FOREST VEGETATION OF WEST-CENTRAL VANCOUVER ISLAND,

BRITISH COLUMBIA

by

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ABSTRACT

The objective of this study was to quantitatively describe the structure, composition and ecological relationships of old-growth forests of west-central Vancouver Island. Data were obtained by sampling 172 plots, at elevations up to 1000 m, located within thirteen drainage areas. Hypothesized relationships between vegetation and environmental variation were examined using gradient analysis and multivariate methods. Successive reciprocal averaging ordination of the vegetation data led to the recognition of six vegetation groups (floodplain, subalpine, Pinus contorta, Pseudotsuga, Thuja, Abies) and twenty-three community types. Data from the tree, sapling, seedling, shrub, herb and bryophyte-lichen strata were used. Vegetation groups are differentiated along macro-climatic and soil parent material gradients. The vegetation of the Pseudotsuga group, dominant inland, appears to respond to gradients of elevation and soil moisture. The Thuja group is found only near the coast, and its vegetation varies along gradients of soil nutrients and elevation; soil moisture having little effect. The vegetation patterns of the Abies group are correlated to elevation and soil moisture. Canonical variates analyses revealed a close relationship between vegetational and environmental patterns within most vegetation groups. A precipitation-continentality gradient was identified as the major determinant of modal vegetation variation. Along this gradient, alpha and beta diversity increased towards the drier and more continental interior as predicted. Tree size-class distribution data indicate that Pseudotsuga menziesii is a seral species in most community types. The dominance of Thuja plicata near the coast may be maintained because of its longevity

and, possibly, its wind damage resistance. Attention is drawn to the

ecological mechanisms operating in coastal forests which have important

implications for their successful management.

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CHAPTER 1

INTRODUCTION

A. GENERAL INTRODUCTION

Vancouver Island possesses the most productive forest stands in
Canada, with the largest total basal area, wood volume per hectare, and
the tallest trees. Small protected areas containing examples of such
stands can be found in MacMillan Provincial Park, better known as
"Cathedral Grove", and in Pacific Rim National Park. Elsewhere on
Vancouver Island, "old-growth" stands have been disappearing steadily
through continued harvesting by the forest industry. Low-elevation,
old-growth forests are almost non-existent in certain parts of Vancouver
Island, especially on the east coast and in the Port Alberni area.
Ecological studies of the few remaining stands of old-growth forests are
urgently needed to provide valuable, or even vital information for future
management of Canada's west coast forests on a scientific basis.

The study of old-growth forests will yield information on how
these forests maintain themselves, where they attain the best growth,
and which site and soil properties are important to their growth. Such
information can assist in developing guidelines for harvesting and post-
harvesting treatments (slashburning, scarification, etc.), as well as
provide site-specific lists of tree species that are suitable for re-
planting. The future success of forest management is due, in large part,
to proper selection of suitable species for replanting after logging.

This need has already been dramatically demonstrated by the numerous failures of Pseudotsuga menziesii plantation, ten to thirty years after planting (Spiers et al., 1983; Carter et al., 1984). The loss of ten to thirty years in what ideally should be an eighty year rotation period is a potential disaster. Forest management on a sound ecological basis aims at preventing such costly errors.

If the study of old-growth forests can contribute valuable information for forest management purposes, it is essential that such studies be undertaken soon, while nearly all the variation expressed in old-growth forest vegetation, along various environmental gradients, can still be found. In response to these concerns, one of the major objectives of this study is to provide a detailed ecological study of old-growth forest communities on west-central Vancouver Island (Fig. 1).

Numerous ecological studies of forest communities in coastal British Columbia have been carried out by Dr. V.J. Krajina and his students. Most of these studies, however, were done on the east coast of Vancouver Island (Krajina and Spilsbury, 1953; Mueller-Dombois, 1959; McMinn, 1960) or on the adjacent mainland (Orloci, 1961, 1964; Brooke et al, 1970; Klinka, 1976). The relatively few ecological studies of western Vancouver Island have been confined to small areas or special habitats (Wade, 1965; Kuramoto, 1965; Cordes, 1972; Kojima and Krajina, 1975). Other researchers also have studied the vegetation of the east coast of Vancouver Island (Beese, 1981; Roy, 1984; Roehmer, 1972). The vegetation of the Carnation Creek Experimental Watershed on western Vancouver Island was described by Oswald (1973, 1974, 1975). Also, two noteworthy

studies of western Vancouver Island forests above the community level
are those of Packee (1976) and Klinka et al. (1979).

B.   OBJECTIVES AND HYPOTHESES

Although the description of the structure, composition and eco-
logical characteristics of the old-growth forest communities of west-
central Vancouver Island is the major objective of this study, several
other objectives will be considered concurrently. These secondary objectives
may be stated in the form of hypotheses, or predictions from the litera-
ture. These working hypotheses are not devised to be examined through
the formal hypotheses testing procedure described as "strong inference"
by Platt (1964). Quinn and Dunham (1983) have argued that, "strict appli-
cation of a formal strong inference methodology to elucidating potential
causes of patterns in nature is frequently infeasible". A great deal
of this difficulty resides in the formulation of appropriate null hypo-
theses. Also, causal factors of ecological patterns are probably not
mutually exclusive, and it becomes impossible to distinguish between
alternative hypotheses if these causal factors operate simultaneously
(Quinn and Dunham, 1983). Therefore, the hypotheses formulated below
should instead serve as reference points for the interpretation and
discussion of the results obtained.

1. ENVIRONMENTAL GRADIENTS AND VEGETATION PATTERNS

Numerous studies have pointed out the major environmental gradients
generally responsible for the largest amounts of variation within vege-
tation. Nevertheless, it remains interesting to examine for the first

time vegetation-environment relationships in a large, climatically diverse area of western Vancouver Island. Specific questions asked at the outset of the research were : Which environmental gradient, or gradients, will be associated with the largest amount of variation in the vegetation over the whole study area? If certain environmental factors are held constant (through manipulation of field data), do others emerge as having potentially significant control over vegetation patterns? Are the predominant environmental gradients the same in climatically different parts of the study area?

These questions can be investigated through the use of a functional approach to plant community ecology. Austin et al. (1984) summarized this approach and pointed out its similarities to gradient analysis. The functional approach was pioneered in the study of soils by Jenny (1941), in which soils were expressed as being a function of climate, parent material, topography, a biotic factor and time. Jenny (1941) suggested that if all factors except one were held constant, relationships between this one factor and soil properties could be demonstrated and analyzed (Austin et al., 1984). A similar functional, factorial approach to plant ecology was later proposed by Major (1951) and Crocker (1952).

Similarly, in his direct gradient analysis of the Great Smoky Mountains, Whittaker (1956) assumed that vegetation properties were related to meso-climate and topography, when parent material, the biotic factor and time were held constant. The meso-climate gradient was estimated by elevation (approximating temperature), and the topography gradient

was measured by slope aspect and degree of exposure (approximating

moisture, Whittaker (1956)). These two gradients served as the axes of

the now classic, two-dimensional diagrams of the vegetation of the

mountainous areas studied by Whittaker (Whittaker, 1956; 1960; Whittaker

and Niering, 1965). A third factor, such as parent material or lati-

tude (macro-climate) or successional status (time) can be introduced by

producing elevation-topography diagrams for areas differing only in the

third factor of interest (Whittaker, 1960; Whittaker and Niering, 1968b;

Perring, 1960; Peet, 1978; Kessel 1979). Kessel (1979) produced a com-

prehensive series of two-dimensional diagrams to display major vegetation-

environment relationships for Glacier National Park, Montana. Such

graphical methods have permitted the ecological interpretation of complex

distribution patterns of individual species and community characteristics,

including species diversity and productivity (Whittaker and Niering,

1975).

Within this study area the biotic factor (herbivory, competition)

is assumed to be constant, as is the time factor, since mostly old-growth

forest stands were sampled. Climate, topography and parent material are

the environmental factors showing the greatest variation within the study

area.

It is generally accepted that macro-climate (mainly temperature

and precipitation) will influence most strongly the vegetation of an

area. Elevation represents a major precipitation and temperature gra-

dient within the present study area; as well, precipitation declines

markedly along a west to east axis from coastal to more interior parts

of the island. Macro-climate and meso-climate levels can be subjectively distinguished by scale. For example, there is a macro-climatic difference between Tofino and Port Alberni (different total precipitation), while there is only a meso-climatic difference between the north and south facing slopes surrounding Sproat Lake.

In his study of the vegetation of the Siskiyou Mountains of Oregon, Whittaker (1960) documented an increase in alpha and beta diversity along a gradient from the coast to the interior. Alpha diversity represents the species richness, or number of species at a site, while beta diversity refers to the rate of change in species composition (termed "species turnover") along an environmental gradient (Whittaker, 1975). A similar trend was detected in the central Washington Cascade Mountains by Del Moral and Watson (1978), and in Finland by Oksanen (1983).

From the above, the following hypotheses were formulated for the study of the vegetation of west-central Vancouver Island using gradient analysis methods :

a) Vegetation and individual species patterns will be most
strongly correlated with macro-climatic factors over the
entire study area.

b) Following macro-climate, parent material factors will exert
the next strongest influence on vegetation and species patterns.

c) If macro-climate and parent material are held fairly constant,
that is if subsections of the entire study area are analysed

separately, meso-climate will be most strongly correlated
with vegetation and species patterns.

d) Within the same subsections as in (c) topographical factors
related to soil moisture will follow meso-climate in their
apparent control over vegetation and species patterns.

e) The macro-climatic gradient of decreasing precipitation and
increasing continentality, progressing inland from the coast,
should be reflected by increases in both alpha and beta diver-
sity in the vegetation.

2. VEGETATION PATTERNS VS. ENVIRONMENTAL PATTERNS

A major assumption of indirect gradient analysis, or indirect
ordination, is that the vegetation patterns illustrated reflect under-
lying environmental patterns (Whittaker, 1967; 1978). A further objec-
tive of this thesis is to examine the validity of this assumption
within the present study area.

The degree to which communities, differentiated by vegetation
attributes, can also be independently delineated using environmental
variables is a good indication of the relationships between vegetation
and environmental patterns. Old-growth forests that have been deve-
loping for centuries would seem to represent a system where vegetation
and environment are in close harmony. Vegetation variability introduced
by most small scale disturbances (eg. deaths of isolated individuals) is
minimized in such forests. Disturbance on a larger scale (eg. fire or

storm damage) may have more profound effects on vegetation patterns depending on the type, intensity, and frequency of the disturbance. Counteracting the deterministic relation between environment and vegetation are stochastic events, such as the establishment of different species in newly opened microsites, or the year to year variation in seed production by different species, which also are characteristic of the developing forest. Thus two identical disturbances, but not occurring at the same time or place, may often promote the establishment of a different vegetation due to stochastic events.

These ideas are reformulated in the following statements or hypotheses :

a) The interplay of competitive forces between populations of species in old-growth forests over long periods of time has resulted in species assemblages best suited, or adapted, to the specific site conditions found within each stand; therefore, the vegetation patterns should closely match the environmental patterns.

b) It follows from the preceding statement, that within parts of the study area where large scale natural disturbances (i.e. fire) are, or have been, more frequent, relationships between vegetation patterns and environmental patterns would be expected to be weaker.

3. VEGETATION HOMOGENEITY

Another expected characteristic of old-growth forests is homo-
geneity of vegetation strata within communities under relatively uniform
environmental conditions. Again, a decrease in vegetation homogeneity
is expected where large scale disturbances have played, or still play
a role. These ideas can be reformulated as follows :

> Where large scale natural disturbances (i.e. fire) are,
>
> or have been, more frequent, vegetation homogeneity will be
>
> reduced; therefore, ecologically similar sites will show a
>
> greater vegetation variability within these parts of the
>
> study area.

4. THE CLIMAX ROLE OF THUJA PLICATA IN COASTAL FORESTS

Thuja plicata is a major forest dominant of the Estevan Coastal
Plain. This area, located on the extreme west coast of Vancouver Island,
receives over 2000 mm of precipitation annually (Fig. 2). Despite the
dominant status of Thuja plicata in this area, there is some doubt that it
is the major climax species. Tsuga heterophylla and Abies amabilis both
show abundant seedling regeneration and might be predicted to eventually
replace Thuja plicata as dominant species. Bellefleur (1981) using a
Markovian simulation model of succession (and an admittedly small data
set) showed that succession should lead quickly to Tsuga heterophylla
dominance. Bellefleur (1981) claimed, however, that the results were
an artifact of the data set and agreed with Packee (1976) that Thuja
plicata should maintain its dominance over time. Klinka et al. (1979)

include <u>Picea</u> <u>sitchensis</u>, <u>Abies</u> <u>amabilis</u> and <u>Tsuga</u> <u>heterophylla</u> as dominant trees of their zonal ecosystem (climax association on mesic sites) in the coastal areas where <u>Thuja</u> <u>plicata</u> dominates. Nevertheless, they describe old-growth stands with very large <u>Thuja</u> <u>plicata</u> trees, which they consider to be nearly climatic climax ecosystems, owing to the virtual absence of forest fires. Since there is a concensus that the largest amount of disturbance in these stands comes from the wind-throw of individual trees (Klinka <u>et</u> <u>al</u>., 1979; personal observation), the following hypothesis will be investigated :

In the old-growth, <u>Thuja</u> <u>plicata</u> dominated forests of the west coast of Vancouver Island, <u>Thuja</u> <u>plicata</u> can be considered a "climax" species, capable of regenerating and maintaining itself indefinitely.

C. GRADIENT ANALYSIS

Gradient analysis is the major conceptual approach used to generate and analyse the results of this study. The origin, basic assumptions and premises of this approach are discussed here briefly.

Gradient analysis is a methodology of vegetation study originally developed by R.H. Whittaker in his study of the vegetation of the Great Smoky Mountains (Whittaker, 1956). He later used the same approach in his studies of the Siskiyou Mountains of Oregon (Whittaker, 1960) and the Santa Catalina Mountains of Arizona (Whittaker and Neiring, 1965; 1968a; 1968b; 1975). Gradient analysis is based on the Gleasonian view of vegetation as a continuum (Gleason, 1926; McIntosh, 1967), and has

been largely responsible for the now general acceptance of this view
(Whittaker, 1978). The approach consists of studying the variation in
the structure and composition of vegetation along environmental gradients,
using variables from three different levels : (1) the abiotic environment,
(2) species populations, and (3) community characteristics such as diver-
sity or productivity (Whittaker, 1967). Interrelations between these
three levels of variables can be studied through the use of two-dimensional
diagrams (Whittaker, 1956; 1960; 1965; 1967; 1978; Kessel, 1979). In this
particular approach, environmental gradients surmised to be important are
represented as axes, and the sampled plots are arranged, or ordinated,
within the reference space. This technique is now referred to as direct
gradient analysis, particularly since the advent of the Wisconsin polar
ordination method and other multivariate techniques based solely on vege-
tation data (Whittaker and Gauch, 1978). Such ordinations are referred
to as methods of indirect gradient analysis (thus, indirect ordinations),
since they represent diagrammatically patterns of variation in the vege-
tation which may be interpreted in terms of ecological gradients. It is
assumed that the pattern of vegetation variation reflects underlying
environmental gradients (Whittaker, 1967; 1978; Whittaker and Gauch,
1978); the strengths of such relationships can be clarified in follow-up
analyses by correlating environmental variables with the derived vege-
tation gradients.

