen and Lewis 1978). Western hemlock is the dominant species in this subzone and is able to regenerate under most stands. Western redcedar and amabilis fir occur frequently; while Sitka spruce, Douglas-fir and yellow cedar are also common (Klinka et al. 1979). The characteristic floristic features of zonal ecosystems are: high species significance of western hemlock, low presence of herbs, and a predominance of several mosses (particularly Hylocomium splendens, Rhytidiadelphus loreus, and Plagiothecium undulatum) (Klinka et al. 1979).

CHAPTER 2: METHODS AND PROCEDURES

Selection of Study Sites and Sample Plots

The sites sampled were in the Wetter Maritime Coastal Western Hemlock Subzone on western Vancouver Island. Sites with easy access were chosen in MacMillan-Bloedel's Franklin-Sarita, Sproat Lake, and Kennedy Lake Divisions. Stands were selected in which western redcedar was a major component of the overstory vegetation, often comprising - 50% of the species compostion. An attempt was made to sample what appeared to be "good" (productive) sites and "poor" (unproductive) sites; as well as wet and dry sites. It was thought that these extreme conditions would provide maximum information, particularly for comparison.

Stands were selected for sampling from MacMillan-Bloedel cover-type maps which provided estimates of species composition, site index, and volume. Identifying "good" sites was more difficult than anticipated. The cover-type maps merely served as a guide; recommendations of divisional foresters and other MB personnel were largely relied upon. One problem, which was particularly prevalent in Kennedy Lake Division, was that the best stands of western redcedar had already been logged (and, typically, planted with Douglas-fir). Consequently, only the "best" of the remaining sites could be sampled.

In each selected site, three random 50 m^2 circular plots were established and sampled. The replication of plots within a site provided an indication of within-site variability. In most instances, a site was defined as a stand, as delineated on a MacMillan-Bloedel cover-type map; and the plots were established within the stand boundaries. Each site is referred to by its stand number. In a few situations; for example, when an area was not represented on a MB map, plots were sampled from similar site types and grouped together.

A total of 40 plots were sampled from 14 sites (Fig. 5). Twelve sites have the usual 3-plot replication. However, in two of the sites, only two plots were sampled apiece. These four plots, sampled from rock bluff communities, were originally grouped together to represent one site type. However, the plots were dissimilar enough to separate them into two sites.

Of the fourteen sites, twelve were undisturbed, old-growth forest communities. One site in Franklin-Sarita division had been recently logged (although not burned). The stumps were still intact and could be identified and measured. Another site, in Kennedy Lake Division, had been logged in 1933, and supported a naturally-regenerated stand, of which redcedar was a major component. Both sites had exceptionally large redcedar stumps, indicating that they had at one time supported very large redcedar trees.

Field Sampling Procedures for Data Collection

Site Information

The following site information was recorded for each plot:

-plot location

-aspect (in degrees to nearest 10°)

-elevation (measured with an altimeter in m)

-macrosite (apex, face, upper slope, middle slope, lower slope, valley floor, plain)

-mesosite (crest, upper slope, middle slope, lower slope, depression, level)

-slope angle (measured in % with a clinometer)

-surface shape (concave, convex, straight, undulating)

-relief position (normal, subnormal, excessive, flat or concave)

-microtopography (smooth, micro-mounded, slightly mounded, moderately mounded, strongly mounded, severely mounded, extremely mounded, ultra-mounded)

-drainage class (very rapidly, rapidly, well, moderately-well, imperfectly, poorly, very poorly)

-moisture regime (very xeric, xeric, subxeric, submesic, mesic, subhygric, hygric, subhydric, hydric)

Additional observations, such as evidence of fire and blowdown, were noted.

Vegetation Data

In each plot the following vegetational data were recorded:

-species name (recorded for all overstory and understory vegetation excluding lichens and liverworts)

-dbh (measured with a diameter tape to nearest 0.5 cm for all trees greater than 10 cm dbh)

-canopy position (estimated for each tree >10 cm dbh, as veteran, dominant, codominant or suppressed)

-vigor (estimated for each species on a scale from 0=dead to 4=excellent)

-saplings (numbers of trees greater than 10 cm dbh and taller than 1.3 m have been approximated)

-seedlings (observations of regeneration have been made)

-% cover (estimated in % in 1% intervals to 10%, and in 5% intervals beyond 10%, for each shrub, herb, and fern species, and for most common mosses)

Mensuration Data

As mentioned, dbh was measured for each tree greater than 10 cm dbh in all plots. In each site, height was measured (in m to nearest 1 m, with a clinometer) for 10 dominant and/or codominant redcedar trees, and for 5 trees of each additional species. Age was estimated from increment cores or cross sections of stumps, for the same number of trees per site as height measurements. It should be noted that the trees which were used for height and age estimates were not necessarily located in the sample plots; they were however, located in the study sites.

Soils Data

A soil pit was dug in each plot to a depth of 1.6 m or until the water table or an impervious layer was reached. A profile description was made and the following information was recorded for each horizon:

-depth and thickness (in cm to nearest 0.5 cm)

-volume of coarse fragments greater than 2 mm (estimated visually as a % of total)

-structure (grade, class, and kind)

-consistency (moist, dry)

-mottling (abundance, size, and contrast)

-roots (abundance, and size)

-horizon boundary (distinctness, and form)

Additional observations were made for the organic horizons including: evidence of matting or compaction, abundance and colour of fungal mycelia, abundance of charcoal and/or decayed wood, and the type and abundance of insects and earthworms. Samples of each soil horizon were collected for laboratory analyses. In addition, bulk density measurements of humus samples were made.

Little attempt was made to classify the soils at the time of sampling. The horizons were identified as A, B, or C, and samples were numbered sequentially (ie. A2, B21, B22, C1). The soils were classified according to the Canadian System of Soil Classification (1978) after completion of the laboratory analyses, and the horizons were re-labelled accordingly.

Soil Sample Preparation

Soil samples were sent to the MacMillan-Bloedel soils laboratory in Nanaimo for preparation. The mineral soil samples were air-dried at room temperature on brown paper, crushed with a wooden rolling pin, sieved for the greater than 2 mm and less than 2 mm fraction and weighed. Organic samples from L, F, and H horizons were air-dried and ground in a Wylie Mill to pass a 2 mm sieve.

Analyses

Soil Analyses

Colour: Colours of moist and dry mineral samples were determined using a Munsell Colour Chart in the Nanaimo soils laboratory.

Bulk density: The bulk density of humus horizons was calculated in g/cc from samples collected in bulk density tins.

pH: The pH of mineral samples was determined in both a 1:1 soil:water suspension and in a 1:1 soil:0.01M $CaCl_2$ suspension. The pH of organic samples was determined in a 1:4 soil:water suspension and in a 1:4 soil:0.01M $CaCl_2$ suspension.

Carbon: The total organic matter content of each sample was determined by weight loss on ignition. The procedure is described by Mitchell (1932). The organic carbon content of each sample was calculated based on the assumption that soil organic matter is 58% carbon. Sample weights were corrected for moisture content and results are reported as percentage of oven-dry weight.

Nitrogen: The total nitrogen content of each sample was determined by the colorimetric procedure (of Black 1965) outlined in the UBC Pedology Laboratory Methods Manual (1978). Samples were digested in sulphuric acid and catalysts (K_2SO_4, $CuSO_4$, and Se) and read on an Autoanalyzer II System. Sample weights were corrected for moisture content and N concentrations are reported as a percentage of oven-dry weight.

Phosphorus: Available phosphorus of each sample was determined by

Bray's procedure which has been described by Jackson (1958) and Black (1965), and is outlined in the UBC Pedology Laboratory Methods Manual (1978). Samples were extracted with 0.03N NH_4F in 0.025N HCl. The colour was developed in ammonium molybdate and stannous chloride solutions, and the resulting colour was read at 660mu on a spectrophotometer. Sample weights were corrected for moisture content and results are reported on an oven-dry basis in ppm P.

Exchangeable Cations: Exchangeable cations (Ca, Mg, Na, K) were determined by atomic absorption spectrophotometry after extraction with neutral (pH 7.0) 1N NH_4OAc. The procedure is described by Black (1965) and outlined in the UBC Pedology Laboratory Methods Manual (1978). Sample weights were corrected for moisture content and results are reported on an oven-dry basis in meq/100g soil.

Texture: Soil texture was determined for mineral samples by hand-texturing in the laboratory.

It should be mentioned that the chemical analyses for 8 of the sample plots (109-1, 109-2, 151-3, 300-1, 300-2, 315-1, 315-2, 818-2) were done by the technicians at the Nanaimo soils laboratory, because these samples were being used in conjunction with another research project. The samples from the other 32 profiles were analyzed at the UBC pedology laboratory by the author. The methods used by both parties were identical with the following exceptions for the Nanaimo samples:

Iron and Aluminum: Fe and Al were determined for samples from B horizons by atomic absorption spectrophotometry after extraction from

100-mesh mineral samples using 0.1M sodium pyrophosphate (pH 10.0). Results are reported on air-dried soils as %Fe and %Al.

Soil texture: Soil texture was determined for mineral samples by the hydrometer method after the organic matter was destroyed by 30% hydrogen peroxide and oven-dry weights were assessed. Hydrometer readings were recorded after 40 seconds and 8 hours. Sand values were checked by wet sieving. The samples were placed in textural classes according to the Canadian Classification System.

Organic Samples

Nitrogen: Total nitrogen of the organic samples was determined on the 60-mesh sample by digestion in H_2O_2 and sulphuric acid; and read on an Auto Analyzer II System.

Phosphorus: Total (NOT available) phosphorus was determined on the organic samples using the same digestion extract as for total nitrogen. Results have not been reported with the chemical data since there is little basis for comparison.

Total Cations: Total elements (including K, Ca, Mg, Na) were determined on the organic samples using the same digestion samples used for total nitrogen and total phosphorus. The samples were read by atomic absorption spectrophotometry. Results, which were reported as % and ppm, were converted to a meq/100g soil basis.

Soil Data Analysis

Analysis of the soils data is discussed in Chapter 3.

Mensuration Data

Site index: An approximation of site index was calculated for each site. Since the height and age measurements were not always paired observations of the same tree, it was not possible to calculate site index by the usual method. Instead, site index of the means was estimated as follows: for each major tree species on a given site, a mean height value was calculated from the height measurements taken for dominant and codominant trees. Similarly, a mean age (or usually, a mean minimum age) was estimated for each species on a site from increment cores and cross sections of stumps. Using the mean height and mean age values for a given species on a particular site, coastal site index curves were consulted (Hegyi *et al*. 1979) and a site index value was obtained. Stands older than 300 years were assessed as being 300 years of age. Results are reported as SI_{100} in metres.

Basal Area: The basal area of each tree larger than 10 cm dbh in each plot was calculated. From these calculations it was possible to estimate the total basal area of all trees for each plot and for each stand, and the total basal area of each individual species for each plot and for each stand. Results are expressed as m^2/ha.

Vegetation Data Analyses

Tabular Comparison

The Ministry of Forests Computer program VEG (written by K. Klinka and S. Phelps, 1979), and subsequently a revised version of the program

F405:VTAB (Emanuel 1983) were run on the vegetation data. This is a traditional preferred method of tabular comparison for plots which are weakly-structured and species-poor (Ceska and Roemer 1971); as is common for many old growth forest stands in British Columbia. The computer program was not designed to perform a classification of plots into groups (synsystematic units). It produces a set of vegetation tables and a summary vegetation table based on the groups designated by the user; from which characteristic combinations of species can be selected. The ultimate goal is to identify units in which mutually exclusive groups of species occur (Klinka and Phelps 1979).

Plots were tentatively grouped into synsystematic units based on information from field notes (ie: moisture regime, macrosite, floristic composition, etc.). These groupings were refined through running and re-running the VEG program, and through running a cluster analysis.

To produce vegetation tables, vegetation data for each plot were entered into the computer and included:

-the plot number

-the species name

-the vegetation layer (tree, shrub, herb and fern, and moss)

-the species significance value (based on Krajina 1933), and

-the species vigor value (based on Peterson 1964).

Species significance values were obtained by transforming the percent cover values which were estimated in the field. Species significance ratings are based on the 10-point Domin-Krajina scale (Krajina 1933) which combines abundance and dominance as follows:

+ very sparsely present
  dominance very small (0.1 - 0.3%)

1 sparsely present
  dominance small (0.3 - 1.0%)

2 very scattered
  dominance small (1.0 - 2.2%)

3 scattered to plentiful
  dominance 2.2 - 5.0%

4 often present
  dominance 5.0 - 10.0%

5 often present
  dominance 10.0 - 25.0%

6 any number of individuals
  dominance 25.0 - 33.0%

7 any number of individuals
  dominance 33.0 - 50.0%

8 any number of individuals
  dominance 50.0 - 75.0%

9 any number of individuals
  dominance over 75.0%

The computer produced a set of vegetation tables which contained a summary of vegetation data for each requested plot group (synsystematic unit), and a vegetation description of each plot within a group. The mean species significance (MS), range of species significance (RS), and presence (P) values were calculated for each species within a group. Presence is defined as the percentage of plots within a group in which a species occurs. Species were arranged vertically in the following order:

a) by layer

b) by decreasing presence within a layer

c) by decreasing mean species significance value, where presence values were identical within a layer

d) by alphabetical order, where presence values and mean species significance values were identical within a layer.

The vegetation tables were of assistance in refining the groupings of plots. Once the plot groups were decided upon, a summary vegetation table was produced. The summary table contained an alphabetical listing of all plant species mentioned in the vegetation tables, and corresponding mean species significance values and constancy class values for each synsystematic unit (plot group). Constancy classes are expressed as Roman numerals according to the Braun-Blanquet scale of constancy and presence (Braun-Blanquet 1928,1932) as follows:

constancy class	species occurring on % of plots	description
I	1-20	rarely present
II	21-40	seldom present
III	41-60	often present
IV	61-80	mostly present
V	81-100	constantly present .

When a group contains less than 5 plots the constancy class is expressed as an integer rather than a Roman numeral.

From the summary table, characteristic combinations of species were selected for each group of plots. The characteristic combination of species (Braun-Blanquet 1965) is used to describe a more or less unique combination of plant species which is characteristic for a group of similar ecosystems. These groups of similar ecosystems are identified as associations. The association is the basic unit in biogeocoenotic classification.

Ordination of Sample Plots

The vegetation data was subsequently run through an ordination program, ORDIFLEX (Gauch 1977), which is an option of the F405:VTAB program (Emanuel and Wong 1983). Reciprocal averaging was the ordination method chosen. Using complex matrix algebra, this technique ordinated the sample plots, with respect to species composition, along a series of imaginary axes. Sample plots which are most similar, in terms of species composition, are plotted closer together along an axis than those which are dissimilar. The results of the ordination are presented in Chapter 3, and have been used to validate the classification of sample plots and selection of associations.

Use of Plant Indicators in Site Interpretation

The presence, relative abundance, and size of various plant species can be used not only for classifying plant associations, but also for indicating forest site conditions (Husch *et al*. 1972; Spurr and Barnes 1973; Carmean 1975). Certain diagnostic plant species are characteristic of certain ecosystems or ecological conditions. Each species has a more or less definitive value in relation to one or more ecosystem characteristic (biotic, edaphic, climatic) (Klinka *et al*. 1984). Thus, the plants can be used to indicate these ecological conditions. Species indicating the same conditions or site can be grouped into indicator species groups.

In southwestern B.C., 18 edatopic indicator species groups (EISG), including a total of 360 species, have been developed to facilitate the use of plants in forest site diagnosis (Klinka *et al.* 1984). Each edatopic indicator species group contains a variable number of species which have similar distribution modes in relation to absolute hygrotope and absolute trophotope (Klinka *et al.* 1984). Each edatopic group indicates a certain range of hygrotope and trophotope. Except for the extreme edatopes, most groups indicate two or more classes of hygrotope and trophotope (Klinka *et al.* 1984). The groups are structured into 3 trophotope categories, which are subdivided into 7 categories of hygrotope (except for the medium trophotope category, in which only 4 categories of hygrotope are recognized). Each group is named by a characteristic plant species, and is further identified by a 2 digit number; the digits indicate the categories of trophotope and hygrotope respectively. The 18 edatopic indicator species groups identified by Klinka *et al.* (1984) are listed in Table 4.

Using the descriptive vegetation data for a given site in conjunction with edatopic indicator species group information, interpretations can be made regarding the moisture and nutrient conditions of the site as reflected by the plant community. Paul Courtin and Karel Klinka, of the B.C. Ministry of Forests, ran a computer program on the vegetation data from this study, which performed the following calculations: first, only plant species listed in one of the edatopic indicator species groups (EISG) were used in the calculations; species not included in one of the EISG were considered to be "indifferent", and were disregarded; using the

Table 3: Synopsis of edatopic indicator species groups (EISG). (reproduced from Klinka *et al.* 1984)

1. Indicators of nutrient-very poor to medium sites:

EISG No. 1.1: Lichen spp.
Very dry, nutrient-very poor to poor sites

EISG No. 1.2: *Chimaphila umbellata*
Very dry to dry, nutrient-very poor to medium sites

EISG No. 1.3: *Goodyera oblongifolia*
Dry to fresh, nutrient-very poor to medium sites

EISG No. 1.4: *Hylocomium splendens*
Dry to moist, nutrient-very poor to medium sites

EISG No. 1.5: *Rhytidiadelphus loreus*
Fresh-moist, nutrient-very poor to medium sites

EISG No. 1.6: *Blechnum spicant*
Moist to wet, nutrient-very poor to medium sites

EISG No. 1.7: *Sphagnum spp.*
Wet, nutrient-very poor to medium sites

2. Indicators of nutrient-medium sites:

EISG No. 2.1: *Arctostaphylos uva-ursi*
Very dry to dry, nutrient (poor) to medium sites

EISG No. 2.2: *Amelanchier alnifolia*
Dry to fresh, nutrient-medium sites

EISG No. 2.3: *Pyrola asarifolia*
Dry to moist, nutrient-medium sites

EISG No. 2.4: *Luzula parviflora*
Fresh to moist, nutrient-medium sites

3. Indicators of nutrient-medium to very rich sites:

EISG No. 3.1: *Juniperus scopulorum*
Very dry, nutrient-medium (to rich) sites

EISG No. 3.2: *Mahonia aquifolia*
Very dry to dry, nutrient-medium to very rich sites

EISG No. 3.3: *Pteridium aquilinum*
Dry to fresh, nutrient-medium to very rich sites

EISG No. 3.4: *Achlys triphylla*
Dry to moist, mutrient-medium to very rich sites

EISG No. 3.5: *Tiarella trifoliata*
Fresh to moist, nutrient-medium to very rich sites

EISG No. 3.6: *Athyrium filix-femina*
Moist to wet, nutrient-medium to very rich sites

EISG No. 3.7: *Lysichitum americanum*
Wet, nutrient-medium to very rich sites

presence and mean species significance values from the vegetation tables produced by F405:VTAB, an importance value (Jaeger 1983), and subsequently, a relative species importance (RSI) value, were calculated for each species where:

$$RSI (\%) = \frac{\text{importance value of a species}}{\text{sum of importance values for a plot}} \times 100).$$

For each plot, the relative importance values for each edatopic indicator species group were summed. These values were plotted to produce a spectrum of edatopic indicator species groups, for use in comparison of sample plots; and were also used to calculate mean RSI values for each EISG for stands and associations.

The edatopic indicator species groups combine hygrotope and trophotope on the same scale. To facilitate interpretation, the RSI values were summed for each hygrotope category and each trophotope category separately, and plotted to produce two graphs: one for hygrotope and one for trophotope.

CHAPTER 3: RESULTS AND DISCUSSION

Use of Vegetation in Site Classification and Interpretation

Classification of Sample Plots

The 14 study sites and their associated sample plots, described in Appendix 2, represent a wide range of site conditions. Nevertheless, there are similarities between plots which allow plots to be grouped into larger, more distinct units.

Vegetation is one feature which can provide a basis for grouping or classifying sample plots into characteristic units. At the phytocoenotic level of the biogeoclimatic system of classification, the units, which include order, alliance, and association, are differentiated by floristic features. The association is actually the basic unit in biogeocoenotic classification which, in addition to vegetation, utilizes edaphic and climatic features for differentiating units. However, these features are not necessary for deriving associations since associations are synthesized from the grouping of similar climatic plant communities and can be differentiated by their characteristic combination of species.

From an analysis of the vegetation data (as described in Chapter 2) the sample plots were classified into 6 associations, or groups of similar ecosystems. With the assistance of Dr. K. Klinka the associations were named (following the nomenclature of Barkman _et al_. 1976) and their respective alliances and orders were identified. This information is presented in Table 5. The characteristic combinations of species for the syntaxa (primarily, associations) recognized in the study area were derived following the procedure for determining characteristic combinations of species written by R. Roy (1984). This list of species is presented in Table 6 and the "accidental" species have been listed in Appendix 6.

The orders and alliances have been previously identified and described by their respective authorities and therefore require no further discussion. A brief description of the associations is contained in the following section. Detailed descriptions of the individual sites used to derive the associations can be found in Appendix 2. It must be stressed that these associations have been derived from a limited data set and must therefore be regarded as tentative. Furthermore, the differentiating values assigned to the species in the characteristic combinations of species must also be regarded as tentative (particularly the "character-species") since these assignments are likely to change as more data become available for this region.

Table 5: Synopsis of syntaxa at the phytocoenotic level.

1. Rhytidiadelpho lorei-Tsugetalia (Krajina 1969) Klinka 1983

  1.1 Gaultherio-Tsugion Klinka _et al_. 1980

    1.11 Cladino-Tsugetum Dickinson et Klinka 1984

2. Polysticho muniti-Thujetalia (Brooke in Krajina 1965) Inselberg _et al_. 1982

  2.1 Blechno-Thujion all. nov. prov.

    2.11 Blechno-Thujetum Dickinson et Klinka 1984

    2.12 Sphagno-Thujetum Dickinson et Klinka 1984

3. Picetalia sitchensis Cordes et Krajina in Cordes 1972

  3.1 Polysticho-Piceion Cordes et Krajina in Cordes 1972

    3.11 Kindbergio praelongi-Piceetum Cordes et Krajina in Cordes 1972

  3.2 Lysichito-Piceion all. nov. prov.

    3.21 Lysichito-Piceetum Cordes et Krajina in Cordes 1972

4. Abietalia amabilis order nov. prov.

  4.1 Streptopo rosei-Abietion Klinka _et al_. 1980

    4.11 Tiarello trifoliatae-Abietetum Dickinson et Klinka 1984

(where: X.= Order
X.X= Alliance
X.XX= Association)

Table 6: Characteristic combinations of species for the plant syntaxa recognized in the study area

Biogeocoenotic associations	1.11	2.11	2.12	3.11	3.21	4.11
Number of sample plots	4	18	6	3	3	3
Cladino-Tsugetum Association						
Chamaecyparis nootkatensis (co)	3 5.3	-	-	-	-	-
Cladina impexa (co)	2 1.8	-	-	-	-	-
Cladina rangiferina (co)	2 3.7	-	-	-	-	-
Cladina sp. (co)	2 3.7	-	-	-	-	-
Cladonia bellidiflora (co)	2 +.3	-	-	-	-	-
Cladonia gracilis (co)	2 1.1	-	-	-	-	-
Cladonia uncialis (co)	2 1.8	-	-	-	-	-
Danthonia spicata (co)	2 +.3	-	-	-	-	-
Dicranum scoparium (co)	2 2.2	-	III 2.2	-	-	-
Dicranum sp. (co)	2 1.8	-	-	-	-	-
Diplophyllum albicans (co)	2 1.1	I +.6	I 1.1	-	-	-
Ditrichum sp. (co)	2 +.3	-	-	-	-	-
Gaultheria shallon (cd)	5 6.1	V 8.0	V 8.0	5 3.5	5 6.9	-
Herberta adunca (co)	3 1.3	I +.0	II +.0	-	-	-
Hieracium albiflorum (co)	2 +.3	-	-	-	-	-
Hylocomium splendens (cd)	5 5.9	V 5.8	V 7.2	4 1.1	5 3.5	-
Hypopythys monotropa (co)	2 +.3	-	-	-	-	-
Isothecium stoloniferum (co)	2 +.3	I 1.0	-	-	2 1.3	-
Menziesia ferruginea (c)	5 4.5	V 4.6	V 3.1	2 +.5	5 4.9	2 3.1
Mylia taylorii (co)	2 +.3	-	I +.0	-	-	-
Phyllodoce empetriformis (co)	2 2.7	-	I 1.4	-	-	-
Pinus monticola (co)	3 4.0	I 3.0	-	-	-	-
Polytrichum commune (co)	2 +.3	I +.5	-	-	-	-
Polytrichum piliferum (co)	2 +.3	-	-	-	2 2.1	2 +.5
Pseudotsuga menzeisii (e)	4 5.3	I 2.1	-	-	-	-
Pteridium aquilinum (co)	2 +.3	-	-	-	-	-
Rhacomitrium canescens (co)	2 2.7	-	-	-	-	-
Rhacomitrium heterostichum (co)	2 3.7	-	-	-	-	-
Rhacomitrium lanuginosum (co)	2 +.3	-	-	-	-	-
Rhytidiadelphus loreus (co,cd)	5 6.1	IV 5.1	V 5.7	-	4 2.6	2 3.1
Saxifraga ferruginea (co)	2 +.3	-	-	-	-	-
Stereocaulon tomentosum (co)	2 +.3	-	-	-	-	-
Tsuga heterophylla (cd)	5 6.1	V 5.2	V 6.2	5 7.6	5 4.2	4 5.3
Vaccinium alaskaense (c)	5 4.4	V 4.8	III 3.0	-	5 5.0	5 6.3
Vaccinium parvifolium (cd)	5 5.1	V 5.4	V 5.2	2 2.1	5 5.7	4 5.4
Blechno-Thujion Alliance						
Blechnum spicant (cd)	3 3.8	V 8.9	V 8.2	5 5.7	5 6.0	5 6.0
Gaultheria shallon (cd)	5 6.1	V 8.0	V 8.0	5 3.5	5 6.9	-
Hylocomium splendens (cd)	5 5.9	V 5.8	V 7.2	4 1.1	5 3.5	-
Menziesia ferruginea (c)	5 4.5	V 4.6	V 3.1	2 +.5	5 4.9	2 3.1
Taxus brevifolia (co)	2 +.3	III 1.7	IV 2.0	-	2 +.5	-
Tsuga heterophylla (cd)	5 6.1	V 5.2	V 6.2	5 7.6	5 4.2	4 5.3
Vaccinium parvifolium (cd)	5 5.1	V 5.4	V 5.2	2 2.1	5 5.7	4 5.4
Blechnum-Thujetum Association						
Abies amabilis (d)	3 2.8	IV 4.5	-	-	-	-
Polypodium glycyrrhiza (s)	2 +.3	IV 1.5	-	-	2 +.5	-
Vaccinium alaskaense (d,c)	5 4.4	V 4.8	III 3.0	-	5 5.0	5 6.5
Sphagno-Thujetum Association						
Boschniakia hookeri (co)	-	-	II +.5	-	-	-
Calamagrostis nutkaensis (co)	-	-	II 1.5	-	-	-
Cornus unalaschkensis (d,cd)	3 4.0	III 4.6	V 6.7	-	2 2.1	5 7.1
Dicranum scoparium (d)	3 2.2	-	III 2.2	-	-	-
Linnaea borealis (p,cd)	3 4.0	II 2.2	V 5.1	-	-	-
Maianthemum dilatatum (cd)	3 3.0	IV 3.9	V 5.3	-	5 4.3	4 4.6
Malus fusca (e,cd)	-	-	V 5.0	-	-	-
Pinus contorta (p,cd)	3 4.5	-	V 5.0	-	-	-
Plagiothecium undulatum (d,c)	3 1.0	I 1.4	V 3.5	-	5 3.5	-
Rhytidiadelphus loreus (cd)	5 6.1	IV 5.1	V 5.7	-	4 2.6	2 3.1
Sphagnum sp. (p,cd)	3 1.3	III 5.0	V 5.1	-	-	-
Picetalia sitchensis Order						
Athyrium filix-femina (c)	-	I +.0	-	4 2.3	5 4.3	5 3.5
Blechnum spicant (cd)	3 3.8	V 8.9	V 8.2	5 5.7	5 6.0	5 3.9
Gaultheria shallon (cd)	5 6.1	V 8.0	V 8.0	5 3.5	5 6.9	-
Hylocomium splendens (c)	5 5.9	V 5.8	V 7.2	4 1.1	5 3.5	-
Kindbergia oregana (co,cd)	4 5.2	IV 4.4	IV 4.5	5 6.5	4 3.1	-
Picea sitchensis (e,cd)	-	I +.0	-	4 5.1	5 7.4	-
Pleurozium schreberi (s)	2 1.8	II 2.9	-	5 5.2	2 5.2	-
Polystichum munitum (cd)	2 1.8	II 2.1	-	5 5.0	5 5.5	5 3.1
Rhizomnium glabrescens (co,cd)	-	IV 5.0	III 3.5	5 5.7	5 5.7	4 3.0
Tiarella trifoliata (c)	-	II 2.1	-	5 2.8	5 3.9	5 6.5
Tsuga heterophylla (cd)	5 6.1	V 5.2	V 6.2	5 7.6	5 4.2	4 5.3
Vaccinium ovatum (co,c)	3 4.7	IV 5.1	V 8.5	4 1.1	5 3.6	4 4.2
Kindbergio praelongi-Piceetum Assoication						
Dryopteris expansa (co,c)	-	-	-	5 3.1	-	4 3.0
Gymnocarpium dryopteris (d)	-	-	-	4 2.3	-	5 5.1
Pleurozium schreberi (d,cd)	2 1.8	II 2.9	-	5 5.2	2 5.2	-
Lysichito-Piceetum Association						
Adenocaulon bicolor (co)	-	-	-	-	2 1.3	-
Blepharostoma trichophyllum (co)	-	I +.0	I 2.2	-	2 +.5	-
Boykinia elata (e)	-	-	-	-	4 1.1	-
Calypogeia muelleriana (co)	-	I +.1	-	-	2 1.3	-
Carex obnupta (s,c)	-	-	II 3.2	-	5 4.7	-
Cephalozia bicuspidata (co)	-	I 2.2	I 2.2	-	2 +.5	-
Festuca subulata (co)	-	-	-	-	2 +.5	-
Galium triflorum (e)	-	-	-	-	4 2.3	-
Hookeria lucens (s)	-	I +.1	II +.5	-	4 1.1	-
Huperizia selago (co)	-	-	-	-	2 3.1	-
Isopterygium elegans (co)	-	-	-	-	2 +.5	-
Kindbergia praelonga (e)	-	-	-	-	4 5.1	-
Leucolepis menziesii (e)	-	-	-	-	4 4.2	-
Luzula parviflora (co)	-	-	-	-	2 +.5	-
Lysichitum americanum (s,cd)	-	II 3.1	-	-	5 5.8	2 2.1
Maianthemum dilatatum (c)	3 3.0	IV 3.9	V 5.3	-	5 4.3	4 4.6
Menziesia ferruginea (d,c)	5 4.5	V 4.6	V 3.1	2 +.5	5 4.9	2 3.1
Pellia neesiana (e)	-	-	-	-	4 2.6	-
Plagiochila porelloides (e)	-	I +.6	-	-	4 2.6	-
Plagiomnium insigne (e,c)	-	-	-	-	5 1.5	-
Plagiothecium undulatum (c)	3 1.0	I 1.4	V 3.5	-	5 3.5	-
Pogonatum alpinum (s)	2 1.8	I +.0	-	-	4 4.9	-
Rhytidiadelphus loreus (d)	5 6.1	IV 5.1	V 5.7	-	4 2.6	2 3.1
Riccardia latifrons (co)	-	I +.0	-	-	2 1.3	-
Rubus spectabilis (d,cd)	-	IV 3.6	III 1.7	-	5 6.0	5 5.3
Scapania bolanderi (e)	-	I +.6	-	-	4 2.6	-
Sphagnum henryense (e)	-	-	-	-	4 1.1	-
Stachys mexicana (co)	-	-	-	-	2 3.1	-
Streptopus amplexifolius (e)	-	-	-	-	4 1.6	-
Tiarella laciniata (e,c)	-	I +.0	-	-	5 3.2	-
Trisetum cernuum (e)	-	-	-	-	4 1.1	-
Vaccinium alaskaense (d,cd)	5 4.4	V 4.8	III 3.0	-	5 5.0	5 6.5
Vaccinium ovalifolium (e)	-	I +.0	-	-	4 3.0	-
Vaccinium parvifolium (d,cd)	5 5.1	V 5.4	V 5.2	2 2.1	5 5.7	4 5.4
Viola glabella (d)	-	-	-	-	4 1.1	5 7.6
Tiarello trifoliatae-Abietetum Association						
Abies amabilis (co,cd)	3 2.8	IV 4.5	-	-	2 2.1	5 7.6
Achlys triphylla (e,c)	-	-	-	-	-	5 4.9
Athyrium filix-femina (c)	-	I +.0	-	4 2.3	5 4.3	5 3.5
Blechnum spicant (c)	3 3.8	V 8.9	V 8.2	5 5.7	5 6.0	5 3.8
Cornus unalaschkensis (cd)	3 4.0	III 4.6	V 6.7	-	2 2.1	5 7.1
Gymnocarpium dryopteris (co,cd)	-	-	-	4 2.3	-	5 5.1
Orthillia secunda (co)	-	-	-	-	-	2 +.5
Petasites palmatus (e)	-	-	-	-	-	4 3.0
Polystichum munitum (c)	2 1.8	II 2.1	-	5 5.0	5 5.5	5 3.1
Rubus spectabilis (cd)	-	IV 3.6	III 1.7	-	5 6.0	5 5.3
Streptopus roseus (s)	-	II 1.6	-	-	2 1.3	4 5.4
Tiarella trifoliata (cd)	-	II 2.1	-	5 2.8	5 3.9	5 6.5
Tiarella unifoliata (s,c)	-	I +.0	-	-	2 5.2	5 4.2
Trillium ovatum (e,c)	-	I +.0	-	-	-	5 4.9
Vaccinium alaskaense (cd)	5 4.4	V 4.8	III 3.0	-	5 5.0	5 6.5
Veratrum viride (s)	-	I +.0	II +.5	-	2 +.5	4 3.3
Viola glabella (co)	-	-	-	-	4 1.1	5 7.6

Description of Associations

Association 1.11: Cladino-Tsugetum (Lichen-Hemlock)

References: Sample plots 818-1, 818-2, 819-1, 819-2; Table 7; Figures 6, 7, 8; Appendices 1-5, 7.

This association was synthesized from the 4 sample plots of the Rock Outcrop (819) and Dry Rock Outcrop (818) sites. These ecosystems occur on rocky knolls, rock outcroppings, and exposed bedrock (Figs. 6, 7). The soils are "Lithic Podzols" and Typic Folisols which have developed from weathering of parent materials (bedrock and colluvium) and decomposition of organic matter. They are very thin and sparse, of xeric to subxeric moisture regime, and rapidly drained. Ecosystem characteristics have been compiled and are presented in Table 7.

The forests of these ecosystems are comprised of small, slow-growing, stunted trees; the dominant species being western hemlock and western redcedar, with varying admixtures of shore pine, yellow cedar, Douglas-fir, and western white pine (Fig. 8). The forest is very open, with relatively light shrub and herb layers characterized by abundant hemlock and redcedar regeneration. In contrast, the moss layer is very well-developed with a number of characteristic mosses and lichens (App. 7).

Fig. 6: View of plot 818-1 from Highway 4.

Fig. 7: View of plot 818-2 from Highway 4.
Notice small size of 150-450+ yr. old trees.

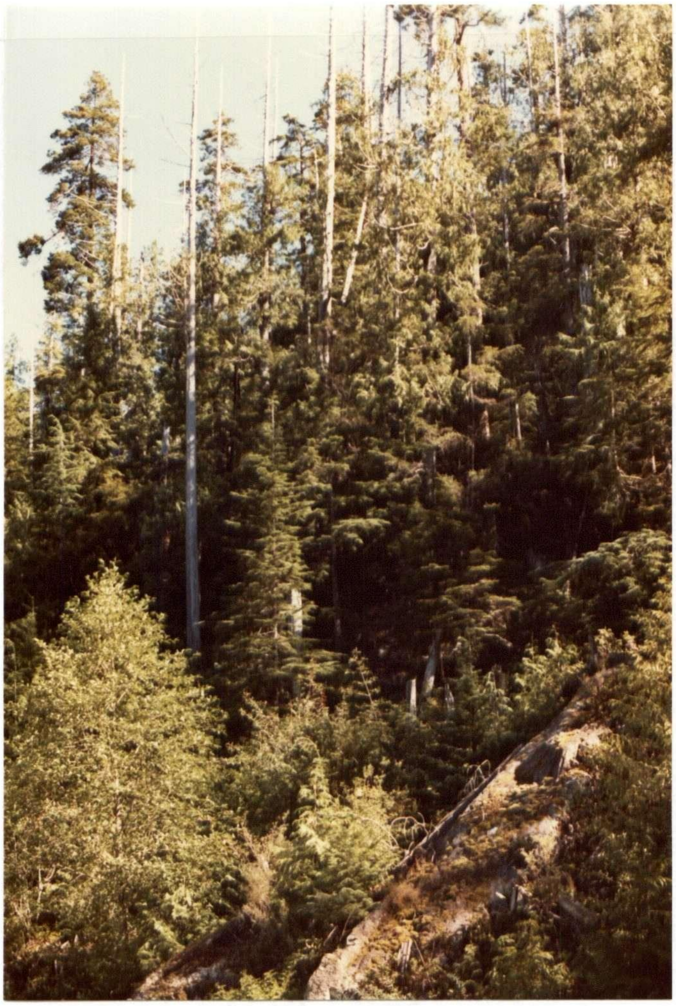


Fig. 8: View of site 819. Notice poor form and small size of trees, and open canopy.

Table 7: Environmental characteristics of Association 1.11

Cladino-Tsugetum (Lichen-Hemlock)

Characteristic	Mean	Range
Elevation (m)	72	60-78
Aspect (^{o})	266 (W)	207-335
Macrosite position	apex, lower slope	
Slope gradient (%)	31	30-32
Soil parent material	bedrock, colluvium	
Soil moisture regime	xeric to subxeric	
Soil drainage	rapid	
Soil type	"Lithic Podzol" (-Typic Folisol)	
Family particle-size class	loamy	
Forest floor thickness (cm)	11	5-20
Total rooting depth* (cm)	18	7-27
Depth to restrictive layer* (cm)	18	7-27
Effective rooting depth* (cm)	18	7-27
Growth class (redcedar)	6, 0	
Site index (redcedar)(m/100 yrs)	17	5.6-24.3
Average height (redcedar)(m)	19	6.5-27.3
Basal area (m^2/ha)	40.5	17-63
Relative density (stems/ha)	625	540-720

(* includes depth of organic horizons)

The characteristic combination of species for this association consists of the following plant species with their differentiating values (as defined in Appendix 8) shown in parentheses:

Chamaecyparis nootkatensis (co)
Pinus monticola (co)
Pseudotsuga menziesii (e)
Tsuga heterophylla (cd)

Gaultheria shallon (cd)
Menziesia ferruginea (c)
Vaccinium alaskaense (c)
Vaccinium parvifolium (cd)

Danthonia spicata (co)
Hieracium albiflorum (co)
Hypopythys monotropa (co)
Phyllodoce empetriformis (co)
Pteridium aquilinium (co)
Saxifraga ferruginea (co)

Cladina impexa (co)
Cladina rangiferina (co)
Cladina sp. (co)
Cladonia bellidiflora (co)
Cladonia gracilis (co)
Cladonia uncialis (co)
Dicranum scoparium (co)
Dicranum sp. (co)
Diplophyllum albicans (co)
Ditrichum sp. (co)
Herberta adunca (co)
Hylocomium splendens (cd)
Isothecium stoloniferum (co)
Mylia taylorii (co)
Polytrichum commune (co)
Polytrichum piliferum (co)
Rhacomitrium canescens (co)
Rhacomitrium heterostichum (co)
Rhacomitrium lanuginosum (co)
Rhytidiadelphus loreus (co,cd)
Stereocaulon tomentosum (co)

The ecosystems of this association have very low productivity, due to moisture stress and severe site conditions, and could not be managed for commercial purposes.

Association 2.11: Blechno-Thujetum (Deer fern-Redcedar)

Reference: Sample plots 131-1,2,3; 144-1,2,3; 151-1,2,3; 152-1,2,3; 152-1,2,3; 109-1,2,3; 199-1,2,3; 150-1,2,3; Table 8; Figures 9-20; Appendices 1-5, 7.

This association was synthesized from 18 sample plots of 6 study sites listed above. As the vegetation data set for stand 144 was incomplete (due to logging) it was not included in the vegetation data analysis. However, the remaining vegetation and other environmental characteristics of these plots suggest that they should be classified in this association.

This association covers a wide range of environmental conditions which have been summarized in Table 8. Ecosystems of this association occur on plains (Fig. 9), mid-slope (Figs. 10, 11) and lower slope positions, from 25 to 230 m elevation. The soils are typically Ferro-Humic Podzols or Humic Podzols derived from morainal parent materials (Figs. 12, 13), but include Gleysols (Fig. 14), Brunisols, and glaciofluvial or glaciomarine parent materials. One feature common to almost all soils of this association is the presence of compaction or cementation in the lower part of the solum, resulting in restricted rooting and drainage. Some soils experience lateral water flow or have perched water tables (Fig. 15), and many have mottling (Fig. 14). The moisture regime ranges from subhygric to subhydric and drainage is moderately-well to poor.

Table 8: Environmental characteristics of Association 2.11

Blechno-Thujetum (Deer fern-Redcedar)

Characteristic	Mean	Range
Elevation (m)	99	25-230
Aspect	SE, E	N, E, SE, S, SW, W, NW
Macrosite position	mid-slope, plain, lower slope	
Slope gradient (%)	15	0-35
Soil parent material	morainal, (glaciofluvial, glaciomarine)	
Soil moisture regime	hygric	subhygric-subhydric
Soil drainage	imperfect	moderately well -poor
Soil type	FHP, HP, (HG, OG, DB, SB, FP)	
Family particle-size class[1]	loamy	fC, L, Lsk, S, Ssk
Forest floor thickness (cm)	15.8	8-29
Total rooting depth* (cm)	42.4	19-76
Depth to restrictive layer* (cm)	49.7	19-94
Effective rooting depth* (cm)	26.2	12-47
Growth class (redcedar)	5	4-6
Site index (redcedar)(m/100 yrs)	28.4	25.2-34.6
Average height (redcedar)(m)	31.8	27.6-38.9
Basal area (m^2/ha)	140	60-347
Relative density (stems/ha)	451	240-780

(* includes depth of organic horizons)

Fig. 9: View of stand 152 from the Pachena Main Line.

Fig. 10: Downslope view of site 144.

Fig. 11: Upslope view of site 144. Notice size of stumps in relation to person in centre of picture.

Fig. 12: Soil cut near plot 131-1: Humic Podzol with humimor on morainal material. Notice abundance of roots in thick humus layer, horizontal orientation of roots, and height and density of salal in background.

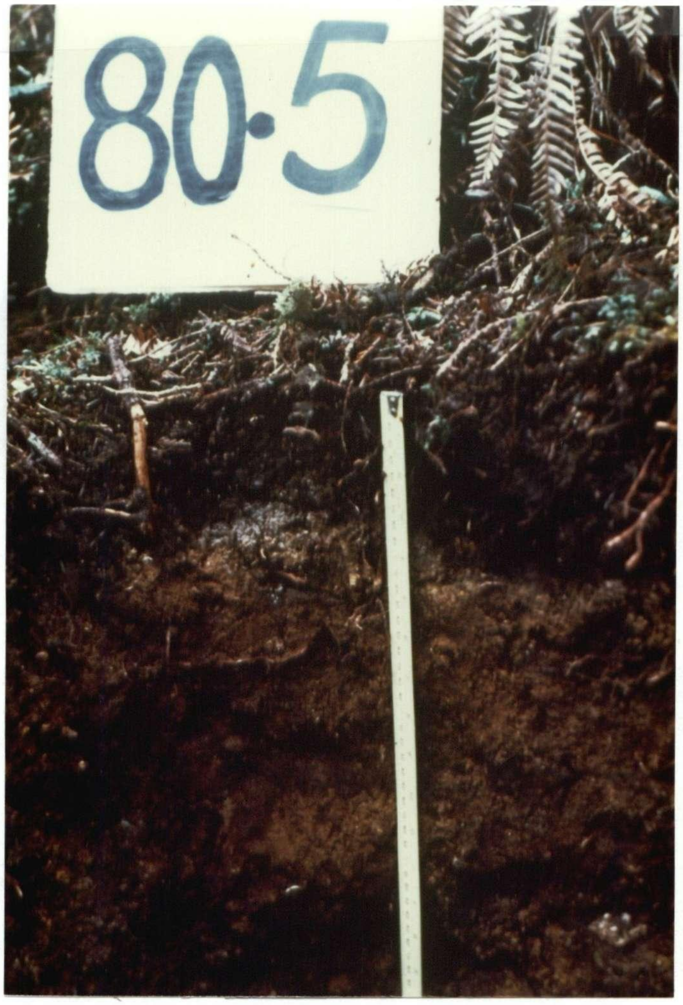


Fig. 13: Soil profile 151-3. Gleyed Ferro-Humic Podzol on morainal veneer over igneous bedrock.

(photo courtesy of D. Gagnon)

Fig. 14: Fine-clayey Orthic Gleysol of plot 109-2. Notice extraordinaty mottling in upper portion of profile.

(photos courtesy of D. Gagnon)

Fig. 15: Roadcut through stand 151, Sarita Seepage Slope. Notice size of stump in shallow soil over bedrock, and horizontal orientation of roots.

Western redcedar dominates these ecosystems; typically comprising over 75% of the total basal area (Figs. 16, 17). Western hemlock is usually abundant, but much smaller in diameter, and often in a codominant or intermediate crown position. Amabilis fir is also common.

The shrub layer is characterized by a tall dense layer of salal (Fig. 18), with admixtures of various _Vaccinium_ species and false-azalea. Deer fern dominates the herb layer which is otherwise poorly developed (Fig. 20). The moss layer contains a variety of species (App. 7) and is well-developed.

The characteristic combination of species for this association consists of the following plant species with their differentiating values (as defined in Appendix 8) in parentheses:

Abies amabilis (d)
Taxus brevifolia (co)
Tsuga heterophylla (cd)

Blechnum spicant (cd)
Polypodium glycyrrhiza (s)

Gaultheria shallon (cd)
Menziesia ferruginea (c)
Vaccinium alaskaense (d,c)
Vaccinium parvifolium (cd)

Hylocomium splendens (cd)

The productivity of western redcedar in this association varies with site position; from poor (SI=25.2) on flat, poorly drained plains, to medium (SI=34.6) on seepage slopes.

Fig. 16: Large, old redcedar trees in Stand 151.

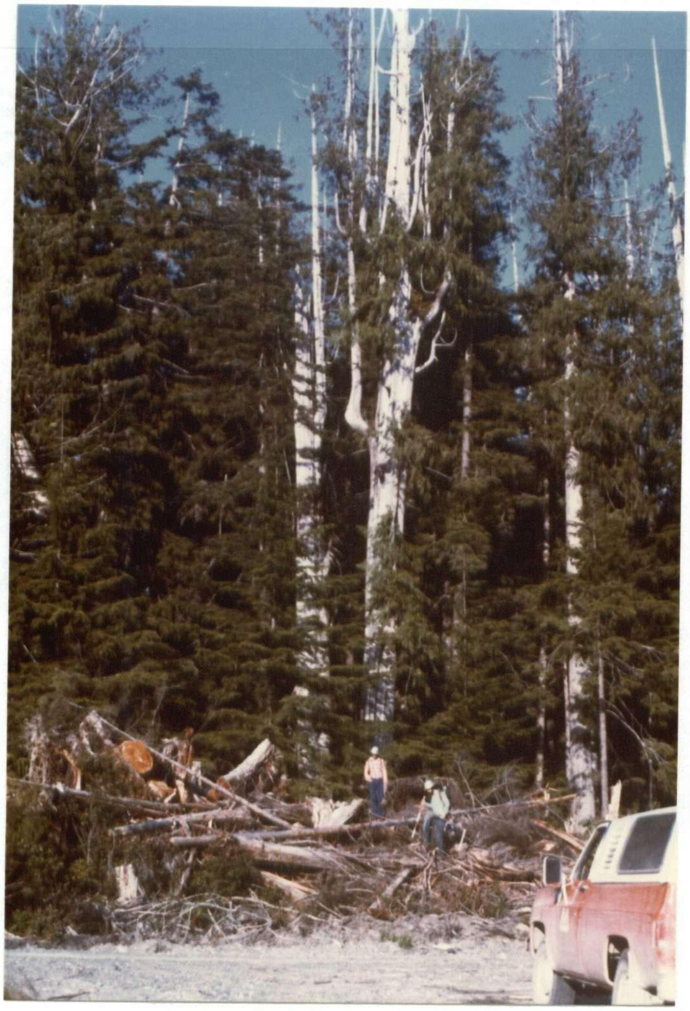


Fig. 17: Large "candellabra" redcedars in plot 109-2.

Fig. 18: Plot 199-3, mid-slope. Notice height and density of salal in relation to person wearing orange hardhat.

Fig. 19: Dense patch of salal and vacciniums in plot 109-1.

Fig. 20: View of plot 109-1. Notice salal and deer fern understory.

(photos courtesy of D. Gagnon)

<u>Association 2.12: Sphagno-Thujetum (Sphagnum-Redcedar)</u>

References: Sample plots 300-1, 300-2, 300-3, 821-1, 821-2, 821-3; Table 9; Figures 21-25; Appendices 1-5, 7.

This association was synthesized from the 6 sample plots of the Port Albion Bog (821) and Ucluelet Scrub (300) sites. Ecosystems of this association occur on flat coastal plains at an elevation of 25 to 80 m (Table 9). The soils are Humic Podzols or Orthic Gleysols which have derived from fluvial or glaciomarine sediments over morainal till (Fig. 21). The soils are shallow, with a hardpan or compacted till occuring close to the surface. As a result of the impervious layer, the soils are poorly drained and of subhydric moisture regime. Abundant mottling of high chroma indicates periods of prolonged saturation. Rooting is confined almost entirely to the organic horizons. The presence of charcoal in the soils suggests that fire played a role in stand origin.

These ecosystems have a very open forest canopy and are comprised of numerous small stunted trees (Figs. 22, 23). Western redcedar dominates the main canopy, with admixtures of western hemlock and shore pine. Western crab apple and western yew are minor but characteristic understory species. The shrub layer is extremely dense and tall, and is dominated by <u>Vaccinium</u> species and salal (Figs. 24, 25). The herb and moss layers are also well-developed (App. 7). Regeneration of western redcedar is abundant in these ecosystems.

Table 9: Environmental characteristics of Association 2.12

Sphagno-Thujetum (Sphagnum-Redcedar)

Characteristic	Mean	Range
Elevation (m)	46	25-80
Aspect	N/A	
Macrosite position	plain	
Slope gradient (%)	0	(0-15)
Soil parent material	fluvial-glaciomarine/morainal	
Soil moisture regime	subhydric	
Soil drainage	poor	
Soil type	Humic Podzol, Orthic Gleysol	
Family particle-size class	loamy, loamy skeletal	
Forest floor thickness (cm)	15	5-22
Total rooting depth* (cm)	37.5	13-74
Depth to restrictive layer* (cm)	44	16-74
Effective rooting depth* (cm)	20	13-27
Growth class (redcedar)	8, 0	
Site index (redcedar)(m/100 yrs)	15.1	13.9-16.3
Average height (redcedar)(m)	17	15.6-18.3
Basal area (m^2/ha)	56	32-77
Relative density (stems/ha)	777	580-1060

(* includes depth of organic horizons)

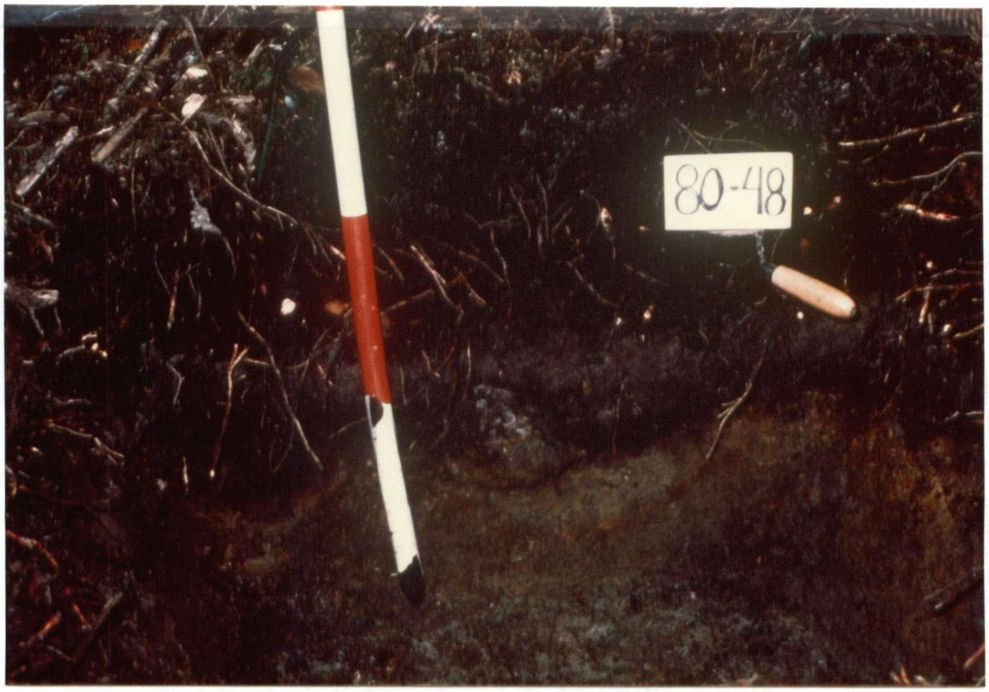


Fig. 21: Soil profile in plot 300-2: Fine-loamy Orthic Gleysol. Notice band of bright orange mottles.

(photo courtesy of D. Gagnon)

Fig. 22: View of stand 821 (near plots 1 and 2) from Port Albion Road. Notice spindly shape of redcedar in background; and abundant redcedar regeneration in foreground.

Fig. 23: Second view of stand 821 (near plots 1 and 2) from Port Albion Road. Notice scrubby appearance and poor form of pine and cedar trees.

Fig. 24: View of plot 300-1. Notice dense, tall understory of salal, vacciniums, and redcedar regeneration; and poor form of trees.

Fig. 25: View of dense understory vegetation in plot 300-2.

(photos courtesy of D. Gagnon)

The characteristic combination of species for this association consists of the following plant species with their differentiating values (as defined in Appendix 8) in parentheses:

Pinus contorta (p,cd)
Malus fusca (e,cd)
Taxus brevifolia (co)
Tsuga heterophylla (cd)

Blechnum spicant (cd)
Boschniakia hookeri (co)
Calamagrostis nutkaensis (co)
Cornus unalaschkensis (d,cd)
Linnaea borealis (p,cd)
Maianthemum dilatatum (cd)

Gaultheria shallon (cd)
Menziesia ferruginea (c)
Vaccinium parvifolium (cd)

Dicranum scoparium (d)
Hylocomium splendens (cd)
Plagiothecium undulatum (d,c)
Rhytidiadelphus loreus (cd)
Sphagnum sp. (p,cd)

The productivity of this association for western redcedar is very low (SI=15.1), primarily due to the shallow, wet soils. This association is slightly more productive for *Pinus contorta* (SI=17.8), but nevertheless these ecosystems could not be managed for commercial purposes.

Association 3.11: Kindbergio praelongi-Piceetum (Fern-Sitka spruce)

Reference: Sample plots 1092-1, 1092-2, 1092-3; Table 10; Figures 26, 27; Appendices 1-5, 7.

The three sample plots of site 1092 have been grouped together and tentatively assigned to the Kindbergio praelongi-Piceetum Association, which has been previously recognized by Krajina and Cordes and described in Cordes (1972). There are some dissimilarities between the "association" identified in this study and that described in Cordes. Many of these discrepancies are undoubtedly due to a difference in the ages of the sampled stands. Cordes sampled old growth stands, whereas stand 1092 was only 48 years old at the time of sampling.

Ecosystems of this association occur on relatively inactive floodplains, commonly situated a fair distance from a main river channel. The soils have developed from fluvial parent materials and are typically classified as Dystric Brunisols, but may include Cumulic Regosols, due to weak profile development (Table 10). A characteristic feature of the soils of this association is the presence of a gravel layer, which is important for both drainage and underground flooding (Cordes 1972). The soils are moderately well drained and of subhygric moisture regime.

Forest stands of this association are comprised of a mixture of western redcedar, Sitka spruce and western hemlock (Fig.26). The stands described by Cordes are dominated by Sitka spruce with highly variable

Table 10: Environmental characteristics of Association 3.11

Kindbergio praelongi-Piceetum (Fern-Sitka spruce)

Characteristic	Mean	Range
Elevation (m)	3	1-5
Aspect	N/A	
Macrosite position	plain	
Slope gradient (%)	0	
Soil parent material	fluvial (glaciomarine?)	
Soil moisture regime	subhygric	
Soil drainage	moderately well	
Soil type	Dystric Brunisol (Cumulic Regosol)	
Family particle-size class	fragmental to sandy	
Forest floor thickness (cm)	13	8-21
Total rooting depth* (cm)	89	69-126
Depth to restrictive layer* (cm)	N/A	
Effective rooting depth* (cm)	49	44-55
Growth class (redcedar)	4	
Site index (redcedar)(m/100 yrs)	33.4	
Average height (redcedar)(m)**	22.3	
Basal area (m^2/ha)**	50	38-57
Relative density (stems/ha)**	872.7	716-1062

(* includes depth of organic horizons)
(** estimated from a second-growth (48 yr. old) stand)

Fig. 26: Large redcedar stump in stand 1092 with second-growth stand of western redcedar, western hemlock, and Sitka spruce in background.

amounts of western redcedar, and a minor component of western hemlock. The hemlocks are numerous, but relatively small. In contrast, stand 1092 (as described in App. 2) is dominated by western hemlock and western redcedar, with a minor component of Sitka spruce. It is difficult to compare the two situations since it is unclear how the structure of stand 1092 will change with time, and whether it will approach that described by Cordes.

The understory vegetation in ecosystems of this association consists of a well-developed herb layer dominated by several fern species (Fig. 27), and an abundant coverage of mosses (App. 7). It is possible that some of the Kindbergia oregana recorded for the sample plots of stand 1092 was misidentified and should include Kindbergia praelonga. Cordes (1972) reported a well-developed shrub layer for this association, which "forms a dense growth in openings in the tree canopy and is quite sparse beneath areas of closely-spaced trees". The closed canopy of stand 1092 probably accounts for its poorly-developed shrub layer.

The characteristic combination of species for this association (as synthesized from the sample plots of stand 1092) consists of the following plant species with their differentiating values (as defined in Appendix 8) shown in parentheses:

Picea sitchensis (e,cd)
Tsuga heterophylla (cd)

Athyrium filix-femina (c)
Blechnum spicant (cd)
Polystichum munitum (cd)
Tiarella trifoliata (c)
Dryopteris expansa (co,c)
Gymnocarpium dryopteris (d)

Gaultheria shallon (cd)
Vaccinium ovatum (co,c)

Hylocomium splendens (c)
Kindbergia oregana (co,cd)
Pleurozium schreberi (s)
Rhizomnium glabrescens (co,cd)

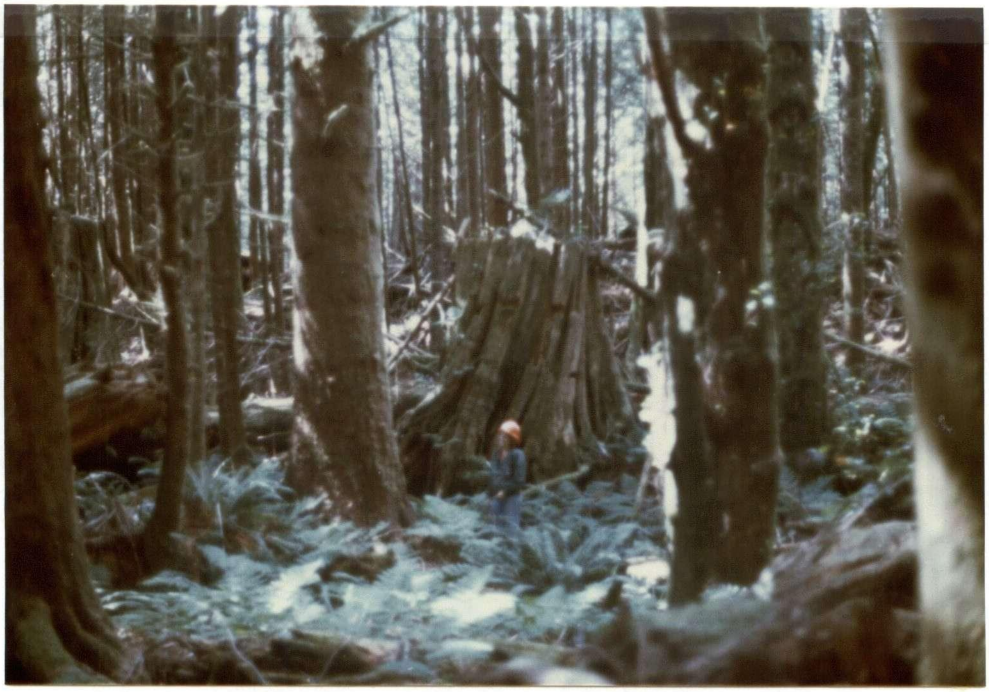


Fig. 27: View from within stand 1092. Notice vigorous understory of ferns; large, old western redcedar stump; and size of 48 year old second-growth trees.

This association is fairly productive for all 3 of the major tree species. The gravel layer in the soil undoubtedly contributes to this productivity, as it promotes drainage, and also provides an additional source of moisture and nutrients through underground flooding. The site indices reported for this association are as follows:

	this study	Cordes (1972)
western redcedar	33.4	35.4
western hemlock	41.3	31.7
Sitka spruce	35.3*	46.0.

However, it must be remembered that the productivity of this study site may have been enhanced as a result of disturbances from logging, and therefore may not be directly comparable to that of an old-growth stand.

(* limited sample size, n=2)

Association 3.21: Lysichito-Piceetum (Skunk cabbage-Sitka spruce)

Reference: Sample plots 315-1, 315-2, 315-3; Table 11; Figures 28-31; Appendices 1-5, 7.

This association was synthesized from the 3 sample plots of stand 315. It has been previously recognized by Krajina and Cordes and described in Cordes (1972). An ecosystem of this association typically occurs on a poorly drained floodplain along a stretch of river, often bordering a swamp. The sites of this type have fairly high water tables and experience periodic flooding. The ground water is slow moving and low in oxygen, resulting in anaerobic conditions. The soils have developed from fluvial parent materials and are most commonly Orthic Humic Gleysols (Figs. 28, 29). They are poorly to very poorly drained and also poorly aerated. Rooting is primarily restricted to the upper horizons of the profile. The soils sampled in this study were fairly fine-textured: silty loam to silty clay loam (Table 11); whereas Cordes (1972) reported coarser soils: fine sandy loam to fine sand.

Forest stands of this association are dominated by Sitka spruce and western redcedar with a minor component of western hemlock. The relative density of these stands is fairly low, although individual trees are often quite large. In some sites the trees grow in clumps on the better drained microsites.

Fig. 28: Soil profile of plot 315-1: Loamy Humic Gleysol on fluvial deposits. Notice mottling, and water at bottom of soil pit.

(photo courtesy of D. Gagnon)

Fig. 29: Soil profile of plot 315-2: Fine-silty Humic Gleysol on fluvial deposits.

(photo courtesy of D. Gagnon)

Table 11: Environmental characteristics of Association 3.21

Lysichito-Piceetum (Skunk cabbage-Sitka spruce)

Characteristic	Mean	Range
Elevation (m)	22	
Aspect	N/A	
Macrosite position	plain	
Slope gradient (%)	0	
Soil parent material	fluvial	
Soil moisture regime	subhydric (to hydric)	
Soil drainage	poor	
Soil type	Humic Gleysol	
Family particle-size class	fine silty to loamy	
Forest floor thickness (cm)	9	5-15
Total rooting depth* (cm)	77	52-97
Depth to restrictive layer* (cm)	92	70-115
Effective rooting depth* (cm)	59	47-73
Growth class (redcedar)	4	
Site index (redcedar)(m/100 yrs)	34.7	
Average height (redcedar)(m)	38.6	
Basal area (m^2/ha)	216.7	179-247
Relative density (stems/ha)	313.0	280-340

(* includes depth of organic horizons)

The understory is very well developed with a dense shrub layer dominated by salmonberry, blueberry, huckleberry, salal, and false-azaela (Fig. 30). The herb and moss layers are very diverse, containing numerous characteristic species (Fig. 31, Table 7).

The characteristic combination of species for this association consists of the following species with their differentiating values (as defined in Appendix 8) shown in parentheses:

Picea sitchensis (e,cd)
Tsuga heterophylla (cd)

Gaultheria shallon (cd)
Menziesia ferruginea (d,c)
Rubus spectabilis (d,cd)
Vaccinium alaskaense (d,cd)
Vaccinium ovalifolium (e)
Vaccinium ovatum (co,c)
Vaccinium parvifolium (d,cd)

Adenocaulon bicolor (co)
Athyrium filix-femina (c)
Blechnum spicant (cd)
Boykinia elata (e)
Carex obnupta (s,c)
Festuca subulata (co)
Galium triflorum (e)
Huperizia selago (co)
Luzula parviflora (co)
Lysichitum americanum (s,cd)
Maianthemum dilatatum (c)
Polystichum munitum (cd)
Stachys mexicana (co)
Streptopus amplexifolius (e)
Tiarella laciniata (e,c)
Tiarella trifoliata (c)
Trisetum cernuum (e)
Viola glabella (d)

Blepharostoma trichophyllum (co)
Calypogeia muelleriana (co)
Cephalozia bicuspidata (co)
Hookeria lucens (s)
Hylocomium splendens (c)
Isopterygium elegans (co)
Kindbergia oregana (co,cd)
Kindbergia praelonga (e)
Leucolepis menziesii (e)
Pellia neesiana (e)
Plagiochila porelloides (e)
Plagiomnium insigne (e,c)
Plagiothecium undulatum (c)
Pleurozium schreberi (s)
Pogonatum alpinum (s)
Rhizomnium glabrescens (co,cd)
Rhytidiadelphus loreus (d)
Riccardia latifrons (co)
Scapania bolanderi (e)
Sphagnum henryense (e)

Fig. 30: View of plot 315-2. Notice sunlight penetrating through forest canopy and lush understory of salmonberry, vacciniums, and hemlock regeneration.

Fig. 31: View of plot 315-1. Notice vigorous understory of salmonberry, skunk cabbage, and sword fern.

(photos courtesy of D. Gagnon)

This association is fairly productive for western redcedar (SI=34.7, this study; 34.1, Cordes (1972)). Productivity of Sitka spruce in ecosystems of this association is variable. On sites sampled for this study, the site index for spruce was very high (SI=51.2). Whereas Cordes reported "moderate to poor" growth rates for spruce and an average site index of 35.1.

Association 4.11: Tiarello trifoliatae-Abietetum (Herbs-Amabilis fir)

Reference: Sample plots 513-1, 513-2, 513-3; Table 12; Figure 31; Appendices 1-5, 7.

This association was synthesized from only one study site (513), which is situated much farther inland than the other study sites; perhaps contributing to its uniqueness. As only 3 plots were sampled, this association should be regarded as tentative.

This association occurs on mature (inactive) floodplains. The soils are typically deep, fine-loamy Orthic Humo-Ferric Podzols which have developed from fluvial deposits. There are no coarse fragments or restrictive layer. The soils are well drained and of mesic moisture regime (Table 12).

The forests are dominated by western redcedar and amabilis fir, with a minor component of western hemlock and occasionally Sitka spruce. The redcedars are very large in size (Fig. 32), but small in number; whereas Amabilis fir is very abundant but much smaller in diameter. Perhaps the most interesting floristic characteristic of this association is the lack of salal. The shrub layer is fairly light and patchy, and is comprised primarily of Vaccinium spp. and salmonberry. The herb layer is very well-developed and diverse; containing numerous ferns and wildflowers (App. 7). The moss layer, in contrast, is very poorly developed.

Table 12: Environmental characteristics of Association 4.11 Tiarello trifoliatae-Abietetum (Herbs-Amabilis fir)

Characteristic	Mean	Range
Elevation (m)	221	215-227
Aspect	N/A	
Macrosite position	valley floor	
Slope gradient (%)	0	
Soil parent material	fluvial	
Soil moisture regime	mesic - (subhygric)	
Soil drainage	well - (moderately-well)	
Soil type	Ferro-Humic Podzol -(Humo-Ferric Podzol)	
Family particle-size class[1]	fine-loamy	
Forest floor thickness (cm)	8	2-14
Total rooting depth* (cm)	128	80-153+
Depth to restrictive layer* (cm)	128+	80-153+
Effective rooting depth* (cm)	74	34-105
Growth class (redcedar)	1	
Site index (redcedar)(m/100 yrs)	45.7	
Average height (redcedar)(m)	51.3	
Basal area (m^2/ha)	141.7	82-199
Relative density (stems/ha)	340	280-420

(* includes depth of organic horizons)

Fig. 32: View of plot 513-1. Notice large redcedars.

The characteristic combinations for this association consists of the following plant species with their differentiating values (as defined in Appendix 8) in parentheses:

Abies amabilis (co,cd)

Rubus spectabilis (cd)
Vaccinium alaskaense (cd)

Achlys triphylla (e,c)
Athyrium filix-femina (c)
Blechnum spicant (c)
Cornus unalaschkensis (cd)
Gymnocarpium drypoteris (co,cd)
Orthilia secunda (cd)
Petasites palmatus (e)
Polystichum munitum (c)
Streptopus roseus (s)
Tiarella trifoliata (cd)
Tiarella unifoliata (s,c)
Trillium ovatum (e,c)
Veratrum viride (s)
Viola glabella (cd)

This association is the most productive of the 6 described in this study for western redcedar (SI 45.7). Undoubtedly the deep, loamy soils, which provide good rooting and drainage, contribute to the high productivity of these ecosystems.

Validation of Classification

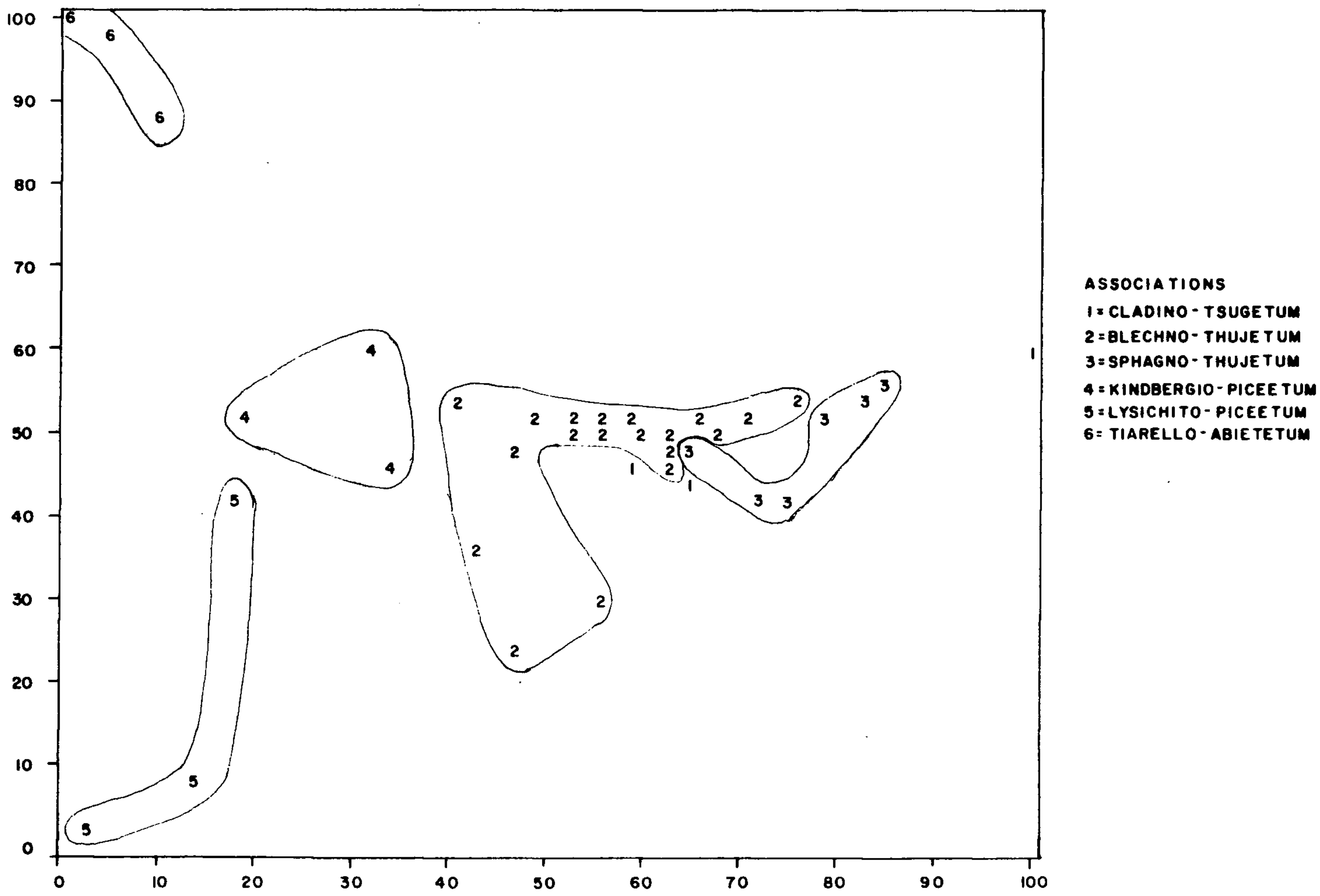
As mentioned in Chapter 2, an ordination technique was run on the vegetation data set to verify the results from the tabular method of grouping sample plots. As Figure 33 illustrates, the ordination confirms the classification scheme presented in Table 5. The sample plots which are most similar in terms of species composition have been plotted closest together.

The sample plots of the three floodplain associations have been plotted on the left side of the graph (Fig. 33). The Kindbergio-Piceetum and Lysichito-Piceetum associations, which are in separate alliances, but in the same order; have been plotted closer together than the Tiarello-Abietetum association, which is in a different order. The ordination also supports the decision to separate sites 1092 and 315 into separate associations.

The sample plots from the Blechno-Thujetum and Sphagno-Thujetum associations have been plotted close together, as would be expected, since these associations are not only in the same order, but also in the same alliance. Furthermore, the plots from the Blechno-Thujetum association which have been plotted closest to those of the Sphagno-Thujetum association are from Stand 152. This site had the wettest hygrotope (App. 2) of the stands in this association, and could probably be regarded as being somewhat transitional between the two associations.

Figure 33: ORDINATION OF SAMPLE PLOTS

X AXIS = AXIS 1 SCORES FOR SAMPLE PLOTS FROM RA ORDINATION
Y AXIS = AXIS 2 SCORES FOR SAMPLE PLOTS FROM RA ORDINATION



The sample plots of the Cladino-Tsugetum association are somewhat scattered on the graph (Fig. 33). However, the vegetation data for this association (App.7) provides an explanation. The two plots from the dry rock outcrop site (818) were plotted on the far right side of the graph. In fact, the point representing plot 818-2 was situated so far away from all the others that it was removed from the ordination. The points representing site 819 have been plotted near those of the Blechno-Thujetum association. This is because they are very similar in terms of their species composition (App. 7). However, environmentally, site 819 is very different from the sites of the Blechno-Thujetum association, and is very similar to site 818. Thus it was logical to classify it in the Cladino-Tsugetum association. This situation illustrates the importance of using environmental data in conjunction with vegetation data for classification. Due to compensating effects, different combinations of environmental properties may produce very similar effects on vegetation (Klinka et al. 1984).

The axis 1 ordination of sample plots, based on the variation of their species composition, strongly reflects a decreasing trend in site productivity and nutrient availability (Table 13). The floodplain sites, which have the highest site indices (Table 14) and the most favourable nutrient regimes (as reflected by the EISG, Fig. 34), have been ordinated at one end of the axis. Whereas, the sites with the lowest site indices and poorest edaphic conditions (the Dry Rock Outcrop, 818; and the wet/ bog, 300,821, sites), have been ordinated at the opposite end of the axis.

Table 13: Ordination scores for sample plots, axis 1

Association	Plot no.	Axis Score	Site Index
Tiarello-Abietetum	513-1	0.0	45.7
Lysichito-Piceetum	315-1	2.6	34.7
Tiarello-Abietetum	513-2	4.5	45.7
Tiarello-Abietetum	513-3	9.7	45.7
Lysichito-Piceetum	315-2	13.7	34.7
Lysichito-Piceetum	315.3	17.9	34.7
Kindbergio-Piceetum	1092-2	18.9	33.4
Kindbergio-Piceetum	1092-3	31.0	33.4
Kindbergio-Piceetum	1092-1	33.5	33.4
Blechno-Thujetum	199-1	40.4	25.2
Blechno-Thujetum	151-3	42.6	34.6
Blechno-Thujetum	150-3	46.7	28.1
Blechno-Thujetum	109-1	46.8	28.9
Blechno-Thujetum	150-1	48.6	28.1
Blechno-Thujetum	150-2	52.2	28.1
Blechno-Thujetum	144-1	52.9	--
Blechno-Thujetum	144-2	55.2	--
Blechno-Thujetum	151-1	55.8	34.6
Blechno-Thujetum	109-2	55.9	28.9
Blechno-Thujetum	199-3	58.5	25.2
Cladino-Tsugetum	819-2	58.5	24.3
Blechno-Thujetum	144-3	58.7	--
Blechno-Thujetum	109-3	59.4	28.9
Blechno-Thujetum	151-2	59.9	34.6
Blechno-Thujetum	199-2	62.5	25.2
Blechno-Thujetum	131-2	62.7	28.3
Blechno-Thujetum	131-1	62.9	28.3
Cladino-Tsugetum	819-1	64.0	24.3
Lysichito-Thujetum	300-1	64.1	16.3
Blechno-Thujetum	152-1	66.0	25.2
Blechno-Thujetum	131-3	67.8	28.3
Blechno-Thujetum	152-3	70.2	25.2
Lysichito-Thujetum	300-2	71.5	16.3
Lysichito-Thujetum	300-1	74.5	16.3
Blechno-Thujetum	152-2	75.1	25.2
Lysichito-Thujetum	821-3	78.3	13.9
Lysichito-Thujetum	821-2	82.3	13.9
Lysichito-Thujetum	821-1	84.8	13.9
Cladino-Tsugetum	818-1	100.0	13.9
Cladino-Tsugetum	818-2	100++	5.6

Table 14: Comparative productivity of the six associations recognized in the study area

Associaton	Mean SI Redcedar (m at 100 yrs)	Mean BA (all species) (m^2/ha)	Average Height Redcedar* (m)
Association 4.11 Tiarello-Abietetum	45.7	141.7 (82-199)	51.3
Association 3.21 Lysichito-Piceetum	34.7	216.7 (179-247)	38.6
Association 3.11 Kindbergio-Piceetum	33.4	50** (38-57)**	22.3**
Association 2.11 Blechno-Thujetum	28.4 (25.2-34.6)	140 (60-347)	31.8 (27.6-38.9)
Association 2.12 Sphagno-Thujetum	15.1 (13.9-16.3)	56 (32-77)	17 (15.6-18.3)
Association 1.11 Cladino-Tsugetum	17 (5.6-24.3)	40.5 (17-63)	19 (6.5-27.3)

* dominants and codominants
** estimated from a second growth (48 yr. old) stand
() range of values indicated in parentheses

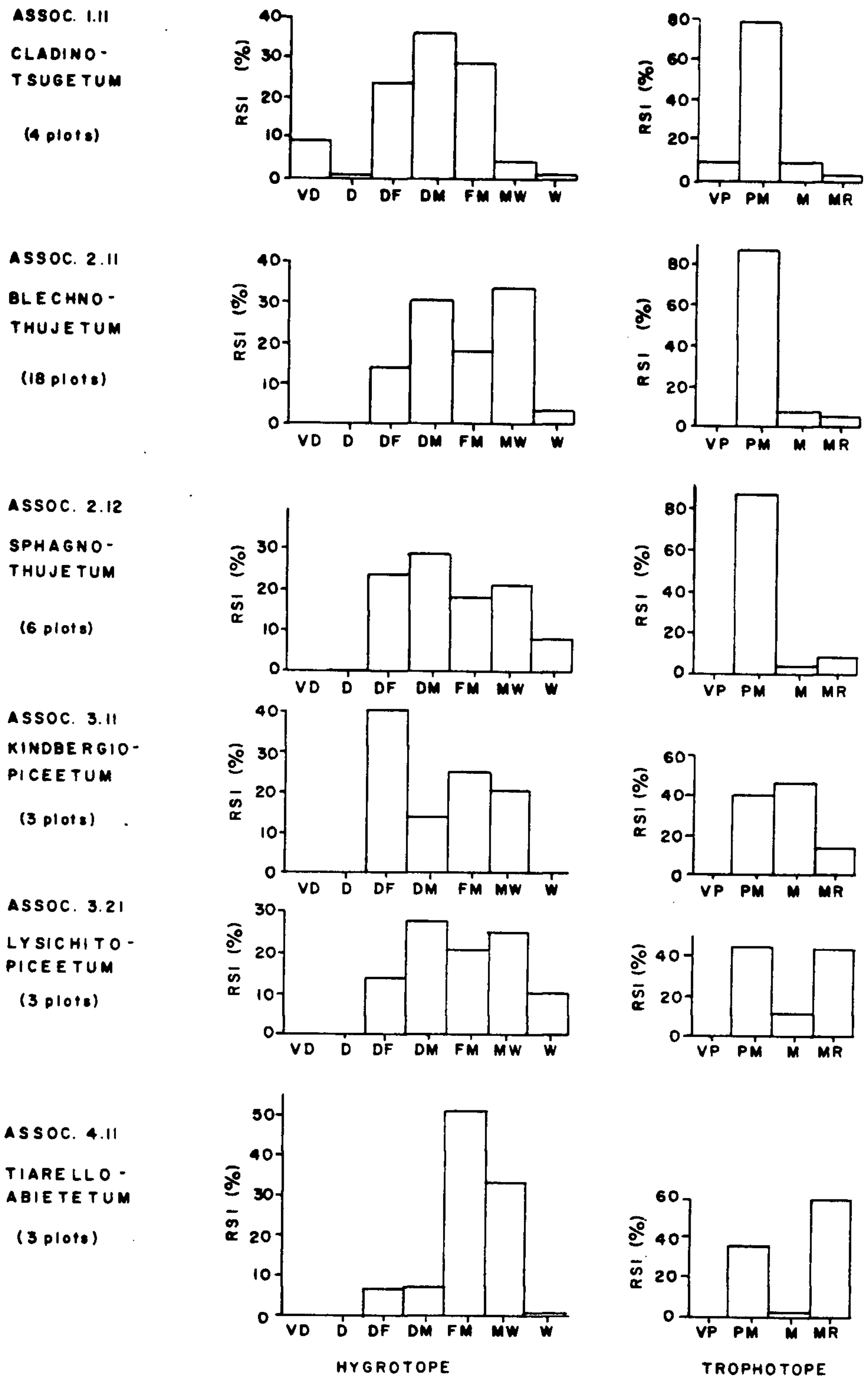


Fig. 34: A comparison of the edatopic indicator species groups for the 6 associations recgonized in the study area, as expressed by relative species importance (RSI), in relation to hygrotope and trophotope, where: VD=very dry, D=dry, DF=dry to fresh, DM=dry to moist, FM=fresh to moist, MW=moist to wet, W=wet, VP=very poor, PM=poor to medium, M=medium, and MR=medium to rich.

This suggests that the species composition of sites may be useful in assessing site productivity, and lends support to the use of indicator plant species (EISG) in site diagnosis and interpretation.

Discussion of Associations

If we consider the productivity of western redcedar (in terms of SI and BA) on an association basis, it is evident that the "floodplain" associations (4.11, 3.21, and 3.11) are the most productive for redcedar (Table 14). The spectra of EISG for these sites reflect favourable nutrient regimes (Fig. 34). The ecosystems of these three associations have fairly productive soils which have developed from fluvial parent materials. The soils are relatively well drained and receive inputs of nutrients through periodic flooding or underground seepage. They generally have thinner organic layers than the other sites, suggesting more rapid decompostion and nutrient cycling. The most productive of these three associations (in terms of SI for redcedar) is the Tiarello-Abietetum association, which has deeper, more highly developed, and better drained soils than the other two associations. Furthermore, its indicator plant species reflect a richer nutrient regime (Fig. 34).

The spectra of EISG for associations shows that Associations 1.11, 2.11, and 2.12 have similar nutrient regimes; with over 80% of the indicator plants contained in the poor-medium category (Fig. 34). Differences in productivity of redcedar between these three associations appears to be related to soil depth and drainage.

Association 2.11 (Blechno-Thujetum) covers a large portion of the study area and contains a majority of the sample plots. Soils of ecosystems of this association have developed from morainal parent materials and characteristically have a hardpan, compacted till, or some other restrictive layer in the subsoil. Productivity of western redcedar in this association is variable and appears to be related to site position. The two sites which seem to be most productive (site 151, SI=34.6; site 144, BA=347 m^2/ha) are situated on slopes. The slope position facilitates drainage and provides moisture and nutrient inputs through seepage water, which flows on top of the restrictive layer. These ecosystems appear to be even more productive for redcedar than some of the sites of the floodplain associations (Table 14). The least productive site in this association is Stand 152, which is situated on a flat site with restricted drainage. The ordination of sample plots suggests that this site may be transitional between the Blechno-Thujetum and the Sphagno-Thujetum associations (Fig. 33).

As would be expected, the two associations which occur on the most severe sites ("driest" and wettest") have the lowest productivity for western redcedar (Table 14). Association 1.11 (Cladino-Tsugetum), which is comprised of rock outcrop communities has a slightly higher site index for redcedar than the bog/forest communities of association 2.12 (Sphagno-Thujetum). However, there is a much wider range of productivity in the rock outcrop association than in the bog/forest association. Consequently, the "best" and "worst" sites of the rock outcrop association have considerably higher and lower site index values than the "best" and "worst" sites of the bog/forest association (SI=27.3 vs SI=18.3; and SI=6.5 vs SI=15.6). The ecosystems of these two associations not only have poor nutrient regimes (Fig. 34), but they also have the most limited volume of available soil for rooting. The Cladino-Tsugetum association is characterized by shallow soils with areas of exposed bedrock. Ecosystems of the Sphagno-Thujetum association are situated on flat areas and have soils with a restrictive layer. Consequently, drainage is impaired, the soils become saturated, and the volume of soil favourable for rooting becomes very limited.

Site Productivity in Relation to Soil Parameters

Assessment of Site Productivity

Site productivity is a function of many environmental variables and their interactions. Of the numerous environmental factors influencing tree growth, the important relationship between soils and tree growth has been so apparent that attention has been directed to it for a long time (Husch *et al*. 1972). Numerous studies have been conducted in which a number of soil, and other environmental, characteristics that influence tree growth have been selected and combined into estimating equations which predict productivity (in terms of site index) (Steinbrenner 1979). Douglas-fir has repeatedly been the subject of these soil-site studies, but there appears to be no information of this type available for western redcedar. Although it was not the intent of this thesis to develop a soil-site estimating equation for redcedar, the data have been checked for possible trends and relationships between the soil parameters measured and the estimated site productivity.

One of the major difficulties of this study, and one which is encountered by foresters and researchers alike, was the accurate assessment of site productivity. Productivity is generally measured in terms of timber yield (or volume) per unit area, which is a function of both the growth rate of the trees and the number of trees on the area (Steinbrenner 1979). The most useful tree-size characteristic for site evaluation is tree height since it is considered to be the one measure most closely related to the capacity of a site to produce wood (Husch *et al*. 1972;

Spurr and Barnes 1973). In addition, height growth for most species is uniform over a wide range of densities (Steinbrenner 1979). Diameter is a less reliable measure of site quality since it is sensitive to stand density. For comparative studies, site index, or the average height of the dominant and codominant trees at a specified index age, is generally regarded as the most useful indicator of potential productivity (Eis 1962; Steinbrenner 1979; Lowe and Klinka 1981).

As mentioned in Chapter 2, the site index of western redcedar was estimated for the study sites. For a number of reasons, this estimate of site productivity is very limited. First, site index is intended to be used for "evaluating site quality for even-aged stands of single species of nearly pure composition" (Husch et al. 1972). The stands evaluated in this study were decadent, old-growth (thus, uneven-aged) stands of mixed species composition. In uneven-aged stands of several species, height in relation to age cannot be used to express site quality (unless stem analysis is used), since the height growth of a species in this type of stand is not closely related to age but more to the varying stand conditions by which it has been affected during its life (Husch et al. 1972). The total height at a given age of a tree is an expression of all past growing conditions, and may be influenced by conditions that prevailed for a few years, such as drought or competition (Spurr and Barnes 1973).

Second, the BC Ministry of Forests site index curves which were utilized (Hegyi et al. 1979) were developed for "coastal western redcedar" and may not be valid for redcedar under the environmental conditions on western Vancouver Island. Spurr and Barnes (1973) mention that

> "...height growth curves should be based upon actual measured growth of trees on specific soils or site-types and not upon the harmonized method of averaging together height and age values from plots for the entire or regional range of sites upon which the species is found."; and furthermore "...height growth patterns are known not only to vary in different parts of the range of a species but also in local areas of contrasting soil and topography.".

Third, estimating site index requires an accurate assessment of tree height and age. This was a very difficult task in old, decadent redcedar stands since many of the trees characteristically have broken, spiked or candellabra tops, or have experienced die-back, creating wide variability in tree height. To reduce this variability in tree height, a much larger number of height measurements would need to be taken. In addition, many old redcedar trees are rotten in the centre, thus obscuring growth rings and making an accurate assessment of age impossible. In most instances, height and age were probably underestimated. However, the underestimation of age may be irrelevant since BC site index curves for coastal western redcedar tend to level off after approximately 200 years, and only continue to 300 years. It was assumed that the curves remain relatively constant beyond year 300, and therefore stands older than 300 years were actually assessed as being 300 years old.

In spite of its limitations, site index was utilized since there are very few alternatives for estimating site productivity. As a comparison, basal area was considered. Since basal area is directly related to volume, it should be indicative of site quality. Unfortunately, basal area is also a measure of stand density. Stand density is more a reflection of the stand history (ie: initial stocking, competition, natural catastrophies, stand age, etc.) than the site quality. The basal area of the stands from this study were often highly variable, largely due to blowdown of very large old trees and natural stand break-up associated with overmaturity. In addition, the basal area of standing dead trees was not measured and this resulted in an underestimate of total basal area for some sites.

Data Conversion and Analysis

In evaluating the soil chemical data for relationships with site productivity, it was decided to express the nutrient data on an areal basis (kg/ha), as well as by concentration in the less than 2mm soil fraction. For forest soils, there tends to be great variation in the physical soil properties that affect nutrient status; such as stone and gravel content, bulk density, and effective soil depth (Lewis 1976). The expression of nutrient status on an areal basis is useful for forest soils since it integrates both chemical and physical soil data.

To express soil nutrient status on an areal basis it was necessary to convert the nutrient values of concentration in the less than 2mm soil fraction to values of kilograms per hectare for the whole soil. The following equation, presented by Lewis (1976), was utilized:

$$N = n \cdot DIL \cdot BD \cdot d \cdot 10^8 \cdot 1/10^3$$

$$\frac{\text{kg N}}{\text{ha}} = \frac{\text{g of n}}{\text{g of soil <2mm}} \cdot \frac{\text{g of soil <2mm}}{\text{g of whole soil}} \cdot \frac{\text{g soil}}{\text{cm}^3\text{ soil}} \cdot \text{cm} \cdot \frac{\text{cm}^2}{\text{ha}} \cdot \frac{\text{kg soil}}{\text{g soil}}$$

where:

N is the amount of nutrient "n" on an areal basis,

n is the concentration of nutrient "n" in the 2mm soil fraction,

DIL is the proportion of the 2mm fraction to the whole soil, inclusive of gravel and stones,

BD is bulk density of the whole soil, and

d is the depth of the soil horizon.

"DIL" expresses the dilution effect of gravel and stone content on the effective soil volume (Lewis 1976). It should be mentioned that this value was derived from the weight of the soil sample taken to the lab, which did not include large stones, cobbles, and boulders. However, a far more serious limitation was the lack of bulk density measurements for the mineral soil horizons.

Since bulk densities of the mineral horizons were not measured, it was necessary to derive estimates for these missing values. Utilizing data from his west coast ecosystem study (unpublished) and from Valentine (1971), Chatterton (pers. comm.)[1] found a direct relationship between the inverse of bulk density and the concentration of carbon for mineral soils on the west coast of Vancouver Island. It is questionable whether the concentration of carbon is consistently related to the bulk density of

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[1] British Columbia Forest Products Resource Planning Group, Crofton, BC

rocky west coast podzols, since the presence of coarse fragments, which largely influences bulk density, is not expressed by or related to the concentration of carbon. Nevertheless, it was decided to utilize Chatterton's equation: $1/BD = 0.59409 + (0.14925 \times \%C)$, to estimate the bulk densities of the mineral horizons, since little bulk density information is available for mineral soils of this region.

Estimating bulk density values for the organic horizons was less difficult. Bulk density measurements had been taken for the humus horizons of 28 out of the 40 sample plots, and these values were used for their respective plots. Following Chatterton's (pers. comm.)[1] approach, a regression was run between the inverse of bulk density and concentration of carbon for these 28 humus horizons, and a positive linear relationship was found, with a correlation coefficient (r) of 0.63. The derived equation, $1/BD = 0.1257 + (3.0408 \times \%C)$ was used to estimate bulk densities for the remaining 12 humus horizons. The relationship between bulk density and carbon concentration is probably much more reliable for organic soils than mineral soils since there are no coarse fragments in the organic horizons to affect bulk density.

The following values from Carter's (pers. comm.)[2] observations were used as bulk density estimates for the L,F,LF, and LFH horizons:

$L = 0.085$ g/cm^3

$F = 0.120$ g/cm^3

$LF = 0.1025$ g/cm^3

$H_{(l)} = 0.150$ g/cm^3 (l=light)

$H_{(h)} = 0.180$ g/cm^3 (h=heavy).

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To check for relationships and trends in the data between site productivity estimates and soil parameters, scattergrams were produced and correlations run for the following:

<u>productivity variables</u>:

-site index -for western redcedar (m/100 yrs.),

-basal area -total live-standing BA for each plot (m^2/ha),

-average height -of dominant and codominant redcedar trees in each site (similar to SI, but not referenced back to age 100),

<u>vs</u>.

<u>soils variables</u>:

-average concentrations of organic C (%); total N (%); available P (ppm); and exchangeable K,Ca,Mg,Na (meq/100g); in the effective rooting zone and in the total rooting zone (averages weighted by horizon thickness),

-total kg/ha of organic C; total N; available P; and exchangeable K,Ca,Mg,Na in the total rooting zone and in the effective rooting zone,

-total thickness of organic horizons (L,F,H) (cm),

-depth to restrictive layer (cm),

-depth of effective rooting zone (cm),

-depth of total rooting zone (cm).

Subsequently, it was decided to run correlations between site index and soil nutrient concentrations of just the humus horizons. In addition to the above-mentioned nutrient concentrations, the following soil parameters were included: pH in H_2O; pH in $CaCl_2$; and organic C/total N ratio.

Results of Data Analysis

In reviewing the correlation matrices and scattergrams, some problems were discovered in the soils data which had been converted to kg/ha. For example, slight negative correlations were found between concentration of carbon and kg/ha of carbon. This does not make biological sense, since a positive correlation is expected. Apparently, the use of carbon for estimating bulk density was not valid for the mineral horizons, and resulted in skewing the converted data set. Consequently, it was decided to disregard the results which included mineral soils data in kg/ha.

No significant correlations or trends were found between the site productivity and soil nutrient variables, regardless of how they were expressed (ie: by effective rooting zone, total rooting zone, or humus horizon). However, positive correlations were found between site productivity (as expressed by site index and average height) and rooting depth (Table 15).

These results are in general agreement with those found in the literature. Several authors have reviewed North American soil-site studies, and have reported that most soil factors that correlated with site productivity were those which influenced the quality and quantity of growing space for tree roots; or in other words, the effective depth of the soil (Coile 1952; Forristall and Gessel 1955; Spurr and Barnes 1973; Carmean 1975; Pritchett 1979).

> "Root growing space, measured as depth of soil above some root restricting layer or water table, has been used as an indicator of site productivity more than most physical factors because it

Table 15: Significant correlations between rooting depth and site productivity of western redcedar

Variable	No. of Plots	r for SI	r for Avg.Ht.
effective rooting depth	38	0.639	0.537
total rooting depth	38	0.676	0.541
depth to restrictive layer	38	0.685	0.572

All correlations significant at the P<0.01 level.

> can be measured with some accuracy in the field, and it is an integrator of many other soil factors important to tree growth." (Pritchett 1979).

Soil depth itself, has little direct influence on tree growth, except in very shallow soils. However, indirectly it affects many chemical and physical soil properties important to tree growth, such as nutrient availability, moisture supplies and aeration.

As illustrated in Table 15, the strongest correlation was between site index and the depth to a restrictive layer. Carmean (1975) cautions that correlations cannot be accepted as evidence of cause and effect relations, but are useful for interpreting and speculating about the basic physiological reasons for site quality differences. Considering the environmental and climatic conditions of the study area, it is not suprising that the depth of the soil to a restrictive layer influences site productivity. As mentioned in the association descriptions, many of the soils have a hardpan or compacted layer which impedes rooting. This restrictive layer defines the rooting zone which is available for plants to obtain their nutrients, moisture, oxygen, and support. Not only does this layer restrict rooting, but it also impedes drainage, which is undoubtedly very important in this region since the major problem for plants is to adjust to excess moisture (Valentine 1971). Thus, on flat sites with a hardpan, water would collect and saturate the soil above the impermeable layer, further restricting the volume of soil suitable for rooting. The importance of drainage to productivity has been previously discussed for associations.

The lack of correlation between soil nutrient parameters and site productivity estimates is not surprising due to: the problems associated with accurately assessing site productivity discussed previously; the interelationships between the site and soil variables; the inherent variablilty of the soil nutrient parameters; additional sources of nutrients not measured in the soil; and efficient internal cycling of nutrients by the trees. Previous studies have shown that relationships between tree growth and soil nutrient status may not be detectable because of short range soil variability (Mader 1963; Blythe and McLeod 1978). Sufficient samples must be collected in order to properly characterize the soil component of a forest site (Carter 1983). Since little soils information is available for the west coast of Vancouver Island, it is not known what the extent of the variability is for various nutrient parameters within a given site, or how many samples would be required to reduce this within-site variability. However, Carter (1983) from his findings, and in his literature review of Douglas-fir stands in the Pacific Northwest, indicated that a relatively large number of samples is needed for most soil parameters to reduce within-site variability. In this study, only three soil pits were sampled in each site. Consequently, if a particular nutrient had a large inherent variability, it would be useless for reflecting differences in productivity between sites. In addition, there are many complex interactions and interdependencies between site and soil variables, which make it difficult to isolate individual variables influencing tree growth. Lastly, the nutrient status of the soils may not be related to site productivity because the soils may not be the only, or the most important source of nutrients for plants on these sites. Additional sources of nutrients may include: seepage water (particularly on slopes with a restrictive layer); fog drip; salt spray (for sites in close proximity to the ocean); and periodic flooding (for areas adjacent to streams and rivers). In these old-growth stands, which are not actively growing, efficient internal cycling of nutrients may negate the need for large supplies of available nutrients. The thin litter layer, characteristic of most of the sites, suggests long-term foliage retention, since rapid decomposition is not likely. This implies that the trees are conserving nutrients by retaining their foliage and cycling nutrients internally.

Although effective soil depth has been used in developing regression equations for estimating site quality; no attempt was made to develop such a predictive equation from the results of this study, since the sampling was not designed for this purpose. To develop an estimating equation properly, sample plots must include and be equally distributed over the full range of site quality and soil features occurring in the study area.

> "The reason is that a proper description of the relations between site quality and site features depends not only on an adequate sampling of average conditions, but also on an adequate representation of extremes." (Carmean 1975).

The sample plots from this study represent a wide range of site condiditons and site quality, but they are not well distributed over this range of conditions. The extreme conditions (ie: very productive, very unproductive, very dry, and very wet sites) were not well sampled, and as illustrated by the association grouping of plots, the majority of plots are very similar. Consequently, the data from this study are not suitable for developing a predictive equation.

Discussion of Earthworms

Earthworms were observed in most (11 out of 14) of the study sites. This was considered to be unusual since earthworms are generally uncommon in acidic soils under conifers (Brady 1974). Also, it was believed that all the native earthworm populations on Vancouver Island had been eliminated during the last ice age. Existing populations were thought to have been introduced by settlers and thus, should only be common near inhabited areas, not in remote forests (Gates 1976; Reynolds 1977).

During the summer of 1981, a research crew (Gagnon and Spiers) doing ecological classification for MacMillan-Bloedel on western Vancouver Island noted earthworms in over 90 study plots located throughout the entire area outlined in Figure 5 (D. Gagnon and G. Spiers, pers. comm.)[3]. Earthworms collected from these study sites have been identified as a new species, *Arctiostrotus simplicigaster vancouverensis* (McKey-Fender and Fender 1982). More specifically, they are a newly discovered subspecies of an earthworm found in the Olympic Mountains of Washington.

These worms were found in a wide variety of sites, from sea level to 625 m elevation (Spiers *et al*. 1983). Gagnon (pers. comm.)[3] observed that they seemed to prefer sites where redcedar was dominant, and where most of the effective rooting took place in the organic horizons. They generally were not found in dry sites or sites with evidence of fire.

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[3] Department of Biological Sciences, Univ. Quebec, Montreal, Quebec; and Department of Soil Science, Univ. Alberta, Edmonton; respectively.

Brady (1974) reported that earthworms generally prefer a moist, well-aerated habitat; and are not common in droughty sands or poorly drained lowlands. Observations from the present study tend to support this claim. Earthworms were not found in the sites with the most extreme moisture regimes: the dry rock outcrop (818) and Port Albion bog (821) sites. Moreover, Spiers (pers. comm.)[3] has observed that the worms appear to be most observable and active during April, May, and June. During warmer, drier periods, and other unfavourable times, they burrow down into the mineral soil, tie themselves into a ball, and aestivate.

Unlike many species of earthworms, these worms do not function in the intermixing of organic material and mineral soil. They are active primarily, if not exclusively, in the organic horizons; and serve to break down organic materials, including wood from rotting logs. They are very tolerant of low pH. The pH (H_2O) of the humus horizons in which earthworms were found in the present study ranged from 3.5 to 5.9, with and average of 4.0. Interestingly, Cotton and Curry (1982) observed that surface-active species of earthworms were the most abundant colonizers of acidic peat (overlying mineral soil) in Dublin; soil-burrowing species were scarce. They suggested that pH tolerance ranges of earthworms may be wider in peat than in mineral soils where, below pH 5, there may be the additional stress of aluminum, iron, or manganese toxicity to biological systems (Donahue _et al_. 1977).