Only recently has gradient analysis been used with a resource
management purpose in mind. Kessel (1979) applied gradient analysis
techniques in the development of a computerized forest fire management
program for Glacier National Park, Montana. This thesis uses gradient

analysis in seeking to provide ecological information necessary for forest management decisions and explores some of the theoretical aspects on which this approach is based.

CHAPTER 2.

STUDY AREA

A.   LOCATION, PHYSIOGRAPHY AND GEOLOGY

1.   LOCATION AND PHYSIOGRAPHY

The study area is located on the west-central coast of Vancouver Island.   The area extends approximately 110 km along the Pacific Ocean coast, from the Cypre River north of Tofino (49° 20'N, 126°W), to the Nitinat River east of Bamfield (48° 45'N, 124° 35'W).   From the coast, the study area extends 60 km inland to Port Alberni (Fig. 1).

The study area lies entirely within the Vancouver Island Mountains physiographic subdivision (Holland, 1964).   This unit is further subdivided into the Vancouver Island Ranges, the Estevan Coastal Plain, and the Alberni Basin.

The Vancouver Island Ranges are formed by several small mountain ranges generally following a northwest to southeast axis, separated and dissected by deep, U-shaped valleys (Holland, 1964).   One of these valleys, flooded by the sea, is the Alberni Inlet, a classical fjord centrally located in the study area and opening to the Pacific Ocean through the Barkley Sound.   Numerous valleys contain large, fjord-like lakes such as Sproat Lake, Nahmint Lake, Henderson Lake, the two arms of Kennedy Lake, and Great Central Lake at the northern boundary of the study area (Fig. 1). Nitinat Lake, at the southeast limit of the study area, has the peculiarity

of being linked directly to the Ocean at high tides. The highest peak within the study area is Mt. Klitsa at 1642 m. The Golden Hinde (2,200 m), north of the study area, is the highest mountain on Vancouver Island. Pre-Pleistocene uplift and erosion produced a rugged topography which was extensively modified during the Pleistocene glaciations (Holland, 1964). During the most recent glaciation the Vancouver Island ice cap was joined with that of the mainland (Muller et al., 1974). There was a southwest flow of ice across the Island when the general topography allowed it, such as along the Alberni Inlet (Fyles, 1963). Recent botanical discoveries suggest that the ice cover was not complete on Vancouver Island's Brooks Peninsula during the Pleistocene Fraser glaciation (Pojar, 1980). Endemic earthworms found on Vancouver Island would also support the existence of a glacial refugium (Spiers et al., 1984).

The Estevan Coastal Plain is a narrow band, 1.5 to 10 km wide, extending nearly 275 km along the west coast of Vancouver Island (Holland, 1964). This coastal plain reaches its maximum width within the study area between Tofino and Ucluelet (Fig. 1). The topography is generally level to strongly rolling with scattered bedrock knolls. Surface materials consist of thick, unconsolidated Pleistocene and Recent deposits. Drainage on these materials is generally imperfect to very poor (Valentine, 1971). In the portion of Pacific Rim National Park situated between Tofino and Ucluelet wave action on these deposits has created long and wide sand beaches.

The Alberni Basin is a low elevation area (below 300 m) with relatively level relief at the head of the Alberni Inlet (Holland, 1964). No plots were sampled in this physiographic section since it is mostly agricultural.

There are numerous rivers within the study area. The drainage basins of some of the largest rivers (Kennedy, Taylor, Nitinat, Sarita, Klanawa, and Nahmint)were used to subdivide the study area for sampling purposes (Fig. 3).

2. BEDROCK GEOLOGY

The bedrock geology of southwestern British Columbia including Vancouver Island is complex. Several authors have described the heterogeneous geology of the area (Muller, 1971; Muller and Carson, 1969; Muller et al., 1974) and a detailed summary is provided by Packee (1976). Rocks of the Mesozoïc era predominate. These are mainly faulted and folded sedimentary and volcanic rocks, frequently intruded by igneous batholiths (Muller and Carson, 1969; Muller, 1971). Limestone, chert, argillite, tuff, and greywacke are the most common types of sedimentary rock (Day et al., 1959; Muller and Carson, 1969). Three cycles of volcanism have been described for Vancouver Island (Northcote, 1973). Recent geological discoveries indicate that Vancouver Island and the Wrangell Mountains, near the coastal Yukon-Alaska border, may have drifted north from south of the equator through plate tectonic activity (Jones et al., 1983).

3. SURFICIAL GEOLOGY

The main factors influencing the surficial geology of the study area have been the last Pleistocene glaciation, which ended approximately 12,000 to 14,000 years ago according to palynological evidence (Hebda, 1983; Mathewes, 1973), and various post-glacial events. The major types of surficial materials found on the west coast of Vancouver Island are glacial tills, glaciofluvial deposits, and marine sediments. Because of the mountainous topography, colluvial material is frequently encountered (Jungen and Lewis, 1978). The colluvium is formed on slopes from bedrock fragments and slumping morainal material. Marine and fluvioglacial deposits, in the form of sands and clays, are predominant on the Estevan Coastal Plain (Valentine, 1971; Jungen and Lewis, 1978). These deposits originated when the land, depressed by the ice pack, was invaded by the sea following the glacial retreat; rebounding of the land has now raised these sediments above sea level. Recent alluvial deposits are found along all major rivers.

B. SOILS

British Columbia has been divided into a number of broad soil
landscapes defined at the soil great group level (C.S.S.C., 1978).
Each is defined as "the total ecosystem with which a soil is associated,
with emphasis placed on the soil itself" (Valentine et al., 1978). The
study area falls within the Ferro-Humic Podzol and the Humo-Ferric Pod-
zol soil landscapes (Jungen and Lewis, 1978). The Ferro-Humic Podzol
soil landscape occurs on the windward side of Vancouver Island. This
area is characterized by abundant rainfall and moist, rarely frozen soils
throughout most of the year (Jungen and Lewis, 1978). The main soil
formation processes are the accumulation of organic matter, iron, and
aluminum producing soil with distinct podzolic Bfh horizons. Continuous
seepage is present throughout most of this soil landscape, and is reflected
by the high organic matter content of the soils, rather than the typical
mottling and gleying (Jungen and Lewis, 1978). Organic matter content
often reaches a maximum, sometimes over 30 %, near the lower part of the
profile (Jungen and Lewis, 1978). The presence of a cemented, indurated
pan (Bc horizon) is the major characteristic of morainal soils (Jungen
and Lewis, 1978). In these soils the Bhf horizon commonly is most pronoun-
ced just above the cemented till which often cannot be broken with a
shovel. Morainal soils are mostly imperfectly to poorly drained while
colluvial soils, with no cementation, are generally well to moderately
well drained (Jungen and Lewis, 1978). Organic horizons between 20 to
40 cm thick frequently were observed on Ferro-Humic Podzols within the
study area. Valentine (1971) noted the high organic matter content of

the soil surface layers of the Tofino-Ucluelet lowland. He suggested

that dense vegetation coupled with moderate temperatures, allowing

nearly continuous biological and chemical activity, forms a "constant

source of raw humic material". Most plant nutrients may be derived from

this organic matter (in organic horizons and upper mineral horizons)

rather than from the mineral solum (Valentine, 1971). Valentine (1971)

also noted a generally shallow rooting zone even under dense tree growth.

The importance of the organic layers in nutrient cycling in soils of

the west coast of Vancouver Island is also supported through the recent

discovery of an endemic earthworm (Arctiostrotus simplicigaster vancou-

verensis) (Spiers et al., 1984). This worm may play a major role in

mediating nutrient cycling within the organic layers where it is res-

tricted (Spiers et al., 1984). Chemically the soils of the Ferro-Humic

Podzol soil landscape have a very low base saturation, low pH (commonly

< 5.0), and high organic carbon, iron, and aluminum contents (Jungen and

Lewis, 1978).

The Humo-Ferric Podzol soil landscape occurs farther inland within

the study area, especially around Port Alberni. Soil moisture is not as

abundant as in the Ferro-Humic Podzol soil landscape owing to the warmer

and drier summer climate (Jungen and Lewis, 1978). Colluvial and morainal

parent materials are common, the latter usually with a weakly to strongly

cemented pan (Bc and Bcc horizons). Cementation, when present, is usu-

ally strongest near the top of the pan (Jungen and Lewis, 1978). Colluvial

soils often are deeply weathered, well to rapidly drained, and contain no

signs of cementation (Jungen and Lewis, 1978). Chemically these soils

have low pH (4.0 to 5.0), moderate to high iron and aluminum content,

and low base saturation (Jungen and Lewis, 1978). In contrast with the soils of the Ferro-Humic Podzol soil landscape, Humo-Ferric Podzol soils have little organic matter accumulation in the upper B horizons (Valentine and Lavkulich, 1978).

Apart from podzols, other soil orders are also encountered within the study area. Folisols, consisting of shallow organic material overlying bedrock, are sometimes found on rock outcrops in high rainfall areas near the coast. Orthic regosols occur on floodplains and on rock outcrops. Gleyed Sombric Brunisols frequently are found on floodplains. Humic Gleysols are most frequent in plots of the Estevan Coastal Plain. Some Dystric Brunisols also occur in the drier inland part of the study area. Other than Folisols, organic soils occasionally are found in bedrock depressions and in areas overlying impervious surficial material; examples of the latter include the bogs on marine clays in the Tofino-Ucluelet area (Valentine, 1971).

The typical Vancouver Island podzol was reported by Lewis (1976) to be different from the classic podzolic profile. Frequently, no eluviated Ae horizon is found. Despite the strong leaching, the constant addition of abundant organic matter and the constant weathering of iron and aluminum in the upper mineral horizon prevent the net depletion necessary to form an Ae horizon (Lewis, 1976; Valentine and Lavkulich, 1978); however, it was also reported that an accumulation of organic matter may sometimes mask the Ae horizon under moist field conditions (Valentine and Lavkulich, 1978). Soils derived from basaltic and andesitic parent materials have no Ae horizons because they contain no silica

to be left behind after weathering (Lewis, 1976). Throughout the study area soil horizon boundaries frequently are very irregular because of the turbic activity associated with windthrow.

Most soils sampled, especially those on colluvial material, were coarse textured and contained a high percentage of large rock fragments. Overall, the pH values of organic horizons varied from 3.0 to 6.2 (H_2O), and the pH values of the upper mineral horizons (mostly B_1) from 3.8 to 6.3 (H_2O). Total nitrogen in the upper mineral horizons varied from 0.02 % to 0.86 %, total carbon from 0.2 % to 24.4 %, and C/N ratios from 10 to 94.

C. CLIMATE

Climatic data are available from several low elevation permanent weather stations within the study area (Anonymous, 1982); high elevation stations are lacking. Most of the study area falls within the humid mesothermal summer-wet climate (Cfb) according to the Köppen system. This is described by Strahler (1965) as a windward, west coast climate with moist maritime polar air masses hitting the coast with frequent eastward-moving cyclonic storms. Precipitation tends to be evenly distributed throughout the year, but there is a winter maximum. The annual temperature range is small for middle latitudes (Strahler, 1965). The air masses collect moisture as they pass over the warm Alaska current and release it as orographic precipitation over the land. A distinctive rain shadow effect is created on leeward mountain slopes and valleys. The driest part of the Port Alberni area as well as all of the southeast coast of Vancouver Island can be classified as a humid mesothermal, summer-dry climate (Csb). This summer-dry, winter-wet climate, predominant farther south along the Pacific Coast, is caused by the replacement of cyclonic, moist maritime polar air masses (Aleutian Low) by a relatively stable, dry maritime tropical air mass (North Pacific High) during the summer (Strahler, 1965). Southern British Columbia is at the northernmost limit of the influence of this system, and rainfall differences between the west and east coasts of Vancouver Island are in a large part due to orographic effects.

Climatic data from Tofino Airport (Fig. 2) are characteristic of the Cfb climate within the study area. Precipitation averages 3288 mm annually, but windward slopes east of Tofino likely receive more. Abundant moisture is always available for plant growth. Dry mineral soil or humus was never observed in summer near the coast, except sometimes on rock outcrops. The temperature is very mild, with the mean daily minimum of the coldest month at $0.8°C$, and the mean daily maximum of the warmest month at $18.3°C$; the mean annual temperature is $8.9°C$ (Fig. 2). The Lupsi Cupsi climatic station near Port Alberni (Fig. 2) is at the wetter limits of a Csb climate. Mean annual precipitation is 1929 mm, and a period of moisture deficit is experienced in mid-summer when the average monthly precipitation reaches 28 mm (Fig. 2). The temperature also is very mild, although a slight continentality effect is noticeable with a lower mean daily minimum temperature of the coldest month $(-1.1°C)$, and a higher mean daily maximum temperature of the warmest month $(24.6°C)$, than at Tofino. The mean annual temperature at Port Alberni is $9.5°C$. Snowfall makes up 5 % of the mean annual precipitation at Port Alberni and less than 2 % at Tofino (Anonymous, 1982). Orloci (1964) considered snow duration and accumulation to be an insignificant ecological factor at low elevation. In contrast, at higher elevations, cooler temperatures (Dfc, microthermal snowy climate) result in a larger percentage of precipitation in the form of snow. Hollyburn Ridge (951 m) near Vancouver receives close to 3000 mm of precipitation annually, of which 28 % falls as snow (Brooke et al., 1970). Heavy snowpacks of moist snow often linger into mid-summer above 1000 m. Snow depths averaged 3 m over several years on April 1st surveys of the north shore mountains near Vancouver (Brooke et al., 1970).

The occurrence of summer fog, particularly in areas nearest to the coast, is another important climatic factor within the study area. Summer fog is formed off the coast of Vancouver Island and moves inland towards a low pressure area created by the daily warming of the land mass. This fog usually covers the Estevan Coastal Plain up to the first mountain slopes. Azevedo and Morgan (1974) have described a similar phenomenon for north-coastal California. Their data show the predominance of fog at night, dissipating during the day. In the study area, as in northern California, fog could last all day during particularly heavy episodes, and the fog would dissipate last nearest to the coast. Fog often appeared in the Tofino-Ucluelet area during summer days which were warm and clear for the rest of the study area. Fog drifting through forest canopies has been shown to cause considerable amounts of precipitation as fog drip (Azevedo and Morgan, 1974). A large portion of this precipitation is probably unrecorded by standard weather stations, but the vegetation should certainly reflect the prevalence of summer fog (Azevedo and Morgan, 1974).