In general, earthworms are reportedly favoured by high levels of exchangeable bases and a high pH (Brady 1974). Worms observed in the present study were most abundant in plot 199-1, which had the highest pH (5.9) and levels of exchangeable calcium (52.4 meq/100g). However, from their study of 112 sites, Spiers _et al_. (1983) recorded the highest population of worms at a site where the pH (H_2O) was 2.9. This suggests that the ecological range of the earthworm described here is not specific to a narrow range of pH (Spiers _et al_. 1983).

Gagnon (pers. comm.)[3] has correlated earthworm abundance with a variety of site and soil characteristics (Spiers _et al_. 1983). He found a highly significant negative correlation (correlation coefficient = -0.53) between earthworm abundance and effective rooting depth. (The correlation coefficient is based on 97 plots, and is significant at the 0.05 level.) In other words, sites with large populations of earthworms tended to have fairly shallow rooting, concentrated in the organic horizons.

This phenomenon was observed in sites from the present study. Those sites in which earthworms were found typically had a dense mat of fine roots concentrated in the humus. Spiers _et al_. (1983) has found from closer (microscopic) inspection, that this humus, which often just appears as a dense mat of roots, is composed largely of earthworm casts. Similar rooting behaviour has been reported by New Zealand researchers studying the effects of earthworms on ryegrass plants (Sharpley _et al_. 1979; Sprigett and Syers 1979; Mansell _et al_. 1981). In both greenhouse and field experiments, ryegrass roots were observed to grow upward out of the soil into cast material which had been recently added to the surface (Sharpley _et al_. 1979; Sprigett and Syers 1979; Mansell _et al_. 1981).

From microscopic examination Spiers _et al_. (1983) has observed that root hairs actually penetrate the worm casts; suggesting an increased availability of plant nutrients therein (Brady 1974). Using ^{15}N as a tracer, he confirmed that these earthworms eat and process wood from hemlock logs (Spiers et al. 1983). He then analyzed woody material of hemlock logs before and after passage through earthworms, and found that the earthworm casts were higher in total nitrogen, phosphorus, calcium, potassium, pH; and had a lower C/N ratio (Table 16) (Spiers et al. 1982). He suggested that these results reflect negative elemental enrichment as a result of carbon utilization by either the worms and/or their gut bacteria (Spiers et al. 1983).

Although no one has studied this particular species of earthworm before, results from research on other earthworms (primarily on pasture land in New Zealand) lend support and interpretation to the findings of Spiers et al. (1983). Many authors have reported earthworm casts to be richer in total nitrogen, exchangeable NH_4 and NO_3, available phosphorus; and to have a lower C/N ratio (Brady 1974; Sharpley and Syers 1976, 1977; Syers et al. 1979; Mansell et al. 1981). Furthermore, the nutrients contained in casts (particularly N and P) are often present in forms which are more readily available for plant uptake than those in soil or litter (Barley and Jennings 1959; Brady 1974; Sharpley and Syers 1976, 1977; Abott and Parker 1981; Mansell et al. 1981). Earthworms not only decompose organic material themselves, but they also stimulate the activity of other decomposers (Barley and Jennings 1959). Plant material which has been subjected to chemical and physical changes during passage through an

Table 16: Compositional changes in woody materials after passage through earthworm gut

Element	Wood	Fecal Material	Actual Change	(%) Change
		Elemental Composition		
		(%)		
C	49.40	48.68	-0.72	1.5
N	0.87	1.29	0.42	48.3
C/N	57	38		
pH	4.1	4.6		
		$ug.gm.^{-1}$		
P	127	510	383	302
Ca	2597	2133	-439	20.6
K	198	255	57	28.8
Mg	610	720	110	18

(reproduced from Spiers _et al_. 1983)

earthworm gut, is readily attacked by other decomposers (Barley and Jennings 1959); contains increased microbial populations (Parle 1963), bacteria (Brady 1974), and mycelia (Spiers et al. 1983); and exhibits increased rates of mineralization and nitrification (Parle 1963; Syers et al. 1979), compared with soil and organic materials. To summarize, previous studies indicate that earthworms have very favourable effects on soil productivity by stimulating biochemical activities and increasing nitrogen and phosphorus cycling (Syers et al. 1979; Abbott and Parker 1981; Mansell et al. 1981; Ross and Cairns 1982).

The function and importance of earthworms in west coast forest ecosystems is not clearly understood. The results from Spiers et al. (1983), and those from other earthworm studies reported in the literature, suggest that earthworms on these sites play a very important role in decomposition and nutrient cycling. The nutritional status of many soils on western Vancouver Island is characteristically very poor. The mineral horizons are heavily leached by the excessive rainfall of the region. Thick layers of organic matter accumulate on the surface and immobilize nitrogen and other nutrients. Many decomposing agents, such as nitrifying bacteria, are very limited or absent in these organic horizons due to the unfavourable, acidic conditions. Consequently, decomposition and nutrient cycling are very slow. "It is known that with increase of accumulation of organic material, podzolization increases. It is also known that with increase of podzolisation the site index decreases." (Eis 1962). It follows then, that any agent which promotes the continuous breakdown of organic matter, and subsequent release of nutrients, is vital to the productivity of these sites.

The maintenance of existing earthworm populations is dependent upon careful silvicultural practices. On a site which had been recently slashburned (with a fairly hot fire), Spiers (pers. comm.)[3] found little or no evidence of earthworms, except under a log where the humus had been protected from the fire. In that one log length area, he found 6 earthworms. This would suggest that forest managers should attempt to conserve humus layers if they want to maintain earthworm populations. In addition, the use of insecticides and other chemicals which may be harmful to earthworms should be avoided. The treatment of a pasture in New Zealand with the insecticide carbaryl depleted the existing earthworm population and, in the absence of earthworm activity, resulted in increased litter production (Sharpley *et al.* 1979). As mentioned, the breakdown of organic matter is important in nutrient cycling and influences site productivity.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The observations and findings from this study on the site requirements of redcedar are in general agreement with those presented in the literature. The amount of available soil moisture is reported to be the most important criterion for redcedar growth (Sudworth 1908; Knapp and Jackson 1914). On western Vancouver Island, where precipitation is abundant and lack of soil moisture is rarely a limitation to plant growth, redcedar was found growing on virtually all sites - from wet bogs to rock outcrops.

Reports found in the literature claim that the best development of redcedar occurs on deep, fertile soils, with abundant moisture and adequate drainage (Boyd 1959; McMinn 1960; Krajina 1969; Sharpe 1974; Hosie 1979). Findings from this study support this claim. Of the 14 sites sampled, the best productivity of redcedar (as estimated by SI) was found on a floodplain site with deep, rich, well-drained soils (sites 513 with SI=45.7). The lowest productivity of redcedar occurred on rock outcroppings and boggy sites (sites 818, 300, and 821) which had shallow, infertile soils and extreme moisture conditions (SI=9.1, 16.3, and 13.9, respectively). Furthermore, the productivity of western redcedar, as estimated by site index, was found to be correlated with soil depth (ie: depth to a restrictive layer, total rooting depth, and effective rooting depth). In this region, where rainfall is excessive, and many soils are underlain by a compacted layer, drainage is often a critical problem. Deep soils, with no restrictive layer, permit drainage, are well-aerated and provide a large zone for rooting, nutrient cycling and anchorage. Whereas shallow soils on flat sites, with a restrictive layer near the surface, had impeded drainage; saturated, anaerobic conditions; limited decomposition and nutrient cycling; and poor anchorage.

Although no correlations were found between site productivity and soil nutrients measured by chemical analyses, results from this study indicated that productivity of redcedar is strongly related to nutrient conditions. The most productive sites were situated either on seepage slopes, and presumedly received inputs of nutrients through seepage water (sites 151, 144); or were situated on fertile floodplains and had rich nutrient regimes as reflected by indicator plant species (sites 513, 315, 1092). The indicator plants on the unproductive sites reflected poor nutrient conditions.

The function and importance of a new species of earthworm found on the study sites is not yet clearly understood. However, the results from Speirs et al. (1983), and those from other earthworm studies reported in the literature, suggest that these earthworms play a very important role in decompostion and nutrient cycling. In western Vancouver Island, silvicultural practices which enhance earthworm populations may be important for maintaining site productivity.

Recommendations

The assessment of site productivity was a difficult task, primarily due to the age and structure of the stands being studied, and the lack of information available for this species and region. Future soil/studies of this nature may be more successful if:

1) a more reliable estimate of productivity is obtained by:
   a) sampling even-aged, second-growth stands,
   b) conducting stem analyses,
   c) validating existing site index curves or developing new curves for this region;
2) better measures of the factors controlling productivity are obtained, which might involve:
   a) foliar analysis of nutrients,
   b) estimating bulk density of soil horizons in the field, to allow soil nutrients to be expressed in terms of kg/ha,
   c) analysis of soil samples for mineralizable nitrogen, in addition to total nitrogen; and
3) the sample plots are evenly-distributed over the entire range of site conditions.

For quick site diagnoses, this study has suggested that the assessment of indicator plant species, physical soil characteristics and site position may provide the most useful information.

Evaluation of the best opportunities available for future development of forestry in B.C. has led silviculturists at MacMillan-Bloedel to suggest that western redcedar is one of our most valuable species. Current knowledge of the silviculture of redcedar is minimal. The growth and yield of redcedar and its associates need to be studied on a variety of sites, under different silvicultural regimes to determine the effects of stand density, species composition, fertilization, and thinning on productivity. Studies should include, but not be limited to those sites on which redcedar is reported to be most productive. Redcedar is able to adapt to a wide range of edaphic and physiographic conditions and it is often relatively productive on sites which are unsuitable for other species. These sites need to be identified since they provide an opportunity for redcedar management.

The following are further suggestions of work that should be conducted for western redcedar:

-initiate a tree improvement program,

-improve current methods of propagation and nursery culture,

-determine factors which contribute to regeneration failure,

-develop regional site index tables or validate existing ones,

-determine the quality and quantity of wood that can be produced under different silvicultural regimes, and

-determine the long-term effects of various management practices on site productivity for western Vancouver Island.

In addition to conducting formal research, operational trials should be implemented. Some operational trials are being conducted on northern Vancouver Island which may provide some very important information (Nuszdorfer, pers. comm.)[4]. The redcedar which is being planted on western Vancouver Island should be carefully monitored. Advantage should be taken of every opportunity which may provide information about redcedar.

Methods of propagating, growing and managing western redcedar should not be limited to the conventional practices used for other species. Redcedar is very adaptable and resilient and lends itself to new techniques. Ideas may be obtained from studying practices which have been developed in other countries. In Japan, clonal plantations of Sugi, *Cryptomeria japonica*, have been grown successfully for over 400 years (Weetman, pers. comm.)[5]. Redcedar, with its inherent resistance to disease and insect attacks may be well-suited for such propagation. In the British Isles, poles and pilings are being produced from plantation grown redcedar (Edlin 1962). Minore (1979) suggests that in mixed conifer stands, redcedar could provide an interim pole crop that would help to carry Douglas-fir and western hemlock to financial maturity. Bolsinger (1979) suggested that redcedar be grown in long rotations in narrow stream-side protection zones, and logged selectively to minimize streambank disturbance. Such a management scheme would provide stream protection, esthetic forest cover, and production of high quality redcedar wood for special products.

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The option for western redcedar as a viable plantation species in British Columbia should be developed. Success will only be achieved with much additional research, an innovative management philosophy, and a commitment from government and industry to grow this species.

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APPENDIX 1

Explanation of terms and symbols used in tables

Drainage Classes

VR - very rapidly
R - rapidly
W - well
MW - moderately-well
IMP - imperfectly
P - poorly
VP - very poorly

Soil Parent Material

FL - fluvial
GF - glaciofluvial
W - marine
GW - glaciomarine
M - morainal
L - lacustrine
C - colluvial

Soil Moisture Regimes

VX - very xeric
X - xeric
SX - subxeric
SM - submesic
M - mesic
SHG - subhygric
HG - hygric
SHD - subhydric
HD - hydric

Soil Texture

S - sand
LS - loamy sand
SL - sandy loam
SCL - sandy clay loam
SiL - silt loam
L - loam
SiCL - silty clay loam
CL - clay loam
SiC - silty clay
Org. - organic
sk - skeletal
frag. - fragmental
f - fine

Absolute Hygrotope Categories

VD - very dry
D - dry
DF - dry to fresh
DM - dry to moist
FM - fresh to moist
MW - moist to wet
W - wet

Absolute trophotope categories

VP - very poor
PM - poor to medium
M - medium
MR - medium to very rich

APPENDIX 1 (cont'd)

Soil Type	
HP	- Humic Podzol
OHP	- Orthic Humic Podzol
OT.HP	- Ortstein Humic Podzol
DHP	- Duric Humic Podzol
PHP	- Placic Humic Podzol
FHP	- Ferro-Humic Podzol
OFHP	- Orthic Ferro-Humic Podzol
GFHP	- Gleyed Ferro-Humic Podzol
OT.FHP	- Ortstein Ferro-Humic Podzol
GHFP	- Gleyed Humo-Ferric Podzol
HG	- Humic Gleysol
OHG	- Orthic Humic Gleysol
OG	- Orthic Gleysol
SB	- Sombric Brunisol
OSB	- Orthic Sombric Brunisol
DB	- Dystric Brunisol
ODB	- Orthic Dystric Brunisol
OR	- Orthic Regosol

Growth Classes (Krajina 1969)

Class	SI_{100} redcedar
1	>43.1
2	39.1 - 43.0
3	35.1 - 39.0
4	31.1 - 35.0
5	27.1 - 31.0
6	23.1 - 27.0
7	19.1 - 23.0
8	15.1 - 19.0
9	<15.0

Site Classes (Hegyi *et al.* '79)

Class	SI_{100} redcedar
good	>39.6
medium	27.5 - 39.6
poor	15.3 - 27.4
low	<15.2

effective rooting depth - the total depth of organic and mineral horizons to which roots have and abundance value of "few" or greater

total rooting depth - the total depth to which roots extend from the surface into the organic and mineral horions

APPENDIX 2: DETAILED DESCRIPTION OF THE STUDY SITES

The following appendix contains a description of each of the 14 study sites. Since there is a volume of data and information, much of it has been tabulated and is found in the appendices. The main purpose of the appendix is to summarize and highlight the information for each site; and to discuss, where relevant, the important differences (ie. variability) between plots within each site. The following appendices should be referred to as a supplement to this chapter:

Appendix 1: Explanation of terms and symbols used in tables

Appendix 3: List of plant species observed in sample plots

Appendix 4: Description of soil profiles

Appendix 5: Tables of soil chemical data

Appendix 7: Vegetation tables for associations

The site descriptions have been organized by associations in the following order:

Stand 818 : Dry Rock Outcrop
Stand 819 : Rock Outcrop
Stand 131 : Sarita Beaver Pond
Stand 144 : Sarita Clearcut
Stand 151 : Sarita Seepage Slope
Stand 152 : Pachena Main Line
Stand 109 : Grice Bay
Stand 199 : Ucluelet Slope
Stand 150 : Mercantile Creek
Stand 300 : Ucluelet Scrub
Stand 821 : Port Albion Bog
Stand 1092 : Kennedy Second Growth
Stand 315 : Kennedy Floodplain
Stand 513 : Sproat Lake .

Study Sites of Association 1.11 : Cladino-Tsugetum

STAND 818 : Dry Rock Outcrop

Reference: Sample plots 818-1, 818-2; Table 17; Figures 6, 7, 35; Appendices 1, 4, 5, 7.

Stand 818 is not actually a stand, but rather two plots with many similar site characteristics, that were grouped together to represent one site type. Originally these two plots were going to be grouped with plots 819-1 and 819-2 to represent rock outcrop communities. However, there was considerable dissimilarity between the four plots, so it was decided to describe them as two separate sites.

Plot 818-1 is situated on a rock outcrop along Highway 4, east of Kennedy Lake, but west of site 819. The site is strongly sloping, with a southwest aspect, at an elevation of 60 m.

Plot 818-2 is also situated on a rock outcrop along Highway 4, west of site 819 and plot 818-1. It overlooks a small lake which is located near the point where the Kennedy River joins the Kennedy Lake. This site has a northwest aspect, is very strongly sloping, and is at an elevation of 75 m. Of the four plots on rock bluffs, this plot is situated on the most severe site.

Due to the severe site conditions, the trees on these plots are very small, stunted, and slow-growing. The trees on plot 1 are approximately 250 years old, but average only 15 m in height. The trees on plot 2 are even more stunted, averaging 6.5 m in height at ages of 150 to 450+ years.

In spite of the difference in tree height between the two plots, their basal areas and relative densities are similar (Table 17), indicating similar tree diameters. The basal area for this site is the lowest of the fourteen study sites: 17.8 m^2/ha.

One very noticeable difference between this site and site 819 is the species composition. The main tree species are Chamaecyparis nootkatensis (yellow cedar), Thuja plicata, and Tsuga heterophylla, which make up 28%, 27%, and 22% of the basal area respectively. Shore pine (Pinus contorta var. contorta) is very dominant in plot 1, but accounts for only 8% of the combined basal area of the two plots. Western white pine is a minor component of both plots.

The tree canopy is quite open, so the understory vegetation receives some direct sunlight. The understory layers are not dense, but they are well-developed. The shrub layer is fairly light and consists of salal, vacciniums, and false azaela. The dominant species in the herb layer are bunchberry, twinflower, and false lily-of-the-valley. Mosses and lichens are very abundant and include Rhytidiadelphus loreus, Hylocomium splendens, Dicranum scoparium, Cladina spp. and Cladonia spp. (App. 7).

Regeneration in this site is very abundant. Western redcedar is exceptionally prolific in both the herb and shrub layers. Regeneration of western hemlock, shore pine, and yellow cedar is also present.

The soils of site 818 are very similar to those of site 819: very shallow and sparse, with exposed bedrock covering approximately 35% of the surface area. They can be classified as Typic Folisols and "Lithic Podzols" over bedrock. They are rapidly to very rapidly drained and have a xeric moisture regime.

Table 17: Environmental data for stand 818

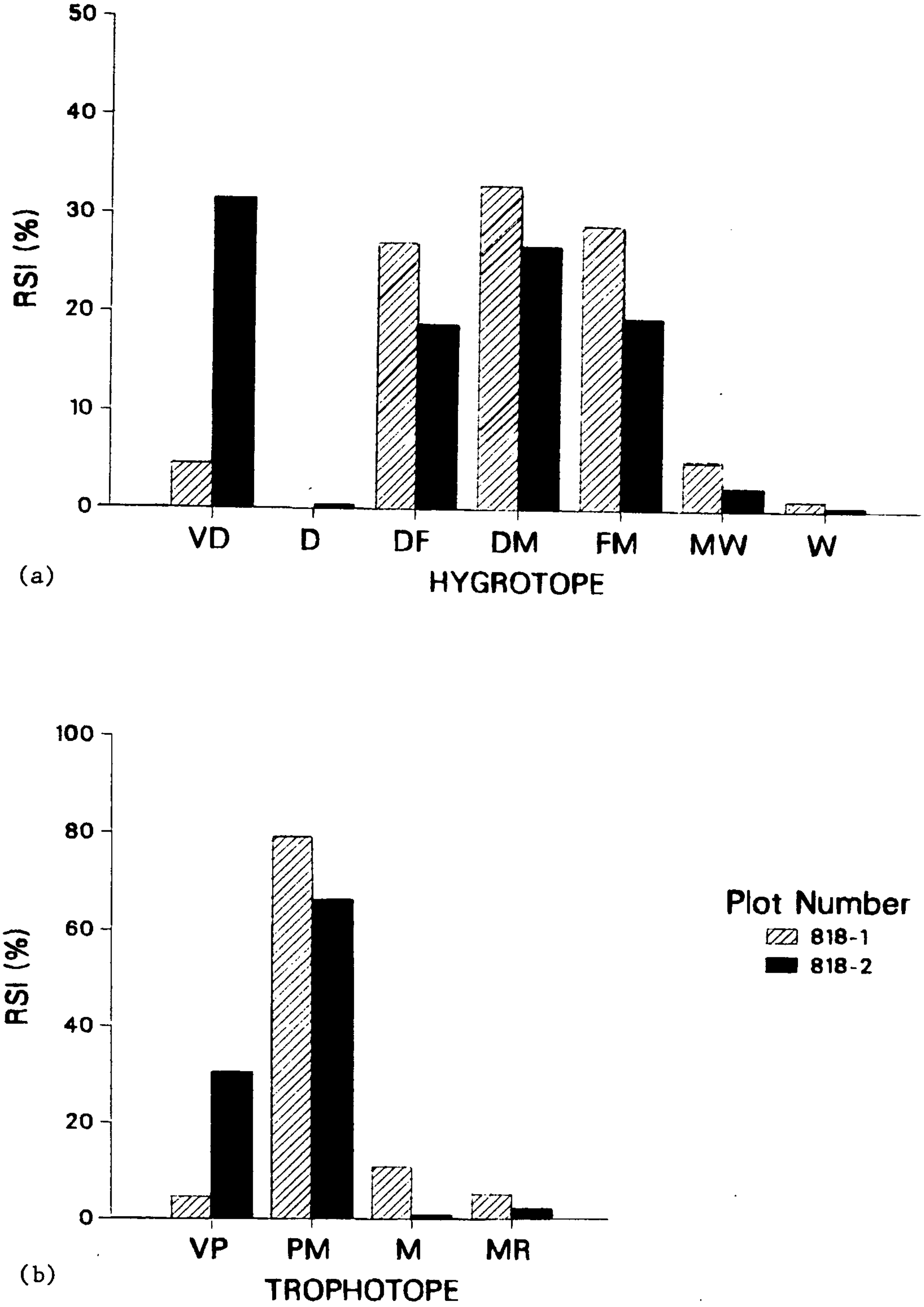
Characteristic	818-1	818-2
Elevation (m)	60	75
Aspect (^{o})	207	316
Slope gradient (%)	30	32
Macrosite position	lower slope	apex
Mesosite position	mid-slope	upper slope
Microtopography (moundedness)	ultra-	extremely
Surface shape	undulating	undulating
Soil parent material	bedrock,colluvium	bedrock,colluvium
Soil moisture regime	xeric	xeric
Soil drainage class	rapid	very rapid
Soil type	Typic Folisol	"Lithic Podzol"
Family particle-size class	organic	loamy skeletal
Forest floor thickness (cm)	9	5
Depth of Ah horizon (cm)	--	20
Total rooting depth* (cm)	7	20
Depth to restrictive layer* (cm)	7	0-40
Depth to bedrock* (cm)	7	0-40
Effective rooting depth* (cm)	7	20
Basal area (m^2/ha)	20	17
Relative density (stems/ha)	540	640

(* includes depth of organic horizons)

The soils of plot 1 consist only of organic horizons; thus, the classification of Typic Folisol. There is a thin (1-3 cm) litter layer, which is made up largely of wood from fallen trees. The humus is dry, felty, sawdust-like, with white and yellow fungal mycelia and abundant roots. It varies in thickness from 5 to 8 cm.

The soils in plot 2 have an Ae horizon in addition to organic layers similar to those described above; thus, they can be classified as "Lithic Podzol". The Ae horizon has a high content of cobbles and stones; and varies in depth from 0 to 40 cm.

This site could not be considered for commercial forest production. The site is highly unproductive due to the severe lack of moisture and subsequent slow rates of decomposition and nutrient cycling. The poor moisture and nutrient conditions are reflected by the indicator plant species. This is the only site which has plants contained in the very dry and very poor edatope categories (Fig. 35). Tree heights, as mentioned, are very low. The site index for redcedar was calculated as 13.9, for plot 1; and 5.6, for plot 2. Both plots are growth class 0 for redcedar. Plot 1 is site class (high) low, and plot 2 is site class (low) low for redcedar.



(a)

(b)

Figure 35: A plot of the edatopic indicator species groups for the 2 sample plots of Stand 818, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

STAND 819 : Rock Outcrop

Reference: Sample plots 819-1, 819-2; Table 18; Figures 8, 36; Appendices 1, 4, 5, 7.

Site 819 is a rock outcrop located east of Kennedy Lake, along Highway 4 (between Port Alberni and Ucluelet) (Fig. 5). Only two plots were sampled in this site. Plot 1 is situated behind a bluff which overlooks the highway and the Kennedy River. Plot 2 is located south of plot 1, farther back from the highway. The site is not necessarily on MacMillan-Bloedel land.

The site is situated at the base of a mountain. It is very strongly sloping, with a northwest aspect, at an elevation of approximately 77 m (Table 18). The topography is very irregular; extremely mounded and broken. Approximately 20% of the surface area is covered by exposed bedrock and very large boulders (colluvium).

The existing forest, probably of fire origin, consists of numerous (660 stems/ha) small-sized trees. Many of the trees are of poor form, with broken or spiked tops. The basal area is low (62.2 m^2/ha) due to the small tree-size and semi-open canopy. Western redcedar forms a major portion of the main canopy and accounts for 39% of the basal area. Western hemlock is the most abundant tree on the site (253 stems/ha). It outnumbers redcedar two to one, but only makes up 27% of the total basal area, due to its small diameters. There are only a few (27 stems/ha), veteran (350+ yrs) Douglas-fir trees scattered throughout the stand; but

Table 18: Environmental data for stand 819

Characteristic	819-1	819-2
Elevation (m)	78	75
Aspect (°)	207	335
Slope gradient (%)	30	32
Macrosite position	lower slope	lower slope
Mesosite position	crest	crest
Microtopography (moundedness)	ultra-	severely
Surface shape	undulating	undulating
Soil parent material	bedrock,colluvium	bedrock,colluvium
Soil moisture regime	subxeric	subxeric
Soil drainage class	rapid	rapid
Soil type	"Lithic Podzol"	"Lithic Podzol"
Family particle-size class	loamy	loamy
Forest floor thickness (cm)	19	20
Depth of Ah horizon (cm)	8	3
Total rooting depth* (cm)	27+	18
Depth to restrictive layer* (cm)	27	18
Depth to bedrock* (cm)	27	18
Effective rooting depth* (cm)	27	18
Bulk density, humus (g/cc)	0.12	0.18
Basal area (m^2/ha)	62	63
Relative density (stems/ha)	720	600

(* includes depth of organic horizons)

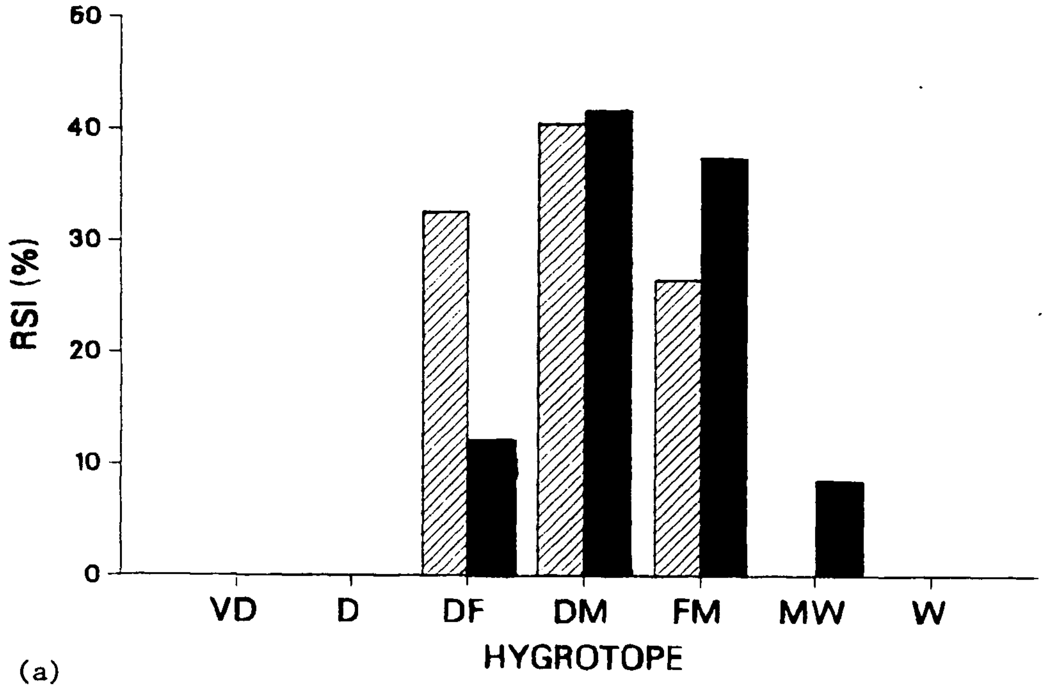
they are very large, and comprise 31% of the basal area. Amabilis fir is a very minor component of the stand.

The understory vegetation is sparse and scattered. The shrub layer is light and consists of salal, Vaccinium alaskaense, V. parvifolium, and Menziesia ferruginea. There are only a few fern species in the undeveloped herb layer: deer fern, sword fern and licorice fern. Mosses are very abundant. Many of the large boulders are covered with a dense carpet of moss. The most common species are Hylocomium splendens, Rhytidiadelphus loreus, and Kindbergia oregana. Regeneration of western hemlock is extremely abundant on this site. Western redcedar and amabilis fir seedlings are also very numerous.

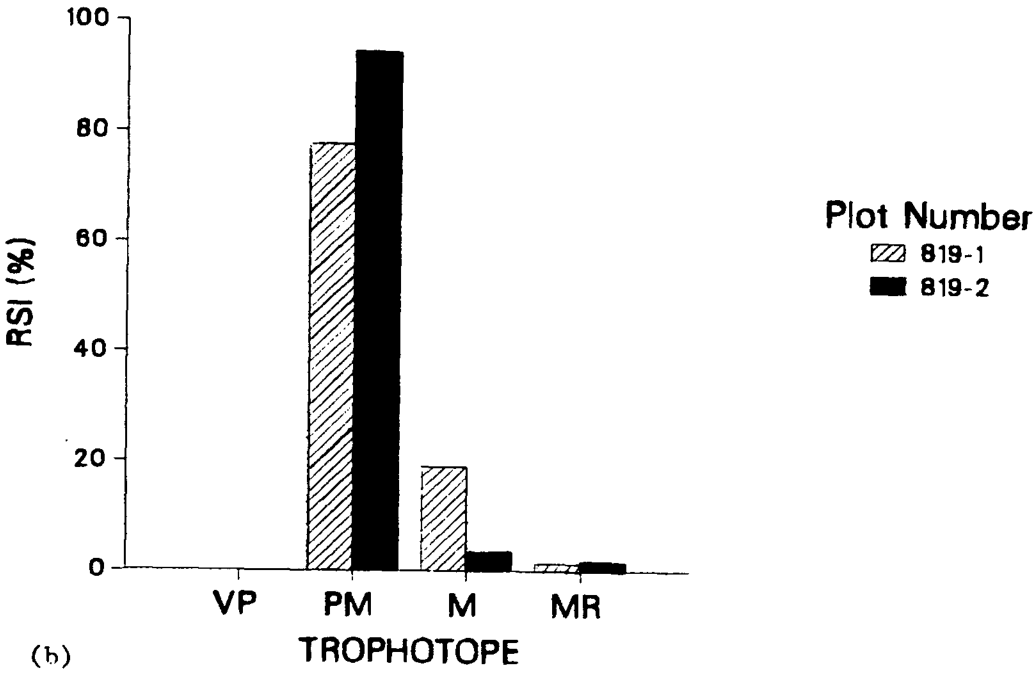
The soil is very shallow and sparse, with areas of exposed bedrock. It has developed from weathering of parent materials (bedrock and colluvium) and decomposition of organic matter. The soil may be classified as loamy "Lithic Podzol"; and consists of a thin litter layer; a humus layer, 0-15 cm thick; and a thin, discontinuous Ae horizon (0-5+ cm). Although the bedrock is very close to the surface, the soil and rooting continue to greater depths through cracks and fissures in the rock. The fine roots are concentrated in the humus; which is dry, light, and fluffy; similar to sawdust or peatmoss. Earthworms were observed in the humus, and are probably responsible for some intermixing between the humus and Ah horizon. Due to the relief position of the site, drainage is rapid and the soil is of subxeric moisture regime. Moisture is undoubtedly limiting to plant growth during parts of the growing season. Vegetation is most vigorous in depressions where moisture is conserved in accumulated organic matter.

The indicator plant species on this site reflect a somewhat moister hygrotope than site 818, with no plants in the very dry or dry categories (Fig 36). They also indicate a relatively poor nutrient regime.

In spite of the severe site conditions, productivity (as measured by site index) of western redcedar was surprisingly good. A site index value of 24.3 was estimated for redcedar from average height (27.3 m) and age (231+ yrs) values. This corresponds to site class (high) poor and growth class 6 for redcedar. From the few (3) Douglas-fir trees which were measured, the site index of fir was found to be higher than that of redcedar. The site index of Douglas-fir was estimated as 32.3 from average height and age values of 34.5 m and 336+ years. Thus, site 819 can be classed as site class (low) medium and growth class 6 for Douglas-fir. Nevertheless, productivity would be much too low for commerial purposes, and the site is fragile and would require careful management practices.



(a)



(b)

Figure 36: A plot of the edatopic indicator species groups for the 2 sample plots of Stand 819, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

Study Sites of Association 2.11 : Blechno-Thujetum Association

STAND 131 : Sarita/Beaver Pond

References: Sample plots 131-1, 131-2, 131-3; Table 19; Figures 12, 37; Appendices 1, 4, 5, 7.

Stand 131 is located in MacMillan-Bloedel's Franklin-Sarita division. The area is gently to moderately sloping, at an elevation of 125 m (Table 19). Plot 1 is somewhat depressional, plot 2 is relatively flat, and plot 3 is slightly upslope.

Stand 131 is an overmature forest characterized by very large, old trees of low vigor (poor to fair). Western redcedar dominates the upper canopy and accounts for over 78% of the total basal area of 151 m^2/ha. Many of the redcedars are old, decadent veterans (482+ yrs) of poor form; often with candelabra, forked or spiked tops. Western hemlock makes up 14% of the stand basal area and is present in all canopy layers. There are a few large, scattered western white pine and Douglas-fir trees in the main canopy, and some suppressed amabilis fir and western yews. Western white pine may, at one time, have been an important component of the stand. Presently, most of the pines are dead or dying; probably victims of the white pine blister rust.

The forest canopy has some openings due to a number of large blowdowns. This allows some sunlight to penetrate to the forest floor which is largely covered with acidic, decaying coniferous wood. Such

Table 19: Environmental data for stand 131

Characteristic	131-1	131-2	131-3
Elevation (m)	122	125	130
Aspect (^{o})	121	90	103
Slope gradient (%)	10	7	14
Macrosite position	mid-slope	mid-slope	mid-slope
Mesosite position	lower slope	mid-slope	upper slope
Microtopography (moundedness)	moderately	slightly	moderately
Surface shape	concave	straight	convex
Soil parent material	morainal	morainal	morainal
Soil moisture regime	hygric	hygric	hygric
Soil drainage class	imperfect	imperfect	imperfect
Seepage water	absent	absent	present
Soil type	OT.HP	OHP	OT.HP
Family particle-size class	loamy sk.	loamy sk.	loamy
Forest floor thickness (cm)	13	17	8
Depth of Ah horizon (cm)	--	--	8
Depth of Ae horizon (cm)	7	12	14
Total rooting depth* (cm)	19	69	36
Depth to restrictive layer* (cm)	19	81+	36
Effective rooting depth* (cm)	12	27	16
Basal area (m^2/ha)	185	129	137
Relative density (stems/ha)	500	380	780

(* includes depth of organic horizons)

conditions favour regeneration of western hemlock (Krajina 1969; Inselberg *et al*. 1982). Hemlock is the most abundant tree species in the shrub and herb layers. Its numbers are approximately twice those of western redcedar. Western yew and amabilis fir are, at most, incidental in the shrub and herb layers.

Regeneration is only a minor component of the shrub layer. *Gaultheria shallon* (salal) is the dominant shrub species. It is extremely dense and very tall; often reaching a height of over 2 m. Other common, but less abundant species in the shrub layer include *Vaccinium parvifolium*, *V. alaskaense*, *V. ovatum*, and *Menziesia ferruginea*.

The herb layer is dominated by deer fern (*Blechnum spicant*) which is quite vigorous, and has a wide coverage (75%). Licorice fern (*Polypodium glycyrrhiza*) is sparse, but grows on some trees in each of the three plots. A complete list of the species and their respective coverages can be found in the vegetation tables in Appendix 7.

The soils of the three sample plots have been described and analyzed (App. 4 and 5). The soils have developed on morainal material, and may be classified as loamy-skeletal (Ortstein) Humic Podzol. The colour of the B horizon(s) suggests that these soils are Ferro-Humic Podzols, but they do not meet the requirement of 5% organic carbon in the B horizon. The B horizons are cemented (ortstein?) and contain approximately 40% gravels and cobbles, by volume. This restrictive layer is largely responsible for the imperfect drainage and subhygric to hygric moisture regime of the site. In addition, it limits rooting almost entirely to the organic horizons. Some roots extend into the Ae horizon, but few or no roots can penetrate the B horizons.

The organic component of the soils consists of a very thin litter layer; a sparse, discontinuous F horizon; and a thick (2-25 cm) humus layer. The humus can be classified as humimor humus (Klinka et al. 1981). It is very strongly acidic (pH 3.5 (H_2O)) due to the abundance of decaying wood and has a high moisture holding capacity. In spite of the acidity, the humus was observed to support an active population of soil fauna, including earthworms. They undoubtedly play a key role in decompostion and nutrient cycling.

It is no surprise that the majority of the redcedar feeding roots are concentrated in the humus, since this layer contains the highest levels of nutrients (App. 5), and is probably the most active region of nutrient cycling in the soil solum. The mineral horizons are not only physically poor, due to cementation; but also nutritionally poor, due to heavy rains and consequent leaching. The mineral soil contains very low levels of organic carbon, total nitrogen, available phosphorus, and exchangeable cations (App. 5).

The indicator plant species on this site reflected the poor nutrient regime, with almost all of the species contained in the poor-medium trophotope category (Fig. 37). The edatopic conditions of the three plots appear to be very similar, as suggested by the spectrum of edatopic indicator species groups (Fig. 37).

The site index for western redcedar on this site was estimated to be 28.3. This value was obtained from coastal site index tables ; using the mean height value (32 m) for dominant and codominant redcedars measured in the stand; and the mean age of redcedar (397+ yrs), was estimated from increment cores and ring counts of stumps. From this site index, Stand 131 can be classified as growth class 5, and site class (low) medium.

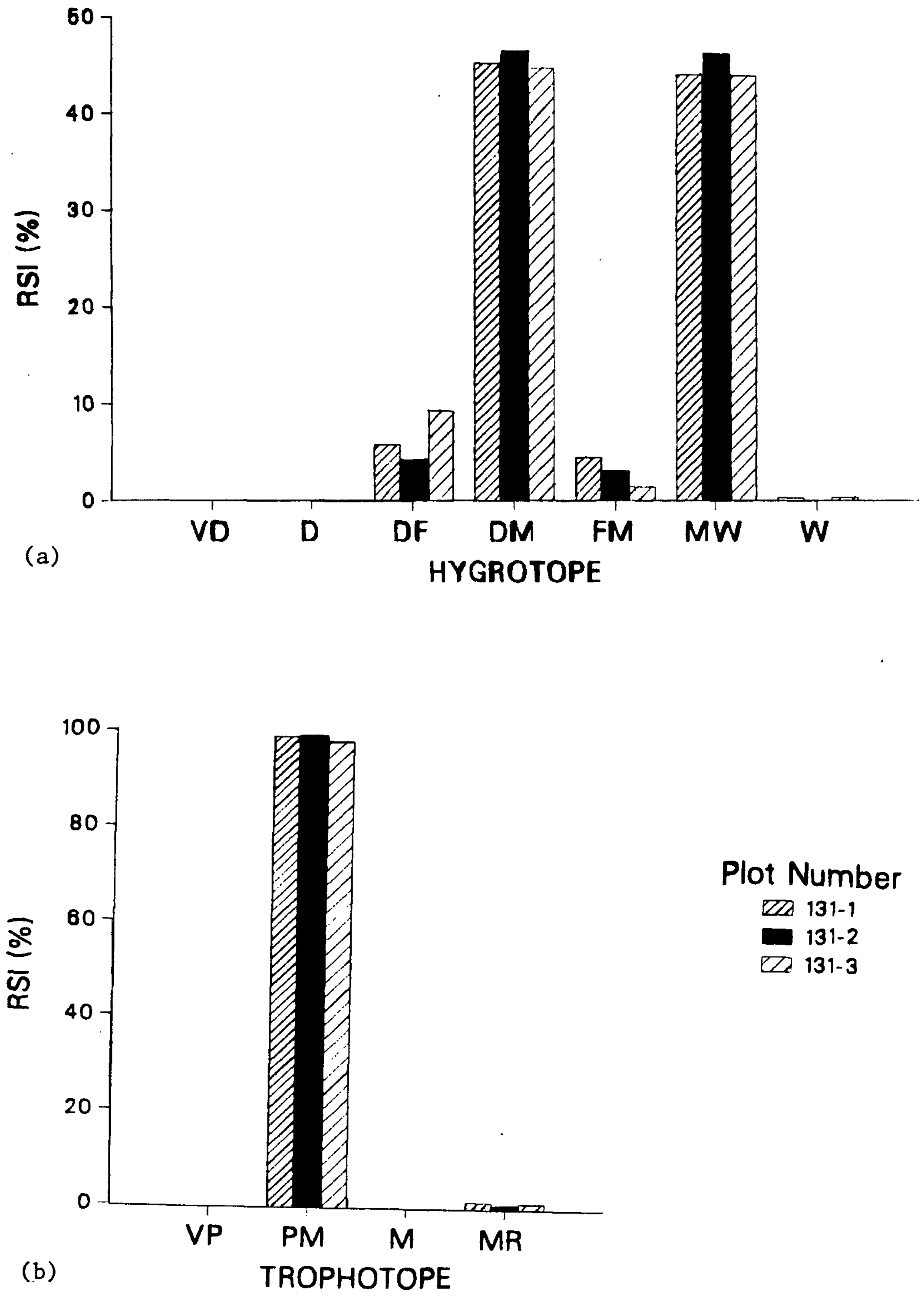


Figure 37: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 131, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

STAND 144 : Sarita Clearcut

Reference: Sample plots 144-1, 144-2, 144-3; Table 20; Figures 10, 11; Appendices 1, 4, 5, 7.

Stand 144 is located in MacMillan-Bloedel's Sarita division, above the Pachena River, off branch road 417B. The plots are situated in a mid-slope position on a strong slope (21%), of southeast aspect,at an elevation of approximately 110 m (Table 20). Prior to sampling, the stand was clearcut, but not burned. Consequently, little or no standing vegetation remained. However, it was possible to identify and measure the stumps, as they were intact.

Of the fourteen study sites, stand 144 has the highest basal area (233.5 m^2/ha). This figure may even be slightly underestimated since some stumps were probably buried, covered with slash, or destroyed by the logging operation, and thus not measured in the sample. The high basal area is predominantly comprised of a relatively small number (347 stems/ha) of extremely large individual trees. In fact, some stumps measured over 2.5 m in diameter. Western redcedar had been the dominant tree species of the stand, accounting for over 83% of the total basal area. Most of the redcedar stumps were very large, indicating that redcedar had probably dominated the main canopy of the stand. Western hemlock and amabilis fir made up 10% and 7% of the basal area, respectively, and probably held a codominant and/or intermediate crown position. Their diameters were generally much smaller than those of the redcedar stumps.

Table 20: Environmental data for stand 144

Characteristic	144-1	144-2	144-3
Elevation (m)	115	108	105
Aspect (°)	120	125	148
Slope gradient (%)	22	24	17
Macrosite position	mid-slope	mid-slope	mid-slope
Mesosite position	depression	mid-slope	depression
Microtopography (moundedness)	slightly	slightly	slightly
Surface shape	concave	straight	concave
Soil parent material	morainal	morainal	morainal
Soil moisture regime	subhygric	subhygric	sybhygric
Soil drainage class	mod. well	mod. well	mod. well
Soil type	GFHP	GFHP	GFHP
Family particle-size class	sandy	loamy sk.	loamy
Forest floor thickness (cm)	8	18	29
Depth of Ae horizon (cm)	12	3	12
Total rooting depth* (cm)	60	76	54
Depth to restrictive layer* (cm)	60	76	73
Effective rooting depth* (cm)	41	20	36
Basal area (m^2/ha)	347	182	171
Relative density (stems/ha)	460	340	240

(* includes depth of organic horizons)

The redcedar trees were not only very large, but also very old. Growth rings were counted from 11 large redcedar stumps. The average age was over 450 years, and one individual was 849 years old.

It was not possible to describe accurately the understory vegetation as it had been since most of it was destroyed by the logging operations. However, the remaining vegetation indicated that the site probably had an understory similar to stand 131: a shrub layer dominated by salal with admixtures of *Vaccinium parvifolium*, *V. alaskaense*, *Menziesia ferruginea*, and *Taxus brevifolia*; and a herb layer comprised mainly of deer fern. All three tree species were observed to be regenerating, but it was not possible to determine if this regeneration was advanced or recent.

The soils of stand 144 are similar to those of stand 133. They have developed on rubbly morainal deposits, and can be classified as Gleyed Ferro- Humic Podzol with Humimor humus. The soils are characterized by a well-developed eluviated A horizon; mottled, podzolic B horizons, enriched with organic matter (possibly a result of lateral seepage); and a cemented, cobbly C horizon. The effective rooting depth is deeper than that of stand 133 as cementation occurs in the C, rather than the B horizon. Nevertheless, rooting is most abundant in the organic and Ae horizons.

Although the forest floor has been disturbed by logging, the components are still recognizable. The organic profile is almost identical to that of stand 133: with a thin litter layer; no obvious F horizon; and a relatively deep humus layer. The humus, which appears to be well-worked by insects and earthworms, is light, porous and well-aerated; thus creating a favourable rooting medium. This horizon contains the highest levels of nutrients, including nitrogen, phosphorus, and exchangeable cations; which are relatively low in the mineral horizons (App. 5).

Stand 144 has many similarities to stand 133, but it probably has a higher potential productivity, due to its site position. The slope position and greater soil depth provide better drainage conditions (moderately well) and a more favourable moisture regime (subhygric). Furthermore, the soils probably receive an additional supply of nutrients through seepage water. Unfortunately, since the stand was clearcut, it was impossible to measure any tree heights or determine the site index.

STAND 151 : Sarita Seepage Slope

Reference: Sample plots 151-1, 151-2, 151-3; Table 21; Figures 13, 15, 16, 38; Appendices 1, 4, 5, 7.

Stand 151 is located in MacMillan-Bloedel's Sarita division, south of the Pachena Main Line. Plots 1 and 3 are situated below branch road 431A, while plot 2 is accessible from branch road 428A. The site is moderately to strongly sloping and has a northwest exposure. Plots 1 and 3 are at mid-slope position at an elevation of approximately 180 m. Plot 2 is farther downslope at 112 m elevation (Table 21).

Stand 151 is an overmature stand characterized by many large blowdowns. Western redcedar is the dominant species, accounting for 73% of the total basal area of 143 m^2/ha. Many of the redcedars are very large, old veterans. The oldest measured redcedar was 640 years of age. The stand has an admixture of amabilis fir and western hemlock, in about equal propotions (15% and 12% of the basal area respectively). Individuals of these species are present in all layers of the canopy, and tend to be much smaller in diameter than redcedar.

Regeneration of western hemlock is abundant, probably due to the favourable conditions created by an accumulation of acidic, decaying wood on the forest floor. There are also a few scattered western redcedar, amabilis fir, and western yew seedlings and saplings.

The understory vegetation is fairly open and easy to walk through. Salal is the dominant shrub species, but its coverage (25%) is relatively

Table 21: Environmental data for stand 151

Characteristic	151-1	151-2	151-3
Elevation (m)	178	112	189
Aspect (^{o})	345	319	314
Slope gradient (%)	15	15	30
Macrosite position	mid-slope	lower slope	mid-slope
Mesosite position	mid-slope	upper slope	mid-slope
Microtopography (moundedness)	slightly	moderately	moderately
Surface shape	concave	concave	concave
Soil parent material	morainal	morainal	morainal
Soil moisture regime	subhygric	subhygric	sybhygric
Soil drainage class	IM -MW	IM -MW	mod. well
Free water	seepage	perched	perched
Soil type	GFHP	GFHP	GFHP
Family particle-size class	loamy	sandy sk.	loamy sk.
Forest floor thickness (cm)	16	16	8
Depth of Ae horizon (cm)	16	4	2
Total rooting depth* (cm)	30	56	54
Depth to restrictive layer* (cm)	43	62	94
Depth to water table* (cm)	30	64	90
Effective rooting depth* (cm)	14	38	22
Bulk density, humus (g/cc)	0.09	0.13	--
Basal area (m^2/ha)	123	186	115
Relative density (stems/ha)	360	380	520

(* includes depth of organic horizons)

low and scattered. It is often growing close to the ground, and is not nearly as dense or as tall as in stand 131. Vaccinium parvifolium, and Menziesia ferruginea are also important components of the shrub layer.

Deer fern is abundant (60% coverage) in the herb layer, but other herb species are generally lacking. There is a sparse, but uniform coverage of mosses over the forest floor. The dominant species are Kindbergia oregana, Hylocomium splendens, and Rhizomnium glabrescens. A detailed species list is presented in the vegetation tables in Appendix 7.

The soils of stand 151 are Gleyed Ferro-Humic Podzols which have developed from morainal veneer over igneous bedrock. The derived soils are of a subhygric to hygric moisture regime, and are moderately well to imperfectly drained. They are relatively shallow (Fig. 15) and receive seepage along the bedrock interface (plot 3) (or cemented horizon), and through the mineral horizons (plot 1). The soils are similar to those of stand 144, except that the B horizons have a much higher content of organic matter; probably from inputs in seepage water.

The soils are characterized by an eluviated A horizon; and gleyed B horizons (Fig. 13) with a high content (20%-60% by volume) of sub-angular and sub-rounded coarse fragments. The B horizon underlying the Ae horizon has a high content (18-22%) of organic matter and is noticeably higher in total nitrogen than the other mineral horizons; and considerably higher than many other soil profiles (App. 5). Nevertheless, rooting is primarily contained in the organic horizons, which have the higher concentrations of nutrients.

The organic horizons consist of very thin L and F layers, and a deep (5-20 cm) humus layer. The humus is light in weight, full of roots, and appears to be well-worked by insects and earthworms. Some white fungal mycelia are present; probably associated with the decomposition of the abundant decaying wood.

The site index of redcedar was estimated from average height (38.9 m) and average age (368+ yrs) values, to be 34.6. This places stand 151 in site class (mid) medium and growth class 4 for redcedar. Of the 13 study sites for which the site index of western redcedar was calculated, this site had the second highest value. This relatively high productivity is probably a function of the site position. Drainage is improved due to the slope position, and in addition, supplies of organic matter and nutrients are received in seepage water. In spite of the favourable site position, the majority of the indicator plant species are contained in the poor-medium trophotope category; although they do reflect a slightly improved nutrient regime compared with Stand 133 (Fig. 38).