Climatic maps compiled by Colidago (1980) for southern Vancouver Island reveal a complex pattern of decreasing summer precipitation and increasing effective growing degree-days as distance from the coast increases (Fig. 12). The "freeze-free" period (mean daily temperature $> 0°C$) varies from 240 days at low elevation on the coast near Tofino, to 160 days inland near Port Alberni (Colidago, 1980).

D. VEGETATION

Most of the study area falls within the Coastal Western Hemlock

biogeoclimatic zone of British Columbia (Krajina, 1965; 1969). The

vegetation of a small area surrounding Port Alberni has been placed

within the wetter subzone of the Coastal Douglas-fir biogeoclimatic zone

(Klinka et al., 1979). Klinka et al. (1979) recognize several subzones

and variants of these two biogeoclimatic zones within the study area.

Subalpine forests, generally above 1000 m elevation, belong to the Moun-

tain Hemlock biogeoclimatic zone (Krajina, 1969; Klinka et al., 1979),

or to the Coastal section (SA.3) of the Subalpine forest region (Rowe,

1972).

The lower elevations of the study area are within the Coast

forest region of Rowe (1972). The drier Port Alberni area supports

vegetation similar to the Strait of Georgia section (C.1) through the

presence of Arbutus menziesii, the only broadleaf evergreen tree in

Canada, and the dominance of Pseudotsuga menziesii in the landscape

(Rowe, 1972). The adjacent Southern Pacific Coast section (C.2) contains

most of the study area and is characterized by stands, often even-aged,

dominated in decreasing order by Pseudotsuga menziesii, Tsuga hetero-

phylla, and Thuja plicata on well drained sites. On valley floors or

on moist, sheltered slopes Pseudotsuga menziesii is sometimes absent while

Tsuga heterophylla, Thuja plicata, and Abies amabilis increase in impor-

tance. These differences indicate the essentially seral character of Pseu-

dotsuga menziesii in this section (Rowe, 1972). Thuja plicata dominance

is associated with seepage areas, while Abies amabilis increases in

abundance with increasing elevation (Rowe, 1972). The Estevan Maritime

Coastal Western Hemlock biogeoclimatic variant of Klinka et al. (1979)

corresponds approximately to the Vancouver Island portion of Rowe's

(1972) Northern Pacific Coast section (C.3). In this section, Tsuga

heterophylla and Abies amabilis dominate on rarely occurring well drained

sites, while Thuja plicata becomes dominant everywhere else where drai-

nage is deficient (Rowe, 1972). Picea sitchensis is found mostly on

alluvial deposits and on the coastal fringe (Cordes, 1972). Because of

the very humid climate, forest fires are rare within this section and

the major source of forest disturbance is wind (Rowe, 1972; Klinka et al.,

1979). Pseudotsuga menziesii is virtually absent within the section

(Rowe, 1972). The most productive stands are produced following wind-

throw (Rowe, 1972; Klinka et al., 1979). Some very productive stands

also were observed on ancient avalanche colluvium within this section of

the study area.

The Coastal Western Hemlock biogeoclimatic zone (Krajina, 1969),

or the Southern Pacific Coast section of the Coastal forest region (Rowe,

1972), have growing conditions suitable for the highest forest produc-

tivity in Canada. In some sites of the Drier Coastal Western Hemlock

biogeoclimatic subzone, Pseudotsuga menziesii reaches the maximum growth

attained by any tree on any site in Canada (Site Index$_{100}$: 54-60 m)

(Krajina, 1969).

The vascular floristic patterns and affinities of coastal British

Columbia are discussed by Schofield (1969) and Scoggan (1978). The bryo-

flora has been analysed in more detail by Schofield (1965, 1968a, 1968b,

1969, 1976, 1980, 1984). Many dominant taxa within the study area are restricted to the relatively narrow Coastal or Cordilleran area along western North America. Several Pacific North American taxa such as Arbutus menziesii, Arctostaphylos columbiana, and Oxalis oregana reach the northern extent of their ranges near the study area.

CHAPTER 3.

METHODS

A. DATA COLLECTION

1. LOCATION OF PLOTS

      The selection of sampling sites over a large, mountainous and

heterogeneous area, for the purpose of gradient analysis and ordination,

requires a minimum of bias, adequate representation of the range of

variation in environment and community composition, homogeneity within

sampling units, lack of disturbance, and a sufficiently large sample

(Whittaker, 1978). Because of the difficulty of selecting plots without

bias, random sampling is often recommended for vegetation studies (Smartt

and Grainger, 1974). However, formal randomization in large scale studies has

been rejected by most researchers (Moore et al., 1970), with some exceptions

(Noy-Meir, 1971), because of drawbacks such as inefficiency (for time and

sample size) and inadequate representation of variation ranges, because

of the high probability of missing many unusual, and often very infor-

mative, communities (Whittaker, 1978; Peet, 1981). The random location

of plots in the field may be time consuming and yield many unsatisfactory

sites (because of heterogeneity or disturbance, especially in an area

with active logging such as in this study). Subjective sampling can yield

a much broader spectrum of vegetational variation in the same amount of

time (Peet, 1981), and the time saved in plot location will permit the

collection of a larger sample. In order to make the plot location selec-

tion as objective as possible, the study area was subdivided into thirteen

drainage areas (Fig. 3). The number of plots sampled in each area depended on the size of the area and on accessibility. Some drainage areas with very difficult access were not sampled. Within each selected drainage area an effort was made to sample examples of all topographic positions (slopes, ridges, floodplains, etc.) and edaphic conditions present, up to an elevation of about 1000 m, reportedly the lower limit of the Mountain Hemlock biogeoclimatic zone (Brooke et al., 1970; Klinka et al., 1979). Also, only homogeneous (within plot boundaries) old-growth forests with no evidence of major disturbance within the last hundred years were sampled. The maximum ages of stands sampled varied from 150 years to well over 500 years, with a few exceptions. Coastal fringe communities of Picea sitchensis, influenced by ocean spray, and Sphagnum bogs, on deep organic soils, were not sampled. These special plant communities have been studied by Cordes (1972) and Wade (1965), respectively. Sand dune vegetation of Long Beach, Pacific Rim National Park, was studied by Kuramoto (1965).

2. VEGETATION SAMPLING

The vegetation was sampled within a circular 500 m^2 plot (Pfister and Arno, 1980) at each site. From a centre-point, two tapes were laid out at 90 degrees, and a radius distance of 12.6 m was flagged around the periphery of the plot, using calibrated ropes (Fig. 4). The diameters at breast height (1.3 m) of all stems within the plot were recorded for each species in 10 cm size-classes. Stems over 10 cm DBH are referred to as trees, and stems between 0 and 10 cm DBH are referred to as saplings.

The understory vegetation and tree seedlings (arbitrarily defined as stems less than 1.3 m tall) were recorded in twenty 1 m^2 microplots. Two different microplot placement designs were used : a systematic design for plots 1 to 61 (1980) and a stratified random design for plots 62 to 172 (1981) (Fig. 4). Randomization avoided the sampling bias toward the centre of the plot, inherent in the systematic design, and yielded data that were more amenable to statistical interpretation. The stratified random design was obtained by determining from a table of random numbers five microplot locations on a grid of each quarter of the plot surface. This design was repeated in the sampling of plots 62 to 172. Percent coverage was estimated for shrubs, herbs, bryophytes and lichens, in each microplot, using a seven-point scale of coverage ranges similar to that of Daubenmire (1968) : 1 (0-1 %), 2 (1-5 %), 3 (5-25 %), 4 (25-50 %), 5 (50-75 %), 6 (75-100 %) and 7 (100 %). Also, the numbers of tree seedlings were recorded by species within the microplots. Vascular species not encountered within the microplots but found within the larger 500 m^2 plot were recorded as present, and arbitrarily assigned values of 0.01 percent coverage and 1.0 % frequency; non-vascular species outside the microplots were not recorded.

These measurements provide for each plot : basal area (or dominance) of trees, density of trees, density of saplings, density of seedlings, and percent coverage (average of 20 microplots) and frequency (over 20 microplots) for shrubs, herbs, bryophytes and lichens. The heights of at least two dominant trees were measured in each plot using a clinometer, and the maximum height of the shrub and herb strata recorded. Cores of two of the largest trees, of different species, were taken for stand age estimates.

3. SOIL AND ENVIRONMENTAL DATA

Within each 500 m^2 plot a soil pit was dug to bedrock, to a layer
of compacted till, or to a depth of one metre, whichever came first.
A soil profile description was written in the field and samples of each
organic and mineral horizon were taken for laboratory analyses. The
field description included features such as, horizon thickness, percent
coarse fragments, field texture (estimated), structure, consistency,
charcoal presence, colour, abundance and size of roots, and organic
material description. Other site and soil data such as elevation,
aspect, percent slope, topographic position, surface shape, soil drai-
nage, estimated soil moisture regime, nature of surficial material,
nature of bedrock, evidence of fire and windfall, and presence of earth-
worms (plots 62 to 172) were also recorded. The distance of each plot
from the Pacific Ocean was determined from a map.

The soil analyses were performed by the MacMillan Bloedel Wood-
lands Services Soil Laboratory, generally following the U.B.C. Pedology
Methods Manual (Lavkulich, 1978). All samples were air dried. After
drying, organic samples were ground in a Wiley mill to pass through a
20-mesh screen, and mineral samples were passed through a 2 mm sieve and
ground to pass a 60-mesh screen. The pH's of all samples were determined
in both a 1:1 water suspension (1:2 for organics) and 1:2 0.01 M $CaCl_2$
suspension (1:4 for organics). Soil texture was determined by the hydro-
meter method for the top B horizon of plots 1 to 61. Total organic carbon
content was determined by the Walkley-Black method of Wet Oxidation. The
total nitrogen content of samples was determined using a Technicon Auto

Analyser II after digestion in sulphuric acid and catalysts (mineral samples), or after digestion in 30 % hydrogen peroxide and sulphuric acid (organic samples). The determinations of pH, total carbon (%) and total nitrogen (%) were chosen because these soil properties show the least within-site variability and are therefore more reliable when only one sample per site is taken (Quesnel and Lavkulich, 1980).

4. NOMENCLATURE

The taxonomic nomenclature of this study generally follows Scoggan (1978-1979) for vascular plants, Ireland et al. (1980) for mosses, Stotler and Crandall-Stotler (1977) for liverworts, and Hale and Culberson (1970) for lichens.

In a few cases the names used in this study are listed as synonyms by the taxonomic sources. Voucher specimens for most vascular plants and all non-vascular plants are deposited at the University of British Columbia's Botany Department Herbarium (UBC).

B. DATA ANALYSIS

1. GRADIENT ANALYSIS AND ORDINATIONS

a) Indirect gradient analysis and ordinations

Gradient analysis is an approach to the study of vegetation that seeks to explain the spatial distribution and variation of vegetation in terms of three sets of variables, (1) environmental factors, (2) species populations and (3) community characteristics (Whittaker, 1967). This approach is based on the view of vegetation as a continuum (Gleason, 1926; McIntosh, 1967; Whittaker, 1967) where "vegetation is considered as a continuously varying, stochastic phenomenon wherein plants respond individualistically to environmental conditions" (Peet, 1981). Indirect gradient analysis, or indirect ordination (Whittaker, 1978), is a technique which attemps to identify major environmental gradients underlying the patterns of vegetation variation. Such patterns are graphically illustrated by ordinations of plots obtained by analysing data on species composition. Thus, an important assumption of indirect ordination is that trends in environmental gradients will be reflected by trends in vegetation variation (Whittaker, 1978). Reciprocal averaging (Hill 1973, 1974), a type of standardized principal components analysis was the ordination technique used in this study. In tests, Gauch et al. (1977) have shown it to be one of the best available techniques in exposing environmental gradients using vegetation data where these gradients were already known. Although distortion can present a problem in axis scaling, the method reliably yields a primary axis of variation which is ecologically

interpretable. When the primary axis of variation corresponds to a particularly strong environmental gradient (Fig. 10), the second axis is often correlated with the first, causing an "arch effect" (Gauch et al., 1977). Experience with this study's and other data sets indicates that the ecological significance of the second axis diminishes with increasing strength of the primary environmental gradient, usually identified by the ordination's first axis (Gauch et al., 1977; Peet, 1980). In such cases the third axis often represents more accurately a second major environmental gradient, while the percentages of variation explained by the second and third axes are nearly equal. Detrended correspondance analysis, a recent modification of reciprocal averaging, is reported to overcome this problem (Hill and Gauch, 1980). Random species fluctuations create noise in community data. Gauch (1982) estimates this noise to be on the order of 10 to 50 % of the total variance in the data. Simulation experiments have shown that eigenvector ordination selectively recover meaningful patterns of correlation among several species in the first few ordination axes, while selectively deferring noise to later axes (Gauch, 1982). This would help to explain the observation that, in general, ordinations of field data are frequently useful even when the percentage of variance explained by the first few axes is small (Gauch, 1982). This also explains the common observation that meaningful ecological interpretations of ordinations axes are difficult past the second or third axis, with some exceptions (Noy-Meir, 1971). The goal of ordination has been viewed as accounting for most of the original data variance in the fewest ordination axes, but field data usually contains x % "noise variance" and (100-x) % "structure variance" (Gauch, 1982). Thus the

goal should be to recover (100-x) %, of the variance, preferably only

the structure variance to the exclusion of noise variance (Gauch, 1982).

Since noise variance has been estimated to be from 10 to 50 %, recovery

of 100 % of the variance implies that the ordination has failed in noise

reduction. A major difficulty with this viewpoint is in deciding what

is "structure variance" and what is "noise variance", anything which can

be interpreted becomes "structure variance" and whatever cannot be inter-

reted becomes "noise variance". Principal components analysis ordinations

based on species covariance and correlation matrices were also tried, but

did not produce superior results to reciprocal averaging. An advantage

of reciprocal averaging is that it simultaneously produces a species

ordination which can be superimposed on the sample ordination (Greenacre,

1981). This can be very helpful in displaying vegetation trends as cha-

racterized by major species. The Wisconsin double standardization of

data, sometimes recommended for use with RA (Peet, 1981), was not done

since the program used included a form of double standardization in the

calculation of resemblance coefficients. Species present in less than

four or three plots, depending on matrix size, were removed for the ana-

lyses. Rare species contribute little information to overall plot simi-

larities, and often cause the plots containing them to be markedly iso-

lated in reciprocal averaging ordinations. The vegetation data analysed

in this study are based on relative importance values of trees (> 10 cm

DBH), relative density of saplings (0-10 cm DBH) and seedlings (below

breast height), and percent coverage of shrubs, herbs, bryophytes and

terricolous lichens. Before this combination of abundance measures and

strata was chosen, several trial ordinations were run. Trees were

ordinated alone using three different abundance measures, which, in
decreasing order of ordination interpretability they provided, were
rated as follows : importance value > relative dominance > relative
density. Relative importance value ([relative dominance + relative
density]/2) is appropriate when tree species occur in a wide range of
maximum sizes and densities. In this study, relative dominance overem-
phasized the importance of a few very large trees, such as Thuja plicata
and Pseudotsuga menziesii, while smaller, often more numerous, trees,
such as Tsuga heterophylla and Abies amabilis, were underrated. Rela-
tive density created the reverse problem. Relative density was selected
instead of absolute density for saplings and seedlings since, espe-
cially for seedlings, absolute density values varied enormously between
plots. The use of different size-classes of trees (trees, saplings,
seedlings) offers potential for regrouping samples with similar regene-
ration trends; thus, differences in canopy dominants, which may have
arisen through different disturbance regimes in the past, are offset by
similar patterns of regeneration in the understory. Several authors
have used this technique for similar purposes (Goff and Zedler, 1972;
Peet and Loucks, 1977; Carleton and Maycock, 1978). The different size-
classes of a tree species are treated as different "pseudo-species"
(Carleton and Maycock, 1980) for the purpose of the ordinations. A
seedling size-class was used here despite the "highly stochastic nature
of establishment and survival (of seedlings) for the first few-years"
(Peet and Louck, 1977). Although this was observed in the widely fluc-
tuating absolute densities of seedlings among plots, it was felt that
the relative density of seedlings of a particular species, with differences

in reproductive potential and life history patterns taken into account, remains a good indicator of that species' potential role in the future composition of the stand, as well as a good indicator of present ecological conditions. Comparisons of ordinations obtained with and without tree size-class data have shown that better results are obtained using this technique where (1) dominant tree species are numerous, (2) regenerating tree species are few, (3) successional stands are common, and (4) environmental diversity of the study area is small. These conditions were met in an earlier study (Gagnon and Bouchard, 1981). In the present study however, the canopy dominants are few and nearly all are regenerating in some stands. Futhermore, most stands are in late stages of development (although many are dominated by P. menziesii, a long-lived successional species), and environmental diversity is great. Despite these drawbacks, the use of tree size-classes provided a clearer separation of some ecologically different communities with similar canopies (eg. montane vs lowland Abies forests). The most interpretable ordination results were obtained using data from shrub, herb and bryophyte-lichen strata along with tree data separated into three size-classes. Peet (1981), studying the vegetation of the Colorado Front Range, and Beese (1981), the vegetation of eastern Vancouver Island, have reported greater success with ordinations of understory data only. In both areas the tree layer was not considered the ideal site indicator since it largely reflected past disturbances. To a certain extent this was also the case in this study, but the partitioning of tree data into size-classes greatly improved the ordinations.

b)   Successive ordinations

Plots that differ markedly in composition from the majority of
plots are usually placed toward the ends of ordination axes. Evidence
from tests (Gauch et al., 1977) and personal experience indicates that
reciprocal averaging is particularly sensitive to outlier plots. Outliers
are defined as plots of unusual composition relative to the majority of
plots in the sample (Gauch et al., 1977). More specifically, outliers
may have (a) unusual combinations of species importances, (b) one or a
few species dominating strongly, or (c) several species which are un-
common and unimportant elsewhere within the matrix. Outliers of type
"a" and "b" are sometimes caused by sampling error, or by the sampling
of disturbed or environmentally unusual sites, and are problematic in
the interpretation of ordinations (Gauch et al., 1977). Type "c" out-
liers can be used to advantage in ordination interpretation. In large
or complex data sets successive ordinations can permit the segregation
of groups or types of communities at the periphery of the ordination
field. This progressive fragmentation of the data set superficially
resembles classification, but the objective is to understand the environ-
mental relationships between groups of similar plots (Peet, 1980). Ordi-
nation is thus used as a classification tool in which distinctive groups
are removed successively from the data after the resulting patterns have
been examined for environmental correlations. If large enough, the groups
removed may also be ordinated to reveal within group patterns and envi-
ronmental correlations. In this study, from an initial ordination of
the total 172 plots sample, three environmentally distinct groups of com-
munities, plus a vegetationally distinct community type (P1), were

segregated from a central cloud of plots. An ordination of the remaining plots indicated that they could be partitioned again into three environmentally and geographically distinct groups. Ordinations of each of these latter groups allowed several community types to be delineated along distinct environmental gradients. Product moment correlations were calculated between sample scores on ordination axes, environmental variables (Table 1), and community characteristics (Table 2) to help identify gradients underlying the vegetation patterns illustrated by the ordinations. Lack of strong correlations with any single variable may indicate that "complex" environmental gradients (Whittaker, 1978) control the variation of the vegetation. A topographic-moisture gradient is "complex" in the sense that it combines the effects of slope and aspect, as well as topographic position, soil texture and drainage. Thus, complex master environmental gradients might show strong correlations with ordination axes, if they could be expressed quantitatively.

A further ordination analysis was done in order to identify major environmental gradients influencing the vegetation pattern at the level of the entire study area, without the noise introduced by edaphic variations. For this purpose, 105 vegetation plots of modal sites were analysed with a reciprocal averaging ordination. Excluded from this analysis were plots from high elevations, lower slopes of steep river valleys (cold air drainage or snow accumulation), rock outcrops, very rapidly and very poorly drained sites, and floodplains. Correlations of ordination axes with environmental variables and community characteristics were used to identify the environmental gradients underlying the modal vegetation pattern. The reciprocal averaging and principal components

analysis programs used were developed by Dr. G.E. Bradfield following Orlóci (1978). Product moment correlations were produced using the MIDAS statistical package supported by the University of British Columbia Computing Centre.

c) Direct gradient analysis

Direct gradient analysis, or direct ordination, refers to the arrangement of plots along one or more known, or accepted as given, environmental gradients (Whittaker, 1967, 1978). These gradients may be derived empirically, surmised from observation, or identified through correlation of environmental variables with indirect ordination axes. Direct ordinations were used to display the spatial distribution of communities along topographic-moisture and elevation gradients within three fairly homogeneous vegetation groups. The topographic-moisture gradient used here is similar to gradients utilised by Whittaker (1956), Whittaker and Neiring (1965) and Peet (1981), but particularly resembles that used by Whittaker (1960) in his study of the Siskiyou Mountains of Oregon. The mesic, or moist, end of the gradient is represented by stands found on level, or near level, ground, proceeding to stands found on lower-slopes, where moisture is provided by seepage, but where drainage is better than on level ground. Further towards the xeric or dry end of the gradient are located stands from mid-slopes and upper-slopes. The xeric endpoint is formed of stands situated on crests, ridges or dry summits. Stands situated on sloping ground are arranged in two categories, (a) lower-slopes and (b) mid-slopes and upper-slopes, according to their

aspect. The lower-slope range is shortened because aspect effects are not as important for these stands with increased shelter and moisture availability. The two slope ranges do not overlap as in Whittaker (1960). One _Pinus_ _contorta_ type was included with the _Pseudotsuga_ group, and one with the _Thuja_ group, in the direct ordination figures because of their floristic and geographical affinities with these groups.

The plotting of species abundance or community characteristics along environmental gradients is a variation of direct gradient analysis. In this study geographical coordinates were used as complex environmental gradients combining variations in temperature, precipitation and continentality. This approach is helpful in identifying relationships of vegetation and soils with geographical patterns. This was particularly useful for data obtained from other sources, such as climatological data. In another type of application, the basal area data of tree species from the 105 modal plots were plotted against a geographical gradient defined by the distances of these plots from the Ocean. The SPSS polynomial regression program was used to obtain equations describing the basal area distribution of tree species along this gradient.

2. TYPE DELIMITATION

a) Definition of groups and types

Ordination techniques were used to assist in the classification of the sample plots, first into vegetation groups, and then into community types. Since the classification involved partitioning a continuum, as the ordinations visually illustrate, the groups and types may intergrade and overlap. Thus, it is not classification in a hierarchical sense, but classification in the sense of typification (Noy-Meir and Whittaker, 1978). Vegetation groups are defined as groups of plots that show a general degree of similarity in dominant species and environmental characteristics. Community types are subdivisions of vegetation groups and are defined as assemblages of plots that show a high degree of similarity in species composition and abundance, as well as in environmental characteristics. Subdivision into groups or types of the largely continuous pattern seen in the ordinations, was done using the following criteria in order of importance : (1) discontinuities in the ordination scatter diagrams when present, (2) careful inspection of the vegetation data for compositional similarity, (3) similar inspection of the environmental data. Where boundaries between types were drawn, some subjectivity was involved as in any classification. Averages, or noda of the community types are distinct vegetationally, and most are also distinct environmentally (see canonical analyses). Some plots could not be classified and are indicated by single dots in the ordinations. These plots either were unusual compositionally because of edaphic factors or disturbance, or were representative of other, undersampled, communities. Groups and types of communities as defined here do not correspond to any

particular traditional classification system; they are used solely for
the purpose of describing useful subdivisions of an otherwise fairly
continuous pattern of vegetation variation. The relationships between
types is well illustrated by the ordinations, and some could very well
be considered as sub-units or variants of other types. Relationships of
types are discussed, but no formal hierarchical arrangement of types was
attempted.

The community types are similar to dominance-types (Whittaker,
1978) since they are defined primarily on the high similarity of their do-
minant species. The community types are also similar to habitat-types[1],
defined by Daubenmire (1968) as the "potential climax vegetation" of a
site. Daubenmire (1968) views the habitat (soil, macroclimate, topo-
graphy) as the most durable part of an ecosystem, eventually control-
ling the final aspect of the vegetation. Successional or preclimax
vegetation can take a more varied appearance, on otherwise similar
sites, due to various disturbances. Tree regeneration and under-
story strata (shrubs, herbs and bryophytes) are most important in
defining habitat-types, since they are established soon: after dis-
turbance and are likely to persist into the "climax" stage. However,
important changes in understory plants have been demonstrated by Alaback
(1982) in south-east Alaska forests during later successional stages. The
use of sapling and seedling data in the ordinations from which the types
were derived allows them to be considered near equivalents of habitat-
types, particularly since most plots come from old-growth stands. Habitat-
types are usually named by a combination of one, or two, potentially
dominant species (climax species) as well as an understory dominant

1 Modal community types are also equivalent to ecosystem associations
   (Klinka et al., 1979).

(Daubenmire & Daubenmire, 1968). Community types are named informally
in this study according to the dominant tree species and, when necessary
for differentiation, characteristic understory species are used. General
ecological and geographical qualifiers are sometimes added to the names.
Community types were also coded by a letter to identify the vegetation
group and a number to identify the community type.

b) Vegetation data summary tables

The presentation of one or a few typical stands per type does not
represent the full range of variation encountered, while a large number
of stands may obscure underlying patterns (Peet, 1981). As an alternative,
the data from each community type were averaged and constancy values,
defined as the percent occurrence of species in the sample plots of a
type, were calculated. In order to keep table length to a minimum,
species had to have 50 % constancy, or more, in at least one of the
types represented in the table to be included (or 100 % when the type
had only two plots). Of the two Pinus contorta types, one was placed in
the Pseudotsuga group and the other in the Thuja group tables, according
to their compositional and geographical affinities. Floodplain types
were included in the tables of the less diverse Thuja group. Community
data summary tables were divided in two, with a table for tree, sapling
and seedling data for each group, and a table for understory data for
each group. The tables also include community characteristics data, such
as mean number of species (species richness or density) and total number
of species for trees, shrubs, herbs and bryophytes-lichens. Mean basal
area, mean density and mean maximum height are given for trees. Mean

total coverage is given for shrubs, herbs, bryophytes-lichens and total understory. Two diversity indices, the reciprocal of Simpson's Index (dominance concentration) and the antilog of the Shannon-Weaver Index (equitability)(Peet, 1974), were calculated for the trees (> 10 cm DBH), the understory vascular plants (shrubs and herbs), and for the bryophytes and lichens. Within the Pseudotsuga group tables the types were arranged, from left to right, in order of increasing soil moisture (except P7 which is drier than P6) and increasing elevation (eg. P3 is drier than P2 but occurs at higher elevations). The Thuja group tables were arranged in order of increasing soil moisture and decreasing drainage (except the F1 type which is moderately well drained). The Abies group tables were organized in order of increasing soil moisture, for high elevation types up to type A4, and in order of decreasing soil moisture for low elevation types (A5 to A7).

3. CANONICAL ANALYSES OF COMMUNITY TYPES AND VEGETATION GROUPS BASED ON ENVIRONMENTAL DATA

Canonical variates analysis was used to examine relationships among the vegetation groups and community types, delineated in the ordinations, on the basis of the environmental data. The environmental variables used are listed in Table 1 (distance from the coast, a geographical variable, was not used, as well as pH for A and B_2 horizons, which were missing from numerous soil profiles). Canonical analysis accentuates differences among preestablished groups (Seal, 1964), and was used to assess the degree of environmental similarity among what are considered to be vegetationally distinct units. Separate canonical analyses were run for the six vegetation groups, all community types, and the community types within each of the Pseudotsuga, Thuja and Abies groups. To show the results graphically, the means of plots belonging to groups or types were plotted along the first two canonical variate axes for each analysis (Figs. 13 and 14). Seal's (1964) method was used to calculate 90 % confidence circles around the means (radius = 1.645 ÷ √n). The size of the confidence circles is linked to sample size; groups or types consisting of few plots will have large confidence circles. The generalized distance measure of Mahalanobis (Mahalanobis squared distance, D^2) was used to measure the distance between the type centroids in the environmental space (Goodall, 1978; Orlóci, 1972). As is the case with most ecological data, the assumptions necessary for the statistical interpretation of canonical analysis are violated, therefore the technique becomes a data-exploratory procedure to provide useful insights (Williams, 1983).

Stepwise forward discriminant analysis also was used to analyse environmental relationships among the groups and types. This method selects environmental variables which best discriminate among the vegetation units, and also reassigns the individual plots to units where they share the greatest overall environmental similarity. Thus, the method provided a means to test the vegetation classification using an independent set of environmental variables. The separation of vegetation groups and community types obtained by discriminant analysis was similar to those produced by canonical analysis; therefore, only the latter results are discussed in detail. The tabular results from discriminant analysis are presented in Appendix 4. Canonical and discriminant analysis were performed using programs from the MIDAS statistical package supported by the University of British Columbia Computing Centre.