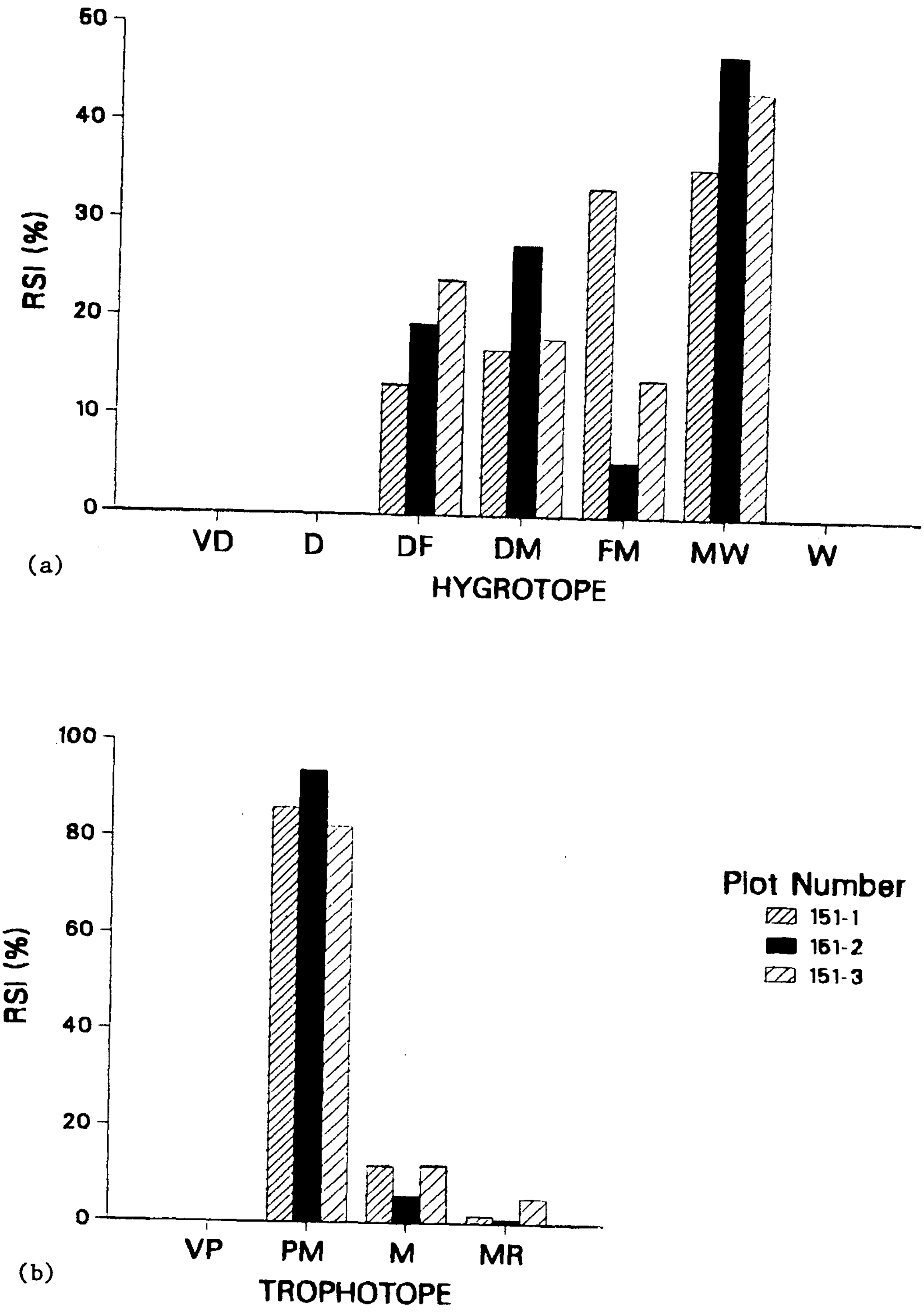


Figure 38: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 151, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

STAND 152 : Pachena Main Line

Reference: Sample plots 152-1, 152-2, 152-3; Table 20; Figures 9, 39; Appendices 1, 4, 5, 7.

Stand 152 is located in MacMillan Bloedel's Sarita division, along the Pachena Main Line toward Bamfield. The site is a flat, relatively level plain at an elevation of 30 m (Table 22). The forest is made up of relatively small, overmature trees of poor form (scrubby, spike tops, etc.) and low vigor (poor to fair). The canopy is fairly open due to incomplete crown closure and numerous large blowdowns.

The stand basal area is quite low (86.1 m^2/ha) due to the relatively small size of the trees. Western redcedar dominates the main canopy, but is present in all canopy layers. It makes up 66% of the total basal area. Western hemlock is even more abundant than redcedar (213 vs 206 stems /ha), but only accounts for 16% of the basal area, due to much smaller tree size. Hemlock is common in the intermediate and suppressed layers of the tree canopy. There are a few, large old western white pine trees scattered throughout the stand. Regeneration of western hemlock and redcedar is very abundant; especially where blowdowns have created large openings in the canopy.

All layers of the understory are well-developed and diverse. The shrub layer is very dense and tall; dominated by salal, with admixtures of *Vaccinium ovatum*, *V. parvifolium*, *V. alaskaense*, and *Menziesia ferruginea*. There are a variety of species in the herb layer, but deer fern (*Blechnum spicant*), bunchberry (*Cornus unalaschkensis*), and false lily-of-the-valley

Table 22: Environmental data for stand 152

Characteristic	152-1	152-2	152-3
Elevation (m)	32	31	30
Aspect (°)	N/A	N/A	N/A
Slope gradient (%)	0	0	0
Macrosite position	plain	plain	plain
Mesosite position	level	level	depression
Microtopography (moundedness)	slightly	slightly	slightly
Surface shape	straight	straight	concave
Soil parent material	morainal	morainal	morainal
Soil moisture regime	hygric	hygric	hygric
Soil drainage class	poor	poor	poor
Free water	perched	perched	perched
Soil type	OT.FHP	OHP	OT.HP
Family particle-size class	loamy	loamy	loamy
Forest floor thickness (cm)	19	11	14
Depth of Ah horizon (cm)	12	--	--
Depth of Ae horizon (cm)	--	11	14
Total rooting depth* (cm)	54	20	24
Depth to restrictive layer* (cm)	54	36	30
Depth to water table* (cm)	54	37	28
Effective rooting depth* (cm)	30	20	24
Bulk density, humus (g/cc)	--	0.14	0.12
" " Ae	--	0.44	0.86
Basal area (m^2/ha)	95	73	90
Relative density (stems/ha)	620	420	500

(* includes depth of organic horizons)

(Maianthemum dilatatum) are most abundant. Skunk cabbage (Lysichitum americanum) is present in water-filled depressions. Mosses, particularly Sphagnum spp. and Hylocomium splendens, are common on the forest floor. A detailed species list is presented in Appendix 7.

The soils have developed on morainal deposits, and may be classified as loamy (Ortstein) Humic Podzol to Ferro-Humic Podzol. The soils are characterized by a well-developed Ae horizon; a podzolic Bh or Bhf; underlain by a cemented (ortstein?) Bfc; and compacted till (Cc). There is lateral water flow created by a perched water table, which flows on top of the cemented Bfc or Cc horizon. This results in poor soil drainage and a hygric moisture regime. Rooting is restricted to approximately 35 cm, and is most abundant in the humus and Ae horizons.

The organic horizons consist of a thin litter layer underlain by a deep (8-23 cm) humus. The humus is wetter and, consequently heavier than that from stands 131 and 144. Nevertheless, it is fairly loose and appears to be well-worked by insects and also earthworms, which are very abundant.

The indicator plant species on this site reflect the poor, wet site conditions (Fig. 39). The trophotope spectrum of EISG is similar to that of Stand 151 (Fig. 38), with the majority of species contained in the poor-medium category. However, the hygrotope spectrum reflects wetter conditions than either Stand 131 or 151 (Figs. 37, 38).

The site index of Stand 152 is 25.2 for western redcedar. This value was obtained using the average height (28.3 m) and age (292+ yrs) estimates for redcedar. Stand 152 can be classified as site class (high) poor and growth class 6 for redcedar.

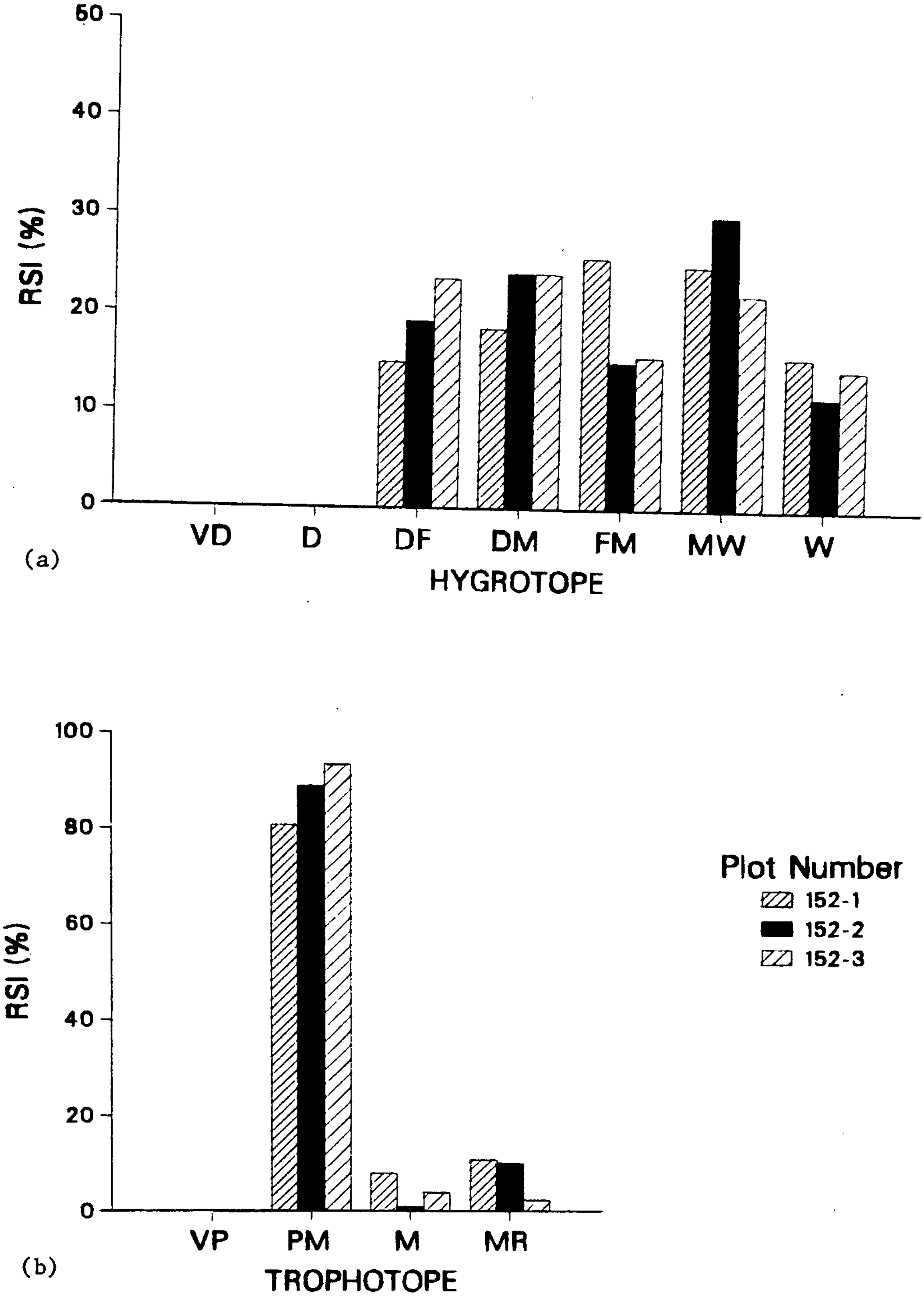


Figure 39: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 152, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

STAND 109 : Grice Bay

Reference: Sample plots 109-1, 109-2, 109-3; Table 23; Figures 14, 17, 19, 20, 40; Appendices 1, 4, 5, 7.

Stand 109 is located in the Grice Bay area of MacMillan-Bloedel's Kennedy Lake division. The sample plots are not actually located in stand 109, but rather, in stands 108 and 105. All three stands (109, 108, and 105) are recorded on the MacMillan-Bloedel cover-type map as having the same cover-type, stand age, site index, volume, and volume class. So, the three plots were grouped together to represent one site.

The area is a relatively flat plain with a few small localized hills, which rise sharply from the general level of the plain (Valentine 1971). Plot 1 is situated on one if these hills, at an elevation of 51 m. The site has a strong, but short slope which faces due west. Plot 3 is located in the same stand as plot 1 (108), but on a very long, gentle, nearly level, southwest facing slope, at an elevation of 40 m. Plot 2 is situated in stand 105. The area is nearly level, at an elevation of 37 m, with a slight southwest aspect (if any) (Table 23).

The present overmature forest probably originated from fire, as indicated by charcoal in the soil profile. There are many large old, fallen trees, which have created openings in the canopy, and serve as nurse logs.

Table 23: Environmental data for stand 109

Characteristic	109-1	109-2	109-3
Elevation (m)	51	37	40
Aspect (°)	270	254	210
Slope gradient (%)	22	0-5	5
Macrosite position	plain	plain	plain
Mesosite position	mid-slope	level	level
Microtopography (moundedness)	strongly	strongly	slightly
Surface shape	undulating	straight	straight
Soil parent material	GF / M	gl.marine	(GF)/M
Soil moisture regime	subhygric	subhygric	subhygric
Soil drainage class	MW - IM	IM - P	imperfect
Free water	(in humus)	absent	absent
Soil type	OFHP	OG	GFHP
Family particle-size class	loamy sk.	fine-clayey	loamy
Forest floor thickness (cm)	14	19	15
Depth of Ae horizon (cm)	0-2	none	0-9
Total rooting depth* (cm)	36	53	47
Depth to restrictive layer* (cm)	63	53	60
Effective rooting depth* (cm)	16	20	24
Bulk density, humus (g/cc)	0.12	0.12	0.09
Basal area (m^2/ha)	186	104	187
Relative density (stems/ha)	400	320	320

(* includes depth of organic horizons)

Western redcedar dominates the main canopy of the stand and accounts for 77% of the total basal area of 158.7 m^2/ha. The individual trees are very large and old; typically 1.5 m in dbh, and up to 2.7 m dbh. One large, old fallen redcedar was estimated from ring counts as being over 650 years old. The remainder of the stand basal area is made up of amabilis fir and western hemlock, in almost equal proportions (12% and 10% respectively). These species occupy all layers of the canopy, and are much smaller in diameter than redcedar.

The understory vegetation is vigorous, but not particularly dense. Salal, the most abundant shrub species, typically reaches a height of 3 m. Vaccinium parvifolium is also common, and very tall (4.5 m). Deer fern has wide coverage in the herb layer, and there are numerous other incidental herb species (App. 7). The moss layer is very well-developed and consists primarily of Hylocomium splendens, Rhizomnium glabrescens, Rhytidiadelphus loreus, Plagiothecium undulatum, Cephalozia bicuspidata, and Kindbergia oregana. Western hemlock regeneration is very abundant; probably a function of the acidic, decaying wood which has accumulated on the forest floor. Western redcedar seedlings are also common, but not nearly as numerous as hemlock.

The soil parent materials of this area consist of marine and fluvio-glacial sediments which were deposited during and immediately after glaciation (Valentine 1971; Jungen and Lewis 1978). Ferro-Humic Podzols occur on the coarse-textured materials and/or the better drained sites. Gleysols are present on the level to depressional areas of the marine clays (Jungen and Lewis 1978). Due to the differences in site positions, the soils of the three sample plots will be described individually.

The soil of plot 1 is very shallow and contains a high percentage (90%) of rounded cobbles and stones. The parent material is probably morainal till modified by water action (fluvioglacial), as suggested by the rounded-shape of the coarse fragments. The soil may be classified as a loamy-skeletal Orthic Ferro-Humic Podzol. The profile consists of a thin, poorly-developed Aej horizon; a podzolic Bhf horizon, high in organic matter, extractable iron and aluminum; a Bh horizon enriched with organic matter and high in available phosphorus; and a stony C horizon (App. 5). Rooting is most abundant in the organic and Ae horizons, being restricted by the high concentration of large boulders and stones, which often extend close to the surface.

The organic portion of the profile consists of a LF horizon, 3 to 5 cm in thickness; and a thick (5-14 cm) humus layer. The humus is somewhat sticky, plastic and greasy. Both earthworms and white fungal mycelia are agents of decomposition. The soil is of subhygric moisture regime and is moderately-well to imperfectly drained.

The soil of plot 3 is very similar to that of plot 1. It is imperfectly drained, of subhygric moisture regime, and probably originated from morainal parent material (compact till). However, the coarse fragment content (15%) is much lower than plot 1; and the fragments are smaller (gravels) and sub-angular. The soil may be classified as a loamy, Gleyed Ferro-Humic Podzol (like plot 1), but without knowing the concentration of extractable iron and aluminum in the podzolic B horizon, it is not possible to differentiate it from a loamy Orthic Humic Podzol. The colour (10 YR 2/2) of the podzolic B horizon suggests that the soil is an Orthic Humic Podzol: high in organic matter, low in iron and aluminum. Mottling is present in all the mineral horizons, possibly a result of restricted drainage by the compacted (cemented?) C horizon. Unfavourable drainage may also influence the rooting, which is concentrated in the organic and Ae horizons. The LF, H and Ae layers are similar to, but thicker than, those of plot 1. The humus is light; appears to be worked by insects and earthworms; contains appreciable amounts of decayed wood; and is slightly plastic, slippery and greasy.

The soil of plot 2 is much different from that of plots 1 and 3. The silty-clay texture suggests that it originated from glaciomarine sediments. The soil can be classified as a fine-clayey Orthic Gleysol. The profile is fairly deep (75+ cm) and consists of four Bg horizons (no A horizon). The Bgl horizon has extraordinary mottling and contains rounded coarse fragments. There are no coarse fragments in the other mineral horizons. There are black Mg deposits in the Bg3 and Bg4 layers.

Rooting is most abundant in the organic horizons, but extends into the Bgl and Bg2 layers. It is probably limited at lower depths by excessive moisture. The soil is imperfectly to poorly drained and of subhygric to hygric moisture regime. In addition, the concentration of organic matter and total nitrogen drops considerably below the Bgl horizon.

The humus is similar to that of plots 1 and 3. A large portion of the humus is derived from decayed wood; and is light, crumbly and peat moss-like. The rest of the humus is clumped, plastic and greasy. White fungal mycelia was very abundant and earthworm casts were observed.

In spite of the differences in soils between plots 1 and 2, the indicator plant species reflect similar moisture and nutrient conditions (Fig. 40). The spectrum of edatopic indicator species groups is similar to that of Stands 133 and 151 (Figs. 37, 38), with the majority of plants contained in the poor-medium trophotope category.

The average height of 10 dominant and codominant redcedar trees on this site was 32.5 m; and the average age, as measured from increment borings from 12 redcedar trees, was 265+ years. From these values the site index of redcedar was estimated to be 28.9. This site index value corresponds to growth class 5 and site class (low) medium for redcedar.

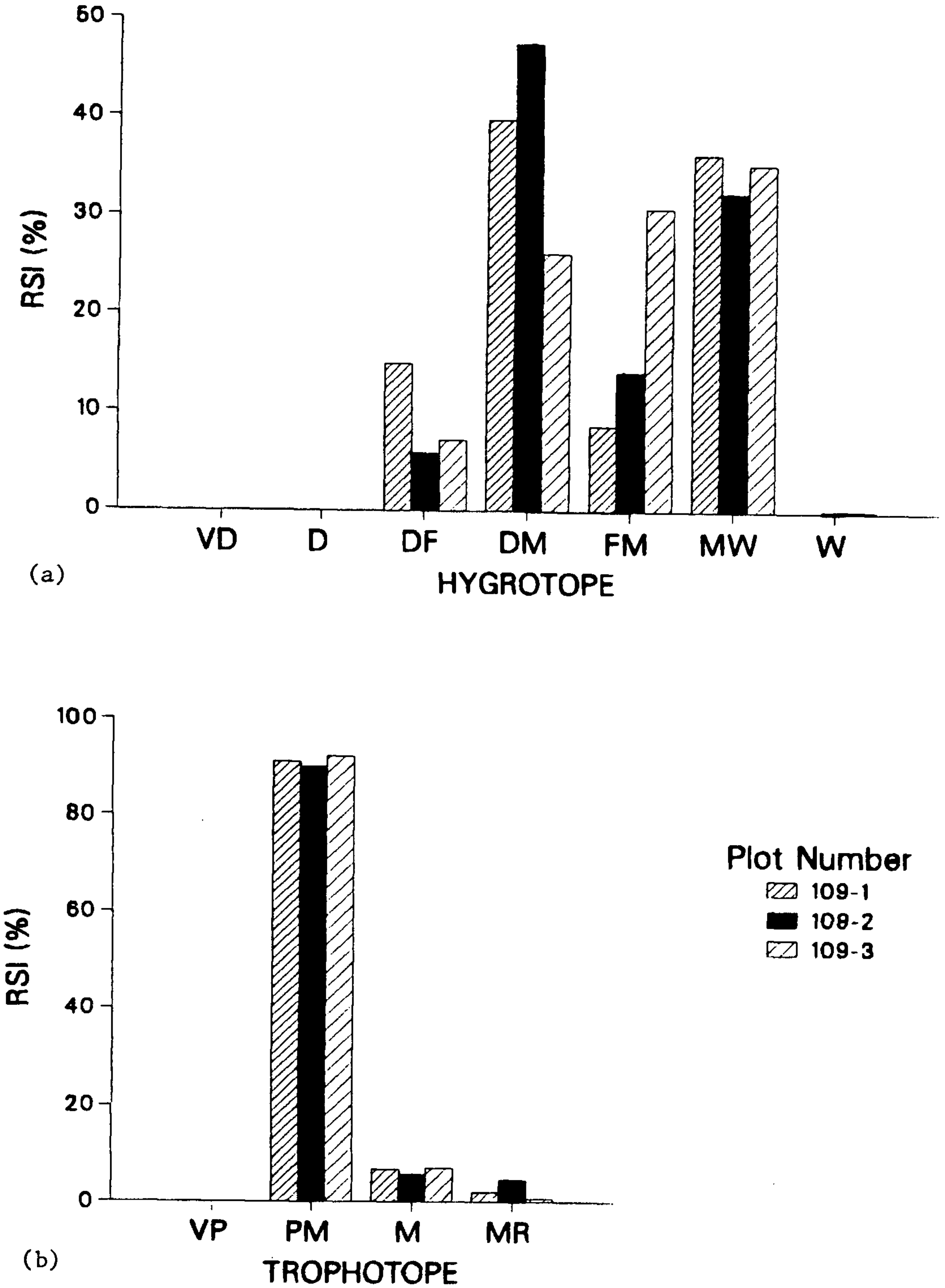


Figure 40: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 109, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

STAND 199 : Ucluelet/Slope

Reference: Sample plots 199-1, 199-2, 199-3; Table 24; Figures 18, 41; Appendices 1,4,5,7.

Stand 199 is located in MacMillan-Bloedel's Kennedy Lake division, on the Ucluth Peninsula beside Highway 4, across from the Ucluelet Inlet. The peninsula is fairly narrow (400-800 m) at this point, so the stand is not far from the Pacific Ocean. Although the overall area is a plain, there is a "low narrow ridge immediately inland from the coast" (Valentine 1971). The three sample plots are situated on the eastern slope of this ridge.

Plot 1, which is slightly depressional, is located on the lower slope at an elevation of 25 m. Plot 2 is situated at the crest of the upper slope at 45 m elevation. The surface shape is convex, and the area slopes strongly in all directions. Plot 3 is at a mid-slope position at 35 m elevation. The site slopes very strongly and faces due east.

The forest is an overmature stand of western redcedar and western hemlock with a minor component of amabilis fir. Western redcedar is the dominant species, accounting for 79% of the total basal area of 118.4 m^2/ha. Many of the redcedar trees are very large, old veterans with spiked or candelabra tops. Western hemlock is present in all canopy layers and, although it is far more abundant than redcedar (206 vs 133 stems/ha), it comprises only 16% of the basal area. Amabilis fir occurred in only 1 of the 3 sample plots (plot 1). It makes up the remaining 5% of the basal area.

The influence of slope position is reflected in the vegetation. Plot 1, at lower slope, and plot 3 at mid-slope, have comparatively similar basal areas and relative densities (Table 24). However, plot 2, at the upper slope position, has much smaller and more numerous trees than plots 1 and 3. Its relative density is twice as large, and its basal area almost half that of either plots 1 or 3.

The most striking floristic feature of this stand is the change in understory vegetation along the slope gradient. At the lower end of the slope, the understory vegetation, particularly the herb layer, is very rich and diverse. The diversity of understory species decreases as the elevation increases.

Plot 1 is positioned on the lower slope. The shrub layer is very dense and tall, often exceeding 3 m in height. The dominant speices are salal, salmonberry, and vacciniums. There are many vigorous flowering plants and ferns in the well-developed herb layer; including Maianthemum dilatatum, Tiarella trifoliata, Polystichum munitum, Lysichitum americanum, Blechnum spicant, Galium boreale, Streptopus roseus, and Athyrium felix-femina. Sword fern is very vigorous, with fronds of 2 m in length. There is a carpet of mosses covering approximately 50% of the forest floor. The dominant species are Rhyzomnium glabrescens, Kindbergia oregana, Rhytidiadelphus triquetrus, R. loreus, and Sphagnum spp.

At approximately 30 m elevation, there is a boundary where many of the herb species drop out of the understory. Plot 3 is located at 35 m elevation, just above this boundary. The shrub layer is similar to plot 1, except that salal is much more abundant and salmonberry is very sparse. The herb layer differs markedly: deer fern is dominant and other herb

Table 24: Environmental data for stand 199

Characteristic	199-1	199-2	199-3
Elevation (m)	25	45	35
Aspect (°)	112	N/A	90
Slope gradient (%)	13	19	35
Macrosite position	plain	plain	plain
Mesosite position	lower slope	crest	mid-slope
Microtopography (moundedness)	slightly	slightly	strongly
Surface shape	concave	convex	undulating
Soil parent material	morainal	morainal	morainal
Soil moisture regime	hygric	hygric	hygric
Soil drainage class	IM - P	imperfect	imperfect
Free water	present	present	seepage
Soil type	OSB	GFP	GDB
Family particle-size class	sandy sk.	loamy	loamy
Forest floor thickness (cm)	29	23	15
Depth of Ah horizon (cm)	20	--	--
Depth of Ae horizon (cm)	--	6	23
Total rooting depth* (cm)	54	29	36
Depth to restrictive layer* (cm)	54	29	46
Depth to water table* (cm)	60	29	48
Effective rooting depth* (cm)	47	29	46
Bulk density, humus (g/cc)	0.09	0.13	0.11
Basal area (m^2/ha)	108	64	183
Relative density (stems/ha)	260	560	280

(* includes depth of organic horizons)

species are inconsequential or absent. The moss layer is less diverse.

Plot 2 is situated at the upper part of the slope at 45 m elevation. Its understory is similar to that of plot 3, with even fewer herb species present.

Both western hemlock and western redcedar were regenerating in all three plots. Hemlock was more abundant than redcedar in plots 2 and 3. Redcedar was somewhat more common in plot 1.

As would be expected, the soils are also influenced by the slope position, and differ amongst the 3 plots. The soil parent material is morainal; compacted and/or cemented, loamy to sandy, gravelly till.

The soil of plot 1, at the lower slope position, is very unique. It is characterized by a deep (25-28 cm), rich humus with an abundant population of earthworms. In spite of the presence of (acidic?) decaying wood, the humus has an unusually high pH (5.9 (H_2O)); the highest value for humus pH of the 40 sample plots. Underlying the humus is a thick (18-22 cm) Ah horizon enriched with organic matter, and relatively high in pH, total N, and exchangeable cations. Rooting is confined almost entirely to the humus and Ah layers. The Bh horizon is a thin (5-10 cm) sandy layer with a high coarse fragment content (40%), enriched with organic matter and high in pH. Beneath it is a cemented, gravelly C layer. All horizons have unusually high levels of calcium, which would account for their associated high pH values. The calcium content is probably, at least partially, a result of nutrient-rich seepage water, which flows on top of the compacted till. The drainage of this site is imperfect to poor and the moisture regime is hygric (to subhydric). Due to the thick Ah horizon the soil can be classified as an Orthic Sombric Brunisol.

The soil of plot 3, at the mid-slope position, is much different from that of plot 1. The humus horizon is only half as thick, and it is much more acidic (pH 3.9 vs 5.9). It is fairly light and appears to be well-aerated and insect-worked, although no earthworms were observed. Slugs and snails were present. There is no Ah or Ae horizon, but rather, a series of B horizons with weak to prominent mottling, and low levels of nitrogen and cations (App. 5). The lowest B layer is enriched with organic matter, probably from seepage water flowing on top of the cemented C horizon; but nevertheless, nitrogen and cation levels are low. Rooting extends into the upper B horizons, but is most abundant in the humus. The soil is imperfectly drained and has a hygric moisture regime. It is difficult to classify this soil without knowing the Fe and Al content of the mineral horizons, but it can probably be classed as a Gleyed Dystric Brunisol.

Since plot 3 was situated just above the boundary where the herbs and ferns dropped out of the understory, a second 'mid-slope' humus sample was taken for comparison, 5m downslope from plot 3, inside the zone of rich understory vegetation. This sample was labelled 199-4. Although a complete profile description was not done, the horizon sequence was noted to be very different from plot 3 and similar to that of plot 1: LF, H1, H2, Ah, Bh, Cc. The humus strongly resembled that of plot 1; with abundant earthworms and high in calcium and pH. Water was seeping through, or on top of, the Bh horizon.

The soil of plot 2, situated at the top of the slope, is very shallow and can (almost) be classified as a loamy "Gleyed Folisolic Podzol", (the LFH horizons are not 40 cm thick, as required for this classification).

The mineral solum is poorly developed; consisting of a thin (2-9 cm) eluviated A horizon with weak mottling, overlying compacted till. The humus makes up the greatest portion of the rooting medium. It is 19-23 cm thick and compares chemically to the humus of plot 3; with a pH value of 3.9. Although earthworms were present; they were smaller in size and number than those in plot 1. Snails and grubs were also observed. The soil is imperfectly drained and has a hygric moisture regime. It experiences seepage through the Aegj horizon.

The differences in edatopic conditions between the 3 plots, especially in trophotope, are reflected by the indicator plant species (Fig. 41). As mentioned, the understory vegetation changes dramatically along the slope gradient. The diverse species compostion of plot 1 indicates fairly rich nutrient conditions; which is probably a function of seepage inputs and relatively rapid decomposition of organic matter by the large population of earthworms. By contrast, the indicator plant species of plots 2 and 3 reflect a poor-medium nutrient regime, similar to Stand 133 (Fig. 37). The hygrotope spectra of EISG for the 3 plots are fairly similar (Fig. 41). As would be expected, plot 2, the uppermost plot on the slope, appears to have a slightly drier hygrotope than the other 2 plots; although the difference is slight.

In spite of the nutrient-rich seepage water, the productivity of this site is relatively low. The site index of western redcedar was estimated as 25.2, from an average height value of 27.6 m and average age of 225+ years. Site 199 can be classified as growth class 6 and site class (high) poor for redcedar.

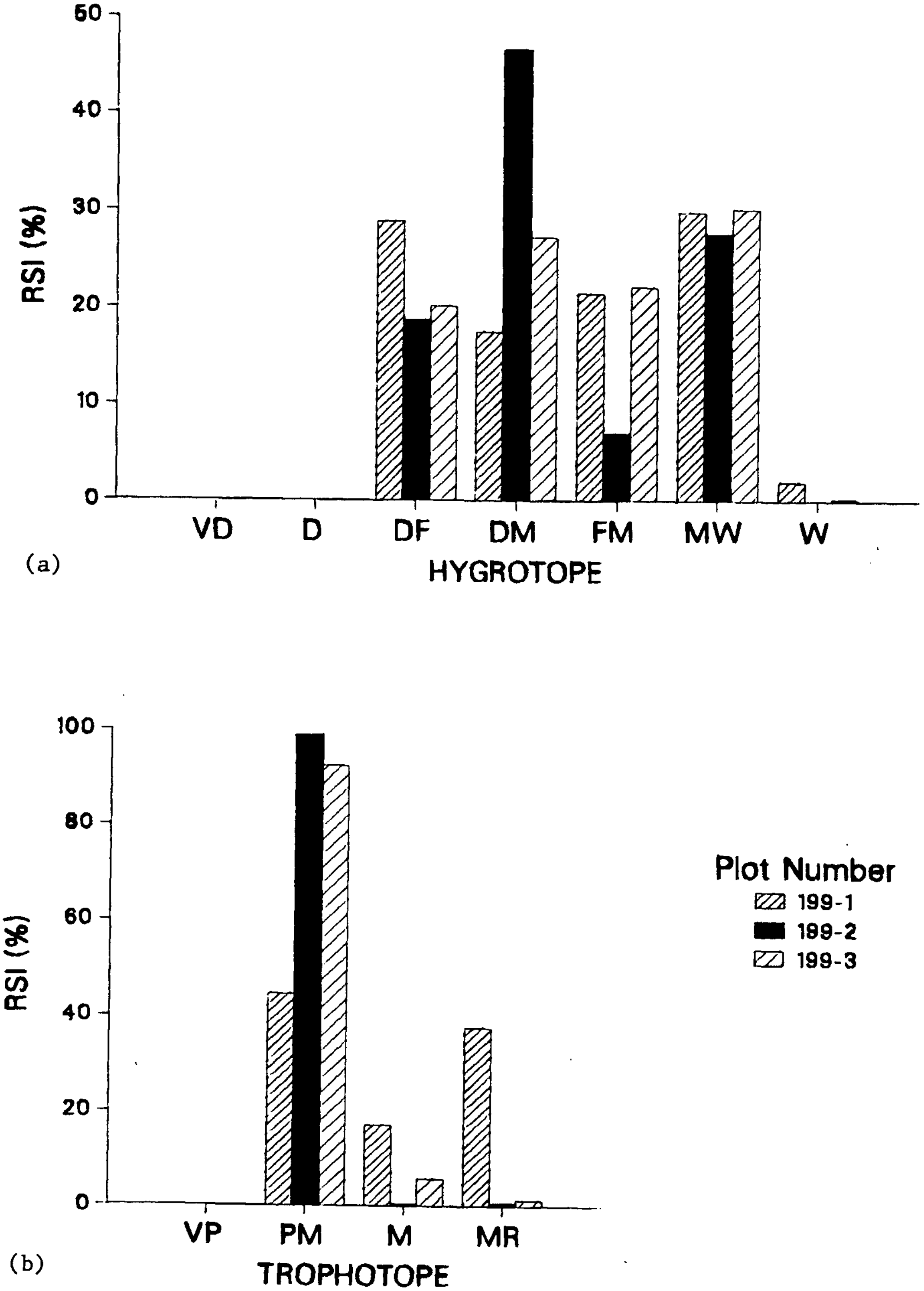


Figure 41: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 199, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

STAND 150 : Mercantile Creek

Reference: Sample plots 150-1, 150-2, 150-3; Table 25; Figure 42; Appendices 1, 4, 5, 7.

Stand 150 is located in MacMillan-Bloedel's Kennedy Lake division, off branch road 552. The stand is situated at the mid-slope position on a strong slope which drains into the Mercantile Creek, below. The site has a southeast aspect and an elevation of approximately 225 m (Table 25).

The stand is covered with an overmature forest of western redcedar with an admixture of western hemlock and amabilis fir. Most of the trees are very old (350+ yrs), and poorly formed, with spiked and candelabra tops. Blowdowns are common and litter the forest floor with debris. The relative density of trees is fairly high (613 stems/ha), and yet the basal area is quite low (92.2 m^2/ha). This suggests that most of the trees are small in diameter; however, there are some large (100 cm dbh) redcedars.

Western redcedar, which is present in all layers of the canopy, dominates the main canopy and accounts for 85% of the stand basal area. Western hemlock is very abundant, but individual trees are small in diameter, so it comprises only 9% of the basal area. Amabilis fir is a minor component of the stand, making up 4% of the basal area. Western yew and red alder are sparse and scattered in the understory.

The understory vegetation is fairly light. The dominant shrub species are salal, vacciniums, false-azaela and salmonberry. In some places these species grow to 2 or 3 m in height, but typically, they are sparse and

Table 25: Environmental data for stand 150

Characteristic	150-1	150-2	150-3
Elevation (m)	225	220	230
Aspect (^{o})	113	133	161
Slope gradient (%)	22	27	13
Macrosite position	mid-slope	mid-slope	mid-slope
Mesosite position	mid-slope	lower slope	mid-slope
Microtopography (moundedness)	moderately	moderately	strongly
Surface shape	undulating	undulating	undulating
Soil parent material	morainal	morainal	morainal
Soil moisture regime	hygric	HG - SHG	hygric
Soil drainage class	IM - P	poor	IM - P
Free water	seepage	present	(seepage)
Soil type	DHP	OG-OHG	OHG
Family particle-size class	loamy sk.	sandy sk.	loamy sk.
Forest floor thickness (cm)	12	12	22
Depth of Ah horizon (cm)	--	8	--
Depth of Ae horizon (cm)	5	11	9
Total rooting depth* (cm)	23	30	36
Depth to restrictive layer* (cm)	23	42	36
Depth to water table* (cm)	23	42	36
Effective rooting depth* (cm)	15	30	36
Bulk density, humus (g/cc)	0.09	0.08	0.23
Basal area (m^2/ha)	60	120	97
Relative density (stems/ha)	540	700	600

(* includes depth of organic horizons)

growing near the ground. The herb layer contains a wide variety of species, of which, deer fern is the most abundant, although it is not particularly vigorous. Other herb species include Lysichitum americanum, Streptopus roseus, Tiarella trifoliata, Cornus unalaschkensis, and Linnaea borealis. The moss layer contains Hylocomium splendens, Rhizomnium glabrescens, Rhytidiadelphus loreus, Sphagnum sp., and Kindbergia oregana.

Regeneration of western hemlock is very abundant in both the herb and shrub layers. Western redcedar is also present in the understory, but there are only a few scattered saplings.

The soils of this site have developed from morainal material: compacted or cemented till. They are loamy to sandy in texture and contain a high content of sub-rounded gravel in the mineral horizons. Cobbles and stones increase with depth. The sub-rounded shape of the coarse fragments and their stratification by depth suggests that the soil parent material may have been modified by water (ie: glaciofluvial). The cemented till restricts drainage, which is imperfect to poor, and contributes to a hygric (to subhydric) moisture regime. The soils vary between the three plots, so they will be described separately.

The soil of plot 1 may be classified as either a loamy-skeletal Orthic Gleysol or a loamy-skeletal Duric Humic Podzol. It is difficult to classify without knowing the Fe and Al content of the mineral horizons. The colours of the B horizons suggest that the soil is a podzol. The solum consists of an eluviated A horizon, with prominent mottles; two thin, mottled B horizons, with lateral water flow between them; a distinctly mottled and cemented (duric ?) BC horizon, with a high content of gravel and cobbles; and a C horizon (App. 4). Rooting is restricted almost entirely to the organic horizons, which consist of thin L and F layers, and a 10 cm thick humus layer. The humus has a relatively high pH (4.7 (H_2O)) in spite of the presence of acidic (?) decaying wood.

As with plot 1, it was difficult to classify the soil of plot 2 without knowing the iron and aluminum concentrations of the B horizons. Plot 2 appears to be wetter than plot 1 (Fig. 42). The low chroma values for the mineral soil samples suggest that the soils are gleysols rather than podzols. Two soil profiles (150-2a and 150-2b) were described and sampled in this plot to provide a means for comparison (App. 4). The two profiles are similar, but there are some differences. Both soils are shallow (37-44 cm), contain a high content of coarse fragments (15-50%), and experience rapidly-flowing seepage water. The soil of pit 150-2a is a sandy-skeletal Orthic Humic Gleysol. The profile consists of thick Ah (17 cm) and Ae (10 cm) horizons; and a Bh horizon enriched with organic matter. The bottom of the pit smells of SO_2, indicating anaerobic conditions. The soil of pit 150-2b is a sandy-skeletal Orthic Gleysol. It is similar to 150-2a, except that it lacks an Ah horizon, and has a BC layer beneath the Bh. The Bh horizons of both soils are enriched with organic matter and contain relatively high levels of calcium (App. 5). Rooting is concentrated in the organic, Ah and Ae horizons. The organic layers are similar to those of plot 1, except that the humus has lower pH (3.9-4.0), and much lower levels of total nitrogen (App. 5).

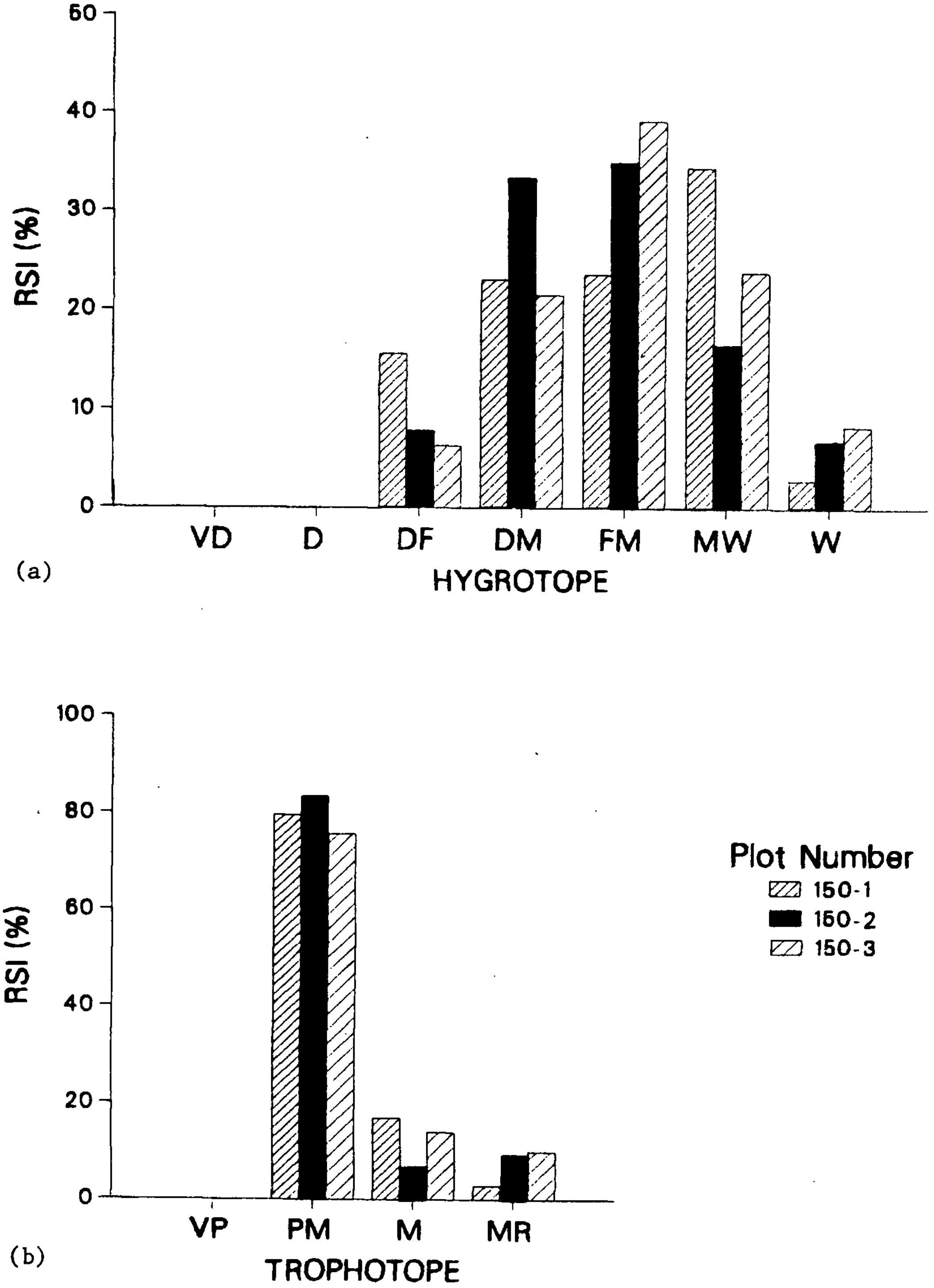


Figure 42: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 150, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

The soil of plot 3 has very deep (22 cm) mineral-organic surface horizons (App. 4). Originally, these horizons were designated as H, Ah1 and Ah2. However, the Ah samples were found to contain very high levels of organic matter (44.8% and 53.1%), so they were re-labelled as Hi1 and Hi2. The soil may be classified as a loamy-skeletal Orthic Humic Gleysol. The profile consists of an eluviated Aeg horizon with prominent mottles; a thin (5-8 cm), black B horizon; underlain by a thin orange band; and a cemented, mottled, C horizon, with a high gravel content (50%). The B horizon is wet; probably from a perched water table, or seepage above the cemented C horizon. Unlike the Bh horizon of the Orthic Humic Gleysol of plot 150-2a, this B horizon is very low in organic matter. Rooting extends through the B horizon, but is most abundant in the thick organic layers, which contain high levels of total nitrogen, available phosphorus, and exchangeable cations (App. 5). These favourable nutrient conditions may explain the increased abundance and diversity of herbs in this plot (App. 7).

The slight differences in nutrient and moisture conditions between the 3 plots are reflected by the spectrum of EISG (Fig. 42). Overall, the edatopic conditions of the 3 plots are quite similar, and are comparable to those of Stand 151 (Fig. 38). Most indicator species are contained in the poor-medium trophotope category. However, there are some medium and medium-rich indicators, which are probably reflecting the nutrient inputs through seepage water.

The hygrotope spectrum of EISG (Fig. 42) suggests that this site experiences somewhat wetter conditions than Stand 151 (Fig. 38), but not as wet as Stand 152 (Fig. 39).

The productivity of this site as measured by site index for western redcedar, was similar to that of Stand 131 in the Franklin-Sarita division. The site index for redcedar was estimated as 28.1, from average height and age values of 31.5 m and 239+ years. This places site 150 in growth class 5 and site class (low) medium for western redcedar. From five height measurements and 6 age estimates, the site index of western hemlock was calculated as 33.6. This would place site 150 in growth class 5 and site class (mid) meduim for western hemlock.

Study Sites of Association 2.12 : Sphagno-Tsugetum

STAND 300 : Ucluelet Scrub

Reference: Sample plots 300-1, 300-2, 300-3; Table 26; Figures 21, 24, 25, 43; Appendices 1, 4, 5, 7.

Stand 300 is located in MacMillan-Bloedel's Kennedy Lake division along Highway 4, across from stand 199, just north of the Ucluelet Inlet. The site is situated on the coastal plain at an elevation of 25 m (Table 26). The stand is covered by a scrubby, overmature forest of western redcedar, western hemlock, and shore pine. The presence of charcoal in the soil suggests that the stand is of fire origin. Most of the trees are very old (200-500 yrs.), and of poor form with crooked, twisted stems; and broken, spiked and forked tops. Although the number of trees is very high (820 stems/ha), tree diameters are small, resulting in a low stand basal area (68.5 m^2/ha). The average height of the dominant trees is only 18.3 m.

Western redcedar, the dominant tree species on the site, is present in all layers of the canopy, has the highest relative density (373 stems/ha), and accounts for 55% of the total basal area. Western hemlock, another major component of the stand, is also found in all canopy layers, and makes up 31% of the basal area. Shore pine (*Pinus contorta* var. *contorta*), forms a significant portion of the main canopy; for although it is minor in terms of both relative density and basal area, it is present only in the dominant crown position.

Table 26: Environmental data for stand 300

Characteristic	300-1	300-2	300-3
Elevation (m)	25	25	25
Aspect (°)	N/A	N/A	N/A
Slope gradient (%)	0	0	0
Macrosite position	plain	plain	plain
Mesosite position	level	level	level
Microtopography (moundedness)	moderately	strongly	strongly
Surface shape	straight	straight	straight
Soil parent material	FL-(GW)/M	FL-(GW)/M	FL-(GW)/M
Soil moisture regime	subhydric	subhydric	subhydric
Soil drainage class	poor	poor	poor
Free water	(in H)	(in H)	(in H)
Soil type	OG	OG	OG
Family particle-size class	fine loamy	fine loamy	loamy
Forest floor thickness (cm)	22	19	18
Depth of Ae horizon (cm)	7	7	13
Total rooting depth* (cm)	74	22	43
Depth to restrictive layer* (cm)	74	49	49
Effective rooting depth* (cm)	24	22	13
Bulk density, humus (g/cc)	0.13	0.10	0.12
Basal area (m^2/ha)	72	77	57
Relative density (stems/ha)	1060	740	660

(* includes depth of organic horizons)

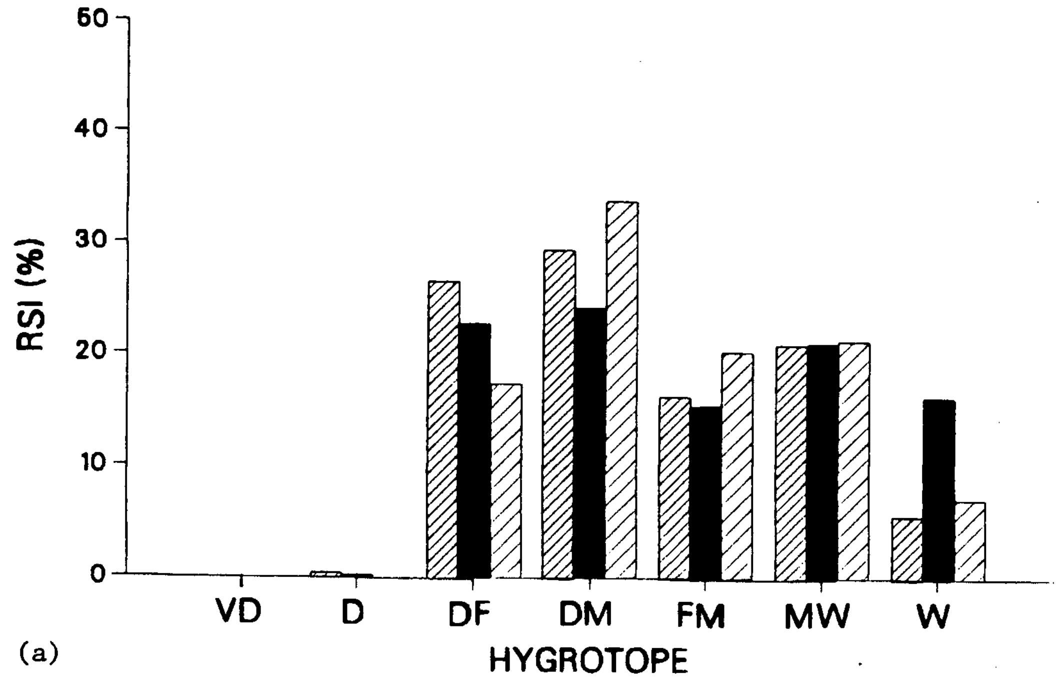
The semi-open canopy allows sunlight to penetrate through to the understory, which is very dense and tall. The shrub layer is dominated by salal, *Vaccinium ovatum* and *V. parvifolium*, which reach heights of 2.5 to 3 m. Western crab apple (*Malus fusca*) is also an important species in the shrub layer, and grows to 5 m in height. The most abundant herbs include *Blechnum spicant*, *Cornus unalaschkensis*, *Maianthemum dilatatum*, and *Linnaea borealis*. The moss layer is well-developed and consists primarily of

Hylocomium splendens, *Rhytidiadelphus loreus*, *Kindbergia oregana*, *Sphagnum* spp., *Rhizomnium glabrescens*, and *Plagiothecium undulatum*. Western redcedar is successfully regenerating on this site. It is abundant in both the herb and shrub layers. Western hemlock seedlings and saplings are also present, but to a much lesser extent.