4. VEGETATION STRATA HOMOGENEITY WITHIN TYPES

As a measure of the homogeneity of the vegetation strata within different community types, interplot similarity matrices were calculated using the data from each stratum for individual community types. The mean interplot similarities would indicate the relative homogeneity of the vegetation within each community type, as well as the variations in homogeneity between vegetation strata (Bradfield and Scagel, 1984). The similarity between plots was defined by the cosine function. The value of this function ranges from 0.0, for plots with no species in common, to 1.0, for plots with the same species occurring in identical proportions (Bradfield and Scagel, 1984).

The homogeneity of the tree, sapling, seedling, shrub, herb and bryophyte-lichen strata of fourteen community types was compared using this measure (Table 31). Community types with less than five plots were not included in this analysis, except for the two Pinus contorta community types, which otherwise would have left that group unrepresented, and the coastal wet Thuja forests (T5, 4 plots), which appeared unusually homogeneous.

5. TREE SIZE-CLASS STRUCTURE OF COMMUNITY TYPES

Graphs showing the size-class distributions of tree species
within community types were plotted to provide descriptions of community
structure, and to assist in the interpretation of community dynamics.
Community types with less than three plots were not analysed. The flood-
plain forests (F1) community type also was not analysed because of the
great heterogeneity of its tree stratum. The data used are the number
of stems of tree species in 10 cm DBH size-classes for all plots of each
community type. These data were transformed into numbers of stems per
size-class per hectare (one plot = .05 ha). The number of tree seedlings
per hectare also was calculated using density data obtained from the
microplots (twenty 1 m^2 microplots per plot).

Graphs of tree species stem density per hectare versus size-class
were made, using a logarithmic scale for stem density. Hand-fitted and
smoothed curves were drawn for the tree species with the highest impor-
tance values within the selected community types (Figs. 15, 16 and 17).

6. TREE SEEDLING ABUNDANCE ON UNDECOMPOSED WOOD AND FOREST FLOOR SUBSTRATA

The tree seedling density data were analysed to determine whether there was a significant difference between average seedling densities on two broad types of substrata. During the sampling,microplots were recorded as being located on forest floor (including mineral soil, humus or litter) or on undecomposed wood (fallen trees, tree stumps, debris and bark at tree bases). Only the data from plots sampled using a random design of microplot location (Fig. 4) were utilised in the statistical test. To be included,tree species had to be present as seedlings in at least fifty percent of the plots (500 m^2), but not necessarily in 50 % of the microplots within each plot. The mean number of tree seedlings per square metre for each species, on each of the two substratum types, was calculated for community types with sufficient data (at least one hundred randomly selected microplots).

The null hypothesis is that tree seedling abundance, of each species, is equal on both substratum types. The two sample z-test was used to make the comparisons (Freedman et al., 1978). Compared to the more familiar t-test, the z-test provides a good approximation of the true value of P even when the data do not follow the normal curve very well, provided the sample size is large enough for the normal approximation to take over. The t-test requires that the data follow the normal curve closely (Freedman et al., 1978).

CHAPTER 4.

RESULTS

A. GRADIENT ANALYSIS OF VEGETATION

1. GENERAL VEGETATION PATTERNS

a) 172 plots ordination

The reciprocal averaging ordination of the 172 sample plots shows
a mass of centrally located plots surrounded by groups of outlier plots
(Fig. 5). The data matrix for this ordination consisted of 172 plots
and a total of 197 species, or pseudo-species for trees divided into
size-classes. Species, or pseudo-species, included in the matrix were
present in at least four plots (14 trees, 11 saplings, 11 seedlings,
24 shrubs, 81 herbs, 56 bryophytes and lichens). The first and second
axes explained 11.0 % and 8.8 %, respectively, of the total variance.
Correlations of environmental variables with the ordination axes are
given in Table 4. The strongest correlation with the first axis is with
effective rooting depth/soil depth ratio, indicating fuller utilization
by tree roots of a decreasing soil layer in plots located towards the
positive end of the axis. Pinus contorta has the largest positive eigen-
vector coefficient on the first axis (Table 3), and is the dominant tree
species in a group of shallow soil, rock outcrop communities identified
at the extreme right of the ordination (Fig. 5). Two community types,
a dry Pinus-Pseudotsuga type (D1) and a coastal dry Pinus type (D2),
were recognized within this group by compositional and geographical

differences. Other environmental correlations with the <u>Pinus</u> types are increasingly better drainage, decreasing soil depth, coarser soil material, increasing percent rock fragments, thinner organic layer, increasing fire disturbance, and ridge topographical position (Table 4).

The two other groups identified on this ordination are separated along the second axis. Elevation is the environmental variable most strongly correlated with the second axis (Table 4). A distinct group of subalpine plots characterised by <u>Abies</u> <u>amabilis</u> (saplings, trees, seedlings), <u>Vaccinium</u> <u>alaskaense</u>, <u>Rhytidiopsis</u> <u>robusta</u> and <u>Tsuga</u> <u>mertensiana</u> is identified at the top left of the ordination (Table 3).

<u>Picea</u> <u>sitchensis</u> (trees, seedlings), <u>Rubus</u> <u>spectabilis</u>, <u>Ribes</u> <u>bracteosum</u> and <u>Polystichum</u> <u>munitum</u> have the largest negative eigenvector coefficients on the second axis (Table 3). These species are characteristic of a group of floodplain and river terrace plots identified toward the bottom of the ordination. Correlated with the lower elevation floodplain plots are an increase in organic layer pH, lower topographical position (level), finer soil material (alluvial), an increase in B_1 horizon pH (richer soil), deeper rooting, and increasing tree total basal area and maximum height (both indirect indications of site productivity) (Table 4). Two community types, subsequently referred to as F1 and F2, were identified within the floodplain group based on compositional and quality of drainage differences.

A final community type, termed the dry <u>Pseudotsuga</u> forests (P1), was recognized toward the lower right of the ordination. This type consists of four plots that share a strong dominance by <u>Pseudotsuga</u> <u>menziesii</u>,

contain <u>Arbutus menziesii</u>, but lack <u>Pinus contorta</u>. <u>Gaultheria shallon</u> strongly dominates the shrub layer. Although not distinctive in the ordination, because of compositional similarities to several other plots dominated by <u>Pseudotsuga menziesii</u>, these sites have in common similar soil characteristics and recent fire histories.

b) 140 plots ordination

Following the removal of plots assigned to community types in the first ordination, a second reciprocal averaging ordination was run on the remaining 140 plots (Fig. 6). The data matrix for this ordination consisted of 140 plots and 149 species (or pseudo-species for trees divided into size-classes). Species included were present in at least four plots (12 trees, 7 saplings, 10 seedlings, 20 shrubs, 62 herbs, 38 bryophytes and lichens). The first and second axes explained 13.6 % and 9.8 %, respectively, of the total variance. In general, the main vegetation patterns on the first two axes appear to be determined by the interaction of complex environmental gradients associated with distance from the coast and elevation. Fire disturbance has the strongest positive correlation with the first axis (Table 6), while <u>Pseudotsuga menziesii</u> trees and seedlings have the largest positive eigenvector coefficients on this axis (Table 5). Distance from the coast has the strongest correlation with the second axis, decreasing toward the positive pole (Table 6), where <u>Gaultheria shallon</u>, <u>Thuja plicata</u> (seedlings, trees, saplings), <u>Vaccinium ovatum</u> and <u>Blechnum spicant</u> increase in coverage (Table 5). <u>Abies amabilis</u> (trees, saplings, seedlings) has the strongest negative eigenvector coefficients on both the first and second axes (Table 5). This tends to pull plots where it dominates, and regenerates itself, toward the lower left of

the ordination. Based on these results and after careful consideration of the vegetation and environmental data, the 140 plots were subdivided into three broadly defined groups : a Pseudotsuga group at the lower right, a Thuja group at the top, and an Abies group at the lower left. Along the first axis, correlations with several ecological variables help to differentiate the Pseudotsuga group from the others, such as : increasing evidence of fire disturbance, better drainage, thinner organic layer, deeper rooting, deeper rooting in mineral soil, increasing distance from the coast (inland), and decreasing evidence of wind disturbance (Table 6). Similarly, on the second axis, correlations with several ecological variables help to differentiate the Thuja group from the two others, such as : geographical proximity to the coast, increasing evidence of wind disturbance, decreasing elevation (nearer to sea level), decreasing tree height and drainage, and decreasing evidence of fire disturbance (Table 6). General characteristics of the Abies group plots include a tendency to occupy higher elevations, where there is little evidence of disturbance by fire or wind, and having no definite geographical area of maximum occurrence. An aberrant plot with a recent fire-history, situated inland near Port Alberni, and dominated by scattered large P. menziesii which survived the fire, was not assigned to any of the groups (small dot on Fig. 6). The dominance in the understory by a dense cover of Vaccinium ovatum, a shrub most commonly associated with open coastal habitats on poor soils, is probably responsible for the positioning of this plot closer to the Thuja group in the ordination.

2. VEGETATION PATTERNS WITHIN THE PSEUDOTSUGA GROUP

The data matrix for the ordination of this group consisted of
59 plots and 119 species (or pseudo-species for trees). Species included
were present in at least three plots (9 trees, 7 saplings, 9 seedlings,
17 shrubs, 51 herbs, 26 bryophytes and lichens). The first and second
axes explained 14.4 % and 9.6 %, respectively, of the total variance.
The ordination of the plots from the Pseudotsuga group reveals a more
detailed pattern within this group (Fig. 7a). The first ordination axis
is best correlated with organic layer pH and vascular species richness
(Table 8). This results in a separation of species rich plots, with
Acer macrophyllum present, at the negative end of the axis, from species
poor plots at the positive end, where Tsuga heterophylla (seedlings,
saplings, trees), Blechnum spicant, and Polystichum munitum are important.
Acer macrophyllum (saplings, seedlings), Cornus nuttallii (seedlings,
saplings, trees) and P. menziesii (seedlings, saplings) have the largest
negative eigenvector coefficients on the first axis (Table 7) helping to
differentiate the Pseudotsuga-Thuja-Acer forests community type (P2).
This is the most floristically rich of the Pseudotsuga types and has the
least acidic organic layer, probably because of the litter input from
the deciduous trees present. Other characteristics of this community
type are a greater understory coverage, furthest distance from the coast
(all plots situated very near Port Alberni), shallower soils and thinner
organic layer (Table 8).

Variables strongly correlated with the second axis are total shrub
coverage and topographical position (Table 8). Plots near the negative

end of the second axis tend to occur in higher topographical positions (ridges, crests, upper slopes), while plots at the positive end tend to occur in lower topographical positions (mid-slopes and lower-slopes). This pattern is also evident in the direct ordination of the _Pseudotsuga_ group (Fig. 7b). For the second axis, a gradient of increasing site productivity, although not directly measured, can be inferred also from several variables such as : decreasing total shrub coverage and total understory coverage (because of closing canopy), increasing total tree basal area and maximum tree height, increasing percent nitrogen in B_1 horizons, and decreasing C/N ratios in B_1 horizons (Table 8). The _Tsuga_-_Pseudotsuga_-_Polystichum_ forests community type (P5) occupies the most productive end of this gradient, as well as lower-slopes (Fig. 7a and 7b). The least productive end of the gradient is occupied by two community types, the _Pseudotsuga_-_Linnaea_ forests (P3) and the montane _Tsuga_-_Gaultheria_ forests (P7) (Fig. 7a). Floristic differences separate these two types clearly on the reciprocal averaging ordination (Fig. 7a). Ecologically, the two types are differentiated by elevation, with the montane _Tsuga_-_Gaultheria_ forests occurring at higher elevations (Fig. 7b).

Two other community types are of intermediate position on the second axis, the _Pseudotsuga_-_Berberis_ forests (P4) and the montane _Tsuga_ forests (P6). These two types are distinguishable floristically, but intergrade more or less continuously along the elevational gradient (Figs. 7a and 7b). On the second axis, _Gaultheria_ _shallon_ and _Hylocomium_ _splendens_ have the largest negative eigenvector coefficients, corresponding to the poorer and drier sites (Fig. 7a), while _Polystichum_ _munitum_ and _Cornus_ _nuttallii_ have the largest positive eigenvector coefficients,

corresponding to the richer and moister sites (Figs 7a and 7b; Table 7).
A gradient of increasing soil moisture availability also can be suggested
for the second axis based on relationships indicated in the direct ordi-
nation (Fig. 7b). The montane Tsuga-Gaultheria forests community type is
situated at the dry end of this gradient on ridges and south-southwest
facing slopes, and the Tsuga-Pseudotsuga-Polystichum forests community
type is situated at the moist end on lower-slopes, with more seepage,
deeper soils and better shelter from drying winds. Communities of inter-
mediate position on the topographic-moisture gradient of Fig. 7b are also
intermediate in position on the second axis of Fig. 7a. The dry Pinus-
Pseudotsuga forests (D1) were added to figure 7b to show their topogra-
phical positions. Three unique plots were not assigned to any community
type within this group. Plot 112 is from the China Creek area, west of
Port Alberni, and has a drier climate and a soil different from that
commonly found within the study area. Plot 89 is from an unusual coastal
stand dominated by Thuja plicata, but with a high cover of Polystichum
munitum which caused this plot to be included with the Pseudotsuga group.
Plot 20 represents a relatively recently disturbed site.

3. VEGETATION PATTERNS WITHIN THE THUJA GROUP

The data matrix for the ordination of this group consisted of 40 plots and 25 species (or pseudo-species for trees). Species included were present in at least three plots (7 trees, 4 saplings, 6 seedlings, 9 shrubs, 22 herbs and 27 bryophytes). The first and second axes explained 23.4 % and 13.5 %, respectively, of the total variance. Five community types were identified within the Thuja group ordination (Fig. 8a). Based on correlations with ecological variables the first axis is interpreted as a site productivity gradient. The strongest correlations with the first axis are with total shrub coverage, total understory coverage and maximum tree height (Table 10). Other variables correlated with the first axis are also indicators of site productivity, such as increasing soil depth, organic layer percent nitrogen, decreasing organic layer C/N ratio, increasing percent nitrogen and carbon in B_1 horizons, and increasing root restricting depth (Table 10). Abies amabilis (saplings, trees, seedlings), Tsuga heterophylla (seedlings, saplings) and Polystichum munitum have the largest positive eigenvector coefficients on the first axis (Table 9), and characterize a group of productive sites at the right of the ordination; Vaccinium ovatum and Thuja plicata (saplings, seedlings) have the largest negative eigenvector coefficients and characterize the less productive sites to the left. The coastal Tsuga-Blechnum-Polystichum forests community type (T2) is considered to be the most productive of this group. This community type occurs on upper and mid-slopes only, mostly above 200 m of elevation (Fig. 8b), where there is better drainage and less coastal fog influence than at lower elevations. The last two factors seem to greatly influence productivity in coastal forests where moisture is often overabundant. The coastal dry Thuja forests (T1) and

the coastal wet Thuja forests (T5) community types are both considered
to occur on the most unproductive sites of this group. The dry type is
found on well drained ridges and steep slopes, while the wet type occurs
on poorly drained level sites (Fig. 8b). In both cases Vaccinium ovatum
dominates the shrub layer, accounting for their close positions on the
reciprocal averaging ordination (Fig. 8a).