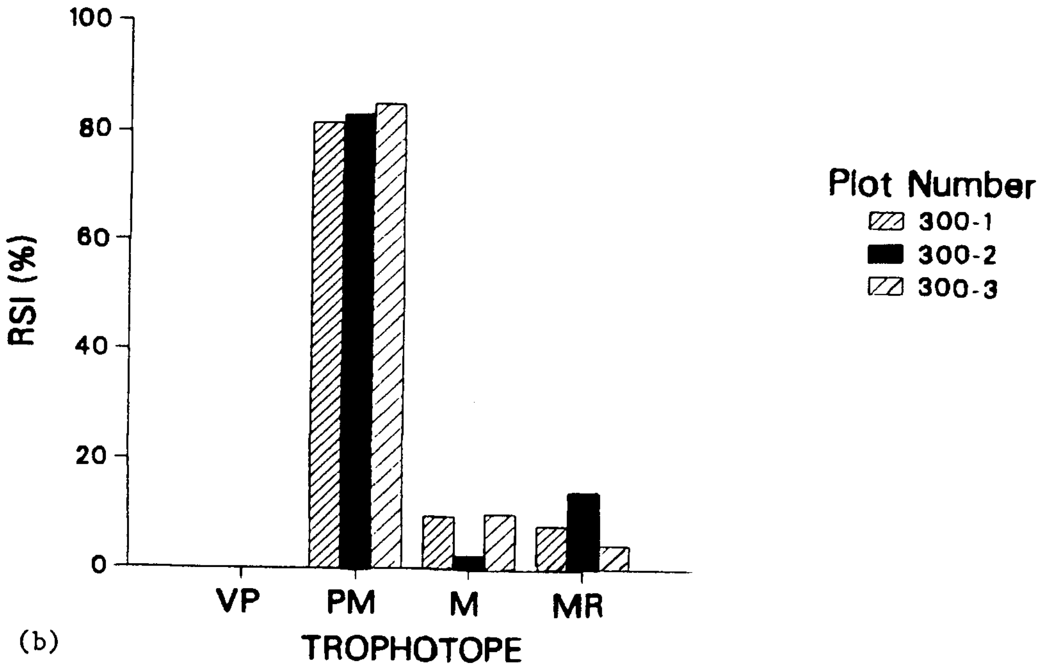
The soil is a shallow, loamy Orthic Gleysol which has developed from a complex interaction of processes, and appears to include beach, fluvial or glaciomarine deposits over compacted (morainal) till. The compacted till, at a depth of approximately 50 cm, contributes to the poor drainage and subhygric moisture regime of the site. The soil is characterized by a gleyed B horizon with prominent mottles of high chroma, indicating periodic or prolonged saturation with water and reducing conditions. The wet conditions of the mineral soil horizons restrict rooting almost entirely to the organic layers. There is a LF layer, 3 to 8 cm thick; and a deep, 12 to 20 cm humus horizon. The humus is somewhat plastic and greasy; with abundant decayed wood and a high water holding capacity. Fine roots and white fungal mycelia are plentiful; creating a matted appearance near the surface. Soil fauna, including earthworms, grubs, and weevils were observed.

The spectrum of EISG (Fig. 43) is similar to that of Stand 152 (Fig. 39), and reflects the poor, wet conditions.

Due to the unfavourable moisture regime and shallow soil, this site has very low productivity. A site index value of 16.3 for western redcedar was estimated from a mean height value of 18.3 m and a mean age of 220+ years. Site 300 can be classified as site class (low) poor and growth class 8 for redcedar. From 6 height measurements and 5 age estimates of *Pinus contorta*, a site index value of 19.1 was calculated. Thus, this site is slightly more productive for shore pine than redcedar, and can be classified as site class (low) medium for shore pine.



(a)



(b)

Figure 43: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 300, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

STAND 821 : Port Albion/Bog

Reference: Sample plots 821-1, 821-2, 821-3; Table 27;
Figures 22, 23, 44; Appendices 1, 4, 5, 7.

Three plots were sampled in a scrub forest, bordering a bog, along the Port Albion Road, just north of Port Albion. The plots were grouped together to represent one site type, and referred to as 'Stand 821'. Plots 1 and 2 were sampled in the forest on the west side of the Port Albion Road. The area is a flat, level coastal plain at an elevation of approximately 60 m. Plot 3 was sampled in the forest on the east side of the road. The area is gently sloping, with a southwest aspect, at an elevation of 80 m (Table 27).

This stand is similar to stand 300. The presence of charcoal in the soil suggests that it too, probably originated from (or has survived) a fire. The open forest is composed of many small, scrubby, old (300-450+ years) trees of low vigor and very poor form (Figs. 22, 23). In spite of the large number of trees (733 stems/ha), the stand basal area is very low (43.2 m^2/ha) due to the small tree diameters.

Western redcedar, the dominant tree species, is present in all layers of the canopy. It accounts for 65% of the basal area and has the highest relative density (420 stems/ha). Western hemlock makes up 24% of the basal area and is also present in all canopy layers. It is approximately half as dense as redcedar. Shore pine has a low basal area and relative density, but still contributes to the main canopy, since it is only found in the

Table 27: Environmental data for stand 821

Characteristic	821-1	821-2	821-3
Elevation (m)	70	50	80
Aspect (°)	N/A	N/A	230
Slope gradient (%)	0	0	15
Macrosite position	plain	plain	plain
Mesosite position	level	level	lower slope
Microtopography (moundedness)	moderately	moderately	strongly
Surface shape	straight	straight	undulating
Soil parent material	GW-GF/M	GW-GF/M	GW-GF/M
Soil moisture regime	subhydric	subhydric	subhydric
Soil drainage class	poor	poor	IM - P
Free water	(in H)	(in H)	--
Soil type	PHP	PHP	OHP
Family particle-size class	loamy sk.	loamy sk.	loamy sk.
Forest floor thickness (cm)	10	14	5
Depth of Ae horizon (cm)	6	10	3
Total rooting depth* (cm)	13	22	51
Depth to restrictive layer* (cm)	32	31	53
Effective rooting depth* (cm)	13	22	27
Bulk density, humus (g/cc)	0.11	0.10	0.10
Basal area (m^2/ha)	32	63	35
Relative density (stems/ha)	720	900	580

(* includes depth of organic horizons)

dominant crown position. A few, scattered western yews occur in the intermediate and suppressed tree layer. Western crab apple is not large enough in diameter to be classified as a tree, but nevertheless, it is abundant in the understory tree layer.

The understory vegetation is extremely dense; undoubtedly a function of the open tree canopy. The thick shrub layer is approximately 2.5 m tall and consists primarily of *Vaccinium ovatum*, salal and *V. parvifolium*. The herb layer is dominated by deer fern, bunchberry, false lily-of-the-valley, and twinflower; but also includes such characteristic species as *Coptis asplenifolia*, *Ledum groenlandicum*, and *Phyllodoce empetriformis*. The moss layer is well-developed, and the most abundant species are *Hylocomium splendens*, *Rhytidiadelphus loreus*, and *Sphagnum spp*.

Regeneration of western redcedar is exceptional in this site. Both seedlings and saplings are very abundant. Western hemlock regeneration is also present, but its numbers are less than half that of redcedar.

The soils of this site are very similar to those of the Wreck Bay series described by Valentine (1971), in his soil survey of the Tofino-Ucluelet lowland. The soils are shallow, loamy-skeletal Humic Podzols, which have developed from sandy and gravelly glaciomarine and/or glacio-fluvial outwash sediments. In many places, large stones occur very near the surface. The soils are poorly drained and of subhydric moisture regime. Evidence of fire and windfall is present throughout the site.

The soils of plots 1 and 2 are similar to the Placic Humic Podzol described by Valentine (1971). The soils are characterized by an eluviated A horizon, underlain by a thin dark band of mineral soil enriched with organic matter (Bh). Below the Bh horizon is a thin, cemented, orange-coloured iron-pan (placic horizon, Bhfc). This iron pan probably formed from iron, aluminum and humus which leached from the Ae horizon and precipitated into the B horizon as a thin band. A cemented, podzolic B horizon (Bfcg(j)) is found beneath the iron-pan. It is characterized by the presence of mottles and, as noted by Valentine (1971), a much higher content of coarse fragments (45% sub-angular gravel) than the overlying mineral horizons.

The iron-pan and cemented B horizon are impermeable to both roots and water, resultlng in saturated soil conditions and restricted rooting. Rooting extends into the Ae horizon, but is most abundant in the organic layers. The thick humus (2-14 cm) has an abundance of decaying wood and a high water holding capacity. It is very heavy and wet; like a big sponge. It is possible that most plant nutrients are derived from the organic matter in the humus horizon. The mineral solum not only has poor physical properties, but also poor chemical properties. It is strongly acid, and low in basic cations, total N, and available P. The H horizon, containing over 90% organic matter, is adequately endowed with basic cations, although total N is somewhat low. The organic matter not only supplies plant nutrients to the soil, but increases the cation-exchange-capacity thus enabling the soil to retain some of these nutrients in a form more available to plants (Valentine, 1971).

The soil of plot 3 differs slightly from that of plots 1 and 2. There is no obvious Bh horizon or placic iron-pan above the podzolic B. Moreover, the podzolic B is thicker, and it is not cemented. It does, however, have a high content (30%) of coarse fragments and distinct mottles. There is a dark band (charcoal?) below the podzolic B, overlying a cemented C horizon (compact till). The organic layers are similar to, but much thinner than those of plots 1 and 2. It is difficult to differentiate the L,F, and H horizons. A snail shell was observed in the humus: an indication of the wet soil conditions.

The indicator plant species on this site reflect edatopic conditions similar to those of Stands 300 and 152 (Figs. 44, 43, 39). The majority of the plants are in the poor-medium trophotope category. The wet moisture regime is also reflected.

The productivity of this site is very low, primarily due to the shallow, impenetrable soil strata and periods of prolonged saturation. The site index for western redcedar was estimated as 13.9, from average height (15.6m) and age (306++ yrs.) values. Only the dry rock outcrop site (818) has a lower site index for redcedar. Site 821 can be classified as growth class 0 and site class (high) low for redcedar. Like stand 300, this site is also somewhat more productive for shore pine than redcedar. The site index of pine was calculated as 16.6, from an average (17.0 m) of 4 height measurements, and 5 age estimates (288+ yrs.). This site index corresponds to site class (mid) poor for shore pine.

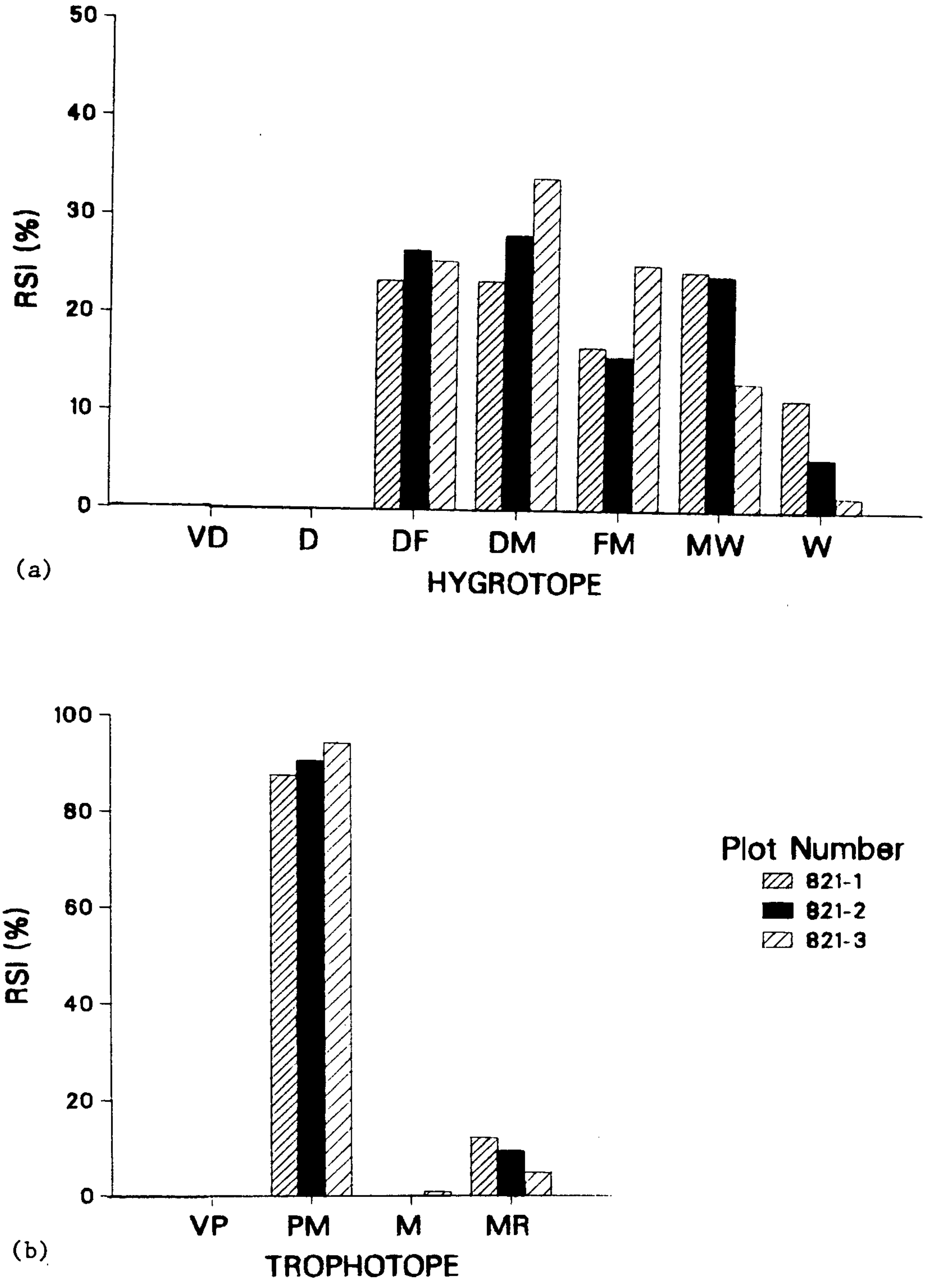


Figure 44: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 821, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

Study Sites of Association 3.11 : Kindbergio-Piceetum

STAND 1092 : Kennedy/Second Growth

Reference: Sample plots 1092-1, 1092-2, 1092-3, (PSPs 715,716,717); Table 28; Figures 26,27,45; Appendices 1,4,5,7.

Stand 1092 is located in MacMillan-Bloedel's Kennedy Lake division, near stand 315, off branch road 500A. The site is a level to slightly sloping plain which borders, to the south and east, on a rocky beach on Barkley Sound. The elevation ranges from 1 to 5 m.

MacMillan-Bloedel established 3 permanent sample plots (PSPs) in this stand in 1967 for growth and yield studies. The plots are square, 1 chain by 1 chain in dimension, and .0405 ha. in area. They have been sampled 3 times since establishment; in 1967, 1972, and 1976. The dbh and height was measured for all trees greater than 10 cm dbh. In addition, age estimates were made from increment cores of several dominant trees in each plot. The data from the most recent sampling (1976) was used for this study. The PSPs correspond to the sample plots as follows: PSP 717 = 1092-1, PSP 715 = 1092-2, PSP 716 = 1092-3.

The old-growth forest on this site was logged (clearcut) in 1933. There are many very large redcedar stumps and logs on the site (Figs. 26), indicating that the previous stand contained many large redcedar trees. The presence of fire scars and charcoal suggests that the stand was slashburned following logging.

The site currently supports a naturally-regenerated second-growth stand of western redcedar, western hemlock, and Sitka spruce. The relative density is quite high: 873 stems/ha (Table 28). The percent stocking of this stand (115%), as listed on the MacMillan-Bloedel cover-type map (92 C/14 9), indicates that the site is over-stocked. Western redcedar, with 476 stems/ha, and western hemlock, with 320 stems/ha, are the most abundant species. They account for 43% and 45% of the total basal area (49.8 m^2/ha) respectively. Sitka spruce only makes up 12% of the stand basal area, but some individuals are quite large.

The understory vegetation is very sparse, possibly due to insufficient sunlight as a result of the closed canopy. The shrub layer is light and poorly-developed. Salal is the most abundant species and there is a small percentage of red huckleberry, evergreen blueberry, and false-azaela. The herb layer is denser than the shrub layer, and is dominated by deer fern, sword fern, spiny shield fern, foamflower, lady fern and oak fern. Mosses, which include Kindbergia oregana, Rhyzomnium glabrescens and Hylocomium splendens, are fairly abundant, and commonly occur in patches.

The soils of this site have developed from fluvial parent materials. The soils characteristically contain very high contents of stratified, rounded, gravel in the upper mineral horizons; underlain by layers of sand. The permeability of the gravel and sand contributes to a subhygric moisture regime and moderately well drained soils. It is difficult to classify the soils without knowing the iron and aluminum concentrations of the mineral horizons. The soils may be podzols, regosols or brunisols.

The soil of plot 1 contains very high levels of organic matter in the upper horizons, which are predominantly gravel (50%). Initially, these

Table 28: Environmental data for stand 1092

Characteristic	1092-1	1092-2	1092-3
Elevation (m)	1	3	5
Aspect (°)	N/A	N/A	(123)
Slope gradient (%)	0	0	0-10
Macrosite position	plain	plain	plain
Mesosite position	level	level	lower slope
Microtopography (moundedness)	moderately	moderately	strongly
Surface shape	undulating	straight	undulating
Soil parent material	FL (GW)	FL (GW)	FL (GW)
Soil moisture regime	subhygric	subhygric	subhygric
Soil drainage class	mod. well	mod. well	mod. well
Seepage water	(slight)	(slight)	present
Soil type	C. Regosol	EDB	ODB
Family particle-size class	frag./sandy	sandy	sandy sk.
Forest floor thickness (cm)	21	10	8
Depth of Ah horizon (cm)	48	--	--
Depth of Ae horizon (cm)	--	7	1
Total rooting depth* (cm)	69	126	73
Depth to water table* (cm)	--	--	75
Effective rooting depth* (cm)	44	55	47
Bulk density, humus (g/cc)	0.16	0.10	0.13
Basal area (m^2/ha)	38	57	55
Relative density (stems/ha)	716	840	1062

(* includes depth of organic horizons)

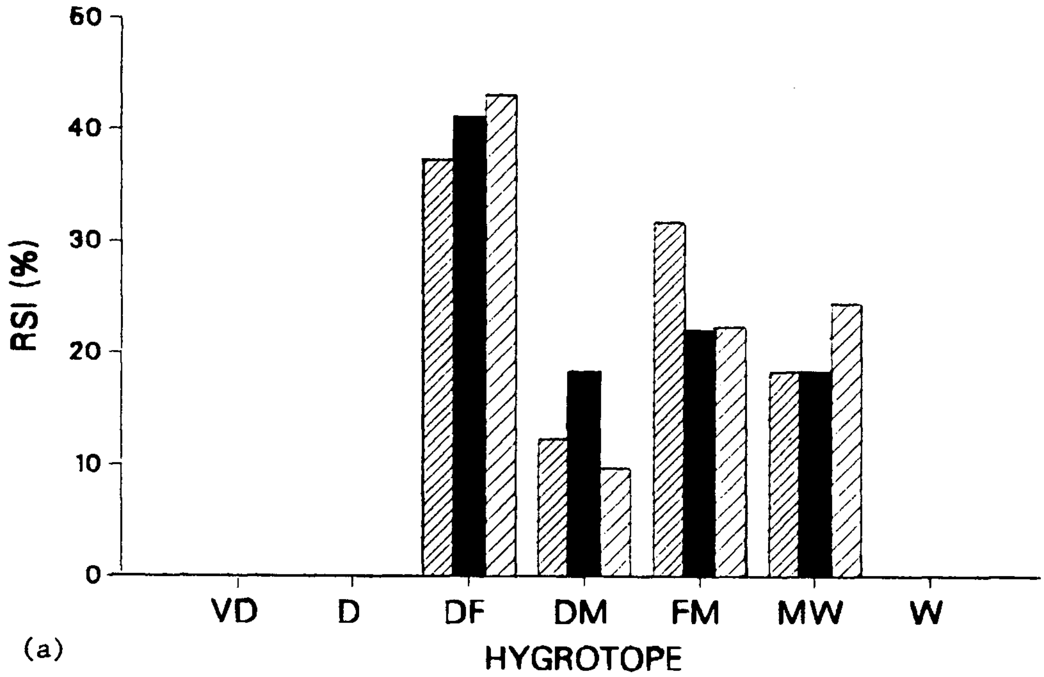
horizons were designated as B21, B22, and B23. However, analysis revealed that the samples from the B21 and B22 layers were actually organic (> 30% organic matter), so they were re-labelled as Hi1, Hi2, and Bm. The gravel in these horizons is egg-shaped, and sorted with depth. Underlying the Bm horizon are two sandy Bm layers, with no coarse fragments. Rooting is confined to the organic layers and gravelly Hi1 (which is high in total N). The organic horizons consist of thin L and F layers, with a dense mat of fine roots; and a thick (15-23 cm) humus layer, which is predominantly decaying wood. The humus contains charcoal, white fungal mycelia, and earthworms. The soil may be classified as a fragmental over sandy, Cumulic Regosol.

The soil of plot 2 contains a much thinner layer of gravel than plot 1, has a well-developed eluviated Ae horizon, and does not have an organic-mineral surface horizon (App. 4). The mineral horizons are not enriched with high levels of organic matter, and generally, have lower levels of exchangeable cations (App. 5). Nevertheless, rooting continues to a much greater depth. The organic horizons are similar to those of plot 1, but are thinner. White fungal mycelia was plentiful, and earthworms were observed in both the humus and Ae horizons. The soil is probably a sandy, Eluviated Dystric Brunisol.

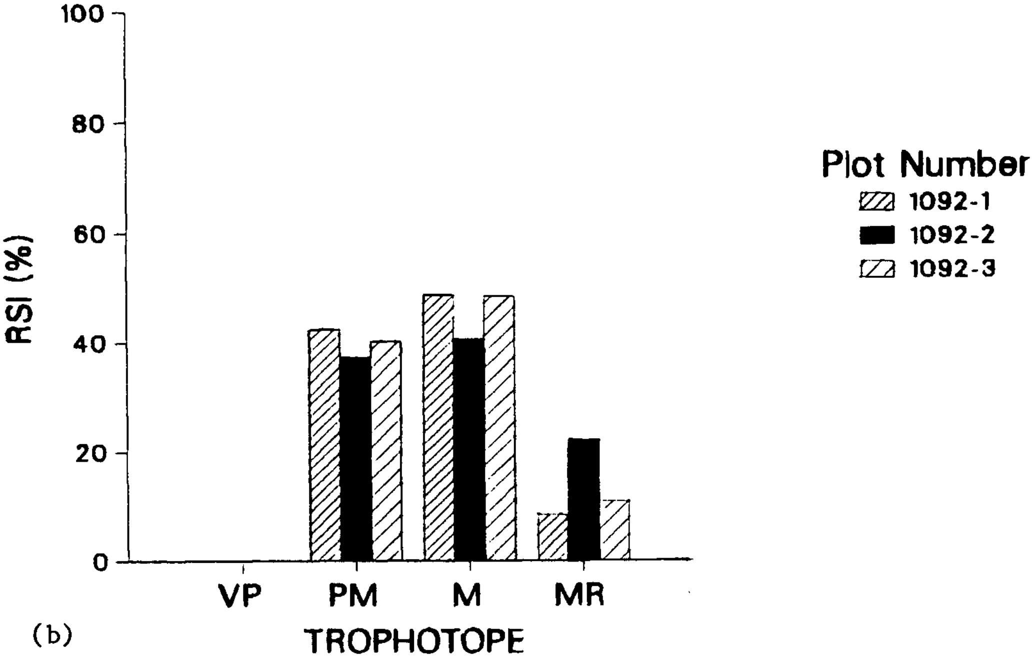
The soil of plot 3 has similarities to that of both plots 1 and 2. The profile consists of a thin, discontinuous Aej horizon; and a sequence of black mineral horizons, which contain a high percentage (45%) of rounded coarse fragments. The upper mineral horizons are enriched with organic matter, but not to nearly the extent of those in plot 1. The water table was encountered at a depth of approximately 75 cm. Rooting extends through the solum to the water table, but is most abundant in the organic and upper mineral horizons. The organic component of the profile is approximately 10 cm thick, and resembles that of plots 1 and 2. The soil can probably be classified as a fragmental Orthic Dystric Brunisol.

The indicator plant species on this site reflect very favourable nutrient and moisture conditions (Fig. 45). The majority of plants are contained in the medium trophotope category; which is richer than most of the study sites, but not as rich as Stands 513 and 315 (Figs. 47, 46). The hygrotope spectrum of EISG reflects somewhat drier conditions than most of the study sites, but not nearly as dry as Stands 818 and 819 (Figs. 17, 18). This may be a function of the high percentage of coarse fragments in the soil, which promote relatively rapid drainage; particularly compared to soils with restrictive layers.

The soils, with their good drainage, enrichment with organic matter, and lateral water-flow, enhance the productivity of the site. In addition, the productivity of this site may have been improved from the disturbances of logging. The site index for western redcedar was calculated as 33.4, from average height and age values of 22.3 m and 48 years. This site index corresponds to site class (mid) medium and growth class 4 for redcedar. The average height of western hemlock (29.8 m) and its corresponding site index (41.3) were considerably higher than those of redcedar. Site 1092 can be classified as growth class 3 and site class (lo) good for western hemlock.



(a)



(b)

Figure 45: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 1092, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

Study Site of Association 3.21 : Lysichito-Piceetum

STAND 315 : Kennedy Floodplain

Reference: Sample plots 315-1, 315-2, 315-3; Table 29; Figures 28, 29, 30, 31, 46; Appendices 1, 4, 5, 7.

Stand 315 is located in MacMillan-Bloedel's Kennedy Lake division off branch road 500A. The site is a level floodplain at 22 m elevation, and has a stream flowing through it. Of the three sample plots, plot 1 is situated farthest upstream. It is the wettest plot and contains some depressions with open, standing water. The wet conditions of plot 1 are reflected by the hygrotope spectrum of edatopic indicator species groups (Fig. 42). The stream flows through plots 2 and 3, and makes up approximately 20% of the surface area of each plot.

The site is covered by an overmature forest comprised of very large, old (350-450+ yrs.) Sitka spruce and western redcedar trees. Of the 14 study sites, this site has the lowest relative density (313 stems/ha) and yet, the second highest basal area (216.7 m^2/ha); indicating that the individual trees are quite large. The presence of charcoal in the soil suggests that the stand was probably established after a fire.

Sitka spruce and western redcedar dominate the main canopy and account for 45% and 48% of the basal area, respectively. Western hemlock, which is present in the codomimant, intermediate and suppressed positions; has the highest relative density (113 stems/ha), but only makes up 5.3% of the basal area due to its small diameters. The stand also contains a very minor component of amabilis fir and western yew.

The understory is very well-developed and rich in species diversity. The shrub layer is quite dense and is dominated by salal, salmonberry, vacciniums and false-azaela. Salmonberry reaches heights of 3-4 m. The herb layer contains a wide range of species including deer fern, skunk cabbage, sword fern, slough sedge, false lily-of-the-valley (Maianthemum dilatatum), lady fern, and foamflower. There are numerous moss species present. The most abundant ones are Rhizomnium glabrescens, Hylocomium splendens, Plagiothecium undulatum, Plagiomnium insigne, and Kindbergia praelonga.

Regeneration of western hemlock is abundant in both the herb and shrub layers of all three plots. Sitka spruce and western redcedar seedlings are also common, but are not nearly as numerous as hemlock. Much of the regeneration occurs on nurse logs.

The soil of this site has developed from fluvial processes. It is characterized by a well-developed mineral-organic surface horizon (H or Ah), and a sequence of gleyed B horizons with features indicative of periods of prolonged saturation. The soil may be classified as loamy to fine-silty Humic Gleysol.

The soil is poorly to very poorly drained and has a subhydric to hydric moisture regime. The water table was encountered at a depth of approximately 80 cm in plots 1 and 2 (Table 29); and the lower mineral horizons of all three plots smelled strongly of SO_2, indicating anaerobic conditions. Rooting was confined to the upper horizons.

The organic horizons are very thin (0-4 cm) and it is difficult to differentiate the L,F, and H horizons from the underlying Ah. Earthworms were found in all three plots, and probably assist in breaking down the

Table 29: Environmental data for stand 315

Characteristic	315-1	315-2	315-3
Elevation (m)	22	22	22
Aspect (°)	N/A	N/A	N/A
Slope gradient (%)	0	0	0
Macrosite position	plain	plain	plain
Mesosite position	level	level	level
Microtopography (moundedness)	extremely	severely	moderately
Surface shape	undulating	straight	undulating
Soil parent material	fluvial	fluvial	fluvial
Soil moisture regime	hydric	subhydric	subhydric
Soil drainage class	very poor	poor	poor
Free water	present	present	--
Soil type	HG	HG	HG
Family particle-size class	fine loamy	fine silty	fine silty
Forest floor thickness (cm)	15	5	6
Depth of Ah horizon (cm)	--	7	10
Total rooting depth* (cm)	52	83	97
Depth to restrictive layer* (cm)	70	90	115
Depth to water table* (cm)	70	90	115
Effective rooting depth* (cm)	47	58	73
Bulk density, humus (g/cc)	--	0.29	0.11
Basal area (m^2/ha)	247	224	179
Relative density (stems/ha)	320	340	280

(* includes depth of organic horizons)

organic matter and incorporating it in the upper mineral horizon. A mat of white fungal mycelia was present near the surface of the organic horizons.

The indicator plant species on this site reflect a fairly rich nutrient regime (Fig. 46); similar to, but not quite as fertile as that of Stand 513 (Fig. 47). However, the soil analyses did not reveal particularly high concentrations of nutrients (App. 5). The soil probably receives additional inputs of nutrients from lateral seepage and periodic flooding.

The site index for western redcedar was calculated as 34.7 from average height and age values of 38.6 m and 216++ years. Of the 13 sites for which the site index of redcedar was claculated, stand 315 had the third highest value. This site index places stand 315 in growth class 4 (almost 3), and site class (mid) medium for western redcedar. However, redcedar was not the most productive species on this site. The site index for Sitka spruce was calculated as being 51.2, from average height (53.5 m) and age (250++ yrs.) values. Thus, this site can be classified as growth class 1 and site class (high) good for Sitka spruce.

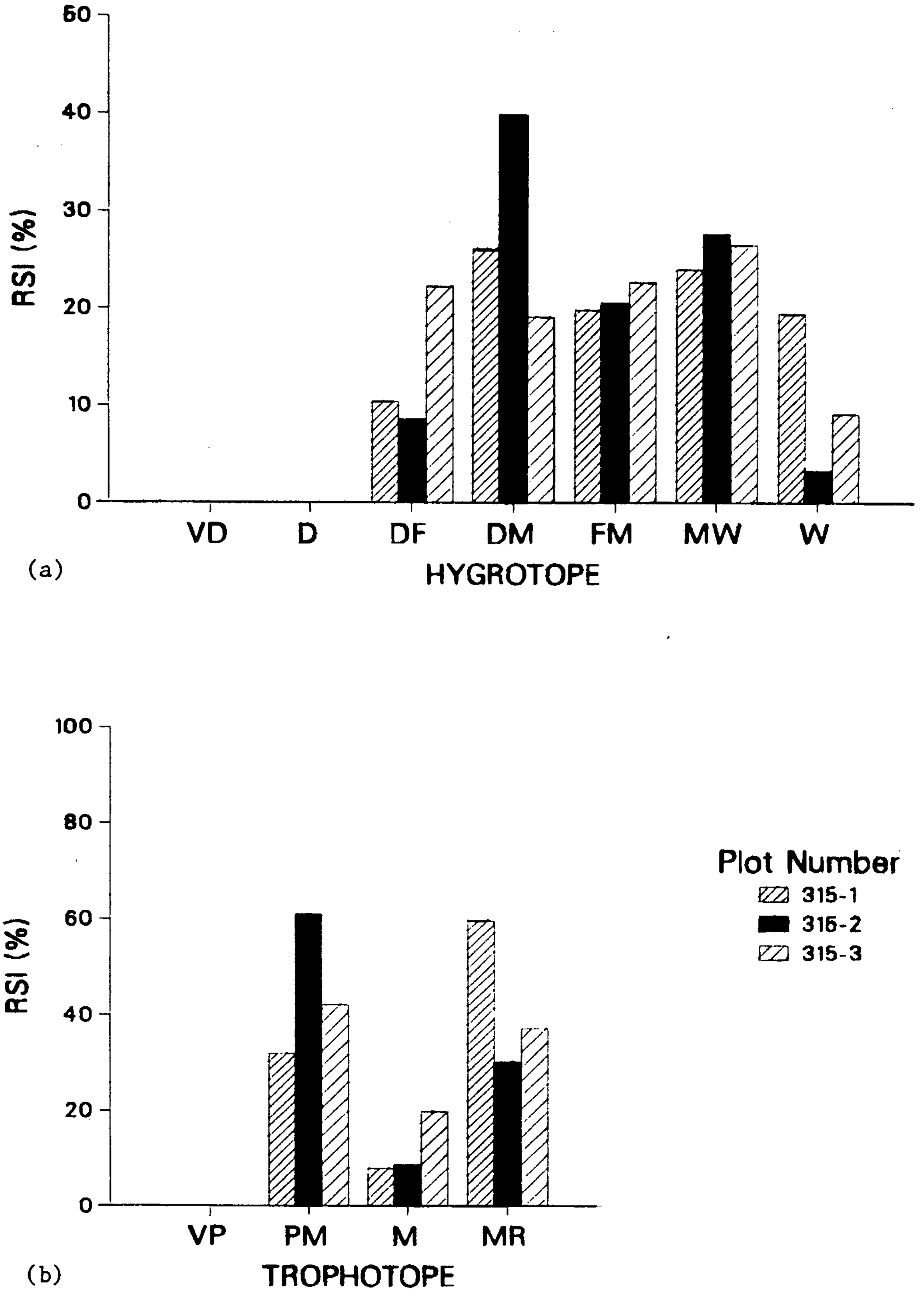


Figure 46: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 315, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

Study Site of Association 4.11 : Tiarello-Abietetum

STAND 513 : Sproat Lake

Reference: Sample plots 513-1, 513-2, 513-3; Table 30; Figures 32, 47; Appendices 1, 4, 5, 7.

Stand 513 is located in MacMillan-Bloedel's Sproat Lake division, off branch road 513, near Highway 4. Of the fourteen study sites, this stand is the farthest inland. It is a flat, valley bottom bordering the Kennedy River, at an elevation of 220 m.

The stand is covered by a mature (300+ yrs) forest of very large, widely spaced trees, and numerous blowdowns. Although the stand is classed as Balsam/Hemlock on the MacMillan-Bloedel cover-type map, it was sampled because there are pockets of huge western redcedars. Thus, the results may be somewhat biased since the areas with redcedar were favoured for

sampling. The redcedars measured in the sample plots were all in the dominant canopy layer. They were small in number (53 stems/ha), but very large in size; and accounted for 51% of the total stand basal area of 141.5 m^2/ha. Amabilis fir was present in all canopy layers and made up 40% of the basal area; but its numbers were large (253 stems/ha) and diameters small. Western hemlock was present in all layers of the canopy and made up the remaining 9% of the basal area. Sitka spruce was not present in the sample plots, but was scattered throughout the stand.

The understory is characterized by a relatively light shrub layer and a very well-developed layer of vigorous herbs. The shrubs are densest in areas where fallen trees have created openings in the canopy. Vaccinium species are the dominant species, especially V. alaskaense, and reach a height of over 2 m. Rubus spectabilis is also common. Salal was not sighted. Twenty-two herb species were observed in the stand (App. 4). They included (in order of decreasing abundance), Viola glabella, Cornus unalaschkensis, Tiarella trifoliata, T. unifoliata, Gymnocarpium dryopteris, Achlys triphylla, Trillium ovatum, Blechnum spicant, Athyrium felix-femina, and Polystichum munitum. Regeneration of western hemlock and

amabilis fir was also abundant in the herb layer. Numbers of hemlock seedlings and saplings were exceptionally high. The site is a mature (inactive) floodplain, and the soils have developed from fluvial deposits. The soils of plots 1 and 2 are very deep (150+ cm), very fine sandy loams with no coarse fragments (Table 30). They are well-drained and of mesic moisture regime. Rooting is unrestricted, and is common to a depth of approximately 90 cm. The soil is characterized by a thin, discontinuous Ae horizon; deep B horizons, high in organic matter (6.4-13.4%); and C horizons with mottling at a depth of 140 cm. The organic matter content of the B horizons contributes to the nitrogen ond phosphorus levels, which are slightly higher than for most of the sampled stands. The soil may be classified as a fine loamy Orthic Ferro-Humic Podzol.

The organic horizons consist of very thin L and F layers, and a humus of 3-18 cm thickness. The humus is very dry, lightweight, crumbly and feels felty. It contains a dense mat of fine roots, and some white fungal mycelia. An earthworm was observed in the stand, but not in the sample plots.

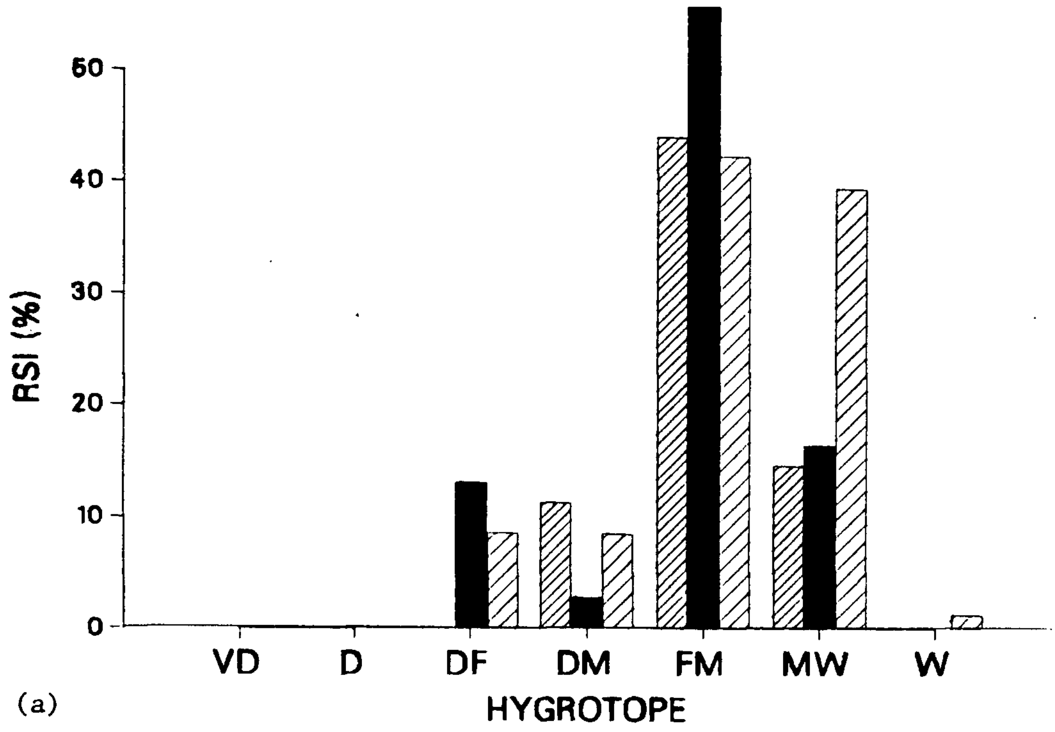
Table 30: Environmental data for stand 513

Characteristic	513-1	513-2	513-3
Elevation (m)	227	215	220
Aspect (^{o})	N/A	N/A	N/A
Slope gradient (%)	0	0	0
Macrosite position	valley floor	valley floor	valley floor
Mesosite position	level	level	depression
Microtopography (moundedness)	smooth	slightly	slightly
Surface shape	straight	straight	concave
Soil parent material	fluvial	fluvial	fluvial
Soil moisture regime	mesic	mesic	subhygric
Soil drainage class	well	well	mod. well
Free water	absent	absent	present
Soil type	OFHP	OFHP	GHFP
Family particle-size class	fine loamy	fine loamy	fine loamy
Forest floor thickness (cm)	7	15	3
Depth of Ah horizon (cm)	--	--	7
Depth of Ae horizon (cm)	thin, discon.	thin, discon.	6
Total rooting depth* (cm)	153+	150+	80
Depth to restrictive layer* (cm)	153+	150+	80
Depth to water table* (cm)	--	--	80
Effective rooting depth* (cm)	83	105	34
Bulk density, humus (g/cc)	0.21	0.25	0.26
" " Ah	--	--	0.44
Basal area (m^2/ha)	144	82	199
Relative density (stems/ha)	280	320	420

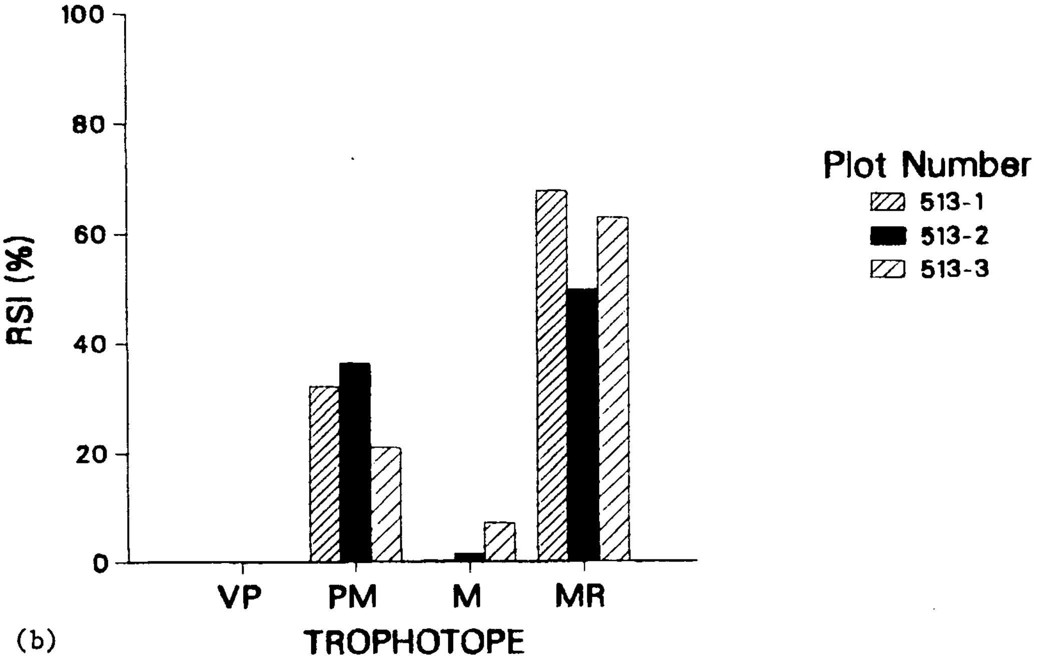
(* includes depth of organic horizons)

Plot 3 is situated on, what appears to be, an old dried-up streambed. Consequently, the soil differs from plots 1 and 2. The indicator plant species on this plot reflect a slightly moister hygrotope than plots 1 and 2 (Fig. 47). The organic horizons are very thin (0-3 cm), and are underlain by well-developed Ah and Ae horizons. The B horizons are mottled, and contain less organic matter (3.7-8.5%). The water table was reached at a depth of 93 cm. Nevertheless, like plots 1 and 2 , the soil is very deep (107+ cm), loamy-textured, and contains no coarse fragments. This soil may be classified as a fine loamy Gleyed Humo-Ferric Podzol.

The soils, with their good drainage, enrichment of organic matter, and deep rooting, greatly enhance the productivity of the site. The indicator plant species on this site reflect the favourable moisture and nutrient conditions (Fig. 47). This is the only study site in which the majority of indicator species are contained in the medium-rich trophotope category. Of the 13 sites for which the site index of redcedar was estimated, this site had the highest value. The site index of western redcedar was estimated as being greater than 45.7, from average height (51.3 m) and age (267+ yrs) values. This site index value places stand 513 in site class (high) good and growth class 1 for western redcedar.



(a)



(b)

Figure 47: A plot of the edatopic indicator species groups for the 3 sample plots of Stand 513, as expressed by relative species importance (RSI), in relation to (a) hygrotope, and (b) trophotope.

APPENDIX 3

List of Plant Species[6]

Abies amabilis (Dougl. ex Loud.) Forbes
    Pacific silver fir
Achlys triphylla (Smith) DC.
    American vanilla leaf
Adenocaulon bicolor Hook.
    Trailplant
Adiantum pedatum L.
    Maidenhair fern
Alnus rubra Bong.
    Red alder
Athyrium filix-femina (L.) Roth.
    Common lady fern
Bazzania denudata (Torr. ex Gott. et al.) Trev.

Blechnum spicant (L.) Roth.
    Deer fern
Blepharostoma trichophyllum (L.) Dum.

Boschniakia hookeri Walpers
    Vancouver groundcone
Boykinia elata (Nutt.) Greene
    Coast boykinia
Calamagrostis nutkaensis (Presl) Steudel
    Pacific small reed grass
Calypogeia muelleriana (Schiffn.) K. Muell.

Carex obnupta Bailey
    Slough sedge
Cephalozia bicuspidata (L.) Dum.

Chamaecyparis nootkatensis (D. Don) Spach.
    Yellow cedar
Cladina impexa (Harm.) B. de Lesd.

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[6] Nomenclature for vascular plants follows Taylor and MacBryde (1977), Ireland *et al.* (1980) for mosses, Hale and Culberson (1970) for lichens, and Stotler and Crandall-Stotler (1977) for liverworts.

Cladina rangiferina (L.) Harm.

Cladonia bellidiflora (Ach.) Schaer.

Cladonia gracilis (L.) Willd.

Cladonia uncialis (L.) Wigg.

Coptis asplenifolia Salisb.
Spleenwort-leaved goldthread
Cornus nuttallii Audub. ex Torr. & Gray
Western flowering dogwood
Cornus unalaschkensis Ledebour
Western cordilleran bunchberry
Danthonia spicata (L.) Beauv. ex Roemer & Schul.
Poverty oat grass
Dicranum fuscescens Turn.

Dicranum scoparium Hedw.

Diplophyllum albicans (L.) Dum.

Diplophyllum plicatum Lindb.

Ditrichum sp.

Dryopteris expansa (Presl) Fraser-Jenkins & Jermy
Spiney shield fern
Equisetum sp.
Horsetail
Festuca subulata Trin. in Bong.
Bearded fescue
Galium boreale L.
Northern bedstraw
Galium triflorum Michx.
Sweet-scented bedstraw
Gaultheria shallon Pursh.
Salal
Goodyera oblongifolia Raf.
Large-leaved rattlesnake orchid
Gymnocarpium dryopteris (L.) Newm.
Oak fern
Herberta adunca (Diks.) S.F. Gray

Hieracium albiflorum Hook.
White hawkweed
Hookeria lucens (Hedw.) Sm.

Huperizia selago (L.) Bernh. ex Schrank & Mar.
Fir club-moss

Hylocomium splendens (Hedw.) B.S.G.

Hypnum circinale Hook.

Hypopythys monotropa Crantz
Fringed pinesap
Isopterygium elegans (Brid.) Lindb.

Isothecium stoloniferum Brid.

Kalmia microphylla (Hook.) A.A. Heller
Western swamp kalmia
Kindbergia oregana (Sull.) Ochyra

Kindbergia oregana (Hedw.) Ochyra

Ledum groenlandicum Ceder
Common Labrador tea
Lepidozia reptans (L.) Dum.

Leucolepis menziesii (Hook.) Steere ex L. Koch

Linnaea borealis L.
Northern twinflower
Listera cordata (L.) R. Br. in Ait.
Heart-leaved twayblade
Luzula parviflora (Ehrh.) Desv.
Small-flowered wood rush
Lycopodium clavatum L.
Running club-moss
Lysichitum americanum Hulter & St.John
American skunk cabbage
Maianthemum dilatatum (Wood) Nels. & MacBr.
Two-leaved false Solomon's seal
Malus fusca (Raf.) Schneider
Pacific crab apple
Menziesia ferruginea Smith
Rusty Pacific menziesia
Mylia taylorii (Hook.) S.F. Gray

Nardia scalaris S. Gray

Orthilia secunda L.
Few-flowered one-sided wintergreen
Pellia neesiana (Gott.) Limpr.

Petasites palmatus (Ait.) Gray
Palmate colt's foot
Phyllodoce empertiformis (Smith) D. Don
Red mountain-heather

Picea sitchensis (Bong.) Carr.
Sitka spruce
Pinus contorta var. *contorta* Dougl. ex Loud.
Shore pine
Pinus monticola Dougl. ex D. Don in Lamb.
Western white pine
Plagiochila porelloides (Torr. ex Nees) Lindenb.

Plagiomnium insigne (Mitt.) Kop.

Plagiothecium undulatum (Hedw.) B.S.G.

Pleurozium schreberi (Brid.) Mitt.

Pogonatum alpinum (Kindb.) Mac. & Kindb.

Polypodium glycyrrhiza D.C. Eaton
Licorice fern
Polystichum munitum (Kaulf.) Presl.
Western sword fern
Polytrichum commune Hedw.

Polytrichum piliferum Hedw.

Prenanthes alata (Hook.) D. Dietr.
Western rattlesnakeroot
Pseudotsuga menziesii (Mirb.) Franco
Coast Douglas-fir
Pteridium aquilinum (L.) Kuhn in Decken
Western bracken fern
Rhacomitrium canescens (Hedw.) Brid.

Rhacomitrium heterostichum (Hedw.) Brid.

Rhacomitrium lanuginosum (Hedw.) Brid.

Rhamnus purshianus D.C.
Cascara
Rhizomnium glabrescens (Kindb.) Kop.

Rhytidiadelphus loreus (Hedw.) Warnst.

Rhytidiadelphus triquetrus (Hedw.) Warnst.

Ribes sp. L.
Gooseberry or current
Riccardia latifrons Lindb.

Rubus spectabilis Pursh
Salmonberry

Salix sp.
Willow
Saxifrage ferruginea Grah.
Alaska saxifrage
Scapania bolanderi Aust.

Sphagnum girgensohnii Russ.

Sphagnum henryense

Stachys mexicana Bentham
Mexican hedge-nettle
Streptopus amplexifolius (L.) DC. in Lam. & DC.
Cucumberroot twistedstalk
Streptopus roseus Michx.
Simple-stemmed twistedstalk
Stereocaulon tomentosum Fr.

Taxus brevifolia Nutt
Western yew
Thuja plicata Donn ex D. Don in Lamb.
Western redcedar
Tiarella laciniata Hook.
Cut-leaved foamflower
Tiarella trifoliata L.
Trifoliate-leaved foamflower
Tiarella unifoliata Hook.
Unifloiate-leaved foamflower
Trisetum cernuum Trin.
Nodding trisetum
Trillium ovatum Pursh
Western white trillium
Tsuga heterophylla (Raf.) Sarg.
Western hemlock
Vaccinium alaskaense Howell
Alaska blueberry
Vaccinium ovalifolium Smith in Rees
Oval-leaved blueberry
Vaccinium ovatum Pursh
Evergreen huckleberry
Vaccinium parvifolium Smith in Rees
Red huckleberry
Veratrum viride Ait.
Green false-hellebore
Viola glabella Nutt. in T. & G.
Yellow wood violet

The following latin names were changed, as follows, to agree with the nomenclature of Taylor and MacBryde (1977):

Kalmia polifolia	=	*K.microphylla*
Lycopodium selago	=	*Huperizia selago*
Petasites speciosa	=	*P. palmatus*
Pogonatum macounii	=	*P. alpinum*
Polytrichum alpinum	=	*Pogonatum alpinum*
Pyrola secunda	=	*Orthilia secunda*

Also, note that the genus *Stokesiella* has been renamed *Kindbergia* (Ochyra 1981); and that *Dryopteris assimilis* (Walker) has been renamed *D. expansa* ((Presl) Fraser-Jenkins & Jermy).

APPENDIX 4 : DESCRIPTION OF THE SOIL PROFILES

Plot no.: 818-1
Location: Dry Rock Outcrop
Associated soil: Typic Folisol with Humimor over bedrock

Horizon	Depth (cm)	Description
LF	9- 7	Plentiful decayed wood; 1-3 cm thick; pH 4.2 (H_2O), 4.1 ($CaCl_2$).
H	7- 0	Dry to moist; composed of mosses and decayed wood; flakey, sawdust-like, felty; very abundant white mycelia, few yellow mycelia; abundant decayed wood; very abundant all-sized roots; abrupt wavy boundary; 5-8 cm thick; pH 3.7 (H_2O), 3.1 ($CaCl_2$).
Bedrock		no mineral horizons present.