Environmental gradients underlying the second axis are not as
clear. Herb species richness and total herb coverage are strongly corre-
lated with the second axis (Table 10), mostly because of plot 85, a unique
sample plot from a rich fen-like coastal Thuja swamp on poorly drained
marine clays. The presence of plot 85 (nearly at sea level) also weakens
the correlation of the second axis with elevation, which otherwise can be
seen on the direct ordination (Fig. 8b). The coastal montane Thuja forests
community type (T3), intergrades continuously with the coastal Thuja
forests community type (T4) along the elevation gradient (Fig. 8b) although
floristic differences (such as higher importance of Abies amabilis in the
T3 type), help to separate them in the indirect ordination (Fig. 8a).
The coastal Thuja forests form the most common and characteristic commu-
nity type of the lowland coastal forests of western Vancouver Island.

4. VEGETATION PATTERNS WITHIN THE ABIES GROUP

The data matrix for the ordination of this group consisted of
40 plots and 87 species (or pseudo-species for trees). Species included
were present in at least three plots (5 trees, 4 saplings, 5 seedlings,
9 shrubs, 36 herbs, 28 bryophytes and lichens). The first, second and
third axes explained 16.7 %, 10.9 % and 10.3 %, respectively, of the
total variance. The reciprocal averaging ordination of the Abies group
is the only case in this study where it was felt that the third axis
offered clearer relationships, patterns, and environmental gradient
interpretations than the second axis (Fig. 9a). The occasional advan-
tage, for interpretation purposes, of using the third reciprocal averaging
axis instead of the second has been noted also by Gauch, et al. (1977) and
Peet (1980). Species with the largest positive eigenvector coefficients
on the first axis are Tsuga heterophylla (saplings, seedlings, trees),
Pseudotsuga menziesii (trees) and Polystichum munitum, while species
with the largest negative eigenvector coefficients are Abies amabilis
(saplings, seedlings, trees), Rubus pedatus and Streptopus streptopoides
(Table 11). Clearly, the first axis separates plots where tree species
regeneration is dominated by either Abies amabilis or Tsuga heterophylla.
Correlation of environmental variables with the first axis indicate that
the plots where Abies regeneration dominates are the furthest from the
coast and the highest in elevation (geographically where the highest
mountains are found). Percent carbon in the organic layer is highest
in these plots while pH of the B_1 horizon is lowest (Table 12). At the
extremities of the first axis, two distinct community types can be iden-
tified, the montane Abies-Streptopus forests (A4), of high elevation,

cool north to north-west facing slopes, and the Tsuga-Blechnum-Polystichum

forests (A7), of low elevation mesic sites (Figs. 9a and 9b). The third

axis is interpreted as a complex environmental gradient associated with

increasing elevation, exposure and fire disturbance, and decreasing

productivity inferred from an increase in organic layer C/N ratio and

a decrease in tree height (Table 12). On the third axis, Gaultheria

shallon, Abies amabilis (seedlings, saplings), Rhytidiopsis robusta and

Pseudotsuga menziesii have the largest positive eigenvector coefficients.

These species characterize the fire prone, most nutrient poor and drier

sites within the Abies group. Sphagnum girgensohnii, Abies amabilis

(tree), Achlys triphylla and Polystichum munitum have the largest nega-

tive eigenvector coefficients on the third axis, and characterize the

mesic, most nutrient rich sites (Table 12). The montane Tsuga-Abies-

Gaultheria forests community type (A1) occurs inland from mid to high

elevations on dry slopes where there is visible evidence of fire (Fig. 9b).

The opposite end of this gradient is occupied by the lowland Abies forests

(A5) and the montane Tsuga-Abies forests (A3). The lowland Abies forests

occur at low elevations in valley bottoms but bear close floristic

resemblance to the elevationally and topographically different montane

Abies-Streptopus forests (Figs. 9a and 9b), montane Tsuga-Abies forests

(A3) occur on higher well drained slopes near the coast (Fig. 9a). Other

community types are, the montane Abies-Tsuga forests (A2), which occur

on high elevation sites with a better drainage than found in sites

occupied by the montane Abies-Streptopus forests (A4), and the Tsuga-

Gaultheria-Blechnum forests (A6), which occupy possibly less productive

sites than the Tsuga-Blechnum-Polystichum forests (A7)(Fig. 9a). Eight

plots were not assigned to any of the types within this group. Plots
28, 83, 127 and 168 are strongly influenced by seepage water, making
their relationships difficult to evaluate through vegetation data.
Plot 151 is a relatively young stand, resulting from a complete blow-
down, sampled for comparison purposes. Plot 113 is from a high elevation
stand in the drier China Creek area (see Pseudotsuga group). Plot 35 is
from a high elevation site (865 m), but lacks the characteristic species
which would have placed it within the subalpine group of Fig. 5. Plot
68 is a partially wind disturbed stand most similar to the montane
Tsuga-Abies forests.

5. <u>VEGETATION AND ENVIRONMENTAL PATTERNS ON A DISTANCE FROM THE COAST</u>

   <u>GRADIENT</u>

The data matrix for the ordination of this group of modal plots consisted of 105 plots and 147 species (or pseudo-species for trees). Species included were present in at least 4 plots (11 trees, 7 saplings, 10 seedlings, 20 shrubs, 61 herbs, 38 bryophytes). The first and second axes of a reciprocal averaging ordination explained 15.0 % and 8.8 %, respectively, of the total variance, and produced a strongly arched scatter of plots (Fig. 10). Species with the largest positive eigenvector coefficients on the first axis are <u>Pseudotsuga menziesii</u> (trees, seedlings), <u>Acer macrophyllum</u> (saplings, seedlings) and <u>Cornus nuttallii</u> (saplings, seedlings), while species with the largest negative eigenvector coefficients are <u>Blechnum spicant</u>, <u>Abies amabilis</u> (saplings, trees, seedlings) and <u>Thuja plicata</u> (trees) (Table 13). The first axis separates plots of the <u>Thuja</u> group from plots of the <u>Pseudotsuga</u> group. This is similar to the separation on the first axis of the 140 plots ordination (Fig. 6), except that, in this case, most plots of the <u>Abies</u> group have been removed. The few plots belonging to the <u>Abies</u> group are centrally located on the 105 modal plots ordination. Correlation of environmental variables with the first axis clearly demonstrates the strong effect that distance from the coast has on vegetation variation in the study area. This geographical gradient summarizes the effects of many separate environmental variables including fire and wind disturbance, organic horizons thickness/ effective rooting depth ratio, drainage and organic horizons thickness (Table 14). However, it must be recognized that organic horizons thickness and effective rooting depth are partially a function of the overlying

vegetation. The increasing precipitation and decreasing growing degree-days towards the coast can be seen on isoline maps adapted from climate maps compiled by Colidago (1980) (Fig. 12). Also, the organic horizons thickness/effective rooting depth ratio decreases and vascular species richness increases with increasing distance from the coast (Fig. 12). Correlations of environmental variables with the second axis show relationships similar to those shown on the first axis (Table 14). Polynomial regression curves of the basal area of major tree species show distinct peaks along the distance from the coast gradient (Fig. 11). Thuja plicata reaches a peak in total basal area 13 km from the coast, while Pseudotsuga menziesii reaches its peak at about 48 km from the coast. Tsuga heterophylla reaches its peak in basal area at 30 km from the coast. The basal area of Abies amabilis increases steadily towards the coast. Thuja plicata shows a marked decrease in basal area when closer than 10 km from the coast. A similar decrease in Tsuga heterophylla basal area occurs at about 50 km from the coast (Fig. 11). The organic horizons thickness/effective rooting depth ratio polynomial regression curve also shows a distinct dip towards the inland part of the island (Fig. 11). The peaks and decreases in basal area of each tree species can be interpreted as responses to climatic variables and disturbance type and regime, which are linked with climate. The variations in the organic horizons thickness/effective rooting depth ratio can be interpreted as the result of climate and vegetation differences. All these relationships are discussed further in chapter 5.

B. CANONICAL ANALYSES OF VEGETATION GROUPS AND

COMMUNITY TYPES BASED ON ENVIRONMENTAL DATA

1. VEGETATION GROUPS

The six vegetation group centroids are separated clearly on the

first and second canonical variates of the environmental data (Fig. 13).

These two axes summarize the main environmental relationships among the

six vegetation groups. The Pinus contorta group (D) and the Floodplain

group (F) are at opposite ends of the first two canonical variates. This

large difference in environmental characteristics also is reflected in

the Mahalanobis squared distance (D^2) between these two groups (Table 16).

Drainage, surficial material, topographic position and coarse fragment

content of the B_1 horizon are the environmental variables most strongly

correlated with the first canonical variate (Table 21). Fire and wind

disturbance are also correlated, positively and negatively, respectively,

with the first axis. The ratio, organic horizons thickness/effective

rooting depth, and organic horizons thickness are negatively correlated

with the second canonical variate, while organic horizons pH is positively

correlated (Table 21). Very rapid drainage, crest or ridge topographic

position, and lack of surficial material (rock outcrops) characterize the

Pinus contorta group (D). Slower drainage, lower-slope or level topo-

graphic positions, and morainal, fluvial or alluvial surficial deposits

characterize the Floodplain (F) and Thuja (T) groups. Group positions on

the second canonical variate can be best interpreted with the organic

horizons thickness/effective rooting depth ratio; the Floodplain group

is characterized by thin organic horizons and deep rooting into mineral soil (ratio closer to zero), while the Thuja group is characterized by thick organic horizons and shallow rooting (ratio closer to one). Although organic horizons are thin in the Pinus contorta group, the rooting is very shallow. The Pseudotsuga group (P) is the group with the higher environmental similarity with the Pinus contorta group, based on D^2 values (Table 16). The Abies group (A), having several plots situated at high elevations, is the group most environmentally similar to the Subalpine group (SA) based on D^2 values. It should be noted that the D^2 values are calculated over all the dimensions of the canonical analysis while only two dimensions are presented in the figures (Figs. 13 and 14). Comparing only the Pseudotsuga, Thuja and Abies groups, we find that the Pseudotsuga and Thuja groups are the most environmentally different (Table 16).

The canonical analysis results correspond generally to those obtained with reciprocal averaging (Figs. 5, 6 and 13). The correlations of environmental variables with the reciprocal averaging axes also are similar to those with the canonical variate axes (Tables 4, 6 and 21). That the results of both analyses conform is interesting since the reciprocal averaging ordinations used vegetation data, and the canonical analysis used environmental data. However, the groups submitted to the canonical analysis were determined using reciprocal averaging ordinations. The results do indicate that environmental patterns correspond to the vegetation patterns.

2. PSEUDOTSUGA TYPES

Most of the Pseudotsuga type centroids are separated clearly on the first two canonical variates (Fig. 13). The dry Pseudotsuga forests (P1), the Pseudotsuga-Thuja-Acer forests (P2), and the Pseudotsuga-Linnaea forests (P3) appear very similar environmentally (Fig. 13; Table 17). Plots belonging to these three community types are found only in the driest inland part of the study area. The dry Pseudotsuga forests (P1) can be separated from the P2 and P3 types (other two community types) on the basis of its vegetation structure, which is hypothesized to have resulted from a recent, intense fire (see Chapter 4. A, section 1_a, and 4. C, section 2). Similarly, the Pseudotsuga-Thuja-Acer forests (P2) show vegetation differences with P1 and P3 which are interpreted to reflect differences in seepage conditions (Chapter 4.C, section 2). Since none of the environmental variables included in the canonical analysis adequately reflected the underlying reasons for the vegetation differences, the three types (P1, P2, P3) were not separated. The Pseudotsuga-Thuja-Acer forests (P2) and the Tsuga-Pseudotsuga-Polystichum forests (P5) are at opposite ends of the first canonical axis. These are the most environmentally different types within the Pseudotsuga group (Fig. 13, Table 17). The two most environmentally similar community types are the Pseudotsuga-Berberis forests (P4) and the montane Tsuga forests (P6) which are differentiated vegetationally only along an elevation gradient (Fig. 7a and b). The Pseudotsuga-Linnaea forests (P3) and the montane Tsuga-Gaultheria forests (P7), both occurring in dry sites, show vegetation similarities (fig. 7a) but are environmentally

quite different (Figs. 7b and 13), mostly because of differences in
elevation. Topographic position, soil depth, effective rooting depth/
soil depth ratio, and organic horizons pH are the environmental variables
most strongly correlated with the first canonical axis (Table 21). The
Thuja-Pseudotsuga-Polystichum forests (P5), with the largest scores on
the first axis, always are found on the lower topographical positions
and on the deepest soils. Elevation, organic horizons pH, B_1 horizon %
nitrogen, and topographic position are strongly correlated with the
second canonical axis. Montane Tsuga-Gaultheria forests (P7), located
toward the top of the second axis, are found at high elevations on ridges
and crests. The Pseudotsuga-Thuja-Acer forests (P2), near the bottom of
the second axis, have the highest organic horizons pH. All of these
environmental variables also were correlated with the reciprocal averaging
ordination axes of the vegetation data (Fig. 7a; Table 8).

3. THUJA TYPES

The Thuja type centroids are very clearly separated on the first two canonical variates of the environmental data (Fig. 13). The coastal Tsuga-Blechnum-Polystichum forests (T2) and the coastal montane Thuja forests (T3) are at opposite ends of the first axis. These two types appear to be the most environmentally different within the Thuja group (Fig. 13; Table 18). The coastal Thuja forests (T4) and the coastal wet Thuja forests (T5) have the most similar environmental characteristics based on the D^2 values (Table 18). The coastal dry Thuja forests (T1) could not be included in the analysis because most of the stands lacked mineral soil, and therefore lacked values for numerous environmental variables. Drainage and B_1 horizon percent nitrogen are the only variables significantly correlated with the first canonical axis (Table 21). Coastal Tsuga-Blechnum-Polystichum forests (T2), with the largest scores on the first axis, are associated with productive sites, higher B_1 horizon % N, and better drainage. Elevation, percent slope, and topographic position are strongly correlated with the second canonical axis (Table 21). The coastal wet Thuja forests (T5) and the coastal Thuja forests (T4), positioned toward the top of the second axis, were found consistently at low elevations on level or moderately sloping terrain. These environmental variables also were strongly correlated with the reciprocal averaging ordination axes of the vegetation data (Fig. 8a; Table 10).

4. ABIES TYPES

The Abies type centroids are not as clearly separated on the
first two canonical axes as are those of the other groups (Fig. 13).
This partly reflects the impression of overlap caused by the larger
confidence circles of the centroids, which are generally based on fewer
plots than in the other groups, and partly the use of only four envi-
ronmental variables in the canonical analysis. This was necessary since
the computer program used would not perform the analysis with a larger
set of variables. The four variables used were preselected with the use
of a stepwise discriminant analysis, selecting the environmental varia-
bles which permitted the maximum separation of the community types
(Appendix 4). The montane Abies-Streptopus forests (A4) and the Tsuga-
Blechnum-Polystichum forests (A7) are at opposite ends of the first cano-
nical axis. These are the most environmentally different types within
the Abies group (Fig. 13; Table 19). Based on the four variables used,
the Abies-Streptopus forests (A4) are markedly different environmentally
from all other community types of the Abies group (Fig. 13; Table 19).
Of particular interest is the notable environmental difference between
this community type and the lowland Abies forests (A5). Despite the en-
vironmental difference both community types show strong vegetational simi-
larities (Fig. 9a; Tables 26 and 27). Elevation and organic horizons
thickness are strongly correlated with the first canonical axis (Table 21).
Stands of the Abies-Streptopus forests (A4), at the positive end of the
first axis, occur at the highest elevations within the Abies group. The
second axis also is correlated with elevation and % slope (Table 21);

thus, the lowland _Abies_ forests (A5), the _Tsuga-Gaultheria-Blechnum_ forests

(A6), and the _Tsuga-Blechnum-Polystichum_ forests (A7), all found at low

elevations on moderate to gentle slopes, are grouped toward the lower end

of the second axis. Montane _Tsuga-Abies-Gaultheria_ forests (A1) appear

environmentally similar to the montane _Abies-Tsuga_ forests (A2) (Fig. 13;

Table 19), but this could be an artifact of the low number of environ-

mental variables used. A better illustration of environmental relation-

ships within the _Abies_ group is obtained through the canonical analysis

of all the community types from all the vegetation groups, where all

the environmental variables were utilised (Fig. 14; Table 20).

5. ALL TYPES AND THE SUBALPINE GROUP

The distribution of community type centroids on the first two
canonical variates (Fig. 14) corresponds closely to the general pattern
shown in the analysis of the vegetation groups (Fig. 13). Furthermore, the
correlations between environmental variables and canonical axes show the
same trends in both cases (Table 21). Although the general patterns of
both analyses are similar, the canonical analysis of separate types indi-
cates that some community types are environmentally more similar to types
belonging to other vegetation groups (Fig. 14; Table 20). For example,
the montane Tsuga-Abies-Gaultheria forests (A1) are environmentally more
similar to the montane Tsuga forests (P6) and the montane Tsuga-Gaultheria
forests (P7), of the Pseudotsuga group, than to any other community type
of the Abies group (Fig. 14; Table 20). These community types also are
similar vegetationally (Tables 22, 23, 26 and 27). The coastal Tsuga-
Blechnum-Polystichum forests (T2) of the Thuja groups, and the Tsuga-
Blechnum-Polystichum forests (A7) of the Abies group are both environ-
mentally (Fig. 14; Table 20) and vegetationally similar (Tables 24, 25,
26 and 27). The two environmentally most similar community types are the
Pseudotsuga-Berberis forests (P4) and the montane Tsuga forests (P6),
based on the D^2 value (Table 20). The environmentally most dissimilar
community types are the coastal dry Pinus forests (D2) and the Lysichi-
tum variant of the Floodplain forests (F2) (Table 20). Relationships
between community types detected in the canonical analyses of separate
vegetation groups generally are maintained in the combined types analysis;
however, the coastal Thuja forests (T4) appear environmentally most similar
to the montane coastal Thuja forests (T3), than to the coastal wet Thuja

forests (T5), in the combined analysis (Tables 18 and 20). The canonical analysis of all the community types is felt to represent environmental relationships more accurately than the analysis of separate vegetation groups. Possibly because of the greater ranges of environmental variation when all types are analysed together. These results also could help to redefine the community type classification(eg. merging types T2 and A7, as well as A1 and P7), although such was not done in this thesis. These community types (T2, A7, A1, P7) were situated at the boundaries of the three vegetation groups separated in the 140 plots reciprocal averaging ordination (Fig. 6). The two pairs of community types which are differentiated vegetationally along an elevation gradient both show high overall environmental similarities (P4 and P6, T3 and T4). This may indicate that no ecological factor, other than elevation (detected by the direct ordinations, Figs 7b and 8b), is responsible for the vegetational differences observed (Figs. 7a and 8a; Tables 22, 23, 24 and 25).

C. DESCRIPTION OF COMMUNITY TYPES

The vegetation and ecological characteristics of the community types delineated within the reciprocal averaging ordinations (Figs. 5, 7a, 8a and 9a) are described in this section. The composition, structure and diversity of the various vegetation strata are described briefly. The geographical distribution, topographical characteristics, soil characteristics and disturbance history are also outlined for each community type. Similarities between community types are indicated, as well as similarities with other community types or associations described previously for coastal British Columbia and, when possible, for Washington and Oregon.

The community types within the Pinus contorta vegetation group are described first, followed by community types of the Pseudotsuga group, the Thuja group, the Abies group and the Floodplain group. Last to be described is the Subalpine vegetation group which was not subdivided into community types.

1. PINUS CONTORTA VEGETATION GROUP

Dry Pinus-Pseudotsuga forests (D1)

These open and low stature forests (average maximum height is 18 m) are strongly dominated by Pinus contorta. This is the only community type within the study area where Arbutus menziesii is always present. Pseudotsuga menziesii seems to be regenerating well (Table 22). At 30.7 m^2/ha, the mean total basal area is the second lowest for the community types described in this study (the lowest is found in coastal dry Pinus forests, of the same vegetation group). The mean tree density (700 trees/ha) is among the highest. The shrub and bryophyte-lichen strata are among the richest found in the study area (Table 23). A large coverage of Vaccinium ovatum and the presence of Arctostaphylos columbiana characterize the shrub stratum (under 1.5 m in height). Several herb species such as Apocynum androsaemifolium, Cryptogramma crispa, Danthonia spicata and Selaginella wallacei are restricted almost entirely to this community type. The bryophyte-lichen stratum is characterized by an abundance of lichens (Cladina rangiferina and many Cladonia species) growing on large bare rock patches representing 28 % of the ground surface (Table 23).

This community type was found only at low elevations in the inland portion of the study area around Port Alberni. It occurs on rock outcrops, predominantly south facing. The soils are very shallow, average 15 cm in depth, and are very rapidly drained. The organic horizons are very thin and roots are abundant down to the bedrock (Appendix 2). Fire is probably responsible for the establishment of Pinus contorta and evidence

of fire is abundant in all stands. Some windthrow also has occurred.
The dry Pinus-Pseudotsuga forests are quite similar to the coastal dry
Pinus forests (D2), which occupy similar habitats near the coast (Figs.
5 and 14). They also have floristic similarities to the dry Pseudotsuga
forests (P1) (Tables 22 and 23).

Krajina (1969) lists several biogeocoenoses (numbers 6, 12, 19
and 29) with lists of species similar to those of the dry Pinus-Pseudo-
tsuga forests. Kojima and Krajina (1975) describe a similar Arbutus
menziesii stand on a rock outcrop in Strathcona Provincial Park, north
of the area studied here. McMinn's (1960) Pseudotsuga-Gaultheria-
Peltigera association also is similar, although probably is not as xeric.

Coastal dry Pinus forests (D2)

Although similar in structure to the dry Pinus-Pseudotsuga forests,
the coastal dry Pinus forests have several co-dominant tree species,
giving them the richest tree stratum in the study area. Thuja plicata,
Chamaecyparis nootkatensis and Tsuga heterophylla are regenerating well
on these sites (Table 24). The mean total basal area is the lowest in
the study area (30.2 m^2/ha) and tree density is very high (695 trees/ha)
as a consequence of numerous small trees (Table 24). The shrub layer,
less than 1.5 m in height, is dominated by Gaultheria shallon and Vacci-
nium ovatum. The herb stratum has a very low total percent coverage and
is relatively poor in species. In contrast, the bryophyte-lichen layer
has a very high coverage and is the richest of all the community types
recognized (Table 25). Some herb species such as Danthonia spicata,

Saxifraga ferruginea and Selaginella wallacei are restricted to this

community type near the coast. Numerous bare rock surfaces (26 % cove-

rage) have a rich assemblage of lichens and mosses including Cladina

species, Cladonia species, Pleurozium schreberi, Polytrichum and Rhaco-

mitrium species (Table 25).

This community type is restricted to low elevation, sloping rock

outcrops near the coast. These sites are very rapidly drained and have

very shallow soils (average soil depth is 11 cm). The organic horizons

are thin and roots extend to the bedrock (Appendix 2). No evidence of

fire was found and wind disturbance appears minimal. This community type

is most similar to the dry Pinus-Pseudotsuga forests (D1), occupying

similar sites inland (Figs. 5 and 14).

No previous descriptions of community types similar to the coastal

dry Pinus forests seem to exist. However, this community type represents

a coastal variation of the Dry Pinus-Pseudotsuga forests (D1) for which

published equivalent descriptions were found.

2. PSEUDOTSUGA VEGETATION GROUP

Dry Pseudotsuga forests (P1)

This community type has a relatively low canopy (average height
is 44 m), low mean total basal area (86.2 m^2/ha), and low mean tree
density (300 trees/ha). Pseudotsuga menziesii dominates and appears
to be the species regenerating best (Table 22). The shrub stratum is
rich in species and its coverage is among the largest within the Pseudo-
tsuga group. The herb layer is the richest found in the study area
(Table 23). The most conspicuous shrubs are Gaultheria shallon (1 m
high), Berberis nervosa and Vaccinium ovatum, while the herbs Chimaphila
umbellata, Festuca occidentalis and Pteridium aquilinum are particularly
abundant. Boschniakia hookeri, a root parasite of Gaultheria shallon,
is always present. The bryophyte-lichen stratum is dominated by Stoke-
siella oregana and Hylocomium splendens, but otherwise shares many spe-
cies with the dry Pinus-Pseudotsuga forests (Table 23).

The dry Pseudotsuga forests were found only inland near Port
Alberni. They occupy low elevations, strong to extreme slopes (Canada
Soil Survey Committee, 1978) with shallow, rapidly drained soils (average
soil depth is 54 cm). The organic horizons are very thin and roots extend
deep into the mineral soil (Appendix 2). This community type often occurs
immediately downslope of the dry Pinus-Pseudotsuga forests (D1). Most
soils are Orthic Dystric Brunisols developing on colluvial material
(Table 29). Fire has occurred fairly recently in all the stands which
probably explains why Pseudotsuga menziesii, with its fire resistant
bark, dominates. The dense shrub coverage may also be fire induced owing

to the improved conditions for shrub growth following fire. Many of the stands studied almost entirely consist of large, widely spaced Pseudotsuga menziesii trees with charred bark. This type has vegetational and environmental similarities with the Pseudotsuga-Thuja-Acer forests (P2) and the Pseudotsuga-Linnaea forests (P3), although the many species of dry sites it shares with the dry Pinus-Pseudotsuga forests (D1) are an indication of its drier moisture regime (Tables 22 and 23; Figs. 13 and 14).

The Dry Pseudotsuga forests have similarities with numerous communities or associations described for British Columbia, such as the Pseudotsuga-Arbutus/Gaultheria habitat type of Beese (1981), the Pseudotsuga-Gaultheria association of McMinn (1960), and the Gaultheria shallon association of Kojima and Krajina (1975). Also similar, is the Pseudotsuga/Holodiscus-Gaultheria association described by Franklin and Dyrness (1973) for dry sites within the Oregon Coast Ranges.

Pseudotsuga-Thuja-Acer forests (P2)

This community type has one of the best developed tree strata in the Pseudotsuga group (mean maximum tree height is 64 m, mean total basal area is 132.5 m^2/ha (Table 22)). The tree stratum is also among the richest found in the study area, and although dominated by Pseudotsuga menziesii, it is characterized by the deciduous trees Acer macrophyllum and Cornus nuttallii. Most tree species seem to be regenerating well (Table 22). The low and sparse shrub layer (under 1 m in height) is dominated by Berberis nervosa, Gaultheria shallon and Rubus ursinus.

The herb stratum is also rich, with high coverages of Achlys triphylla,
Festuca subuliflora, Linnaea borealis, Polystichum munitum and Trientalis
latifolia. Stokesiella oregana and Hylocomium splendens share dominance
in the bryophyte-lichen layer. Leucolepis menziesii, a moss of moist
soils (Schofield, 1976), is relatively abundant (Table 23).

The Pseudotsuga-Thuja-Acer forests occur only inland within the
study area, close to Port Alberni. They occupy mid-slope positions on
strong to extreme, mostly south facing slopes at low elevations (Fig. 7b).
The soils are moderately deep (average soil depth is 65 cm) and well
drained, with relatively high pH values (LFH average = 4.8, B_1 average =
5.2). The organic horizons are very thin and rooting occurs throughout
the mineral soil (Appendix 2). Most soils are Orthic Humo-Ferric Podzols
developing on colluvial material (Table 29). The mid-slope topographic
position, as well as the vegetation, suggest that seepage probably
contributes significant amounts of water and nutrients to the soils.
Evidence of fire is abundant, in the form of buried charcoal and charred
bark on Pseudotsuga trees. Vegetational and environmental similarities
between this community type, the dry Pseudotsuga forests (P1) and the
Pseudotsuga-Linnaea forests (P3) are high (Tables 22 and 23; Figs. 13
and 14), although the vegetation is sufficiently different to warrant
the distinction made (Fig. 7a). Also, the moisture regime is not as dry
as in the other two types.

The Pseudotsuga/Holodiscus/Polystichum habitat type described for
eastern Vancouver Island by Beese (1981) is very similar to this commu-
nity type. Both contain Acer macrophyllum and have similar understories

(although Holodiscus discolor is more abundant in the eastern Vancouver

Island type). Beese (1981) found no previous description of his type within

within British Columbia and suggested that it may have been included in

other frequently described types where Polystichum munitum dominates the

herb layer. Of these, the Achlys-Polystichum association of Kojima and

Krajina (1975) comes closest to resembling the Pseudotsuga-Thuja-Acer

forests. This community type probably represents the "classical" Poly-

stichum type in what would be the equivalent of the Coastal wetter

Douglas-fir subzone in this study area (Klinka et al., 1979), while the

Tsuga-Pseudotsuga-Polystichum forests (P5), represent the Polystichum

type in what would be the Coastal drier Western Hemlock subzone in this

study area (Klinka et al., 1979).