APPENDIX 4 (cont'd)

Plot no.: 818-2
Location: Dry Rock Outcrop
Associated soil: Loamy-skeletal "Lithic Podzol" over bedrock

Horizon	Depth (cm)	Description
LFH	5- 0	Very dark grayish brown (10YR 3/2 d); very friable, non-plastic; plentiful, fine and medium roots; non-distinct wavy boundary; 0-8 cm thick; pH 3.8 (H_2O), pH 4.1 ($CaCl_2$).
Ae	0-15	Dark grayish brown to light brownish gray (10YR 4/2 m, 6/2 d); cobbley silt loam; friable (m), soft (d); non-plastic; abundant, all-sized roots; 50% rounded cobbles, 25% stones; non-distinct wavy boundary; 0-40 cm thick; pH 3.8 (H_2O), 3.2 ($CaCl_2$).
Bedrock		

APPENDIX 4 (cont'd)

Plot no.: 819-1
Location: Rock Outcrop
Associated soil: Loamy "Lithic Podzol" with Humimor over bedrock

Horizon	Depth (cm)	Description
LF	19-15	Abundant fine roots; 2-6 cm thick; pH 3.8 (H_2O), 3.4 ($CaCl_2$).
H	15- 0	Wet; composed of mosses and decayed wood; lightweight, clumps held together by fine roots; somewhat slippery; plentiful decayed wood; charcoal present; plentiful white mycelia, few yellow mycelia; earthworms observed; very abundant all-sized roots; 10-40 cm thick; pH 3.6 (H_2O), 3.2 ($CaCl_2$); bulk density 0.120 g/cc.
Ae	0- 8	Very dark grayish brown to light brownish gray (10YR 3/2 m, 6/2 d); very fine sandy loam; moderate, medium to coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, all-sized roots; 5% sub-angular gravel, 5% cobbles; few charcoal particles; 2-18+ cm thick; pH 3.8 (H_2O), 2.9 ($CaCl_2$).
Bedrock		

APPENDIX 4 (cont'd)

Plot no.: 819-2
Location: Rock Outcrop
Associated soil: Loamy "Lithic Podzol" with Xeromor over bedrock

Horizon	Depth (cm)	Description
L	20-15	3-7 cm thick; pH 4.4 (H_2O), 4.1 ($CaCl_2$).
FH	15- 0	Dry to moist; composed of mosses, decayed wood, and coniferous litter; lightweight, fluffy, sawdust-like; plentiful decayed wood; few charcoal particles; plentiful white mycelia, few yellow mycelia; very abundant, all-sized roots; 40% angular gravel; 10-20 cm thick; pH 3.9 (H_2O), 3.3 ($CaCl_2$); bulk density 0.180 g/cc.
Ae	0- 3+	Dark brown to grayish brown (10YR 3/3 m, 5/2 d); gravelly loam; structureless, single-grained; friable (m), loose (d); abundant, all-sized roots; 20% angular gravel, 10% cobbles; 0-3+ cm thick; pH 3.8 (H_2O), 3.2 ($CaCl_2$).
Bedrock		

APPENDIX 4 (cont'd)

Plot no.: 131-1
Location: Sarita Beaver Pond
Associated soil: Loamy-skeletal Ortstein Humic Podzol with Humimor on morainal deposits.

Horizon	Depth (cm)	Description
L	13-12	Coniferous litter, moss and wood; abrupt wavy boundary; 1-2 cm thick; pH 4.6 (H_2O), 4.3 ($CaCl_2$).
H	12- 0	Moist; few white mycelia; plentiful insects; decayed wood present; abundant, fine roots; abrupt wavy boundary; 2-25 cm thick; pH 3.5 (H_2O), 3.1 ($CaCl_2$).
Aeg	0- 7	Dark gray to light gray (10YR 4/1 m, 6/1 d); fine, sandy loam; common to few, fine mottles; moderate to strong, coarse, sub-angular blocky; very friable to friable (m), slightly hard (d); 5% sub-rounded gravel; few, fine to medium roots; abrupt wavy boundary; 5-9 cm thick; pH 3.5 (H_2O), 3.1 ($CaCl_2$).
Bhgc	7-20	Dark brown (7.5YR 3/4 m, 4/6 d); gravelly sandy loam; few, fine mottles; strong, coarse, sub-angular blocky; friable (m), slightly hard (d); 30% sub-angular gravel; cemented (ortstein?); clear, smooth boundary; 12-14 cm thick; pH 4.7 (H_2O), 4.6 ($CaCl_2$).
Bgc	20-33+	Dark brown to brownish gray (7.5YR 3/4 m, 10YR 6/8 d); very gravelly sandy loam; moderate, coarse, sub-angular blocky; few, fine mottles; friable (m), slightly hard (d); cemented or compacted; 45% sub-rounded gravels and cobbles; pH 4.9 (H_2O), 5.1 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 131-2
Location: Sarita Beaver Pond
Associated soil: Loamy-skeletal Orthic Humic Podzol with Humimor on morainal deposits.

Horizon	Depth (cm)	Description
L(F)	17-15	Coniferous litter; abrupt wavy boundary; 2-3 cm thick; pH 3.1 (H_2O), 4.3 ($CaCl_2$).
H	12- 0	Moist; few white mycelia; abundant roots; abrupt wavy boundary; 10-20 cm thick; pH 3.5 (H_2O), 3.1 ($CaCl_2$).
Ae	0-12	Very dark grayish brown to grayish brown (10YR 3/2 m, 5/2 d); sandy loam; moderate to strong, coarse, sub-angular blocky; moderately friable (m), slightly hard (d); 10% sub-angular gravel; plentiful roots; abrupt broken boundary; 8-16 cm thick; pH 4.3 (H_2O), 3.5 ($CaCl_2$).
B21g	12-31	Dark yellowish brown to yellowish brown (10YR 3/6 m, 5/6 d); gravelly sandy loam; common mottles; moderate, medium, sub-angular blocky; moderately friable (m), soft (d); 40% sub-angular gravels and cobbles; few roots; clear, wavy boundary; 8-30 cm thick; pH 4.9 (H_2O), 5.0 ($CaCl_2$).
B22g	31-43	Dark yellowish brown to yellowish brown (10YR 3/4 m, 10YR 5/6 d); gravelly sandy loam; abundant mottles; moderate, medium, sub-angular blocky; moderately friable (m), soft (d); 40% sub-angular gravels and cobbles; very few roots; clear wavy boundary; 8-15 cm thick; pH 5.0 (H_2O), 5.4 ($CaCl_2$).
BCg	43-54	Dark yellowish brown (10YR 3/6 m, 4/4 d); gravelly sandy loam; abundant mottles; moderate, medium to coarse, sub-angular blocky; moderately friable (m), soft (d); 30% sub-angular gravels and cobbles; very few, fine roots; clear smooth boundary; 10-12 cm thick; pH 5.0 (H_2O), 5.0 ($CaCl_2$).
Cg	54-64+	Very dark brown to olive brown (10YR 2/2 m, 2.5Y 4/4 d); very gravelly loamy sand; friable (m), soft (d); 50% gravels; 10+ cm thick; pH 5.1 (H_2O), 4.5 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 131-3
Location: Sarita Beaver Pond
Associated soil: Loamy Ortstein Humic Podzol with Hemihumimor on morainal deposits.

Horizon	Depth (cm)	Description
L	17-16	Moist; coniferous litter; very abundant decayed wood; abrupt wavy boundary; 1-2 cm thick; pH 4.5 (H_2O), 4.4 ($CaCl_2$).
F	16-14	Moist; white and yellow mycelia present; slight matting and/or compaction; very abundant all-sized roots; 2-3 cm thick; (sampled with L).
H	14- 8	Very moist; fairly lightweight and porous; few earthworms; very abundant, all-sized roots; clear wavy boundary; 5-7 cm thick; pH 3.6 (H_2O), 3.0 ($CaCl_2$).
Hil	8- 0	Black to dark gray (10YR 2/1 m, 4/1 d); loamy sand; common mottles; moderate, coarse, sub-angular blocky; friable (m), hard (d); abundant, all-sized roots; abrupt, wavy boundary; 6-10 cm thick; pH 4.2 (H_2O), 3.3 ($CaCl_2$).
Ae	0-14	Very dark grayish brown to light brownish gray (10YR 3/2 m, 6/2 d); silty clay loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); few, fine roots; 5% sub-angular gravels and cobbles; abrupt wavy boundary; 12-16 cm thick; pH 4.0 (H_2O), 3.3 ($CaCl_2$).
AB	14-20	Black to dark grayish brown (10YR 2/1 m, 4/2 d); gravelly loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); very few, fine roots; 5% sub-angular gravel; abrupt broken boundary; 2-8 cm thick; pH 4.3 (H_2O), 3.7 ($CaCl_2$).
Bgc	20-34	Very dark brown to olive brown (10YR 2/2 m, 2.5Y 4/4 d); gravelly loam to gravelly sandy loam; common mottles; moderate, medium to coarse, sub-angular blocky; friable (m), soft (d); 45% sub-rounded gravels and cobbles; cemented hardpan; abrupt wavy boundary; 11-16 cm thick; pH 4.8 (H_2O), 4.1 ($CaCl_2$).

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APPENDIX 4 (cont'd)

Plot no.: 131-3 (cont'd)

Horizon	Depth (cm)	Description
BCgc	34-40	Dark yellowish brown to olive brown (10YR 3/4 m, 2.5Y 4/4 d); gravelly loamy sand; few mottles; moderate, medium, sub-angular blocky; friable (m), soft (d); 15% rounded gravel and cobbles; cemented impermeable hardpan; abrupt smooth boundary; 5-7 cm thick; pH 4.8 (H_2O), 4.2 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 144-1
Location: Sarita Clearcut
Associated soil: Sandy gleyed Ferro-Humic Podzol with Humimor on morainal deposits.

Horizon	Depth (cm)	Description
L	8- 6	Coniferous litter and decayed wood; abrupt wavy boundary; 0-3 cm thick; pH 4.3 (H_2O), 3.7 ($CaCl_2$).
H	6- 0	Moist; abundant decayed wood; sub-angular; very friable; appears well-worked by insects; very abundant, all-sized roots; 0-12 cm thick; pH 3.6 (H_2O), 3.1 ($CaCl_2$).
Ae	0-12	Dark grayish brown to light brownish gray (10YR 4/2 m, 6/2 d); loamy sand; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); very abundant, all-sized roots; 20% sub-angular gravels and cobbles; abrupt, wavy boundary; 1-23 cm thick; pH 3.7 (H_2O), 3.1 ($CaCl_2$).
Bhfgj	12-35	Very dark brown to dark yellowish brown (10YR 2/2 m, 3/6 d); gravelly loamy sand; few mottles; moderate, coarse, sub-angular blocky; friable (m), soft (d); plentiful roots; 35% sub-angular cobbles and stones; abrupt wavy boundary; 14-32 cm thick; pH 4.6 (H_2O), 4.0 ($CaCl_2$).
Bfg	35-47	Dark yellowish brown to yellowish brown (10YR 3/6 m, 5/6 d); gravelly sandy loam; common mottles; weak to moderate, medium, sub-angular blocky; very friable (m), soft (d); few roots; 30% sub-angular gravel; abrupt broken boundary; (horizon is sporadic, found in pockets); 10-14 cm thick; pH 4.9 (H_2O), 4.7 ($CaCl_2$).
BC	47-54	Black to dark grayish brown (10YR 2/1 m, 4/2 d); very gravelly loamy sand; weak to moderate, medium sub-angular blocky; very friable (m), soft (d); very few fine roots; 30% sub-rounded gravel; abrupt smooth boundary; 4-11 cm thick; pH 4.5 (H_2O), 3.8 ($CaCl_2$).
Cc	54+	not sampled.

APPENDIX 4 (cont'd)

Plot no.: 144-2
Location: Sarita Clearcut
Associated soil: Loamy-skeletal Gleyed Ferro-Humic Podzol with Humimor on morainal deposits

Horizon	Depth (cm)	Description
L	18-17	Coniferous litter and very abundant decayed wood; 1-2 cm thick; pH 4.1 (H_2O), 3.7 ($CaCl_2$).
H	17- 0	Moist; very abundant decayed wood; lightweight and porous; appears well-worked by insects (millipedes, mites, and spiders observed); very abundant roots; abrupt wavy boundary; 10-24 cm thick; pH 3.7 (H_2O), 3.2 ($CaCl_2$).
Ae	0- 3	Dark grayish brown to light gray (10YR 4/2 m, 7/1 d); loamy sand; weak to moderate, medium, sub-angular blocky; friable (m), slightly hard (d); plentiful roots; 30% sub-angular cobbles; abrupt, wavy boundary; 1-5 cm thick; pH 3.7 (H_2O), 3.0 ($CaCl_2$).
Bhfg	3-34	Dark yellowish brown to brownish yellow (10YR 4/6 m, 6/6 d); very gravelly sandy loam; common mottles; moderate, medium to coarse, sub-angular blocky; friable (m), soft (d); few roots; 50% sub-angular gravel,cobbles and stones; abrupt wavy boundary; 28-35 cm thick; pH 4.9 (H_2O), 5.0 ($CaCl_2$).
Bfg	34-43	Dark yellowish brown to brown (10YR 3/4 m, 5/3 d); gravelly loam to gravelly sandy loam; common mottles; moderate, medium, sub-angular blocky; friable (m), slightly hard (d); very few fine roots; 35% sub-rounded gravel; abrupt broken boundary; 8-10 cm thick; pH 5.1 (H_2O), 4.8 ($CaCl_2$).
BC	43-59	Dark yellowish brown to yellowish brown (10YR 3/6 m, 5/6 d); very gravelly loamy sand; weak to moderate, medium, sub-angular blocky; very friable (m), soft (d); very few fine roots; 50% sub-angular gravels and cobbles; abrupt smooth boundary; 13-19 cm thick; pH 4.9 (H_2O), 4.7 ($CaCl_2$).
Cc	59+	cemented, cobbly (not sampled).

APPENDIX 4 (cont'd)

Plot no.: 144-3
Location: Sarita Clearcut
Associated soil: Loamy Ferro-Humic Podzol with Lignohumimor on morainal deposits

Horizon	Depth (cm)	Description
L	29-24	Coniferous litter and very abundant decayed wood; abrupt wavy boundary; 1-10 cm thick; pH 3.9 (H_2O), 4.0 ($CaCl_2$).
H	24- 0	Moist; very abundant decayed wood; lightweight and porous; appears well-worked by insects (insects and earthworms plentiful); very abundant all-sized roots; abrupt wavy boundary; 16-32 cm thick; pH 3.7 (H_2O), 3.2 ($CaCl_2$).
Ae	0-12	Dark grayish brown to gray (10YR 4/2 m, 6/1 d); gravelly sandy loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); abundant, medium and fine roots; 10% sub-angular cobbles; abrupt, wavy boundary; 10-15 cm thick; pH 4.3 (H_2O), 3.2 ($CaCl_2$).
Bhfg	12-30	Very dark brown to olive brown (10YR 2/2 m, 2.5Y 4/4 d); gravelly loamy sand; common mottles; moderate, coarse, sub-angular blocky; friable (m), soft (d); few, fine roots; 5% sub-rounded gravel; charcoal present; abrupt wavy boundary; 7-30 cm thick; pH 4.5 (H_2O), 3.9 ($CaCl_2$).
Bfgj	30-40	Dark brown to brown (10YR 3/3 m, 5/3 d); gravelly sandy loam; very few mottles; moderate, coarse, sub-angular blocky; friable (m), soft (d); 20% sub-rounded gravels and cobbles; abrupt broken boundary; 10-11 cm thick; pH 4.5 (H_2O), 4.0 ($CaCl_2$).
BC	40-49	Very dark brown to dark brown (10YR 2/2 m, 4/3 d); gravelly fine sandy loam; moderate, coarse, sub-angular blocky; very friable (m), soft (d); 10% sub-rounded gravels and cobbles; abrupt wavy boundary; 8-10 cm thick; pH 4.6 (H_2O), 4.0 ($CaCl_2$).

(/...)

APPENDIX 4 (cont'd)

Plot no.: 144-3 (cont'd)

Horizon	Depth (cm)	Description
Cc	49-56+	Dark yellowish brown to olive brown (10YR 3/4 m, 2.5Y 4/4 d); loamy sand; moderate to strong, coarse, sub-angular blocky; firm to friable (m), soft (d); 10% gravels; abrupt smooth boundary; 5-10+ cm thick; pH 4.8 (H_2O), 4.3 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 151-1
Location: Sarita Seepage Slope
Associated soil: Loamy Gleyed Ferro-Humic Podzol with Lignohumimor on morainal veneer

Horizon	Depth (cm)	Description
L(F)	16-14	Coniferous litter; abrupt wavy boundary; 1-3 cm thick; pH 4.4 (H_2O), 4.1 ($CaCl_2$).
H	14- 0	Moist; abundant decayed wood; lightweight; appears well-worked by soil fauna, earthworms and centipedes observed; very abundant, all-sized roots; 9-18 cm thick; pH 4.0 (H_2O), 3.4 ($CaCl_2$); bulk density 0.089 g/cc.
Aeg	0-16	Dark brown to light brownish gray (10YR 3/3 m, 6/2 d); gravelly loam; few, coarse, prominent (black and orange) mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); few, fine roots; 5% sub-angular gravel; seepage water present; abrupt, wavy boundary; 10-21 cm thick; pH 4.3 (H_2O), 3.5 ($CaCl_2$); bulk density 0.667 g/cc.
Bhfg	16-29	Very dark brown to dark brown (10YR 2/2 m, 3/3 d); very gravelly loam; common, medium, distinct (orange) mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); 10% sub-angular gravels, 20% cobbles; seepage water present; abrupt wavy boundary; 10-16 cm thick; pH 4.6 (H_2O), 4.0 ($CaCl_2$).
BCc	29-31	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); gravelly sandy loam; very friable (m), slightly hard (d); cemented; 10% sub-rounded gravel, 10% sub-angular cobbles; abrupt smooth boundary; 1-3 cm thick; pH 5.1 (H_2O), 4.4 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 151-2
Location: Sarita Seepage Slope
Associated soil: Sandy-skeletal Gleyed Ferro-Humic Podzol with Humimor on morainal veneer

Horizon	Depth (cm)	Description
L(F)	16-14	Moist; coniferous litter; abrupt wavy boundary; 1-3 cm thick; pH 4.5 (H_2O), 4.2 ($CaCl_2$).
H	14- 0	Moist; decayed wood present; white fungal mycelia present; appears worked by soil fauna and fungus; very abundant, all-sized roots; 8-20 cm thick; pH 3.7 (H_2O), 2.9 ($CaCl_2$); bulk density 0.125 g/cc.
Ae	0- 4	Dark grayish brown to light gray (10YR 4/2 m, 7/1 d); sandy loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, medium roots; 5% sub-angular gravel, 10% cobbles; abrupt, wavy boundary; 1-7 cm thick; pH 3.6 (H_2O), 2.9 ($CaCl_2$).
Bhfg	4-24	Very dark brown to dark yellowish brown (10YR 2/2 m, 3/4 d); gravelly loamy sand; common, medium, distinct mottles; moderate to strong, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful fine roots; 5% sub-angular gravel, 5% cobbles, 30% stones; abrupt wavy boundary; 12-28 cm thick; pH 4.3 (H_2O), 3.9 ($CaCl_2$).
Bfg	24-42	Dark yellowish brown to yellowish brown (10YR 3/6 m, 5/6 d); gravelly loamy sand; many, medium, distinct, mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); few, fine roots; 5% sub-angular gravel, 5% cobbles, 30% stones; abrupt irregular boundary; 12-25 cm thick; pH 5.2 (H_2O), 4.7 ($CaCl_2$).
BCg	42-48	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); gravelly sandy loam; common, medium, distinct mottles; moderate, medium, sub-angular blocky; friable (m), slightly hard (d); 30% sub-angular gravel, 5% cobbles; abrupt smooth boundary 5-7 cm thick; pH 4.9 (H_2O), 4.6 ($CaCl_2$).
Cc	48+	cemented, gray hardpan (not sampled).

APPENDIX 4 (cont'd)

Plot no.: 151-3
Location: Sarita Seepage Slope
Associated soil: Loamy-skeletal Gleyed Ferro-Humic Podzol with Hemihumimor on morainal veneer

Horizon	Depth (cm)	Description
L(F)	8- 6	Moist; coniferous litter; diffuse smooth boundary; 1-2 cm thick; pH 4.3 (H_2O), 3.9 ($CaCl_2$).
H	6- 0	Abundant, medium to fine roots; non-distinct, smooth boundary; 5-8 cm thick; pH 4.4 (H_2O), 3.9 ($CaCl_2$).
Aegj	0- 2	Grayish brown to light gray (10YR 5/2 m, 7/2 d); loam; few, fine, faint mottles; very weak, fine to medium platey; very friable (m), slightly hard (d), sticky; few fine roots; 10% rounded gravel, 10% cobbles; clear, wavy boundary; 0-3 cm thick; pH 4.3 (H_2O), 3.7 ($CaCl_2$).
Bfgj	2-16	Strong brown to brownish yellow (7.5YR 4/6 m, 10YR 6/8 d); gravelly loam; few, fine, faint, mottles; very weak, fine to medium, sub-angular blocky; very friable (m), slightly hard (d), slightly sticky (w); plentiful, fine roots; 10% rounded gravel, 10% cobbles; diffuse wavy boundary; 10-18 cm thick; pH 4.7 (H_2O), 4.1 ($CaCl_2$).
Bhf	16-23	Dark reddish brown to dark yellowish brown (5YR 3/3 m, 10YR 4/6 d); gravelly loam; structureless; soft (d) slightly sticky (w); few fine roots; 10% rounded gravel, 30% cobbles; clear smooth boundary; 5-8 cm thick; pH 4.6 (H_2O), 4.1 ($CaCl_2$).
Bfg	23-48	Dark brown to yellowish brown (7.5YR 3/4 m, 10 YR 5/6 d); gravelly to very gravelly loam; common, medium, distinct mottles; weak, medium, sub-angular blocky; friable (m), slightly hard (d), sticky (w); very few fine roots; 5% rounded gravel, 25% cobbles, 10% stones; seepage water; clear smooth boundary; 25+ cm thick; pH 5.0 (H_2O), 4.6 ($CaCl_2$).

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APPENDIX 4 (cont'd)

Plot no.: 151-3 (cont'd)

Horizon	Depth (cm)	Description
BCg1	48-68	Strong brown to yellowish brown (7.5YR 4/6 m, 10YR 5/6 d); gravelly to very gravelly loam; many, medium, prominent, dark reddish brown (5YR 3/4 m) to dark yellowish brown (10YR 4/4 d) mottles; structureless, massive; slightly hard (d), slightly sticky (w); 5% rounded gravel, 25% cobbles, 30% stones; seepage water present; clear smooth boundary; 20+ cm thick; pH 4.9 (H_2O), 4.5 ($CaCl_2$).
BCg2	68-88+	Very dark brown to brown (10YR 2/2 m, 4/3 d); very stony sandy loam; many, medium, prominent, dark reddish brown to strong brown (5YR 3/3 m, 7.5YR 4/6 d) mottles; structureless, massive; slightly hard (d), slightly sticky (w); 5% rounded gravel, 25% cobbles, 30% stones; seepage water present; clear smooth boundary; 20+ cm thick; pH 5.3 (H_2O), 4.9

APPENDIX 4 (cont'd)

Plot no.: 152-1
Location: Pachena Main Line
Associated soil: Loamy Ortstein Ferro-Humic Podzol with Humimor on morainal materials

Horizon	Depth (cm)	Description
L	19-18	Coniferous litter; 1-2 cm thick; pH 4.7 (H_2O), 4.3 ($CaCl_2$).
H	18- 0	Moist; some decayed wood; very abundant all-sized roots, forming a mat; appears well-worked by soil fauna, earthworms abundant; abrupt wavy boundary; 12-23 cm thick; pH 3.9 (H_2O), 3.3 ($CaCl_2$).
Ah	0-12	Black to dark gray (10YR 2/1 m, 4/1 d); loam; moderate coarse, sub-angular blocky; friable (m), very hard (d); plentiful fine roots; 5% sub-rounded gravel; abrupt wavy boundary; 9-14 cm thick; pH 4.2 (H_2O), 3.4 ($CaCl_2$).
Bhfg	12-36	Dark yellowish brown to light olive gray (10YR 3/4 m, 2.5Y 5/4 d); gravelly, very fine sandy loam; common mottles; friable (m), slightly hard (d); few fine roots; 20% sub-rounded gravels and cobbles; abrupt, smooth boundary; 21-28 cm thick; pH 5.0 (H_2O), 4.5 ($CaCl_2$).
Bfcgj	36-48	Dark grayish brown to light gray (2.5Y4/2 m, 2.5Y 7/2 d); gravelly, silt loam; strong, coarse, sub-angular blocky; firm to very firm (m), hard (d); (slightly cemented); seepage water present; abrupt wavy boundary; 9-14 cm thick; pH 5.0 (H_2O), 4.8 ($CaCl_2$).
Cc	48+	Cemented or compacted (not sampled).

APPENDIX 4 (cont'd)

Plot no.: 152-2
Location: Pachena Main Line
Associated soil: Loamy Orthic Humic Podzol with Humimor on morainal materials.

Horizon	Depth (cm)	Description
L	11- 9	Coniferous litter and sphagnum moss; 1-2 cm thick; abrupt wavy boundary; pH 4.2 (H_2O), 3.8 ($CaCl_2$).
H	9- 0	Very moist; fairly loose; very abundant all-sized roots; appears worked by soil fauna; abrupt wavy boundary; 8-10 cm thick; pH 4.1 (H_2O), 3.3 ($CaCl_2$); bulk density 0.142 g/cc.
Ae	0-11	Very dark gray to gray (10YR 3/1 m, 5/1 d); sandy clay loam; moderate, coarse, sub-angular blocky; very friable (m), slightly hard (d); plentiful fine roots; 5% sub-angular gravel; abrupt wavy boundary; 9-13 cm thick; pH 4.5 (H_2O), 3.8 ($CaCl_2$).
Bhg	11-27	Very dark grayish brown to light yellowish brown (2.5Y 3/2 m, 6/4 d); silt loam to silty clay loam; many, coarse, prominent mottles; moderate, coarse, sub-angular blocky; very friable (m), slightly hard (d); 10% sub-angular gravel; abrupt, smooth boundary; seepage water flows on top of Cc; 13-19 cm thick; pH 5.1 (H_2O), 4.3 ($CaCl_2$).
Cc	27+	Dark grayish brown to light gray (2.5Y 4/2 m, 7/2 d); sandy clay loam; moderate, medium, sub-angular blocky; friable (m), slightly hard (d); cemented or compacted; 15% coarse fragments; pH 5.2 (H_2O), 4.5 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 152-3
Location: Pachena Main Line
Associated soil: Loamy Ortstein Humic Podzol with Humimor on morainal materials.

Horizon	Depth (cm)	Description
L	14-12	Coniferous litter and sphagnum moss; 1-2 cm thick; abrupt wavy boundary; pH 4.1 (H_2O), 4.3 ($CaCl_2$).
F		Very abundant decayed wood; very abundant roots; horizon is a dense mat of roots; (combined with H for chemical analysis)
H	12- 0	Moist to wet; fairly loose; very abundant all-sized roots; appears worked by soil fauna; abrupt wavy boundary; 10-13 cm thick (including F); pH 3.6 (H_2O), 3.0 ($CaCl_2$); bulk density 0.116 g/cc.
Ae	0-12	Dark gray to light gray (10YR 4/1 m, 7/1 d); sandy loam; moderate to weak, medium, sub-angular blocky; very friable (m), slightly hard (d); plentiful fine roots; 10% sub-angular gravels and cobbles; abrupt wavy boundary; 8-15 cm thick; pH 3.9 (H_2O), 3.1 ($CaCl_2$).
Bh	12-18	Black to dark grayish brown (10YR 2/1 m, 4/2 d); sandy loam; moderate to weak, medium, sub-angular blocky; very friable (m), slightly hard (d); few, fine roots; 20% sub-rounded gravel; abrupt, wavy boundary; seepage water flows on top of Bfgc; 5-7 cm thick; pH 4.2 (H_2O), 3.7 ($CaCl_2$).
Bfgc	18-31	Very dark gray to light olive brown (10YR 2/2 m, 2.5Y 5/4 d); gravelly loam; common, medium, distinct, mottles; moderate to strong, coarse, sub-angular blocky; friable (m), slightly hard (d); 30% sub-angular gravel; abrupt wavy boundary; 10-15 cm thick; pH 4.7 (H_2O), 4.7 ($CaCl_2$).
Cc	31-44+	Olive to light yellowish brown (5Y 4/4 m, 2.5Y 6/4 d); sandy loam; moderate, coarse, sub-angular blocky; friable (m), soft (d); cemented; 20% sub-rounded gravel; 13+ cm thick; pH 4.8 (H_2O), 4.6 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 109-1
Location: Grice Bay
Associated soil: Loamy-skeletal Orthic Ferro-humic Podzol with Hemihumimor on glaciofluvial/morainal deposits

Horizon	Depth (cm)	Description
L(F)	14-10	Coniferous litter; plentiful fine and medium roots; non-distinct wavy boundary; 3-5 cm thick; pH 4.6 (H_2O), 4.3 ($CaCl_2$).
H	10- 0	Moist; dark reddish brown (5YR 3/2 d); sticky (w), plastic, slightly greasy; plentiful decayed wood; white mycelia present; very abundant all-sized roots; earthworms present; non-distinct wavy boundary; 5-14 cm thick; pH 3.8 (H_2O), 3.4 ($CaCl_2$); bulk density 0.121 g/cc.
Aej	0- 2	Black to very dark grayish brown (10YR 2/1 m, 3/2 d); friable (m), slightly hard (d); plastic; plentiful, fine and medium roots; 10% rounded cobbles; 80% rounded stones; few charcoal particles; non-distinct wavy boundary; 0-5 cm thick; sporadic, discontinuous horizon; pH 4.2 (H_2O), 3.7 ($CaCl_2$).
Bhf	2-22	Dark yellowish brown (10YR 3/4 m, 4/6 d); stony loam; reddish yellow (5YR 6/8 m) mottles present; very friable (m), soft (d); plastic; few, fine and medium roots; 40% rounded cobbles, 80% stones; few charcoal particles present; non-distinct broken boundary; 0-40 cm thick; pH 4.4 (H_2O), 4.0 ($CaCl_2$).
Bh	22-49	Black to very dark grayish brown (10YR 2/1 m, 3/2 d); stony clay loam; reddish yellow (5YR 6/8) mottles present; friable (m), hard (d); very plastic; 10% rounded cobbles, 80% stones; few charcoal particles present; non-distinct broken boundary; 20-35 cm thick; pH 4.6 (H_2O), 3.8 ($CaCl_2$).
C	49+	100% very large cobbles and stones (not sampled).

APPENDIX 4 (cont'd)

Plot no.: 109-2
Location: Grice Bay
Associated soil: Fine-clayey Orthic Gleysol with Humimor on glaciomarine deposits

Horizon	Depth (cm)	Description
L(F)	20-15	Coniferous litter; plentiful fine and medium roots; non-distinct wavy boundary; 3-5 cm thick; pH 4.3 (H_2O), 4.0 ($CaCl_2$).
H	15- 0	Moist; dark brown (7.5YR 3/2 d); humus primarily formed from decayed wood - lightweight, peatmoss-like; remainder of humus is slightly sticky (w), plastic, very greasy; very abundany white mycelia; very abundant decayed wood; very abundant all-sized roots; earthworm droppings present; non-distinct wavy boundary; 10-17 cm thick; pH 3.8 (H_2O), 3.1 ($CaCl_2$); bulk density 0.115 g/cc.
Bgl	0-15	Dark yellowish brown to yellowish brown (10YR 3/6 m, 5/6 d); very gravelly clay; many, coarse, prominent, reddish-yellow (7.5YR 6/8 m) mottles; firm (m),very sticky (w); plastic; few, medium to coarse roots; 2% rounded cobbles; non-distinct wavy boundary; 12-19 cm thick; pH 4.2 (H_2O), 3.6 ($CaCl_2$).
Bg2	15-33	Dark yellowish brown to yellowish brown (10YR 3/6 m, 5/6 d); silt clay; many, coarse, prominent, reddish-yellow (7.5YR 6/8 m) mottles; firm (m), hard (d); plastic; very few, medium roots; gradual wavy boundary; 11-16 cm thick; pH 4.6 (H_2O), 3.8 ($CaCl_2$).
Bg3	33-57	Dark yellowish brown to yellowish brown (10YR 4/6 m, 6/6 d); silty clay; many, coarse, prominent yellowish brown (10YR 5/8 m) mottles; firm (m), hard (d); plastic; black Mg deposits; abrupt boundary; pH 4.7 (H_2O), 3.8 ($CaCl_2$).
Bg4	57-79+	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); silty loam; many, coarse, prominent, yellowish brown (10YR 5/8 m) mottles; firm (m), hard (d); plastic; black Mg deposits; pH 4.7 (H_2O), 3.8 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 109-3
Location: Grice Bay
Associated soil: Loamy Orthic Humic Podzol with Hemihumimor on (glaciofluvial)/morainal deposits

Horizon	Depth (cm)	Description
L(F)	15-10	Coniferous litter; abundant fine roots; 2-7 cm thick; pH 4.3 (H_2O), 3.9 ($CaCl_2$).
H	10- 0	Moist; slightly slippery, greasy; slightly plastic lightweight; very abundant decayed wood; white fungal mycelia present; charcoal particles present; appears worked by soil fauna; earthworms, mites, and spiders observed; very abundant all-sized roots; 2-19 cm thick; 2-19 cm thick; pH 3.5 (H_2O), 2.9 ($CaCl_2$); bulk density 0.091 g/cc.
Aejg	0- 9	Black to dark brown (10YR 2/1 m, 3/3 d); sandy clay loam to clay loam; common, medium, prominent, mottles; moderate, medium to coarse, sub-angular blocky; friable (m),slightly hard (d); plentiful, medium roots; 5% sub-angular gravel; charcoal particles common; gradual irregular boundary; 2-15 cm thick; pH 4.0 (H_2O), 3.3 ($CaCl_2$).
Bhg	9-32	Very dark brown to olive brown (10YR 2/2 m, 2.5Y 4/4 d); gravelly sandy loam; many, coarse, prominent, mottles; weak to moderate, medium, sub-angular blocky; very friable (m), slightly hard (d); few, fine roots; 10% sub-angular gravel; charcoal particles common; gradual wavy boundary; 16-29 cm thick; pH 4.8 (H_2O), 4.2 ($CaCl_2$).
BCg	32-45	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); gravelly fine sandy loam; few, fine faint, mottles; weak to moderate, medium, sub-angular blocky; very friable (m), slightly hard (d); 10% sub-angular gravel; few charcoal particles, (charcoal layer between BCg and Ccg);abrupt smooth boundary; 9-16 cm thick; pH 5.0 (H_2O), 4.4 ($CaCl_2$).
Ccg	45-48+	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); gravelly sandy clay loam; few, fine, faint mottles; moderate to strong, fine, sub-angular blocky; very friable (m), slightly hard (d); cemented or compacted; 35% sub-angular gravel; 3+ cm thick; pH 5.3 (H_2O), 4.0 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 199-1
Location: Ucluelet Slope
Associated soil: Sandy-skeletal Orthic Sombric Brunisol with Leptomoder on morainal deposits

Horizon	Depth (cm)	Description
L	29-27	Coniferous and herbaceous litter; abrupt wavy boundary; 1-3 cm thick; pH 3.7 (H_2O), 4.4 ($CaCl_2$).
H	27- 0	Moist; very well-worked by soil fauna; very abundant earthworms; decayed wood present; abundant all-sized roots; abrupt wavy boundary; 25-28 cm thick; pH 5.9 (H_2O), 5.5 ($CaCl_2$); bulk density 0.093 g/cc.
Ah	0-20	Black (10YR 2/1 m, d); sand; moderate, very coarse, sub-angular blocky; friable (m), very hard (d); abundant all-sized roots; abrupt wavy boundary; 18-22 cm thick; pH 5.4 (H_2O), 5.1 ($CaCl_2$).
Bh	20-27	Black to very dark brown (10YR 2/1 m, 2/2 d); gravelly sand; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); very few, fine roots; 15% angular gravel; 15% cobbles, 10% stones; abrupt wavy boundary; 5-10 cm thick; pH 6.0 (H_2O), 5.5 ($CaCl_2$).
Cc	27+	Gravelly cemented layer; water table reached; (no sample taken).

APPENDIX 4 (cont'd)

Plot no.: 199-2
Location: Ucluelet Slope
Associated soil: Loamy "Gleyed Folisolic Podzol" with Hydromor on morainal deposits

Horizon	Depth (cm)	Description
L	23-21	Coniferous and herbaceous litter; abrupt wavy boundary; 1-3 cm thick; pH 4.9 (H_2O), 4.5 ($CaCl_2$).
H(OH)	21- 0	Moist; few earthworms; very abundant decayed wood; white fungal mycelia present; dense mat of fine roots; abrupt wavy boundary; 19-23 cm thick; pH 3.9 (H_2O), 3.3 ($CaCl_2$); bulk density 0.129 g/cc.
Aegj	0- 6	Black to gray (10YR 2/1 m, 5/1 d); gravelly loam; few, medium, distinct black mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful all-sized roots; cemented or compacted; 15% sub-angular gravel, 10% cobbles, 5% stones; water flowing through and/or beneath Aegj; abrupt wavy boundary; 2-9 cm thick; pH 4.1 (H_2O), 3.4 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 199-3
Location: Ucluelet Slope
Associated soil: Loamy Gleyed Dystric Brunisol with Humimor on morainal deposits

Horizon	Depth (cm)	Description
L	15-13	Coniferous and herbaceous litter; 1-3 cm thick; pH 4.9 (H_2O), 4.8 ($CaCl_2$).
H	13- 0	Moist; lightweight, well-aerated; appears worked by soil fauna; plentiful decayed wood; few white fungal mycelia; very abundant all-sized roots; abrupt wavy boundary; 8-18 cm thick; pH 3.9 (H_2O), 3.4 ($CaCl_2$); bulk density 0.105 g/cc.
Bhfjg1	0-16	Dark yellowish brown to yellowish brown (10YR 3/4 m, 5/4 d); gravelly clay loam; many, coarse, prominent, orange mottles; moderate, very coarse, sub-angular blocky; friable (m), hard (d); plentiful medium roots; 15% sub-angular gravel, 5% cobbles; abrupt wavy boundary; 9-24 cm thick; pH 4.3 (H_2O), 3.6 ($CaCl_2$).
Bhfjg2	16-23	Dark grayish brown to light brownish gray (10YR 4/2 m, 6/2 d); gravelly silt loam; few, fine, distinct orange mottles; moderate, very coarse, sub-angular blocky; friable (m), slightly hard (d); few, fine roots; 15% sub-angular gravel, 5% cobbles; abrupt wavy boundary; 4-10 cm thick; pH 4.8 (H_2O), 3.4 ($CaCl_2$).
Bhfjg3	23-30	Very dark grayish brown to light brownish gray (10YR 3/2 m, 6/2 d); gravelly loam; weak to moderate, medium to coarse, sub-angular blocky; very friable (m), slightly hard (d); 20% sub-angular gravel, 5% cobbles; abrupt wavy boundary; 4-9 cm thick; pH 4.4 (H_2O), 3.7 ($CaCl_2$).
Bhfjg4	30-33	Black to very dark grayish brown (10YR 2/1 m, 3/2 d); gravelly sandy loam; moderate to strong, very coarse, sub-angular blocky; firm (m), slightly hard (d); abrupt smooth boundary; 1-4 cm thick; pH 4.7 (H_2O), 3.7 ($CaCl_2$).
Cc	33+	Cemented hardpan; water slowly seeping on top; not sampled.

APPENDIX 4 (cont'd)

Plot no.: 150-1
Location: Mercantile Creek
Associated soil: Loamy-skeletal Duric Humic Podzol on morainal deposits.

Horizon	Depth (cm)	Description
L	12-10	Coniferous litter; abrupt wavy boundary; 1-3 cm thick; pH 4.3 (H_2O), 3.9 ($CaCl_2$).
FH	10- 0	Moist; slightly slippery, greasy; decayed wood present; very abundant all-sized roots; abrupt wavy boundary; 9-11 cm thick; pH 4.7 (H_2O), 4.2 ($CaCl_2$); bulk density 0.089 g/cc.
Aeg	0- 5	Very dark grayish brown to gray (10YR 3/2 m, 6/1 d); sandy clay loam to loam; few, medium, prominent orange mottles; weak to moderate, very coarse, sub-angular blocky; very friable (m), hard (d); plentiful medium to fine roots; 5% sub-rounded gravel; abrupt wavy boundary; 4-7 cm thick; pH 4.3 (H_2O), 3.7 ($CaCl_2$).
Bhg	5-13	Very dark grayish brown to dark grayish brown (10YR 3/2 m, 4/2 d); gravelly sand; few, medium, prominent orange mottles; moderate, medium, sub-angular blocky; friable (m), soft (d); very few, fine roots; 35% sub-rounded gravel; abrupt wavy boundary; 6-8 cm thick; pH 4.8 (H_2O), 4.0 ($CaCl_2$).
Bg	13-19	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); gravelly sandy loam; many, coarse, prominent, orange mottles; moderate, medium to coarse, sub-angular blocky; friable (m), slightly hard (d); 25% sub-rounded gravels, 5% cobbles; abrupt wavy boundary; seepage water present; 4-8 cm thick; pH 5.3 (H_2O), 4.8 ($CaCl_2$).
BCcg	19-40	Olive gray to light brownish gray (5YR 4/2 m, 2.5Y 6/2 d); gravelly loam; common, medium, distinct, orange mottles; strong, medium to coarse, sub-angular blocky; very firm (m), slightly hard (d); 15% sub-rounded gravel, 25% cobbles; cemented or compacted; abrupt wavy boundary; 15-28 cm thick; pH 5.5 (H_2O), 4.6 ($CaCl_2$).

(/...)

APPENDIX 4 (cont'd)

Plot no.: 150-1 (cont'd)

Horizon	Depth (cm)	Description
C	40-63+	Olive gray to light olive gray (5Y 4/2 m, 6/2 d); gravelly, very fine sandy loam; medium to strong, coarse, sub-angular blocky; friable (m), slightly hard (d); 20% sub-rounded stones; 22-24 cm thick; pH 5.7 (H_2O), 4.7 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 150-2a
Location: Mercantile Creek
Associated soil: Sandy-skeletal Orthic Humic Gleysol on morainal deposits

Horizon	Depth (cm)	Description
L	10- 8	Coniferous litter; 1-3 cm thick; pH 4.6 (H_2O), 4.7 ($CaCl_2$).
FH	8- 0	Moist; slightly slippery; decayed wood present; very abundant all-sized roots; abrupt wavy boundary; 5-11 cm thick; pH 4.0 (H_2O), 3.6 ($CaCl_2$); bulk density 0.079 g/cc.
Ah	0-17	Black (10YR 2/1 m, d); sand; weak to moderate, massive, sub-angular blocky; friable (m), hard (d); abundant, all-sized roots; abrupt wavy boundary; 15-18 cm thick; pH 4.3 (H_2O), 3.8 ($CaCl_2$).
Ae	17-27	Black to very dark brown (10YR 2/1 m, 2/2 d); very gravelly loamy sand; weak, fine to medium, sub-angular blocky; loose (m), soft (d); plentiful, fine roots; 40% sub-rounded gravel, 5% cobbles; abrupt wavy boundary; 9-11 cm thick; pH 4.6 (H_2O), 3.2 ($CaCl_2$).
Bh	27+	Black to dark brown (10YR 2/1 m, 3/2 d); very gravelly loamy sand; weak, fine, sub-angular blocky; very friable (m), soft (d); 40% sub-rounded gravels, 5% cobbles, 5% stones; pH 4.6 (H_2O), 4.0 ($CaCl_2$).
		bottom of pit smells of SO_2.

APPENDIX 4 (cont'd)

Plot no.: 150-2b
Location: Mercantile Creek
Associated soil: Sandy-skeletal Orthic Gleysol on morainal deposits

Horizon	Depth (cm)	Description
L	14-12	Coniferous litter; 1-3 cm thick; pH 4.6 (H_2O), 4.7 ($CaCl_2$); sampled with 150-2a.
FH	12- 0	Moist; slightly slippery; moderate, medium, coarse sub-angular blocky; abundant, firm to hard, decayed wood present; white fungal mycelia present; very abundant all-sized roots; abrupt wavy boundary; 10-13 cm thick; pH 3.6 (H_2O), 3.0 ($CaCl_2$); bulk density 0.088 g/cc.
Ae	0-12	Very dark grayish brown to gray (10YR 3/2 m, 5/1 d); gravelly loam to gravelly sandy loam; moderate, very coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, medium roots; 5% sub-rounded gravel, 5% cobbles, 5% stones; abrupt wavy boundary; 10-14 cm thick; pH 3.9 (H_2O), 3.9 ($CaCl_2$).
Bh	12-24	Black to dark grayish brown (10YR 2/1 m, 4/2 d); gravelly loamy sand to gravelly sand; weak to moderate, medium, sub-angular blocky; firm (m), slightly hard (d); 10% sub-rounded gravel, 5% cobbles, 10% stones; abrupt wavy boundary; 7-16 cm thick; pH 4.1 (H_2O), 3.5 ($CaCl_2$).
BC	24-32+	Very dark brown to dark grayish brown (10YR 2/2 m, 4/2 d); very gravelly sand; structureless, single-grained; very friable (m), soft (d); 30% sub-rounded gravels, 5% cobbles, 5% stones; 8+ cm thick; pH 4.5 (H_2O), 4.1 ($CaCl_2$).
		water rapidly flowing into pit.

APPENDIX 4 (cont'd)

Plot no.: 150-3
Location: Mercantile Creek
Associated soil: Loamy-skeletal Orthic Humic Gleysol with Humimor on morainal deposits

Horizon	Depth (cm)	Description
L	22-20	Coniferous litter; 1-3 cm thick; pH 4.3 (H_2O), 3.9 ($CaCl_2$).
H	20-12	Moderately dry; coarse, moderate, sub-angular blocky; crumbly; very abundant, all-sized roots, forming mat; plentiful white and yellow fungal mycelia; 6-9 cm thick; pH 4.1 (H_2O), 3.6 ($CaCl_2$); bulk density 0.227 g/cc.
Hi1	12- 6	Black to dark gray (10YR 2/1 m, 4/1 d); fine sandy loam; moderate, coarse, sub-angular blocky; friable (m), hard (d); abundant, all-sized roots; abrupt wavy boundary; 4-7 cm thick; pH 4.2 (H_2O), 3.6 ($CaCl_2$).
Hi2	6- 0	Black to very dark gray (10YR 2/1 m, 3/1 d); loamy sand; moderate, coarse, sub-angular blocky; friable (m), hard (d); abundant, all-sized roots; abrupt wavy boundary; 4-7 cm thick; pH 4.2 (H_2O), 3.6 ($CaCl_2$).
Aeg	0- 9	Very dark grayish brown to light brownish gray (10YR 3/2 m, 6/2 d); silty clay loam; few, medium, prominent, orange mottles in root channels; moderate, coarse, sub-angular blocky; friable (m), hard (d); abundant, medium roots; 5% sub-angular gravel; 5-13 cm thick; pH 4.3 (H_2O), 3.5 ($CaCl_2$).
Bgj	9-16	Black to dark grayish brown (10YR 2/1 m, 4/2 d); wet, very gravelly loamy sand; weak to moderate, medium to coarse, sub-angular blocky; slightly hard (d); plentiful fine roots; 30% sub-rounded gravel; abrupt wavy boundary; 5-8 cm thick; pH 4.5 (H_2O), 3.9 ($CaCl_2$).
Ccg	16-29+	Very dark grayish brown to grayish brown (2.5Y 3/2 m, 5/2 d); very gravelly loam; common, medium, distinct, orange mottles; strong, very coarse, sub-angular blocky; very firm (m), hard (d); cemented or compacted; 50% sub-angular gravel; 13+ cm thick; pH 4.9 (H_2O), 4.2 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 300-1
Location: Ucluelet Scrub
Associated soil: Fine Loamy Orthic Gleysol with Hemihydromor on glaciomarine or fluvial deposits over morainal till

Horizon	Depth (cm)	Description
L(F)	22-16	Coniferous and herbaceous litter, moss, and decayed wood; smells of fungus; plentiful, all-sized roots; gradual wavy boundary; 3-8 cm thick; pH 3.8 (H_2O), 3.3 ($CaCl_2$).
H	16- 0	Wet; Very dusky red (2.5YR 2/2 pm); slightly plastic,slippery; slighty clumped from mat of roots; plentiful decayed wood; very abundant all-sized roots; 12-20 cm thick; pH 3.5 (H_2O), 3.0 ($CaCl_2$); bulk density 0.135 g/cc.
Ae	0- 7	Dark grayish brown to gray (10YR 4/2 m, 6/1 d); silt loam; moderate, coarse, sub-angular blocky; slightly hard (d), firm (m), sticky (w); very plastic; few, medium and coarse roots; 5% rounded gravel; non-distinct wavy boundary; 5-8 cm thick; pH 4.0 (H_2O), 3.3 ($CaCl_2$); dark humic deposits between Ae and Bgl
Bgl	7-24	Light olive brown to light brownish gray (2.5Y 4/2 m, 6/2 d); silty clay loam; many, coarse, prominent, dark yellowish-brown (10YR 4/6 m) mottles; strong, medium sub-angular blocky; hard (m); very firm (d), sticky (w); non-plastic; few, coarse roots; 2% rounded gravel; gradual wavy boundary; 10-20 cm thick; pH 4.9 (H_2O), 4.0 ($CaCl_2$).
Bg2	24-50	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); sandy loam; many, coarse, prominent, yellowish brown (10YR 5/8 m) mottles; moderate to strong, medium to coarse, sub-angular blocky; hard (d), firm (m), sticky (w); slightly plastic; very few, coarse roots; 5% rounded gravel; non-distinct, irregular boundary; 20-35 cm thick; pH 5.1 (H_2O), 3.9 ($CaCl_2$).
C	50+	Olive brown to light olive brown (2.5Y 4/4 m, 5/4 d); silty loam; moderate, coarse, sub-angular blocky; soft (d), friable (m), slightly sticky (w); non-plastic; 5% rounded gravel; black Mg deposits present; pH 5.4 (H_2O), 4.2 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 300-2
Location: Ucluelet Scrub
Associated soil: Fine-loamy Orthic Gleysol with Hydromor on glaciomarine or fluvial deposits over morainal till

Horizon	Depth (cm)	Description
L(F)	19-15	Coniferous and herbaceous litter, moss, and decayed wood; plentiful, fine and medium roots; non-distinct wavy boundary; 3-5 cm thick; pH 4.5 (H_2O), 3.8 ($CaCl_2$).
H	15- 0	Wet; Dark reddish brown (5YR 3/2 pm); sticky (w); very plastic, plentiful decayed wood; plentiful white fungal mycelia; very abundant all-sized roots, forming dense mat on top; non-distinct, wavy boundary 12-20 cm thick; pH 3.7 (H_2O), 3.2 ($CaCl_2$); bulk density 0.103 g/cc.
Ae	0- 7	Very dark gray to gray (10YR 3/1 m, 5/1 d); silty loam; slightly hard (d), very sticky (w); very plastic; plentiful, medium and coarse roots; 5% rounded gravel; non- distinct wavy boundary; 7-8 cm thick; pH 4.2 (H_2O), 3.5 ($CaCl_2$); dark humic deposits between Ae and Bhfg.
Bhfg	7-28	Very dark brown to brown (10YR 2/2 m, 5/3 d); clay loam; many, coarse, prominent, yellowish-red (6YR 5/8 m) mottles; slighty hard (d), friable (m); plastic; 5% rounded gravel, 5% stones; gradual irregular boundary; 17-26 cm thick; pH 4.7 (H_2O), 3.9
Bg	28-32	Gray to grayish brown (10YR 5/1 m, 2.5Y 5/2 d); gravelly loam; common, coarse, prominent, dark yellowish brown (10YR 4/6 m) mottles; firm (m), very sticky (w); very plastic; 10% rounded gravel; non-distinct, wavy boundary; 3-10 cm thick; pH 5.0 (H_2O), 4.5 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 300-3
Location: Ucluelet Scrub
Associated soil: Loamy Orthic Gleysol with Hemihydromor on glaciomarine or fluvial deposits over morainal till

Horizon	Depth (cm)	Description
L(F)	18-13	Coniferous and herbaceous litter, moss, and decayed wood; 2-7 cm thick; pH 4.5 (H_2O), 4.1 ($CaCl_2$).
H	13- 0	Wet; medium to coarse blocky; greasy, powdery (silty?); slightly plastic, plentiful decayed wood; very abundant white fungal mycelia forming discontinuous mat, few yellow mycelia; very abundant all-sized (especially fine) roots; earthworm observed; 7-20 cm thick; pH 3.8 (H_2O), 3.2 ($CaCl_2$); bulk density 0.117 g/cc.
Ae	0-13	Black to grayish brown (10YR 2/1 m, 5/2 d); loam to clay loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); few, fine roots; few charcoal particles present; 5% sub-rounded gravel; abrupt, irregular boundary; 6-21 cm thick; pH 4.0 (H_2O), 3.3 ($CaCl_2$).
Bg	13-30	Very dark brown to olive brown (10YR 2/2 m, 2.5Y 4/4 d); loamy sand; many, coarse, prominent, orange mottles; strong, coarse, sub-angular blocky; very firm (m), slighty hard (d); very few, fine roots; 30% sub-rounded gravel; plentiful charcoal particles; abrupt wavy boundary; 3-38 cm thick; pH 4.9 (H_2O), 4.5 ($CaCl_2$); (orange continuous band on bottom of horizon).
BC	30-36	Very dark grayish brown to olive brown (2.5Y 3/2 m, 4/4 d); gravelly loamy sand; structureless, single-grained; very friable (m), soft (d); 25% sub-rounded gravel; abrupt, discontinuous boundary; 0-12 cm thick; pH 4.8 (H_2O), 4.6 ($CaCl_2$).
Ccg	36-39+	Dark grayish brown to light brownish gray (10YR 3/4 m, 2.5Y 5/4 d); very gravelly, fine loamy sand; cemented or compacted; many, coarse, prominent orange mottles; friable (m), slightly hard (d); 50% sub-rounded gravel; 3+ cm thick; pH 5.0 (H_2O), 4.6 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 821-1
Location: Port Albion Bog
Associated soil: Loamy-skeletal (Ortstein) Humic Podzol with Hemihydromor on glaciomarine or glaciofluvial over morainal deposits

Horizon	Depth (cm)	Description
LF	10- 7	Coniferous and herbaceous litter, moss, and decayed wood; 2-4 cm thick; pH 4.5 (H_2O), 4.2 ($CaCl_2$).
H	7- 0	Wet; very slippery, slightly gritty; very abundant decayed wood; white fungal mycelia present; very abundant all-sized roots; abundant charcoal particles present; 2-12 cm thick; pH 3.6 (H_2O), 3.0 ($CaCl_2$); bulk density 0.113 g/cc.
Ae	0- 6	Very dark grayish brown to gray (10YR 3/2 m, 6/1 d); clay loam; moderate, medium to coarse, sub-angular blocky; friable (m), slightly hard (d); abundant, fine to medium roots; 15% sub-angular gravel; abrupt, wavy boundary; 3-10 cm thick; pH 3.8 (H_2O), 3.2 ($CaCl_2$).
Bh	6- 9	Dark humic deposits forming a thin horizon, (sampled with Bhfcg).
Bhfcg	9-13	Dark yellowish brown to yellowish brown (10YR 3/8 m, 5/6 d); gravelly sandy loam; many, coarse, prominent, mottles; cemented (or compacted?); strong, very coarse, sub-angular blocky; very firm (m), slighty hard (d); 45% sub-angular gravel (plus large boulder at bottom of horizon); abrupt wavy boundary; 0-7 cm thick; pH 4.7 (H_2O), 4.1 ($CaCl_2$).
Bfcg	13-22+	Dark yellowish brown to light yellowish brown (10YR 3/4 m, 2.5Y 6/4 d): gravelly loam; common, fine, distinct mottles; cemented or compacted; moderate, medium, sub-angular blocky; friable (m), slightly hard (d); 30% sub-angular gravel; 9+ cm thick; pH 4.1 (H_2O), 5.0 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 821-2
Location: Port Albion Bog
Associated soil: Loamy-skeletal (Placic) Humic Podzol with hydromor on glaciomarine or glaciofluvial over morainal deposits

Horizon	Depth (cm)	Description
LF	14-12	Coniferous and herbaceous litter, moss, and decayed wood; 2-3 cm thick; pH 4.5 (H_2O), 4.1 ($CaCl_2$).
H	12- 0	Wet; very slippery, slightly gritty; plentiful decayed wood; white fungal mycelia present; very abundant all-sized roots; plentiful charcoal particles present; 9-14 cm thick; pH 3.7 (H_2O), 3.1 ($CaCl_2$); bulk density 0.104 g/cc.
Ae	0- 6	Very dark grayish brown to light brownish gray (10YR 3/2 m, 6/2 d); gravelly loam to gravelly sandy loam; weak to moderate, coarse, sub-angular blocky; very friable (m), slightly hard (d); plentiful, all-sized roots; 15% sub-angular gravel; very few charcoal particles present; abrupt, wavy boundary; 7-12 cm thick; pH 3.8 (H_2O), 3.2 ($CaCl_2$).
Bh	10-12	Very dark brown to dark grayish brown (10YR 2/2 m, 4/2 d); sandy loam; weak to moderate, fine, sub-angular blocky; very friable (m), slightly hard (d); 10% sub-angular gravel; (placic horizon?); plentiful to few charcoal particles present; abrupt wavy boundary; 1-2 cm thick; pH 4.3 (H_2O), 3.7 ($CaCl_2$).
Bfcgj	12-17+	Dark yellowish brown to yellowish brown (10YR 3/6 m, 5/6 d); gravelly sandy loam; common, medium, faint mottles; cemented (or compacted?); strong, medium, sub-angular blocky; very firm (m), slighty hard (d); 45% sub-angular gravel; 5+ cm thick; pH 5.0 (H_2O), 4.7 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 821-3
Location: Port Albion Bog
Associated soil: Loamy-skeletal Orthic Humic Podzol with hemihydromor on glaciomarine or glaciofluvial over morainal deposits

Horizon	Depth (cm)	Description
LF	5- 3	Coniferous and herbaceous litter, moss, and decayed wood; 1-2 cm thick; pH 4.4 (H_2O), 4.3 ($CaCl_2$).
H	3- 0	L,F, and H very thin, difficult to separate into individual horizons; wet to moist; loose, crumbly; slightly slippery, felty; slightly matted and/or compacted; plentiful decayed wood; white fungal mycelia present; very abundant all-sized roots, forming a mat; plentiful charcoal particles present; 1-4 cm thick; pH 3.7 (H_2O), 3.2 ($CaCl_2$); bulk density 0.099 g/cc.
Ae	0- 3	Dark brown to light brownish gray (10YR 4/3 m, 6/2 d); sandy loam; few, medium, distinct, mottles; moderate, medium to coarse, sub-angular blocky; friable (m), slightly hard (d); abundant all-sized roots; 10% sub-angular gravel; few charcoal particles present; abrupt, wavy boundary; 1-5 cm thick; pH 3.9 (H_2O), 3.9 ($CaCl_2$).
Bhgl	3-24	Dark brown to dark yellowish brown (7.5YR 3/4 m, 10YR 5/8 d); gravelly loamy sand; many, medium, distinct mottles; weak to moderate, medium to coarse, sub- angular blocky; very friable (m), soft (d); plentiful, medium to fine roots; 10% sub-rounded gravel, 20% cobbles; gradual wavy boundary; 21-27 cm thick; pH 4.7 (H_2O), 4.6 ($CaCl_2$).
Bh		Dark brown discontinuous horizon, sampled with Bhgl.
Bhg2	24-48	Dark brown to yellowish brown (7.5YR 3/4 m, 10YR 5/6 d); gravelly sandy loam; common, coarse, distince, mottles; weak, medium, sub-angular blocky; very friable (m); few, medium to fine roots; few charcoal particles present; 5% sub-rounded gravel, 25% cobbles; abrupt wavy boundary; 16-32 cm thick; pH 4.9 (H_2O), 5.0 ($CaCl_2$); (dark band on bottom of horizon, may be charcoal (?)).
Cc	48+	Compacted or cemented, not sampled.

APPENDIX 4 (cont'd)

Plot no.: 1092-1
Location: Kennedy Second Growth
Associated soil: Fragmental over sandy Cumulic Regosol with Lignohumimor on fluvial deposits

Horizon	Depth (cm)	Description
L	21-19	Very abundant matting of roots; decayed wood and charcoal present; abrupt wavy boundary; pH 4.2 (H_2O), 3.9 ($CaCl_2$).
(F)H	19-18	Humus is primarily decaying wood and charcoal; lightweight and crumbly, slightly greasy; white fungal
wood	18- 0	mycelia present; plentiful earthworms; abundant roots; abrupt wavy boundary; 10-30 cm thick; pH 3.8 (H_2O), 3.3 ($CaCl_2$); bulk density 0.162 g/cc.
Hi1	0-19	Black (10YR 2/1 m, d); very gravelly sand; structureless, single-grained; firm (m), hard (d); abundant, fine and medium roots; 50% rounded gravel; abrupt, wavy boundary; 15-23 cm thick; pH 4.3 (H_2O), 3.6 ($CaCl_2$).
Hi2	19-48	Black (10YR 2/1 m, d); very gravelly sand; structureless, single-grained; friable (m), slightly hard (d); 30% rounded gravel, 20% sub-rounded cobbles; very few roots; abrupt wavy boundary; 23-35 cm thick; pH 4.9 (H_2O), 4.2 ($CaCl_2$).
Bm1	48-64	Black to very dark grayish brown (10YR 2/1 m, 3/2 d); very gravelly sand; structureless, single-grained; loose (m), loose (d); abrupt wavy boundary; 14-19 cm thick; pH 4.9 (H_2O), 4.1 ($CaCl_2$).
Bm2	64-81	Black to very dark brown (10YR 2/1 m, 2/2 d); sand; weak to moderate, coarse, sub-angular blocky; friable (m), soft (d); abrupt wavy boundary; 14-20 cm thick; pH 5.3 (H_2O), 4.3 ($CaCl_2$).
Bm3	81-91+	Black to very dark gray (10YR 2/1 m, 3/1 d); sand; weak, medium, sub-angular blocky; very friable (m), soft (d); 10+ cm thick; pH 5.3 (H_2O), 4.3 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 1092-2
Location: Kennedy Second Growth
Associated soil: Sandy Eluviated Dystric Brunisol with Humimor on fluvial deposits

Horizon	Depth (cm)	Description
L	10- 8	Abrupt wavy boundary; pH 4.5 (H_2O), 4.2 ($CaCl_2$).
H	8- 0	Slightly moist; coarse, sub-angular blocky; crumbly, slightly slippery; plentiful white fungal mycelia; present; decayed wood present; earthworms present; very abundant all-sized roots; abrupt wavy boundary; 7-10 cm thick; pH 3.9 (H_2O), 3.3 ($CaCl_2$); bulk density 0.103 g/cc.
Ae	0- 7	Very dark gray to dark grayish brown (10YR 3/1 m, 4/2 d); sand to loamy sand; weak, medium, sub-angular blocky; very friable (m), soft (d); 5% sub-rounded gravel; abundant, all-sized roots; abrupt, wavy boundary; 2-12 cm thick; pH 4.7 (H_2O), 3.9 ($CaCl_2$).
Bm1	7-22	Very dark brown to dark yellowish brown (10YR 2/2 m, 3/4 d); sand; weak to moderate, coarse, sub-angular blocky; friable (m), loose (d); plentiful, medium to fine roots; abrupt wavy boundary; 10-20 cm thick; pH 5.6 (H_2O), 4.4 ($CaCl_2$).
Bm2	22-47	Black to very dark brown (10YR 2/1 m, 2/2 d); very gravelly sand; structureless, single-grained; loose (m), loose (d); 45% sub-rounded gravel, 5% cobbles; plentiful, medium roots; abrupt wavy boundary; 19-31 cm thick; pH 5.3 (H_2O), 4.4 ($CaCl_2$).
Bm3	47-62	Black to very dark brown (10YR 2/1 m, 2/2 d); coarse sand; weak to moderate, coarse, sub-angular blocky; friable (m), loose (d); very few, very fine roots; 7% sub-angular gravel (dense layer of gravel 4-7 cm thick between B23-B24); abrupt wavy boundary; 10-19 cm thick; pH 5.4 (H_2O), 4.5 ($CaCl_2$).
Bm4	62-72+	Very dark brown to dark yellowish brown (10YR 2/2 m, 3/4 d); sand; weak to moderate, coarse, sub-angular blocky; friable (m), loose (d); very few, fine roots; 5% rounded gravel; abrupt, broken boundary; 9-11 cm thick; pH 5.6 (H_2O), 4.7 ($CaCl_2$).

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APPENDIX 4 (cont'd)

Plot no.: 1092-2 (cont'd)

Horizon	Depth (cm)	Description
IIC1	72-84	Very dark grayish brown to olive brown (2.5Y 3/2 m, 4/4 d); sand; weak, medium to coarse, sub-angular blocky; very friable (m), loose (d); very few, fine roots; abrupt wavy boundary; 11-14 cm thick; pH 5.7 (H_2O), 4.8 ($CaCl_2$).
IIC2	84-95	Very dark brown to dark yellowish brown (10YR 2/2 m, 3/6 d); sand; weak, medium to coarse, sub-angular blocky; very friable (m), loose (d); very few, very fine roots; abrupt wavy boundary; 10-12 cm thick; pH 5.6 (H_2O), 4.6 ($CaCl_2$).
IIC3	95-106	Very dark grayish brown to dark yellowish brown (2.5Y 3/2 m, 10YR 3/6 d); sand; weak, medium, sub-angular blocky; very friable (m), soft (d); abrupt wavy boundary; 10-12 cm thick; pH 6.3 (H_2O), 4.7 ($CaCl_2$).
IIC4	106-118+	Very dark grayish brown to olive brown (2.5Y 3/2 m, 4/4 d); sand; weak, medium to coarse, sub-angular blocky; very friable (m), loose (d); very few, very fine roots; 12+ cm thick; pH 5.6 (H_2O), 4.8 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 1092-3
Location: Kennedy Second Growth
Associated soil: Sandy-skeletal Dystric Brunisol on fluvial deposits.

Horizon	Depth (cm)	Description
L	8- 6	Abrupt wavy boundary; 1-3 cm thick; pH 4.1 (H_2O), 3.7 ($CaCl_2$).
H	6- 0	Dry to moist; crumbly, loose, lightweight, peat-moss like; very abundant, all-sized roots form dense mat; abundant decaying wood; white fungal mycelia present; charcoal present; abrupt wavy boundary; 4-8 cm thick; pH 3.4 (H_2O), 3.2 ($CaCl_2$); bulk density 0.127 g/cc.
Aej	0- 1	Broken, sporadic horizon; abundant roots; insufficient for sample.
Bm1	1-17	Black to very dark brown (10YR 2/1 m, 2/2 d); very gravelly sand; structureless, single-grained; loose (m), loose (d); 20% sub-rounded gravel, 5% cobbles; abundant, all-sized roots; abrupt wavy boundary; 13-19 cm thick; pH 4.7 (H_2O), 3.8 ($CaCl_2$).
Bm2	17-41	Black to very dark brown (10YR 2/1 m, 2/2 d); very gravelly sand; structureless, single-grained; loose (m), loose (d); plentiful, fine to medium roots; 30% sub-rounded gravel, 15% cobbles; abrupt wavy boundary; 19-30 cm thick; pH 5.4 (H_2O), 4.8 ($CaCl_2$).
Bm3	41-67	Black (10YR 2/1 m); very gravelly sand; structureless, single-grained; loose (m), loose (d); few, fine roots; 40% sub-rounded gravel, 5% cobbles; abrupt wavy boundary; seepage water flowing through Bm3 and C; 21-32 cm thick; pH 5.5 (H_2O), 5.0 ($CaCl_2$).
C	67-89+	Black (10YR 2/1 m,d); very gravelly coarse sand; structureless, single-grained; loose (m), loose (d); 40% sub-rounded gravel; abrupt wavy boundary; seepage water flowing through Bm3 and C; 17-28+ cm thick; pH 6.3 (H_2O), 5.5 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 315-1
Location: Kennedy Floodplain
Associated soil: Fine Loamy Humic Gleysol with Hemihumimor on fluvial deposits

Horizon	Depth (cm)	Description
LF	15-10	Non-distinct, wavy boundary; few, fine roots; pH 4.6 (H_2O), 4.2 ($CaCl_2$).
H	10- 0	Black to very dark grayish brown (10YR 2/1 m, 3/2 d); organic; firm (m), sticky (w); very plastic; abundant all-sized roots; earthworm present; gradual, irregular boundary; 9-12 cm thick; pH 4.0 (H_2O), 3.7 ($CaCl_2$).
Bg1	0-12	Dark brown to dark grayish brown (10YR 3/3 m, 4/2 d); silty clay loam; firm (m), sticky (w); very plastic; plentiful, all-sized roots; gradual, irregular boundary; 10-15 cm thick; pH 4.3 (H_2O), 3.7 ($CaCl_2$).
Bg2	12-37	Dark grayish brown to light brownish gray (2.5Y 4/2 m, 10YR 6/2 d); loam; many, coarse, prominent, yellowish-red (5YR 5/8 m) mottles; friable (m), very sticky (w); very plastic; plentiful coarse roots; many fine concretions; diffuse smooth boundary; 23-26 cm thick; pH 4.7 (H_2O), 4.0 ($CaCl_2$).
Bg3	37-67	Very dark grayish brown to grayish brown (10YR 3/2 m, 5/2 d); sandy loam; friable (m), very sticky (w); very plastic; anaerobic (SO_2 smell); water table present; pH 4.8 (H_2O), 4.1 ($CaCl_2$).
C	67+	Very dark grayish brown to grayish brown (2.5Y 3/2 m, 5/2 d); very gravelly loamy sand; very friable (m), soft (d); 90% rounded gravel; pH 5.0 (H_2O), 4.2 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 315-2
Location: Kennedy Floodplain
Associated soil: Fine-silty Humic Gleysol with Mullmoder on fluvial deposits

Horizon	Depth (cm)	Description
LFH	3- 0	Moist; humus very thin, non-distinct; crumbly, plastic; matted and/or compacted; plentiful white fungal mycelia; decayed wood present; very abundant, all-sized roots; non-distinct wavy boundary; 2-3 cm thick; pH 4.4 (H_2O), 4.0 ($CaCl_2$); bulk density 0.285 g/cc (F,H,Ah).
Ah	0- 7	Dark brown to dark grayish brown (10YR 3/3 m, 4/2 d); silty clay loam; slightly sticky (w), firm (m), soft (d); plastic; abundant all-sized roots; diffuse, wavy boundary; 20-25 cm thick; pH 4.4 (H_2O), 3.8 ($CaCl_2$).
Bg1	7-29	Dark yellowish brown to olive brown (10YR 3/4 m, 2.5Y 4/4 d); silty clay loam; firm (m), soft (d); plastic; plentiful, medium and coarse roots; diffuse wavy boundary; 20-25 cm thick; pH 4.4 (H_2O), 3.8 ($CaCl_2$).
Bg2	29-55	Dark brown to brown (10YR 3/3 m, 5/3 d); silt loam to silty clay loam; yellowish brown (10YR 5/8 m) mottles; friable (m), slightly hard (d); very plastic; plentiful, medium and coarse roots; non-distinct wavy boundary; 22-29 cm thick; pH 4.5 (H_2O), 3.9 ($CaCl_2$).
Bg3	55-60	Very dark brown to dark grayish brown (10YR 2/2 m, 4/2 d); silt loam to silty clay loam; yellowish brown (10YR 5/8 m) mottles; firm (m), slightly hard (d); very plastic; few, coarse roots; abundant, fine charcoal particles; non-distinct wavy boundary; 3-8 cm thick; rounded gravel; pH 4.5 (H_2O), 3.8 ($CaCl_2$).
Bg4	60-80	Dark grayish brown to light brownish gray (2.5Y 4/2 m, 6/2 d); silt loam; yellowish brown (10YR 5/8 m) mottles; firm (m), hard (d); very plastic; few, coarse roots; water table present (90cm); pH 5.3 (H_2O), 4.4 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 315-3
Location: Kennedy Floodplain
Associated soil: Fine-silty Humic Gleysol with Mullmoder on fluvial deposits

Horizon	Depth (cm)	Description
LF(H)	3- 0	pH 4.5 (H_2O), 3.9 ($CaCl_2$)
H (Ah)	0-10	Dry; crumbly, cloddy, hard; mat of white fungal mycelia on surface; decayed wood present; very abundant, all-sized roots; charcoal present; earthworms present; 8-13 cm thick; pH 4.5 (H_2O), 3.9 ($CaCl_2$); bulk density 0.108 g/cc; (originally sampled as H, but classified as Ah since Org.C=12.1%).
Bg1	10-24	Very dark grayish brown to olive brown (2.5Y 3/4 m, 4/4 d); silty clay loam to silt loam; moderate to strong, medium, sub-angular blocky; firm (m), hard (d); plentiful all-sized roots; clear wavy boundary; 13-16 cm thick; pH 4.4 (H_2O), 3.8 ($CaCl_2$).
Bg2	24-45	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); clay loam to silty clay loam; firm (m), hard (d); plentiful, all-sized roots; abrupt wavy boundary; 19-23 cm thick; pH 4.7 (H_2O), 3.9 ($CaCl_2$).
Bg3	45-70	olive brown to pale brown (2.5Y 4/4 m, 10YR 6/3 d); silty clay loam; common, coarse, distinct orange mottles; moderate, coarse, sub-angular blocky; friable (m), hard (d); plentiful, medium roots; gradual wavy boundary; 24-26 cm thick; pH 4.6 (H_2O), 3.8 ($CaCl_2$).
Bg4	70-90	Dark grayish brown to light brownish gray (2.5Y 4/4 m, 6/2 d); silt loam; moderate, very coarse, sub-angular blocky; friable(m), slightly hard (d); few, medium roots; gradual wavy boundary; 19-21 cm thick; pH 5.0 (H_2O), 4.0 ($CaCl_2$).
Bg5	90-94	Very dark grayish brown to light brownish gray (10YR 3/2 m, 6/2 d); silty clay loam to silt loam; many, coarse, prominent, orange mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); few, medium roots; abrupt wavy boundary; 4-5 cm thick; pH 5.1 (H_2O), 4.0 ($CaCl_2$).

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APPENDIX 4 (cont'd)

Plot no.: 315-3 (cont'd)

Horizon	Depth (cm)	Description
Cb1	94-112	Black to dark grayish brown (10YR 2/1 m, 4/2 d); silty loam to clay loam; weak to moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); common charcoal; buried wood present; abrupt smooth boundary; 18-19 cm thick; pH 4.8 (H_2O), 4.1 ($CaCl_2$).
Cb2	112-130	Dark grayish brown to light brownish gray (10YR 5/4 m, 6/2 d); clay loam; weak to moderate, coarse, sub-angular blocky; firm (m), hard (d); few charcoal particles, and dead (buried) plants present; anaerobic (SO_2 smell); 18+ cm thick; pH 4.8 (H_2O), 4.4 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 513-1
Location: Sproat Lake
Associated soil: Fine-loamy Orthic Ferro-Humic Podzol on Fluvial deposits

Horizon	Depth (cm)	Description
L	7- 5	Coniferous and herbaceous litter; 1-2 cm thick; pH 4.4 (H_2O), 4.2 ($CaCl_2$).
FH	5- 0	Very dry; massive, flat clumps; very lightweight, crumbly, felty; slightly sandy; very dense mat of roots; abundant fine-very fine roots; very abundant white mycelia; abundant decayed wood; pH 3.9 (H_2O), 3.3 ($CaCl_2$); bulk density 0.207 g/cc.
Aej	0- 3	Very thin, discontinuous layer. (not sampled)
B21h	3- 7	Olive brown (2.5Y 4/4 m, d); loam; moderate, coarse sub-angular blocky; friable (m), slightly hard (d); plentiful all-sized roots; abrupt wavy boundary; 2-11 cm thick; pH 4.9 (H_2O), 4.1 ($CaCl_2$).
B22	7-14	Very dark grayish brown to olive brown (2.5Y 3/2 m, 4/4 d); very fine sandy loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, all-sized roots; abrupt wavy boundary; 4-11 cm thick; pH 4.8 (H_2O), 4.0 ($CaCl_2$).
B23	14-25	Olive brown to dark olive brown (2.5Y 4/4 m, 3/4 d); fine sandy loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, all-sized roots; abrupt wavy boundary; 10-12 cm thick; pH 4.6 (H_2O), 4.0 ($CaCl_2$).
B24c	25-34	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); very fine sandy loam; moderate, medium to coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, all-sized roots; abrupt wavy boundary; 8-10 cm thick; pH 4.5 (H_2O), 4.0 ($CaCl_2$).
B25	34-45	Dark brown to dark yellowish brown (7.5YR 3/4 m, 10YR 4/6 d); fine, sandy loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, all-sized roots; abrupt broken boundary; 8-13 cm thick; pH 4.5 (H_2O), 4.0 ($CaCl_2$).

(/...)

APPENDIX 4 (cont'd)

Plot no.: 513-1 (cont'd)

Horizon	Depth (cm)	Description
B26	45-64	Dark yellowish brown to light yellowish brown (10YR 3/4 m, 2.5Y 6/4 d); loam; moderate, coarse sub-angular blocky; friable (m), slightly hard (d); plentiful all-sized roots; abrupt irregular boundary; 17-21 cm thick; pH 4.7 (H_2O), 4.1 ($CaCl_2$).
B27	64-78	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); loam; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful, all-sized roots; abrupt wavy boundary; 12-16 cm thick; pH 4.6 (H_2O), 4.1 ($CaCl_2$).
BC	78-93	Very dark grayish brown to olive brown (2.5Y 3/2 m, 4/4 d); fine sandy loam; moderate, medium to coarse, sub-angular blocky; friable (m), soft (d); few, medium to fine roots; abrupt wavy boundary; 12-17 cm thick; pH 4.9 (H_2O), 4.5 ($CaCl_2$).
C1	93-109	Olive to pale olive (5Y 4/4 m, 6/4 d); loamy sand; moderate, medium to coarse, sub-angular blocky; very friable (m), soft (d); few, medium to fine roots; clear wavy boundary; 13-20 cm thick; pH 5.1 (H_2O), 4.4 ($CaCl_2$).
C2	109-131	Olive (5Y 4/4 m, 5/3 d); loamy, fine sand; moderate, coarse, sub-angular blocky; very friable (m), soft (d); few, medium to fine roots; clear wavy boundary; 16-27 cm thick; pH 4.9 (H_2O), 4.7 ($CaCl_2$).
C3g	131-148+	Olive brown (2.5Y 4/4); loamy fine sand; few, fine, distinct mottles; moderate, coarse to very coarse, sub-angular blocky; friable (m), soft (d); few, fine roots; clear wavy boundary; 17+ cm thick; pH 4.9 (H_2O), 4.6 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 513-2
Location: Sproat Lake
Associated soil: Fine-loamy Orthic Ferro-Humic Podzol with Mycohumimor on fluvial deposits

Horizon	Depth (cm)	Description
LF	15-12	Coniferous and herbaceous litter; 1-3 cm thick; pH 4.2 (H_2O), 4.0 ($CaCl_2$).
H	12- 0	Dry; firm, cloddy to crumbly, felty; slightly matted; roots; abundant fine roots; abundant white mycelia; decayed wood present; pH 3.8 (H_2O), 3.1 ($CaCl_2$); bulk density 0.247 g/cc.
Aej	0- 3	Very thin, discontinuous layer. (not sampled)
B21	3-10	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/6 d); very fine sandy loam; moderate, very coarse, sub-angular blocky; firm (m), soft (d); abundant all-sized roots; abrupt wavy boundary; 3-16 cm thick; pH 4.5 (H_2O), 3.9 ($CaCl_2$).
B22	10-18	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); very fine sandy loam; moderate, very coarse, sub-angular blocky; firm (m), soft (d); abundant all-sized roots; abrupt wavy boundary; 5-12 cm thick; pH 4.6 (H_2O), 4.1 ($CaCl_2$).
B23	18-25	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); very fine sandy loam; weak to moderate, coarse, sub-angular blocky; firm (m), soft (d); abundant all-sized roots; abrupt wavy boundary; 4-9 cm thick; pH 4.9 (H_2O), 4.4 ($CaCl_2$).
B24	25-37	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); very fine sandy loam; moderate, very coarse, sub-angular blocky; firm (m), soft (d); plentiful roots; abrupt irregular boundary; 5-18 cm thick; pH 4.9 (H_2O), 4.3 ($CaCl_2$).
B25	37-43	Very dark brown to yellowish brown (10YR 2/2 m, 5/4 d); very fine sandy loam; weak to moderate, medium, sub-angular blocky; firm (m), soft (d); plentiful roots; abrupt broken boundary; 3-10 cm thick; pH 4.8 (H_2O), 4.1 ($CaCl_2$).

(/...)

APPENDIX 4 (cont'd)

Plot no.: 513-2 (cont'd)

Horizon	Depth (cm)	Description
B26	43-49	Dark yellowish brown to light olive brown (10YR 3/6 m, 2.5Y 5/4 d); very fine sandy loam; moderate, coarse, sub-angular blocky; firm (m), soft (d); plentiful roots; abrupt irregular boundary; 3-9 cm thick; pH 4.6 (H_2O), 4.2 ($CaCl_2$).
B27	49-56	Very dark grayish brown to olive brown (2.5Y 3/2 m, 4/4 d); very fine sandy loam; moderate, coarse, sub-angular blocky; firm (m), slightly hard (d); plentiful roots; abrupt broken boundary; 4-10 cm thick; pH 4.8 (H_2O), 4.2 ($CaCl_2$).
B28	56-60	Very dark brown to olive brown (10YR 2/2 m, 2.5Y 4/4 d); fine sandy loam; moderate, medium, sub-angular blocky; firm (m), slightly hard (d); plentiful roots; abrupt broken boundary; 0-7 cm thick; pH 4.8 (H_2O), 4.2 ($CaCl_2$).
B29	60-68	Dark yellowish brown to light olive brown (10YR 3/4 m, 2.5Y 5/4 d); fine sandy loam to loam; moderate, very coarse, sub-angular blocky; firm (m), slightly hard (d); plentiful roots; clear wavy boundary; 5-12 cm thick; pH 5.0 (H_2O), 4.3 ($CaCl_2$).
B30	68-77	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); fine sandy loam to loam; weak to moderate, medium to coarse, sub-angular blocky; firm (m), slightly hard (d); plentiful roots; clear wavy boundary; 7-10 cm thick; pH 4.8 (H_2O), 4.4 ($CaCl_2$).
B31	77-90	Very dark grayish brown to light olive brown (2.5Y 3/2 m, 5/4 d); very fine sandy loam; moderate, coarse, sub-angular blocky; firm (m), slightly hard (d); plentiful roots; abrupy wavy boundary; 10-16 cm thick; pH 4.8 (H_2O), 4.4 ($CaCl_2$).
B32	90-100	Dark yellowish brown to light olive brown (10YR 3/6 m, 2.5Y 5/4 d); very fine sandy loam; moderate, medium to coarse, sub-angular blocky; firm (m), slightly hard (d); few roots; abrupt wavy boundary; 8-13 cm thick; pH 4.6 (H_2O), 4.4 ($CaCl_2$).

(/...)

APPENDIX 4 (cont'd)

Plot no.: 513-2 (cont'd)

Horizon	Depth (cm)	Description
C1	100-	Very dark grayish brown to grayish brown (2.5Y 3/2 m, 5/2 d); loamy fine sand; moderate, coarse, sub-angular blocky; firm (m), slightly hard (d); few, very fine roots; gradual wavy boundary; 35+ cm thick (C1+C2); pH 4.6 (H_2O), 4.6 ($CaCl_2$).
C2	-135+	Very dark grayish brown to light yellowish brown (2.5Y 3/2 m, 6/4 d); very fine sandy loam; few, fine, faint mottles; moderate, coarse, sub-angular blocky; firm (m), slightly hard (d); few, very fine roots; 35+ cm thick (C1+C2); pH 5.3 (H_2O), 4.6 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 513-3
Location: Sproat Lake
Associated soil: Fine-loamy Gleyed Humo Ferric Podzol on Fluvial deposits

Horizon	Depth (cm)	Description
L	3- 1	Coniferous and herbaceous litter; .5-2 cm thick; pH 4.7 (H_2O), 4.6 ($CaCl_2$).
FH	1- 0	Moist; primarily decaying coniferous wood; crumbly, slightly greasy; few, white fungal mycelia; FH forms a thin mat covering Ah; plentiful fine roots; pH 4.2 (H_2O), 3.9 ($CaCl_2$); bulk density 0.257 g/cc.
Ah	0- 7	Very dark grayish brown to grayish brown (10YR 3/2 m, 5/2 d); silty loam; moderate, very coarse, sub-angular blocky; friable (m), slightly hard (d); abundant all-sized roots; abrupt wavy boundary; 6-8 cm thick; pH 4.6 (H_2O), 4.2 ($CaCl_2$); bulk density 0.442 g/cc.
Aeg	7-13	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/6 d); sandy clay loam; common, coarse, prominent orange mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful all-sized roots; abrupt wavy boundary, (mixed with B21g in some places); 2-8 cm thick; pH 4.8 (H_2O), 4.3 ($CaCl_2$).
B21g	13-33	Olive brown to olive yellow (2.5Y 4/4 m, 6/6 d); silty loam; many, coarse, prominent orange mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); plentiful medium roots; abrupt wavy boundary; 18-22 cm thick; pH 4.9 (H_2O), 4.6 ($CaCl_2$).
B22g	33-49	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); silty loam; common, medium, faint orange mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); few fine roots; abrupt wavy boundary; 12-20 cm thick; pH 5.2 (H_2O), 4.7 ($CaCl_2$).
B23g	49-64	Olive brown to light yellowish brown (2.5Y 4/4 m, 6/4 d); very fine sandy loam; few, medium, faint orange mottles; moderate, coarse, sub-angular blocky; friable (m), slightly hard (d); few, fine roots; abrupt wavy boundary; 13-16 cm thick; pH 5.3 (H_2O), 4.8 ($CaCl_2$).

APPENDIX 4 (cont'd)

Plot no.: 513-3 (cont'd)

Horizon	Depth (cm)	Description
B24g	64-79	Olive brown to light olive brown (2.5Y 4/4 m, 5/4 d); very fine sandy loam; common, medium, faint orange mottles; moderate, coarse, sub-angular blocky; friable (m), soft (d); very few, fine roots; abrupt wavy boundary, 14-17 cm thick; pH 5.4 (H_2O), 4.9 ($CaCl_2$).
B25g	79-93	Dark yellowish brown to olive brown (10YR 3/6 m, 2.5Y 6/6 d); fine sandy loam; many, coarse, prominent orange mottles; weak to moderate, coarse, sub-angular blocky; very friable (m), soft (d); water table encountered, water rapidly filling pit; abrupt wavy boundary; 13-15 cm thick; pH 5.3 (H_2O), 5.1 ($CaCl_2$).
Cg	93-107+	Olive to light olive gray (5Y 4/3 m, 6/2 d); fine sandy loam; common, coarse, prominent, orange mottles; moderate, very coarse, sub-angular blocky; very friable (m), soft (d); 16+ cm thick; pH 5.1 (H_2O), 4.8 ($CaCl_2$).

APPENDIX 5

LIST OF SOIL CHEMICAL DATA FOR EACH SAMPLE PLOT

Soil Chemical Analysis : Stand 818

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 818-1: Typic Folisol over bedrock												
LF	9- 7	4.2	4.1	35.8	61.7	0.72	49.7	37.6	3.09	25.50	6.52	0.32
H	7- 0	3.7	3.1	20.7	35.7	0.31	66.3	18.3	0.39	5.07	1.77	0.16
Plot 818-2 : Loamy-skeletal "Lithic Podzol" over bedrock												
LFH	5- 0	3.8	3.4	42.1	72.6	0.62	73.1		3.87	31.77	12.97	2.64
Ae	0-15	3.8	3.2	6.2	10.6	0.15	41.6	0.5	0.18	0.43	0.40	0.07
Bf		5.4	4.7	9.9	17.1	0.29	37.3	2.7	0.13	1.01	0.16	0.06

Soil Chemical Analysis : Stand 819

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 819-1: Loamy "Lithic Podzol" over bedrock												
LF	19-15	3.8	3.4	53.5	92.3	0.60	88.9	64.8	2.08	19.54	4.93	0.29
H	15- 0	3.6	3.2	40.9	70.5	0.70	57.9	46.9	1.07	3.24	4.72	0.38
Ae	0- 8+	3.8	2.9	6.0	10.3	0.11	56.1	5.1	0.17	0.12	0.36	0.08
Plot 819-2 : Loamy "Lithic Podzol" over bedrock												
L	20-15	4.4	4.1	55.5	95.7	0.66	83.8	70.6	2.37	28.11	8.62	0.18
FH	15- 0	3.9	3.3	30.7	53.0	0.47	65.2	35.4	0.80	7.66	2.05	0.20
Ae	0- 3+	3.8	3.2	7.4	12.8	0.12	60.7	7.2	0.22	0.87	0.40	0.09

Soil Chemical Analysis : Stand 131

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 131-1 : Loamy-skeletal, Ortstein Humic Podzol, with Humimor on morainal deposits												
L	13-12	4.6	4.3	25.9	44.6	0.84	31.0	57.5	3.61	45.15	10.73	0.58
H	12- 0	3.5	3.1	35.7	61.6	1.04	34.4	45.1	0.82	12.39	5.82	0.49
Aeg	0- 7	3.8	2.9	1.6	2.8	0.04	43.2	0.7	0.04	0.23	0.33	0.04
Bhgc	7-20	4.7	4.6	4.0	6.8	0.11	37.4	0.8	0.02	—	0.03	0.04
Bgc	20-33+	4.9	5.1	3.0	5.1	0.07	41.7	0.2	0.01	0.04	0.02	0.03
Plot 131-2 : Loamy-skeletal, Orthic Humic Podzol, with Humimor on morainal deposits												
L(F)	17-15	3.1	4.3	38.4	66.2	0.74	51.8	64.3	2.73	14.88	9.09	0.76
H	15- 0	3.5	3.1	28.3	48.7	0.76	37.1	19.2	0.96	6.41	7.22	0.94
Ae	0-12	4.3	3.5	3.2	5.6	0.10	32.3	1.6	0.05	0.01	0.21	0.05
B21g	12-31	4.9	5.0	2.7	4.6	0.10	27.3	0.5	0.06	—	0.03	0.05
B22g	31-43	5.0	5.4	2.5	4.2	0.04	67.6	0.9	0.01	—	0.01	0.03
BCg	43-54	5.0	5.0	3.5	6.1	0.06	59.3	2.0	0.02	0.01	0.02	0.04
Cg	54-64+	5.1	4.5	1.9	3.3	0.05	40.4	5.3	0.01	0.14	0.05	0.03

Soil Chemical Analysis : Stand 131 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 131-3 : Loamy Ortstein Humic Podzol, with Humimor on morainal deposits												
L(F)	17-14	4.5	4.4	39.9	68.9	0.59	67.5	34.8	2.03	27.48	8.09	0.37
H	14- 8	3.6	3.0	25.8	44.4	1.01	44.1	40.3	1.09	5.67	5.40	0.55
Hil	8- 0	4.2	3.3	22.2	38.3	0.79	28.2	34.3	0.28	1.08	0.94	0.23
Ae	0-14	4.0	3.3	4.5	7.7	0.12	36.9	3.2	0.05	0.07	0.24	0.09
AB	14-20	4.3	3.7	4.6	7.9	0.13	35.4	8.5	0.04	0.14	0.03	0.07
Bgc	20-34	4.8	4.1	3.6	6.2	0.07	52.2	2.8	0.01	—	0.03	0.03
BCgc	34-40	4.8	4.2	1.7	2.3	0.04	41.5	4.0	0.02	—	0.01	0.03

Soil Chemical Analysis : Stand 144

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 144-1 : Sandy Gleyed Ferro-Humic Podzol, with Humimor on morainal deposits												
L	8- 6	4.3	3.7	38.0	65.5	0.75	50.5	35.4	0.98	13.21	4.47	0.41
H	6- 0	3.6	3.1	19.0	32.8	1.03	18.4	20.7	0.94	5.38	3.40	0.38
Ae	0-12	3.7	3.1	2.3	4.1	0.08	29.9	1.6	0.07	0.02	0.22	0.09
Bhfgj	12-35	4.6	4.0	5.9	10.2	0.29	20.7	1.2	0.13	—	0.14	0.09
Bfg	35-47	4.9	4.7	2.6	4.6	0.08	32.1	0.6	0.02	—	0.02	0.03
BC	47-54	4.5	3.8	2.0	3.4	0.13	15.9	8.8	0.04	—	0.08	0.05
Cc	54+	not sampled										
Plot 144-2 : Loamy-skeletal Gleyed Ferro-Humic Podzol, with Humimor on morainal deposits												
L	18-17	4.1	3.7	39.5	68.1	0.56	70.7	37.7	1.33	20.85	5.39	0.34
H	17- 0	3.7	3.2	26.2	45.2	0.94	28.0	27.0	0.81	10.60	4.34	0.41
Ae	0- 3	3.7	3.0	2.2	3.9	0.06	37.3	2.0	0.07	0.23	0.42	0.06
Bhfg	3-34	4.9	5.0	4.9	8.4	0.12	41.2	0.5	0.04	—	0.04	0.04
Bfg	34-43	5.1	4.8	3.1	5.4	0.06	50.0	0.7	0.05	—	0.02	0.08
BC	43-59	4.9	4.7	7.1	12.3	0.15	47.0	1.4	0.04	0.07	0.07	0.06
C	59+	not sampled										

Soil Chemical Analysis : Stand 144 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 144-3 : Loamy Gleyed Ferro-Humic Podzol, with Humimor on morainal deposits												
L	29-24	3.9	4.0	38.6	66.6	0.56	68.6	36.9	2.36	20.49	6.11	0.50
H	24- 0	3.7	3.2	26.8	46.3	0.82	32.7	25.5	0.80	9.45	6.49	0.48
Ae	0-12	4.3	3.2	1.4	2.5	0.04	31.8	0.8	0.05	0.31	0.23	0.08
Bhfg	12-30	4.5	3.9	4.6	8.0	0.14	33.8	1.6	0.09	0.77	0.34	0.11
Bfgj	30-40	4.5	4.0	2.8	4.9	0.10	28.3	0.7	0.09	0.49	0.23	0.07
BC	40-49	4.6	4.0	3.1	5.3	0.12	25.0	1.2	0.08	0.43	0.20	0.06
Cc	49-56+	4.8	4.3	0.9	1.5	0.04	21.9	5.5	0.09	0.09	0.05	0.04

Soil Chemical Analysis : Stand 151 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na	Fe %	Al %
Plot 151-3: Loamy-skeletal Gleyed Ferro-Humic Podzol on morainal veneer														
LF	8- 6	4.3	3.9	53.3	91.8	0.91	65.2		2.06	27.27	8.07	0.86		
H	6- 8	4.4	3.9	48.7	83.9	1.41	38.7		2.01	9.54	2.24	1.51		
Aegj	0- 2	4.3	3.7	4.6	7.9	0.15	32.2	2.0	0.11	0.77	0.35	0.07		
Bfgj	2-16	4.7	4.1	13.0	22.3	0.33	43.0	4.1	0.16	0.57	0.38	0.07	2.69	2.17
Bhf	16-23	4.6	4.1	12.0	20.6	0.46	26.1	1.8	0.17	0.46	0.28	0.11	2.36	2.76
Bfg	23-48	5.0	4.6	11.0	19.0	0.19	64.3	1.6	0.04	0.01	0.03	0.04	0.79	2.05
BCg1	48-68	4.9	4.5	14.2	24.5	0.31	51.4	1.7	0.04	0.02	0.06	0.05	1.85	2.85
BCg2	68+	5.3	4.9	8.9	15.3	0.23	42.0	2.5	0.04	0.99	0.11	0.04	0.78	1.77

Soil Chemical Analysis : Stand 151 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)				Fe %	Al %
									K	Ca	Mg	Na		
Plot 151-3: Loamy-skeletal Gleyed Ferro-Humic Podzol on morainal veneer														
LF	8- 6	4.3	3.9	53.3	91.8	0.91	65.2		2.06	27.27	8.07	0.86		
H	6- 8	4.4	3.9	48.7	83.9	1.41	38.7		2.01	9.54	2.24	1.51		
Aegj	0- 2	4.3	3.7	4.6	7.9	0.15	32.2	2.0	0.11	0.77	0.35	0.07		
Bfgj	2-16	4.7	4.1	13.0	22.3	0.33	43.0	4.1	0.16	0.57	0.38	0.07	2.69	2.17
Bhf	16-23	4.6	4.1	12.0	20.6	0.46	26.1	1.8	0.17	0.46	0.28	0.11	2.36	2.76
Bfg	23-48	5.0	4.6	11.0	19.0	0.19	64.3	1.6	0.04	0.01	0.03	0.04	0.79	2.05
BCg1	48-68	4.9	4.5	14.2	24.5	0.31	51.4	1.7	0.04	0.02	0.06	0.05	1.85	2.85
BCg2	68+	5.3	4.9	8.9	15.3	0.23	42.0	2.5	0.04	0.99	0.11	0.04	0.78	1.77

Soil Chemical Analysis : Stand 152

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 152-1 : Loamy Ortstein Ferro-Humic Podzol, on morainal materials												
L	19-18	4.7	4.3	35.6	61.3	0.62	57.2	32.0	2.04	32.30	16.15	0.74
H	18- 0	3.9	3.3	23.8	41.1	1.15	20.6	27.8	0.77	2.39	2.25	0.45
Ah	0-12	4.2	3.4	10.8	18.7	0.29	37.6	5.3	0.06	0.35	0.33	0.12
Bhfg	12-36	5.0	4.5	6.0	10.3	0.07	83.3	2.2	0.45	0.21	0.05	0.06
Bfcgj	36-48	5.0	4.8	1.9	3.3	0.02	95.0	7.9	0.05	0.13	0.04	0.05
Cc	not sampled											
Plot 152-2 : Loamy Orthic Humic Podzol, on morainal materials												
L	11- 9	4.2	3.8	39.9	68.7	0.67	59.5	27.3	1.70	20.28	8.54	0.51
H	9- 0	4.1	3.3	23.7	40.9	0.69	34.2	28.9	0.39	1.05	2.86	0.33
Ae	0-11	4.5	3.8	6.2	10.7	0.22	27.9	3.6	0.07	—	0.10	0.07
Bhg	11-27	5.1	4.3	3.3	5.8	0.07	45.2	2.5	0.03	—	0.02	0.04
Cc	27+	5.2	4.5	1.9	3.3	0.03	73.1	20.2	0.03	0.03	0.03	0.04

Soil Chemical Analysis : Stand 152 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 152-3: Loamy Ortstein Humic Podzol, on morainal materials												
L	14-12	4.1	4.3	30.4	52.5	0.56	54.8	26.3	2.02	22.35	8.16	0.43
(F)H	12- 0	3.6	3.0	40.2	69.4	0.72	56.1	23.4	0.95	4.32	6.33	0.49
Ae	0-12	3.9	3.1	2.4	4.1	0.08	30.0	2.9	0.04	0.04	0.27	0.06
Bh	12-18	4.2	3.3	5.0	8.5	0.13	37.3	6.7	0.04	0.16	0.29	0.07
Bfgc	18-31	4.7	4.7	4.5	7.7	0.06	70.3	3.9	0.01	—	0.02	0.03
Cc	31-44+	4.8	4.6	1.6	2.7	0.02	72.7	11.2	0.01	0.02	0.02	0.02

Soil Chemical Analysis : 109

Plot 109-1: Loamy-skeletal Orthic Ferro-Humic Podzol on glaciofluvial/morainal deposits

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na	Fe %	Al %
LF	14-10	4.6	4.3	53.5	92.3	0.95	62.5		3.44	47.47	12.70	0.64		
H	10- 0	3.8	3.4	48.1	82.9	1.05	45.8		1.79	30.91	8.98	2.21		
Aej	0- 2	4.2	3.7	10.5	18.0	0.31	35.5	3.7	0.21	0.57	0.41	0.12		
Bhf	2-22	4.4	4.0	7.5	13.0	0.21	38.1	2.5	0.12	0.05	0.11	0.12	2.27	1.73
Bh	22-49	4.6	3.8	11.4	19.6	0.40	30.4	23.6	0.10	0.25	0.21	0.07	0.31	1.61
C	49+	not sampled												

Plot 109-2: Fine-clayey Orthic Gleysol on glaciomarine deposits

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na	Fe %	Al %
LF	20-15	4.3	4.0	55.1	95.1	0.87	69.8		3.70	33.43	9.46	0.60		
H	15- 0	3.8	3.1	33.3	57.5	0.72	46.4		3.96	6.44	14.23	2.19		
Bgl	0-15	4.2	3.6	7.2	12.4	0.22	34.6	1.6	0.24	0.15	0.69	0.12	1.93	1.31
Bg2	15-33	4.6	3.8	4.4	7.6	0.07	69.8	1.4	0.17	0.04	0.47	0.10	0.70	1.05
Bg3	33-57	4.7	3.8	3.4	5.9	0.06	63.0	10.1	0.18	0.16	0.60	0.11	0.29	0.85
Bg4	57-79+	4.7	3.8	2.8	4.9	0.05	59.6	5.6	0.25	0.53	1.13	0.12	0.19	0.67

Soil Chemical Analysis : Stand 109 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 109-3: Loamy Orthic Humic Podzol on glaciofluvial/morainal deposits												
LF	15-10	4.3	3.9	51.3	88.5	0.74	69.0	41.1	2.04	22.27	6.65	0.60
H	10- 0	3.5	2.9	50.2	86.5	1.00	50.1	21.1	0.69	5.81	4.91	0.51
Aejg	0- 9	4.0	3.3	6.7	11.6	0.21	32.4	1.2	0.12	—	0.35	0.13
Bhg	9-32	4.8	4.2	8.5	14.7	0.18	48.0	0.2	0.06	—	0.04	0.08
BCg	32-45	5.0	4.4	2.1	3.6	0.08	25.0	4.8	0.03	—	0.02	0.07
Ccg	45-48+	5.3	4.0	1.1	1.9	0.03	42.3	5.6	0.05	0.45	0.28	0.12

Soil Chemical Analysis : Stand 199

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 199-1: Sandy-skeletal Orthic Sombric Brunisol on morainal deposits												
L	29-27	3.7	4.3	37.6	64.9	0.94	39.9	70.7	2.48	23.51	7.26	0.92
H	27- 0	5.9	5.5	46.6	80.3	0.20	239.0	5.1	0.42	52.39	5.27	0.60
Ah	0-20	5.4	5.1	13.1	22.6	1.16	11.3	1.5	0.15	22.52	1.95	0.37
Bh	20-27	6.0	5.5	8.5	14.7	0.28	30.2	1.5	0.09	12.41	1.04	0.23
Cc	27+	not sampled										
Plot 199-2 : Loamy "Gleyed Folisolic Podzol" on morainal deposits												
L	23-21	4.9	4.5	46.5	80.3	0.67	69.9	52.6	1.74	24.28	9.79	1.14
H(OH)	21- 0	3.9	3.3	51.9	89.5	0.88	59.2	18.2	1.87	14.19	14.21	2.33
Aegj	0- 6	4.1	3.4	5.0	8.6	0.22	22.8	4.4	0.06	1.27	0.98	0.20
Plot 199-3 : Loamy Gleyed Dystric Brunisol on morainal deposits												
L	15-13	4.9	4.8	39.4	67.9	0.80	49.1	48.9	2.41	22.59	12.39	0.88
H	13- 0	3.9	3.4	52.3	90.1	1.06	49.4	22.4	1.12	12.68	7.90	0.77
Bhfjg1	0-16	4.3	3.6	5.1	8.7	0.12	43.2	0.9	0.03	0.89	0.93	0.16
Bhfjg2	16-23	4.8	3.4	2.3	3.9	0.09	24.5	2.1	0.05	0.40	0.21	0.13
Bhfjg3	23-30	4.4	3.7	3.4	5.9	0.11	29.8	2.0	0.04	0.60	0.52	0.12
Bhfjg4	30-33	4.7	3.7	5.9	10.1	0.13	44.7	0.7	0.04	0.49	0.28	0.09
Cc	33+	not sampled										

Soil Chemical Analysis : Stand 150

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 150-1 : Loamy-skeletal Duric Humic Podzol on morainal material												
L	12-10	4.5	3.9	42.2	72.8	0.62	68.2	28.9	1.67	29.12	7.61	0.28
FH	10- 0	4.7	4.2	34.9	60.3	1.15	30.3	16.8	0.68	9.44	4.60	0.43
Aeg	0- 5	4.3	3.7	6.1	10.5	0.27	22.4	6.5	0.13	1.12	0.57	0.12
Bhg	5-13	4.8	4.0	3.0	5.3	0.11	27.3	5.1	0.03	0.58	0.24	0.06
Bg	13-19	5.3	4.8	2.3	4.0	0.04	65.7	8.6	0.03	0.24	0.07	0.05
BCcg	19-40	5.5	4.6	1.2	2.1	0.01	85.7	22.0	0.04	0.77	0.12	0.07
C	40-63+	5.7	4.7	0.7	1.2	0.01	77.8	29.4	0.03	0.43	0.05	0.07
Plot 150-2a : Sandy-skeletal Orthic Humic Gleysol on morainal material												
L	10- 8	4.6	4.7	35.2	60.7	0.78	45.1	36.6	1.34	27.79	8.69	0.37
FH	8- 0	4.0	3.6	52.3	90.1	0.15	344.1	21.6	1.39	1.94	7.53	0.61
Ah	0-17	4.3	3.8	17.0	29.3	0.17	100.6	8.2	0.30	3.70	2.02	0.41
Ae	17-27	4.6	3.2	8.2	14.2	0.19	42.7	17.7	0.05	0.82	0.32	0.09
Bh	27+	4.6	4.0	10.0	17.3	0.20	50.5	20.1	0.03	1.00	0.36	0.08

Soil Chemical Analysis : Stand 150 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 150-2b: Sandy-skeletal Orthic Gleysol on morainal material												
L	14-12	same as 150-2a										
FH	12- 0	3.6	3.0	37.9	65.3	0.13	293.8	25.4	1.26	11.48	8.67	0.70
Ae	0-12	3.9	3.9	6.4	11.0	0.23	28.4	4.0	0.12	0.26	0.46	0.12
Bh	12-24	4.1	3.5	13.5	23.3	0.41	33.3	4.7	0.21	2.29	3.05	0.22
BC	24-32+	4.5	4.1	3.7	6.3	0.14	27.2	4.8	0.06	2.41	0.81	0.09
Plot 150-3 : Loamy-skeletal Orthic Humic Gleysol on morainal material												
L	22-20	4.5	4.2	38.1	65.7	0.68	56.1	37.3	2.03	15.56	8.64	0.29
H	20-12	4.1	3.6	16.3	28.1	1.10	14.9	9.1	0.53	2.70	1.36	0.36
Hi1	12- 6	4.2	3.6	26.0	44.8	1.28	20.4	10.9	0.81	2.92	1.95	0.31
Hi2	6- 0	4.0	3.8	30.8	53.1	1.29	23.9	7.8	0.32	4.15	2.16	0.34
Aeg	0- 9	4.3	3.5	4.1	7.1	0.16	25.3	2.3	0.07	0.79	0.38	0.12
Bgj	9-16	4.5	3.9	1.3	2.3	0.14	9.2	4.9	0.07	0.76	0.39	0.09
Ccg	16-29+	4.8	4.2	2.8	4.9	0.05	58.3	18.9	0.03	0.21	0.08	0.06

Soil Chemical Analysis : 300

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na	Fe %	Al %
Plot 300-1: Fine Loamy Orthic Gleysol on fluvial or glaciomarine over morainal deposits														
LF	22-16	3.8	3.3	53.6	92.4	0.81	72.7		3.15	21.51	11.45	1.28		
H	16- 0	3.5	3.0	53.8	92.7	0.94	57.0		2.05	6.67	25.28	1.48		
Ae	0- 7	4.0	3.3	3.2	5.5	0.13	25.6	3.9	0.11	0.18	0.67	0.08		
Bg1	7-24	4.9	4.0	3.0	5.1	0.04	69.8	11.5	0.16	0.08	0.19	0.09	0.24	0.61
Bg2	24-50	5.1	3.9	2.5	4.3	0.03	92.6	1.2	0.23	0.14	0.73	0.15	0.18	0.38
C	50+	5.4	4.2	1.2	2.0	0.02	70.6	21.4	0.12	0.91	0.40	0.11	0.09	0.18
Plot 300-2: Fine-loamy Orthic Gleysol on fluvial or glaciomarine over morainal deposits														
LF	19-15	4.2	3.8	50.9	87.8	0.68	142.1		4.79	26.23	15.30	2.24		
H	15- 0	3.7	3.2	53.7	92.6	0.96	97.0		2.10	17.16	19.79	1.83		
Ae	0- 7	4.2	3.5	6.3	10.9	0.31	36.1	2.8	0.13	1.12	1.47	0.15		
Bhfg	7-28	4.7	3.9	7.0	12.1	0.14	90.3	7.5	0.06	0.05	0.08	0.06	1.39	1.48
Bg	28-34	5.0	4.5	2.7	4.6	0.05	92.0	17.8	0.04	0.08	0.03	0.05	0.34	0.84
BCcg	34+	not sampled												

Soil Chemical Analysis : Stand 300 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 300-3: Loamy Orthic Gleysol on fluvial or glaciomarine over morainal deposits												
L(F)	18–13	4.5	4.1	53.8	92.7	0.81	66.7	43.0	2.04	25.07	8.70	1.13
H	13– 0	3.8	3.2	52.9	91.2	1.06	49.9	38.3	0.98	10.62	8.10	1.01
Ae	0–13	4.0	3.3	2.7	4.6	0.15	18.6	0.7	0.05	0.41	0.57	0.13
Bg	13–30	4.9	4.5	3.7	6.3	0.06	62.7	4.1	0.02	—	0.02	0.04
BC	30–36	4.8	4.6	2.3	4.0	0.03	67.6	9.7	0.02	—	0.02	0.04
Ccg	36–39+	5.0	4.6	1.3	2.2	0.01	92.8	14.2	0.01	0.01	0.02	0.03

Soil Chemical Analysis : Stand 821

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 821-1 : Loamy-skeletal Placic Humic Podzol on glaciomarine or glaciofluvial/morainal deposits												
LF	10- 7	4.5	4.2	51.6	89.0	0.64	81.8	27.7	2.07	37.59	12.98	0.38
H	7- 0	3.6	3.0	52.5	90.6	0.74	71.1	18.8	0.82	6.27	7.25	0.61
Ae	0- 6	3.8	3.2	1.8	3.1	0.12	14.9	1.4	0.07	—	0.29	0.08
Bh	not sampled											
Bhfcg	6-13	4.7	4.1	9.1	15.6	0.12	74.0	0.5	0.02	—	0.05	0.04
Bfcg	13-22+	5.1	5.0	3.3	5.7	0.07	49.2	1.4	0.02	—	0.02	0.03
Plot 821-2 : Loamy-skeletal Placic Humic Podzol on glaciomarine or glaciofluvial/morainal deposits												
LF	14-12	4.5	4.1	54.1	93.3	0.59	91.1	19.2	1.33	22.31	7.20	0.55
H	12- 0	3.7	3.1	53.9	92.9	1.23	44.0	16.7	0.84	7.54	9.34	0.80
Ae	0-10	3.8	3.2	4.4	7.6	0.17	25.6	5.9	0.05	0.42	0.37	0.10
Bh	10-12	4.3	3.7	6.9	11.8	0.17	39.9	3.9	0.05	0.07	0.24	0.08
Bhfc	not sampled											
Bfcgj	12-17+	5.0	4.7	1.3	2.1	0.02	54.2	7.1	0.02	0.01	0.02	0.03

Soil Chemical Analysis : Stand 821 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 821-3 : Loamy-skeletal Orthic Humic Podzol on glaciomarine or glaciofluvial/morainal deposits												
L	5– 3	4.3	4.3	37.6	64.9	0.66	57.0	17.8	1.67	23.42	10.28	0.88
FH	3– 0	3.7	3.2	44.7	77.1	0.68	65.9	19.5	1.52	6.46	9.27	0.17
Ae	0– 3	3.9	3.3	3.3	5.6	0.05	70.2	1.2	1.42	0.17	0.29	0.07
Bhg1	3–24	4.7	4.6	5.8	10.0	0.15	38.2	0.4	0.08	—	0.09	0.06
Bhg2	24–48	4.9	5.0	9.3	16.0	0.14	64.6	0.6	0.06	—	0.04	0.05
Cc	48+	not sampled										

Soil Chemical Analysis : Stand 1092

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 1092-1 : Fragmental over sandy, Cumulic Regosol on fluvial deposits												
L	21-19	4.2	3.9	35.3	60.8	1.03	34.4	57.6	2.02	20.60	7.16	0.84
FH	19- 0	3.8	3.3	46.3	79.9	1.43	32.4	40.3	0.54	19.57	8.18	0.87
Hi1	0-19	4.3	3.6	18.6	32.0	0.51	36.8	4.0	0.17	2.76	2.12	2.12
Hi2	19-48	4.9	4.2	25.0	43.2	0.77	32.5	2.4	0.21	3.64	2.60	0.47
Bm1	48-64	4.9	4.1	9.7	16.7	0.25	39.3	2.0	0.06	1.44	0.85	0.17
Bm2	64-81	5.3	4.3	2.8	4.8	0.08	36.8	2.3	0.03	0.48	0.19	0.06
Bm3	81-91+	5.3	4.3	2.9	3.0	0.09	30.9	5.4	0.03	0.71	0.23	0.07
Plot 1092-2 : Sandy Eluviated Dystric Brunisol on fluvial deposits												
L	10- 8	4.5	4.2	30.7	53.0	1.10	27.8	55.2	2.38	21.66	8.52	0.92
H	8- 0	3.9	3.3	49.3	85.0	0.18	267.9	43.5	0.69	16.45	9.20	1.76
Ae	0- 7	4.7	3.9	2.5	4.3	0.11	22.1	2.6	0.05	1.28	0.77	0.18
Bm1	7-22	5.6	4.4	2.1	3.7	0.08	25.0	1.9	0.04	1.10	0.43	0.18
Bm2	22-47	5.3	4.4	4.2	7.2	0.16	27.1	2.3	0.05	1.66	0.53	0.19
Bm3	47-62	5.4	4.5	1.4	2.4	0.04	32.5	1.1	0.04	1.03	0.24	0.13
Bm4	62-72	5.6	4.7	1.7	2.9	0.05	32.1	1.9	0.03	1.07	0.22	0.11
IIC1	72-84	5.7	4.8	1.2	2.1	0.05	25.0	1.8	0.05	0.88	0.20	0.13
IIC2	84-95	5.6	4.6	1.1	1.8	0.02	47.8	2.2	0.02	0.89	0.31	0.09
IIC3	95-106	6.3	4.7	1.0	1.7	0.02	100.0	2.3	0.03	0.71	0.11	0.10
IIC4	106-118+	5.6	4.8	1.0	1.7	0.01	153.8	1.9	0.02	0.51	0.09	0.08

Soil Chemical Analysis : Stand 1092 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 1092-3 : Sandy-skeletal Orthic Dystric Brunisol on fluvial deposits												
L	8- 6	4.1	3.7	56.4	97.2	0.78	72.5	74.1	1.69	15.58	6.44	0.89
H	6- 0	3.7	3.1	47.7	82.2	0.16	296.3	108.2	0.81	10.71	8.47	0.81
Aej	0- 1	too small to sample										
Bm1	1-17	4.7	3.8	5.6	9.7	0.19	29.8	3.8	0.05	0.71	0.27	0.11
Bm2	17-41	5.4	4.7	8.1	14.0	0.23	34.6	3.9	0.05	3.99	1.14	0.22
Bm3	41-67	5.5	5.0	2.8	4.9	0.11	26.7	9.4	0.02	5.14	0.81	0.11
C	67-89+	6.3	5.5	1.3	2.3	0.03	46.4	11.5	0.01	6.29	0.62	0.09

Soil Chemical Analysis : 315

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na	Fe %	Al %
Plot 315-1: Fine Loamy Humic Gleysol on fluvial deposits														
LF	15-10	4.6	4.2	42.3	72.8	0.99	46.5		9.19	32.67	19.47	4.23		
H	10- 0	4.0	3.7	26.2	45.1	0.80	34.8	17.7	1.87	11.33	5.96	0.91		
Bg1	0-12	4.3	3.7	8.3	14.3	0.28	31.2	3.7	0.37	1.20	1.23	0.31	1.02	0.60
Bg2	12-37	4.7	4.0	3.8	6.6	0.11	35.5	9.4	0.10	0.38	0.36	0.13	0.53	0.60
Bg3	37-67	4.8	4.1	2.8	4.9	0.12	24.8	32.3	0.04	0.30	0.33	0.13	0.10	0.46
C	67+	5.0	4.2	1.7	2.9	0.04	43.6	27.9	0.04	0.37	0.48	0.08	0.10	0.28
Plot 315-2: Fine-silty Humic Gleysol on fluvial deposits														
LFH	3- 0	4.4	4.0	37.1	64.1	0.76	52.8		11.29	26.31	23.50	4.75		
Ah	0- 7	4.0	3.6	14.9	25.7	0.59	26.6	17.0	0.46	1.94	2.29	0.36		
Bg1	7-29	4.4	3.8	6.0	10.4	0.27	22.8	3.3	0.32	0.39	0.86	1.39	1.10	0.64
Bg2	29-55	4.5	3.9	5.1	8.7	0.19	48.1	3.9	0.11	0.15	0.23	0.12	1.08	0.68
Bg3	55-60	4.5	3.8	6.1	10.5	0.23	27.7	7.0	0.10	0.19	0.26	0.13	0.39	0.59
Bg4	60-80	5.3	3.4	3.6	6.2	0.12	30.3	11.4	0.08	2.56	0.93	0.13	0.29	0.40

Soil Chemical Analysis : Stand 315 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 315-3: Fine-silty Humic Gleysol on fluvial deposits												
LFH	3- 0	4.7	4.3	50.0	86.2	0.89	56.2	62.9	1.02	11.26	3.38	0.79
Ah	0-10	4.5	3.9	12.1	20.8	0.40	30.2	8.3	0.51	7.06	2.87	0.35
Bg1	10-24	4.4	3.8	3.1	5.3	0.24	13.0	2.9	0.18	1.45	0.79	0.18
Bg2	24-45	4.7	3.9	3.9	6.7	0.16	24.8	2.3	0.13	0.33	0.39	0.17
Bg3	45-70	4.6	3.8	1.3	2.2	0.08	16.3	3.3	0.05	0.08	0.18	0.12
Bg4	70-90	5.0	4.0	2.9	5.0	0.11	26.9	6.7	0.04	0.19	0.16	0.11
Bg5	90-94	5.1	4.0	2.7	4.6	0.10	26.7	13.1	0.05	1.06	0.49	0.17
Cb1	94-112	4.8	4.1	5.4	9.3	0.49	10.9	12.5	0.03	2.57	0.84	0.21
Cb2	112-130+	4.8	4.4	2.7	4.7	0.08	32.5	10.3	0.03	2.81	0.85	0.20

Soil Chemical Analysis : Stand 513

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 513-1 : Fine-loamy Orthic Ferro-Humic Podzol, on fluvial deposits												
L	7- 5	4.4	4.2	38.5	66.5	0.99	39.0	59.8	2.03	29.91	5.59	0.23
FH	5- 0	3.9	3.3	26.2	45.2	0.77	34.1	10.9	0.79	6.22	1.88	0.22
Aej	not sampled											
B21h	0- 7	4.9	4.1	5.6	9.7	0.13	44.1	1.0	0.06	0.01	0.12	0.09
B22	7-14	4.8	4.0	6.6	11.4	0.18	36.7	2.4	0.02	—	0.06	0.06
B23	14-25	4.5	4.0	7.1	12.2	0.20	35.5	1.3	0.03	—	0.07	0.07
B24c	25-34	4.5	4.0	7.6	13.1	0.15	51.7	1.2	0.01	—	0.05	0.06
B25	34-45	4.5	4.0	7.7	13.3	0.19	40.7	1.1	0.04	—	0.08	0.05
B26	45-64	4.7	4.1	7.6	13.1	0.16	46.6	1.7	0.03	—	0.05	0.06
B27	64-78	4.6	4.1	6.8	11.7	0.14	47.5	0.8	0.02	—	0.03	0.05
BC	78-93	4.9	4.5	4.1	7.1	0.09	44.1	2.7	0.01	—	0.01	0.02
C1	93-109	5.1	4.7	2.0	3.4	0.04	57.1	6.4	0.01	0.01	0.01	0.02
C2	109-131	4.9	4.7	1.8	3.1	0.04	42.9	10.6	0.01	0.01	—	0.02
C3g	131-148+	4.9	4.6	2.0	3.5	0.05	41.7	15.0	0.01	0.04	—	0.02

Soil Chemical Analysis : Stand 513 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g)			
									K	Ca	Mg	Na
Plot 513-2 : Fine-loamy Orthic Ferro-Humic Podzol, on fluvial deposits												
LF	15-12	4.2	4.0	32.5	56.1	0.79	41.2	61.3	2.03	27.29	5.59	0.31
H	12- 0	3.8	3.1	20.1	34.7	0.61	33.2	4.0	0.18	0.99	0.74	0.11
Aej	not sampled											
B21	0-10	4.5	3.9	6.7	11.5	0.16	42.1	1.5	0.03	—	0.14	0.05
B22	10-18	4.6	4.1	7.8	13.4	0.17	45.3	2.3	0.01	—	0.12	0.05
B23	18-25	4.9	4.4	5.0	8.6	0.10	52.6	1.4	0.01	—	0.03	0.05
B24	25-37	4.9	4.3	3.7	6.4	0.06	59.7	2.3	0.01	—	0.02	0.03
B25	37-43	4.8	4.1	4.3	7.4	0.10	42.6	1.2	0.01	—	0.03	0.04
B26	43-49	4.6	4.2	7.2	12.5	0.13	55.4	1.3	0.01	—	0.06	0.05
B27	49-56	4.8	4.2	5.4	9.4	0.12	46.9	0.9	0.03	—	0.03	0.05
B28	56-60	4.8	4.3	6.6	11.4	0.05	124.5	1.0	0.03	—	0.03	0.05
B29	60-68	5.0	4.3	6.6	11.4	0.14	46.8	1.1	0.02	—	0.03	0.05
B30	68-77	4.8	4.4	5.4	9.3	0.14	37.8	2.3	0.01	0.01	0.05	0.05
B31	77-90	4.8	4.4	5.7	9.9	0.13	43.8	1.1	0.01	0.01	0.04	0.05
B32	90-100	4.6	4.4	5.1	8.9	0.11	46.8	1.1	0.01	—	0.03	0.04
C1	100-	4.6	4.6	3.6	6.1	0.09	39.6	3.0	0.04	0.14	0.02	0.03
C2g	-135+	5.3	4.6	3.8	6.6	0.10	37.6	4.0	0.01	0.05	0.02	0.03

Soil Chemical Analysis : Stand 513 (cont'd)

Horizon (cm)	Depth (cm)	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	O.M. (%)	Tot. N (%)	Org. C / Tot. N	Av. P (ppm)	Exchangeable Cations (meq/100 g) K	Ca	Mg	Na
Plot 513-3 : Fine-loamy Gleyed Humo-Ferric Podzol, on fluvial deposits												
L	3- 1	4.7	4.5	40.7	70.1	0.84	48.3	44.7	2.37	33.97	5.59	0.95
FH	1- 0	4.2	3.9	26.8	46.1	1.07	25.0	24.0	0.54	12.05	2.39	0.14
Ah	0- 7	4.6	4.2	7.3	12.5	0.45	16.3	23.4	0.16	2.50	0.39	0.07
Aeg	7-13	4.8	4.3	3.4	5.9	0.19	18.2	7.5	0.04	4.80	0.07	0.04
B21g	13-23	4.9	4.6	4.9	8.5	0.16	31.0	1.8	0.04	0.40	0.06	0.05
B22g	33-49	5.2	4.7	4.1	7.2	0.14	28.9	2.0	0.03	0.35	0.05	0.05
B23g	49-64	5.3	4.8	3.5	6.1	0.13	28.0	4.0	0.03	0.39	0.05	0.04
B24g	64-79	5.4	4.9	2.2	3.7	0.07	29.7	6.3	0.01	0.21	0.02	0.03
B25g	79-93	5.3	5.1	2.3	3.9	0.09	25.8	7.5	0.02	0.16	0.01	0.04
Cg	93-107+	5.1	4.8	0.8	1.4	0.05	16.3	18.3	0.01	0.09	—	0.02

APPENDIX 6 : List of accidental species for the plant syntaxa recognized in the study area

Biogeocoenotic associations	1.11	2.11	2.12	3.11	3.21	4.11
Number of sample plots	4	18	6	3	3	3
Adiantum pedatum	-	I +.0	-	-	-	-
Alnus rubra	-	I 1.1	-	-	-	-
Bazzania denudata	-	I +.0	-	-	-	-
Coptis asplenifolia	-	I +.9	II 2.7	-	-	2 3.1
Cornus nuttallii	-	I 2.0	-	-	-	-
Dicranum fuscescens	-	-	I +.0	-	-	-
Diplophyllum albicans	2 1.1	I +.6	II 1.1	-	-	-
Equisetum sp.	-	I +.0	-	-	-	-
Galium boreale	-	I +.0	-	-	-	-
Goodyera oblongifolia	-	I +.0	-	-	-	-
Hypnum circinale	-	-	I +.0	-	-	-
Kalmia microphylla	-	-	I 1.4	-	-	-
Ledum groenlandicum	-	-	I 1.4	-	-	-
Listera cordata	-	I +.3	-	-	-	-
Lycopodium clavatum	-	I +.0	-	-	-	-
Prenanthes alata	-	-	-	-	2 2.1	2 +.5
Rhamnus purshianus	-	I +.0	-	-	-	-
Rhytidiadelphus triquetrus	-	I 1.1	-	-	-	-
Salix sp.	-	I +.0	-	-	-	-
Thuja plicata	5 7.2	V 9.0	V 8.3	5 7.9	5 7.8	5 7.4

APPENDIX 7:

VEGETATION TABLES FOR ASSOCIATIONS

<u>abbreviations</u>:

P = presence

MS = mean significance

RS = range of significance

VEGETATION TABLES FOR ASSOCIATIONS

ASSOCIATION 1.11 CLADINO-TSUGETUM

PLOT NUMBER	AVERAGE VALUES			KL8 182		KL8 181		KL8 191		KL8 192	
SPECIES	P	MS	RS	SPECIES SIGNIFICANCE AND VIGOR							
THUJA PLICATA	100.0	7.2	5-8	5	1	6	1	7	1	8	1
TSUGA HETEROPHYLLA	100.0	6.1	5-6	6	1	5	1	6	1	6	1
PSEUDOTSUGA MENZIESII	75.0	5.3	0-7	2	1			7	1	5	1
CHAMAECYPARIS NOOTKATENSIS	50.0	5.3	0-7	5	1	7	1				
PINUS CONTORTA	50.0	4.5	0-6	6	1	2	1				
PINUS MONTICOLA	50.0	4.0	0-5	3	1	5	1				
ABIES AMABILIS	50.0	2.8	0-4					1	1	4	1
TAXUS BREVIFOLIA	25.0	+.3	0-1					1	1		
GAULTHERIA SHALLON	100.0	6.1	5-7	5	1	5	1	6	1	7	1
VACCINIUM PARVIFOLIUM	100.0	5.1	3-5	3	1	4	2	5	2	5	3
MENZIESIA FERRUGINEA	100.0	4.5	2-5	3	1	4	1	2	1	5	3
VACCINIUM ALASKAENSE	100.0	4.4	1-5	1	1	3	2	4	2	5	2
VACCINIUM OVATUM	50.0	4.7	0-5	5	1	5	2				
CORNUS UNALASCHKENSIS	50.0	4.0	0-5	3	1	5	2				
LINNAEA BOREALIS	50.0	4.0	0-5	3	1	5	2				
BLECHNUM SPICANT	50.0	3.8	0-5			1	2			5	2
MAIANTHEMUM DILATATUM	50.0	3.0	0-4	2	1	4	2				
PHYLLODOCE EMPETRIFORMIS	25.0	2.7	0-4	4	1						
POLYSTICHUM MUNITUM	25.0	1.8	0-3							3	1
DANTHONIA SPICATA	25.0	+.3	0-1	1	1						
HIERACIUM ALBIFLORUM	25.0	+.3	0-1	1	1						
HYPOPYTHYS MONOTROPA	25.0	+.3	0-1	1	1						
POLYPODIUM GLYCYRRHIZA	25.0	+.3	0-1					1	2		
PTERIDIUM AQUILINUM	25.0	+.3	0-1			1	3				
SAXIFRAGA FERRUGINEA	25.0	+.3	0-1	1	1						
RHYTIDIADELPHUS LOREUS	100.0	6.1	5-7	5	1	5	3	6	3	7	3
HYLOCOMIUM SPLENDENS	100.0	5.9	4-7	4	1	5	3	6	3	7	3
KINDBERGIA OREGANA	75.0	5.2	0-6			5	3	6	3	4	2
DICRANUM SCOPARIUM	50.0	2.2	0-3	3	1	2	2				
HERBERTA ADUNCA	50.0	1.3	0-2	2	1	1	1				
SPHAGNUM SP.	50.0	1.3	0-2	1	1	2	2				
PLAGIOTHECIUM UNDULATUM	50.0	1.0	0-1	1	1					1	1
CLADINA RANGIFERINA	25.0	3.7	0-5	5	1						
CLADINA SP.	25.0	3.7	0-5			5	3				
RHACOMITRIUM HETEROSTICHUM	25.0	3.7	0-5	5	1						
RHACOMITRIUM CANESCENS	25.0	2.7	0-4			4	3				
CLADINA IMPEXA	25.0	1.8	0-3	3	1						
CLADONIA UNCIALIS	25.0	1.8	0-3	3	1						
DICRANUM SP.	25.0	1.8	0-3					3	1		
PLEUROZIUM SCHREBERI	25.0	1.8	0-3	3	1						
POGONATUM ALPINUM	25.0	1.8	0-3					3	2		
CLADONIA GRACILIS	25.0	1.1	0-2	2	1						
DIPLOPHYLLUM ALBICANS	25.0	1.1	0-2	2	1						
CLADONIA BELLIDIFLORA	25.0	+.3	0-1	1	1						
DITRICHUM SP.	25.0	+.3	0-1	1	1						
ISOTHECIUM STOLONIFERUM	25.0	+.3	0-1							1	1
MYLIA TAYLORII	25.0	+.3	0-1	1	1						
POLYTRICHUM COMMUNE	25.0	+.3	0-1	1	1						
POLYTRICHUM PILIFERUM	25.0	+.3	0-1	1	1						
RHACOMITRIUM LANUGINOSUM	25.0	+.3	0-1			1	1				
STEREOCAULON TOMENTOSUM	25.0	+.3	0-1	1	1						

VEGETATION TABLES FOR ASSOCIATIONS

ASSOCIATION 2.11 BLECHNO-THUJETUM

PLOT NUMBER	AVERAGE VALUES			FS1 511	FS1 512	FS1 513	KL1 091	KL1 092	KL1 093	FS1 311	FS1 312	FS1 313	FS1 521	FS1 522	FS1 523	KL1 991	KL1 992	KL1 993	KL1 501	KL1 502	KL1 503
SPECIES	P	MS	RS	SPECIES SIGNIFICANCE AND VIGOR																	
THUJA PLICATA	100.0	9.0	6-9	9 1	8 1	8 1	9 1	8 1	9 1	9 1	8 1	9 1	9 1	8 1	8 1	9 1	6 1	9 1	9 1	9 1	9 1
TSUGA HETEROPHYLLA	100.0	5.2	3-6	4 1	4 1	5 1	5 1	5 1	3 1	5 1	5 1	5 1	5 1	5 1	5 1	4 1	6 1	5 1	4 1	4 1	4 1
ABIES AMABILIS	77.8	4.5	0-6	4 1	6 1	4 1	4 1	5 1	4 1	2 1	2 1	1 1			3 1	5 1			5 1	5 1	2 1
TAXUS BREVIFOLIA	50.0	1.7	0-3		+ 1			3 1		2 1	+ 1	2 1	3 1		+ 1		+ 1				3 1
PINUS MONTICOLA	16.7	3.0	0-5									4 1		5 1	5 1						
PSEUDOTSUGA MENZIESII	11.1	2.1	0-5								5 1		3 1								
ALNUS RUBRA	11.1	1.1	0-4																	+ 1	4 1
CORNUS NUTTALLII	5.5	+.0	0-1											1 1							
PICEA SITCHENSIS	5.5	+.0	0-2																		2 1
GAULTHERIA SHALLON	100.0	8.0	5-9	7 3	6 2	5 2	8 1	9 1	7 2	9 3	9 3	9 3	7 2	7 2	8 3	7 3	8 3	8 3	5 1	7 2	5 2
VACCINIUM PARVIFOLIUM	100.0	5.4	3-6	6 3	5 3	5 3	5 1	3 1	5 1	4 3	4 3	5 2	5 3	5 3	5 3	5 3	5 3	5 3	5 1	5 1	5 2
MENZIESIA FERRUGINEA	100.0	4.6	1-5	4 2	4 3	1 2	3 1	1 1	5 1	2 2	2 3	2 1	5 3	5 3	5 3	3 3	5 3	4 3	3 1	4 2	5 2
VACCINIUM ALASKAENSE	83.3	4.8	0-6	5 2		4 2	3 1	5 1	5 1	4 3	3 3	1 2	5 3	3 2	6 3	5 3			4 1	3 1	4 1
VACCINIUM OVATUM	66.7	5.1	0-8				1 1	1 1	1 1	3 3		1 1	5 2	6 3	8 3	6 3	7 3	7 3	1 1		
RUBUS SPECTABILIS	61.1	3.6	0-7			3 2	1 1	1 1	1 2				5 2			7 3	1 2	1 2	2 1	2 2	1 1
VACCINIUM OVALIFOLIUM	11.1	+.0	0-1				1 1	1 1													
CORNUS NUTTALLII	5.5	1.9	0-5											5 2							
RHAMNUS PURSHIANUS	5.5	+.0	0-1					1 1													
SALIX SP.	5.5	+.0	0-1																		1 1
BLECHNUM SPICANT	100.0	8.9	5-9	9 3	8 3	7 3	8 1	8 1	9 2	9 3	9 3	9 3	9 3	9 3	9 3	5 2	9 3	9 3	9 1	7 1	8 1
MAIANTHEMUM DILATATUM	66.7	3.9	0-7	1 1			1 1		1 1		1 2	1 1	5 3	5 3	4 2	7 3	1 2	1 2			1 1
POLYPODIUM GLYCYRRHIZA	61.1	1.5	0-3		1 1					1 1	1 1	1 2		1 1	3 1	1 1		1 1	2 1	2 1	1 1
CORNUS UNALASCHKENSIS	55.5	4.6	0-9			1 1		1 1	3 1		1 1	1 1	9 3	6 3	3 2					5 2	1 2
LYSICHITUM AMERICANUM	38.9	3.1	0-5									+ 1	5 3	1 2		3 3		1 2		5 1	4 2
POLYSTICHUM MUNITUM	27.8	2.1	0-5			1 1	1 1									5 3		1 3	2 2		
STREPTOPUS ROSEUS	27.8	1.6	0-4						1 2							2 3			2 2	2 2	4 2
LINNAEA BOREALIS	22.2	2.2	0-4						4 2				4 2	3 2						3 1	
TIARELLA TRIFOLIATA	22.2	2.1	0-5													5 2			1 2	2 1	2 2
LISTERA CORDATA	16.7	+.3	0-2				1 1	1 1													2 2
COPTIS ASPLENIFOLIA	11.1	+.9	0-3										3 2	2 2							
GOODYERA OBLONGIFOLIA	11.1	+.0	0-1				1 1	1 1													
ADIANTUM PEDATUM	5.5	+.0	0-1															1 2			
ATHYRIUM FILIX-FEMINA	5.5	+.0	0-1													1 3					
EQUISETUM SP.	5.5	+.0	0-1													1 2					
GALIUM BOREALE	5.5	+.0	0-2													2 2					
LYCOPODIUM CLAVATUM	5.5	+.0	0-1				1 1														
TIARELLA LACINIATA	5.5	+.0	0-1																		1 1
TIARELLA UNIFOLIATA	5.5	+.0	0-1																		1 2
TRILLIUM OVATUM	5.5	+.0	0-1			1 1															
VERATRUM VIRIDE	5.5	+.0	0-1																1 2		
HYLOCOMIUM SPLENDENS	94.4	5.8	0-9	1 1	4 2	1 1	4 1	4 1	5 1	1 1	1 1	1 3	7 1	7 2	7 3		9 3	5 2	7 2	7 2	7 2
RHYTIDIADELPHUS LOREUS	72.2	5.1	0-7	6 3			1 1	3 1	5 2				4 1	3 1	5 3	3 1	3 2	7 3	4 2	7 2	7 2
RHIZOMNIUM GLABRESCENS	61.1	5.0	0-7	6 3		2 1	3 1	3 1	5 1							6 3	2 2	5 1	7 2	5 2	7 2
KINDBERGIA OREGANA	61.1	4.4	0-7	1 1	4 2	4 1	4 1	4 1					7 2	3 1	5 2	6 2			3 1	1 2	
SPHAGNUM SP.	55.5	5.0	0-8					1 1	1 +	1 3		1 2	8 2	7 2	8 3	3 2			4 1		5 2
PLEUROZIUM SCHREBERI	33.3	2.9	0-5													5 3	2 2	1 1	5 1	1 1	1 1
CEPHALOZIA BICUSPIDATA	16.7	2.2	0-4			4 1	4 1	4 1													
PLAGIOTHECIUM UNDULATUM	16.7	1.4	0-3				3 1	3 1	3 1												
ISOTHECIUM STOLONIFERUM	16.7	1.0	0-3			3 1	2 1		1 1												
RHYTIDIADELPHUS TRIQUETRUS	11.1	1.1	0-3	3 2												3 2					
DIPLOPHYLLUM ALBICANS	11.1	+.6	0-3			1 1		3 1													
PLAGIOCHILA PORELLOIDES	11.1	+.6	0-3			3 1	1 1														
SCAPANIA BOLANDERI	11.1	+.6	0-3			1 1	3 1														
CALYPOGEIA MUELLERIANA	11.1	+.1	0-2				2 1	1 1													
HOOKERIA LUCENS	11.1	+.1	0-2				2 1	1 1													
BLEPHAROSTOMA TRICHOPHYLLUM	11.1	+.0	0-1				1 1	1 1													
POLYTRICHUM COMMUNE	5.5	+.5	0-3			3 1															
BAZZANIA DENUDATA	5.5	+.0	0-1				1 1														
DIPLOPHYLLUM PLICATUM	5.5	+.0	0-1					1 1													
HERBERTA ADUNCA	5.5	+.0	0-1			1 1															
POGONATUM ALPINUM	5.5	+.0	0-1			1 1															
RICCARDIA LATIFRONS	5.5	+.0	0-1					1 1													

VEGETATION TABLES FOR ASSOCIATIONS

ASSOCIATION 2.12 SPHAGNO-THUJETUM

PLOT NUMBER	AVERAGE VALUES			KL3 001		KL3 002		KL3 003		KL8 211		KL8 212		KL8 213	
SPECIES	P	MS	RS	SPECIES SIGNIFICANCE AND VIGOR											
THUJA PLICATA	100.0	8.3	7-8	7	1	8	1	8	1	8	1	8	1	8	1
TSUGA HETEROPHYLLA	100.0	6.2	5-7	6	1	5	1	7	1	6	1	5	1	6	1
PINUS CONTORTA	83.3	5.0	0-5	5	1	5	1			4	1	4	1	5	1
TAXUS BREVIFOLIA	66.7	2.0	0-3	2	1	1	1			3	1	1	1		
VACCINIUM OVATUM	100.0	8.5	5-9	7	1	8	1	5	3	9	2	9	3	9	3
GAULTHERIA SHALLON	100.0	8.0	6-9	9	1	8	1	7	2	6	1	7	2	7	2
VACCINIUM PARVIFOLIUM	100.0	5.2	3-5	5	1	3	3	5	3	4	1	5	2	5	2
MENZIESIA FERRUGINEA	100.0	3.1	1-3	3	1	3	1	3	3	1	+	1	1	3	2
MALUS FUSCA	83.3	5.0	0-5	5	1	5	1			5	+	4	+	3	+
VACCINIUM ALASKAENSE	50.0	3.0	0-4	3	1	3	1			4	1				
RUBUS SPECTABILIS	50.0	1.7	0-3	1	1	1	1	3	2						
BLECHNUM SPICANT	100.0	8.2	7-8	8	1	8	1	7	1	8	2	8	2	7	2
CORNUS UNALASCHKENSIS	100.0	6.7	3-8	5	1	5	1	3	2	7	3	7	3	8	2
MAIANTHEMUM DILATATUM	100.0	5.3	3-6	3	1	3	1	4	2	6	3	6	2	5	2
LINNAEA BOREALIS	100.0	5.1	1-7	1	1	4	1	1	1	5	2	4	1	7	2
CAREX OBNUPTA	33.3	3.2	0-5	1	1	5	1								
COPTIS ASPLENIFOLIA	33.3	2.7	0-4							4	2	3	2		
CALAMAGROSTIS NUTKAENSIS	33.3	1.5	0-3	1	1	3	1								
BOSCHNIAKIA HOOKERI	33.3	+.5	0-1	1	1	1	1								
VERATRUM VIRIDE	33.3	+.5	0-1			1	1					1	2		
KALMIA MICROPHYLLA	16.7	1.4	0-3									3	2		
LEDUM GROENLANDICUM	16.7	1.4	0-3									3	2		
PHYLLODOCE EMPETRIFORMIS	16.7	1.4	0-3							3	1				
HYLOCOMIUM SPLENDENS	100.0	7.2	4-8	4	1	4	1	7	3	7	2	8	2	8	2
RHYTIDIADELPHUS LOREUS	100.0	5.7	5-7	5	1	5	1	5	2	5	2	5	2	7	2
SPHAGNUM SP.	100.0	5.1	1-6	1	1	5	1	5	2	6	2	4	2	3	2
PLAGIOTHECIUM UNDULATUM	83.3	3.5	0-4	4	1	3	1	4	2	1	2	3	2		
KINDBERGIA OREGANA	66.7	4.5	0-6	6	1	4	1	4	2					3	1
RHIZOMNIUM GLABRESCENS	50.0	3.5	0-5	3	1	1	1	5	2						
DICRANUM SCOPARIUM	50.0	2.2	0-3	1	1					3	3	3	2		
DIPLOPHYLLUM ALBICANS	33.3	1.1	0-2	2	1	1	1								
HERBERTA ADUNCA	33.3	+.5	0-1	1	1	1	1								
HOOKERIA LUCENS	33.3	+.5	0-1	1	1	1	1								
BLEPHAROSTOMA TRICHOPHYLLUM	16.7	2.2	0-4	4	1										
CEPHALOZIA BICUSPIDATA	16.7	2.2	0-4			4	1								
CLADINA SP.	16.7	1.4	0-3							3	2				
DICRANUM FUSCESCENS	16.7	+.0	0-1	1	1										
HYPNUM CIRCINALE	16.7	+.0	0-1	1	1										
MYLIA TAYLORII	16.7	+.0	0-1	1	1										

VEGETATION TABLES FOR ASSOCIATIONS

ASSOCIATION 3.11 KINDBERGIO PRAELONGI-PICEETUM

PLOT NUMBER	AVERAGE VALUES			KLO 921		KLO 922		KLO 923	
SPECIES	P	MS	RS	SPECIES SIGNIFICANCE AND VIGOR					
THUJA PLICATA	100.0	7.9	7-8	8	1	7	1	7	1
TSUGA HETEROPHYLLA	100.0	7.6	6-8	7	1	6	1	8	1
PICEA SITCHENSIS	66.7	5.1	0-6	4	1	6	1		
GAULTHERIA SHALLON	100.0	3.5	3-3	3	1	3	1	3	1
VACCINIUM OVATUM	66.7	1.1	0-1	1	1	1	1		
VACCINIUM PARVIFOLIUM	33.3	2.1	0-3					3	1
MENZIESIA FERRUGINEA	33.3	+.5	0-1					1	1
BLECHNUM SPICANT	100.0	5.7	5-6	5	1	5	1	6	2
POLYSTICHUM MUNITUM	100.0	5.0	4-5	4	2	5	2	4	2
DRYOPTERIS EXPANSA	100.0	3.1	1-3	1	1	3	2	3	1
TIARELLA TRIFOLIATA	100.0	2.8	1-3	1	2	3	3	2	1
ATHYRIUM FILIX-FEMINA	66.7	2.3	0-3			3	1	1	1
GYMNOCARPIUM DRYOPTERIS	66.7	2.3	0-3			1	1	3	1
KINDBERGIA OREGANA	100.0	6.5	5-7	5	2	6	3	7	3
RHIZOMNIUM GLABRESCENS	100.0	5.7	5-6	6	3	5	3	5	3
PLEUROZIUM SCHREBERI	100.0	5.2	4-5	5	3	5	3	4	2
HYLOCOMIUM SPLENDENS	66.7	1.1	0-1	1	2			1	3

VEGETATION TABLES FOR ASSOCIATIONS

ASSOCIATION 3.21 LYSICHITO-PICEETUM

PLOT NUMBER	AVERAGE VALUES			KL3 151		KL3 152		KL3 153	
SPECIES	P	MS	RS	SPECIES SIGNIFICANCE AND VIGOR					
THUJA PLICATA	100.0	7.8	5-8	5	1	8	1	8	1
PICEA SITCHENSIS	100.0	7.4	6-8	8	1	6	1	6	1
TSUGA HETEROPHYLLA	100.0	4.2	3-4	3	1	4	1	4	1
ABIES AMABILIS	33.3	2.1	0-3	3	1				
TAXUS BREVIFOLIA	33.3	+.5	0-1			1	1		
GAULTHERIA SHALLON	100.0	6.9	5-8	5	1	8	1	5	2
RUBUS SPECTABILIS	100.0	6.0	5-7	5	1	5	1	7	3
VACCINIUM PARVIFOLIUM	100.0	5.7	5-6	5	1	5	1	6	3
VACCINIUM ALASKAENSE	100.0	5.0	4-5	4	1	4	1	5	3
MENZIESIA FERRUGINEA	100.0	4.9	3-5	3	1	4	1	5	3
VACCINIUM OVATUM	100.0	3.6	1-4	3	1	1	1	4	1
VACCINIUM OVALIFOLIUM	66.7	3.0	0-3	3	1	3	1		
BLECHNUM SPICANT	100.0	6.0	5-7	5	1	7	1	5	1
LYSICHITUM AMERICANUM	100.0	5.8	4-7	7	1	4	1	5	3
POLYSTICHUM MUNITUM	100.0	5.5	4-6	6	1	5	1	4	3
CAREX OBNUPTA	100.0	4.7	1-5	4	1	1	1	5	3
ATHYRIUM FILIX-FEMINA	100.0	4.3	1-5	1	1	2	1	5	3
MAIANTHEMUM DILATATUM	100.0	4.3	2-5	2	1	2	1	5	1
TIARELLA TRIFOLIATA	100.0	3.9	3-4	4	1	3	1	3	2
TIARELLA LACINIATA	100.0	3.2	2-3	3	1	2	1	3	2
GALIUM TRIFLORUM	66.7	2.3	0-3			1	1	3	1
STREPTOPUS AMPLEXIFOLIUS	66.7	1.6	0-2	1	1	2	1		
BOYKINIA ELATA	66.7	1.1	0-1	1	1	1	1		
TRISETUM CERNUUM	66.7	1.1	0-1	1	1	1	1		
VIOLA GLABELLA	66.7	1.1	0-1	1	1	1	1		
TIARELLA UNIFOLIATA	33.3	5.2	0-7					7	2
STACHYS MEXICANA	33.3	3.1	0-4					4	2
CORNUS UNALASCHKENSIS	33.3	2.1	0-3					3	2
PRENANTHES ALATA	33.3	2.1	0-3					3	3
ADENOCAULON BICOLOR	33.3	1.3	0-2	2	1				
STREPTOPUS ROSEUS	33.3	1.3	0-2					2	2
FESTUCA SUBULATA	33.3	+.5	0-1	1	1				
LUZULA PARVIFLORA	33.3	+.5	0-1	1	1				
POLYPODIUM GLYCYRRHIZA	33.3	+.5	0-1					1	2
VERATRUM VIRIDE	33.3	+.5	0-1	1	1				
RHIZOMNIUM GLABRESCENS	100.0	5.7	5-6	5	1	5	1	6	3
HYLOCOMIUM SPLENDENS	100.0	3.5	2-4	2	1	2	1	4	3
PLAGIOTHECIUM UNDULATUM	100.0	3.5	3-3	3	1	3	1	3	3
PLAGIOMNIUM INSIGNE	100.0	1.5	1-1	1	1	1	1	1	3
KINDBERGIA PRAELONGA	66.7	5.1	0-5	5	1	5	1		
POGONATUM ALPINUM	66.7	4.9	0-6			1	1	6	3
LEUCOLEPIS MENZIESII	66.7	4.2	0-5	5	1	1	1		
KINDBERGIA OREGANA	66.7	3.1	0-4			1	1	4	2
PELLIA NEESIANA	66.7	2.6	0-3	2	1	3	1		
PLAGIOCHILA PORELLOIDES	66.7	2.6	0-3	2	1	3	1		
RHYTIDIADELPHUS LOREUS	66.7	2.6	0-3	2	1	3	1		
SCAPANIA BOLANDERI	66.7	2.6	0-3	3	1	2	1		
HOOKERIA LUCENS	66.7	1.1	0-1	1	1	1	1		
SPHAGNUM HENRYENSE	66.7	1.1	0-1	1	1	1	1		
PLEUROZIUM SCHREBERI	33.3	5.2	0-7					7	3
HUPERIZIA SELAGO	33.3	3.1	0-4					4	3
CALYPOGEIA MUELLERIANA	33.3	1.3	0-2			2	1		
ISOTHECIUM STOLONIFERUM	33.3	1.3	0-2	2	1				
RICCARDIA LATIFRONS	33.3	1.3	0-2			2	1		
BLEPHAROSTOMA TRICHOPHYLLUM	33.3	+.5	0-1			1	1		
CEPHALOZIA BICUSPIDATA	33.3	+.5	0-1			1	1		
ISOPTERYGIUM ELEGANS	33.3	+.5	0-1	1	1				

VEGETATION TABLES FOR ASSOCIATIONS

ASSOCIATION 4.11 TIARELLO TRIFOLIATAE-ABIETETUM

PLOT NUMBER	AVERAGE VALUES			SL5 131		SL5 132		SL5 133	
SPECIES	P	MS	RS	SPECIES SIGNIFICANCE AND VIGOR					
ABIES AMABILIS	100.0	7.6	6-8	7	1	8	1	6	1
THUJA PLICATA	100.0	7.4	5-8	7	1	5	1	8	1
TSUGA HETEROPHYLLA	66.7	5.3	0-6	5	1	6	1		
VACCINIUM ALASKAENSE	100.0	6.5	5-7	6	3	7	3	5	3
RUBUS SPECTABILIS	100.0	5.3	2-7	3	2	2	2	7	3
VACCINIUM PARVIFOLIUM	66.7	5.4	0-7			7	3	4	3
VACCINIUM OVATUM	66.7	4.2	0-5			1	1	5	3
MENZIESIA FERRUGINEA	33.3	3.1	0-4			4	2		
VIOLA GLABELLA	100.0	7.6	6-8	8	3	7	3	6	3
CORNUS UNALASCHKENSIS	100.0	7.1	5-8	6	3	8	3	5	3
TIARELLA TRIFOLIATA	100.0	6.5	5-7	5	3	7	3	6	3
GYMNOCARPIUM DRYOPTERIS	100.0	5.1	2-5	2	2	5	2	5	3
ACHLYS TRIPHYLLA	100.0	4.9	3-5	5	3	4	3	3	3
TRILLIUM OVATUM	100.0	4.9	3-5	4	3	3	3	5	3
TIARELLA UNIFOLIATA	100.0	4.2	1-5	1	1	1	1	5	2
BLECHNUM SPICANT	100.0	3.9	3-4	3	2	3	2	4	1
ATHYRIUM FILIX-FEMINA	100.0	3.5	3-3	3	3	3	3	3	3
POLYSTICHUM MUNITUM	100.0	3.1	1-3	3	2	1	2	3	2
STREPTOPUS ROSEUS	66.7	5.4	0-7			7	3	4	3
MAIANTHEMUM DILATATUM	66.7	4.6	0-5	4	3			5	1
VERATRUM VIRIDE	66.7	3.3	0-4	2	3			4	3
DRYOPTERIS EXPANSA	66.7	3.0	0-3			3	3	3	3
PETASITES PALMATUS	66.7	3.0	0-3	3	3	3	3		
COPTIS ASPLENIFOLIA	33.3	3.1	0-4					4	3
LYSICHITUM AMERICANUM	33.3	2.1	0-3					3	1
ORTHILIA SECUNDA	33.3	+.5	0-1			1	1		
PRENANTHES ALATA	33.3	+.5	0-1					1	2
RHIZOMNIUM GLABRESCENS	66.7	3.0	0-3			3	3	3	2
RHYTIDIADELPHUS LOREUS	33.3	3.1	0-4					4	3

APPENDIX 8

Criteria for differentiating values of plant species in Characteristic Combinations of Species (modified from Inselberg *et al.*, 1982)

Name (symbol)	Description
Character-species:	
exclusive (e)	Displays a distribution exclusively, or almost exclusively, restricted to a particular syntaxon; presence class ≥IV, species significance variable; may be rarely associated with other syntaxa within the same rank, but only when these syntaxa are geographically adjacent, and the species' presence class in these syntaxa is =I
selective (s)	Displays a distribution which is strongly associated with a particular syntaxon; presence class ≥IV, species significance variable; may be infrequently associated with other syntaxa within the same rank, but only when these syntaxa are geographically adjacent, and the species' presence class in these syntaxa is ≤II
preferential (p)	Displays a distribution which is definitely associated with a particular syntaxon; presence class ≥IV, species significance variable; may be associated with other syntaxa within the same rank, but only when these syntaxa are geographically adjacent, and the species' presence class in these syntaxa is ≤III
companion (co)	Displays a distribution which shows an association to a particular syntaxon; presence class ≥II and at least one presence class higher than in all other (geographically adjacent) syntaxa of the same rank, species significance variable
Differential-species:	
differential (d)	Displays a distribution which shows an association to a particular syntaxon; presence class ≥III and at least two presence classes higher than in all other syntaxa within the same rank and circumscription, species significance variable
Constant-species:	
constant-dominant (cd)	A species with presence class =V and species significance ≥5.0 in a particular syntaxon
constant (c)	A species with presence class =V and species significance <5.0 in a particular syntaxon
Accidental-species:	
accidental (a)	Displays a distribution which does not meet with any of the above criteria; such species do not appear to be allied to any particular syntaxon and should not be used in a Character Combination of Species