Pseudotsuga-Linnaea forests (P3)

Although of similar composition to the tree stratum of the Pseudo-

tsuga-Thuja-Acer forests, the tree stratum of this community type is

lower (average maximum height is 48 m) and has a much smaller mean basal

area (89.4 m^2/ha, Table 22). Tsuga heterophylla becomes the second

dominant after Pseudotsuga menziesii, and deciduous trees are often absent.

Tsuga heterophylla shows the best regeneration (Table 22). This community

type has a shrub stratum characterized by a high coverage of Gaultheria

shallon under 1 m in height. The rich herb layer is similar to that of

the Pseudotsuga-Thuja-Acer forests (P2), except that Linnaea borealis

attains a high coverage and Polystichum munitum is relatively unimportant.

Hylocomium splendens dominates the bryophyte-lichen stratum covering most

of the forest floor (Table 23).

This community type occurs mostly at mid-elevations, on mid- and upper-slopes (Fig. 7b), inland within the study area near Port Alberni. It is found on strong to extreme slopes with moderately deep (average soil depth is 65 cm), well drained soils, formed mostly on colluvial material. Organic horizons and mineral horizons have relatively high pH values (LFH average = 4.9; B_1 average = 5.2). The organic horizons are thin and rooting occurs throughout the mineral soil (Appendix 2). All soils are Orthic Humo-Ferric Podzols (Table 29). The higher up-slope position, as well as the absence of certain moisture indicator plant species (Tables 22 and 23), suggest that moisture input through seepage is not as pronounced here as in the Pseudotsuga-Thuja-Acer forests. Evidence of fire was present in all stands. Similarities between this type, the dry Pseudotsuga forests (P1) and the Pseudotsuga-Thuja-Acer forests (P2) are evident (Tables 22 and 23; Figs. 13 and 14).

The Pseudotsuga-Linnaea forests resemble the Pseudotsuga/Gaultheria-Berberis habitat type described by Beese (1981) for eastern Vancouver Island. Other similarities are with the biogeocoenosis 5 of Krajina (1969) and the Salal-Oregon grape-Douglas-fir biogeocoenotic zonal type of Klinka et al. (1979) for the Drier Maritime Coastal Douglas-fir Sub-zone (the Pseudotsuga-Linnaea forests are situated on drier sites within the Wetter Subzone found in this study area). Beese (1981) lists several other similar community types described for British Columbia. Similar types in Oregon and Washington are summarized by Franklin and Dyrness (1973).

Pseudotsuga-Berberis forests (P4) (Fig. 18b)

The Pseudotsuga-Berberis forests have one of the best developed tree strata within the Pseudotsuga group (mean maximum tree height is 58 m and, mean total basal area is 138.4 m^2/ha (Table 22)). Pseudotsuga menziesii dominates, with Tsuga heterophylla as a close second. Tree regeneration is strongly dominated by Tsuga heterophylla (Table 22). Although the shrub layer is similar in most community types of the Pseudotsuga group, Berberis nervosa is notably abundant in the low shrub layer of this type (average height under 1 m). The low cover, but rich, herb stratum has no particularly characteristic species. Hylocomium splendens and Stokesiella oregana again share dominance in the bryophyte-lichen layer (Table 23).

The Pseudotsuga-Berberis forests are found only inland within the study area. They are found mostly on mid-slope topographic positions at mid-elevations (Fig. 7b). They occur mostly on very strong slopes with deep, rapidly drained soils. The organic horizons are moderately thick (average of 8.6 cm) and rooting occurs throughout most of the mineral soil (Appendix 2). Most soils belong to the Orthic Humo-Ferric Podzol subgroup (Table 29). The majority of stands show evidence of fire disturbance. This community type has similarities with the Montane Tsuga forests (P6), which are usually found on similar sites but at higher elevations. It also has similarities with the Tsuga-Pseudotsuga-Polystichum forest (P5), often found on adjacent, lower-slope topographic positions (Figs. 7a and b, 13 and 14; Tables 22 and 23).

The Pseudotsuga-Berberis forests are most similar to the "moss" association considered to be the zonal vegetation type for lower elevations in Strathcona Provincial Park by Kojima and Krajina (1975). This association is dominated by Hylocomium splendens and Stokesiella oregana in the bryophyte layer, and Berberis nervosa in the shrub layer. The moss association is interpreted as being intermediate in moisture regime to associations of drier sites, dominated by Gaultheria shallon, and associations of wetter sites, dominated by Polystichum munitum (Kojima and Krajina, 1975). The same interpretation is reached here for the Pseudotsuga-Berberis forests (Fig. 7a and b; Tables 22 and 23). Krajina's (1969) biogeocoenoses 18 and 25, and McMinn's (1960) Pseudotsuga-Tsuga-Hylocomium association also correspond to these forests. The Tsuga/Gaultheria-Berberis/Achlys habitat type of Beese (1981) is somewhat similar, but has much richer herb and shrub strata. The Tsuga/Rhododendron/Berberis association described by Franklin and Dyrness (1973) for the Tsuga heterophylla Zone of the western Oregon Cascade Range, is very similar to the Pseudotsuga-Berberis forests, although the latter have no Rhododendron macrophyllum. According to Franklin and Dyrness (1973), this association typifies the climatic climax for the western Oregon Cascades. The Pseudotsuga-Berberis forests may also be considered the climatic climax in the vicinity of Port Alberni.

Tsuga-Pseudotsuga-Polystichum forests (P5) (Fig. 18c)

This community type has the largest mean total basal area (158.4 m^2/ha), and the second largest mean maximum tree height (61 m) in the Pseudotsuga group (Table 22). Tsuga heterophylla and Pseudotsuga menziesii

share dominance nearly equally in the tree stratum, but only Tsuga hete-
rophylla is regenerating well (Table 22). The shrub and bryophyte-
lichen layers have small coverages and are poor in species; the herb
stratum has a high coverage of Polystichum munitum (Table 23; Fig. 18c).

The Tsuga-Pseudotsuga-Polystichum forests are located centrally
inland within the study area, almost exclusively on lower-slopes (Fig. 7b)
, where they receive seepage and runoff water. They occur from low eleva-
tion up to 500 m, on generally south facing, steep to gentle slopes
(Fig. 7b). They are always found on deep soils (average soil depth is
100 cm) formed mostly of very rapidly to rapidly drained colluvial mate-
rial. Some stands are found on nearly level fluvial material, with slower
drainage, but only in the driest part of the study area (plots 1 and 17).
The organic horizons are moderately thick (average of 10 cm) and rooting
occurs throughout most of the mineral soil. Most soils of this community
type are classified as Orthic Humo-Ferric Podzols (Table 29). Traces of
fire are evident in most of the stands, and fire is believed to be at the
origin of all the stands. This community type shows similarities to the
Pseudotsuga-Berberis forests (P4), a commonly adjacent type on upslope
topographical positions (less influenced by seepage water), and also to
the Montane Tsuga forests (P6) (Figs 7a and b, 13 and 14; Tables 22 and
23).

The Tsuga-Pseudotsuga-Polystichum forests are undoubtedly very
similar to the many Pseudotsuga-Polystichum community types or associa-
tions described for coastal British Columbia, Washington and Oregon.
For British Columbia, the biogeocoenoses 2b and 24 of Krajina (1969),

the Achlys-Polystichum association of Kojima and Krajina (1975), the

Polystichum forest type of Orlóci (1961), the Pseudotsuga-Polystichum

association of McMinn (1960), and the Tsuga-Polystichum habitat type of

Beese (1981), are comparable to the Tsuga-Pseudotsuga-Polystichum forests.

Franklin and Dyrness (1973) describe a similar Tsuga heterophylla/Poly-

stichum munitum community type for Washington and Oregon based on several

published descriptions.

Montane Tsuga forests (P6)

These forests have a high mean total basal area (114.5 m^2/ha) but

a relatively low stature (mean maximum height of 50 m) (Table 22). Tsuga

heterophylla dominates the tree stratum, and is regenerating well, while

Pseudotsuga menziesii becomes the second dominant (Table 22). The species

poor shrub layer is characterized by a high coverage of Vaccinium parvi-

folium, averaging 1 m in height. The sparse herb stratum shows no cha-

racteristic species. Rhytidiopsis robusta, a moss associated with high

elevations (Schofield, 1976), is often abundant in the bryophyte-lichen

layer (Table 23).

This community type occurs within the central and inland portion

of the study area, mostly above 400 m in elevation (Fig. 7b). It is found

on moderate to steep mid-slopes and upper-slopes, over deep, rapidly to

well drained colluvial material. The organic horizons are moderately

thick (average of 8.5 cm) and rooting occurs throughout most of the mine-

ral soil (Appendix 2). Most soils were classified as Orthic Humo-Ferric

Podzols (Table 29). Evidence of fire was found in nearly all stands.

This community type shows similarities to the Pseudotsuga-Berberis
forests (P4) with which it intergrades at lower elevations (Figs. 7a
and b, 13 and 14; Tables 22 and 23). McMinn's (1960) Pseudotsuga-Tsuga-
Hylocomium association has a bare forest floor variant which is similar
to the Montane Tsuga forests.

Montane Tsuga-Gaultheria forests (P7) (Fig. 18a)

This community type has the smallest mean total basal area
(86 m^2/ha) and mean maximum tree height (41 m) of the Pseudotsuga group.
Tsuga heterophylla dominates the tree, sapling, and seedling strata
(Table 22). The understory is characterized by a nearly continuous,
species poor shrub layer, dominated by low (< 1 m) Gaultheria shallon
(Fig. 18a). The herb stratum is species poor and very sparse. Rhyti-
diadelphus loreus is abundant in the bryophyte-lichen layer (Table 23).

The montane Tsuga-Gaultheria forests occur inland within the
study area, generally above 500 m, on moderate to extreme slopes (Fig. 7b).
They are found on upper-slopes or ridges, on deep soils formed mostly by
colluvial material. The organic horizons are moderately thick (average
of 10 cm) and rooting occurs throughout most of the mineral soil (Appen-
dix 2). Nearly all soils are rapidly to well drained Orthic Humo-Ferric
Podzols (Table 29). Half of the stands show no evidence of fire distur-
bance, but fire probably remains at the origin of all the stands. This
community type has similarities with the Pseudotsuga-Linnaea forests (P3)
of which it appears to be a high elevation equivalent with Tsuga regene-
ration. It also has similarities with the montane Tsuga-Abies-Gaultheria
forests (A1) (Figs. 7a and b, 9a and b, and 14; Tables 22, 23, 26 and 27).

The montane _Tsuga-Gaultheria_ forests are similar to the _Pseudo-_
tsuga-Tsuga-Gaultheria association of McMinn (1960) and the _Tsuga-_
Gaultheria habitat type of Beese (1981). This type is also similar to
Kojima and Krajina's (1975) _Gaultheria shallon_ association, although
Tsuga heterophylla does not regenerate successfully in their association.
Del Moral and Long (1977) describe a similar _Pseudotsuga-Gaultheria_ com-
munity type for the montane forests of western Washington.

3. THUJA VEGETATION GROUP

    Coastal dry Thuja forests (T1)

        The coastal dry Thuja forests have the lowest mean total basal
    area (86 m^2/ha) within the Thuja group; they also are low in stature
    (mean maximum tree height of 30 m). Thuja plicata, followed by Tsuga
    heterophylla, Pseudotsuga menziesii and Taxus brevifolia, dominate the
    tree stratum. This is the only community type within the Thuja group
    with an appreciable amount of Pseudotsuga menziesii. Thuja plicata and
    Tsuga heterophylla seem to be regenerating very well (Table 24). The
    dense and continuous shrub layer is dominated by Gaultheria shallon and
    Vaccinium ovatum, averaging 2 and 3 m high, respectively. The herb stra-
    tum is relatively poor and sparse for the Thuja group, and consists
    nearly entirely of Blechnum spicant. The abundance of Rhytidiadelphus
    loreus and Hylocomium splendens characterizes the well developed bryo-
    phyte-lichen layer (Table 25).

        This community type is restricted to the coastal part of the study
    area. It is found at low elevations on very strong to extreme slopes,
    mostly on ridges (Fig. 8b). Soils are rapidly drained and very shallow
    (average soil depth is 16 cm). The soils of most stands are Typic Foli-
    sols with organic horizons exceeding 10 cm in thickness and directly
    overlying the bedrock (Appendix 2; Table 29). No evidence of fire was
    found in these stands, but all show signs of wind disturbance. The rela-
    tively dry habitats occupied by this community type contribute to its
    vegetational similarities with the coastal dry Pinus forests (D2) (Tables
    24 and 25). It also is vegetationally similar to the coastal wet Thuja

forests (T5), although the habitats are entirely different (Fig. 8a and b; Tables 24 and 25).

No references to forest types similar to the coastal dry Thuja forests could be found.

Coastal Tsuga-Blechnum-Polystichum forests (T2)

This community type has a large mean total basal area (142.3 m^2/ha) and excellent tree height (average of 52 m) (Table 24). Tsuga hetero-phylla dominates the tree stratum and its regeneration occupies nearly the entire sapling and seedling layers (Table 24). Abies amabilis and Thuja plicata are, respectively, the second and third dominants. The shrub layer is comprised mainly of scattered, 2 m high Vaccinium parvi-folium. The herb stratum, although poor in species, is well developed and is characterized by an abundance of Blechnum spicant and Polystichum munitum. The bryophyte-lichen layer is poor and has low coverage (Table 25).

This community type is found in the coastal part of the study area. It occurs from low to mid-elevations on very strong to extreme slopes. All stands are situated on mid-slope topographic positions (Fig. 8b). Soils are deep, well to moderately well drained, developing mostly on colluvial material. Half of the stands are found on ancient rock slide colluvial material. The organic horizons are thick (average of 15 cm) and nearly half of the rooting occurs in them (Appendix 2). Most soils encountered are Orthic Ferro-Humic Podzols (Table 29). No

evidence of fire was found in any of the stands, but most have been sub-
jected to some wind disturbance. This community type shows some simila-
rities with the Tsuga-Blechnum-Polystichum forests (A7), a community type
with less Abies amabilis and Thuja plicata, and one which is not strictly
coastal in character (Fig. 14; Tables 24, 25, 26 and 27).

The coastal Tsuga-Blechnum-Polystichum forests generally corres-
pond to the biogeocoenotic types described by Klinka et al. (1979) for
their Estevan Submontane and West Vancouver Island Submontane Wetter
Coastal Western Hemlock biogeoclimatic subzone variants. The coastal
Tsuga-Blechnum-Polystichum forests appear to have better drainage than
the more widespread coastal Thuja forests (T4). Half of the stands of
the coastal Tsuga-Blechnum-Polystichum forests were found on old land-
slides, which probably created improved drainage and nutrient conditions
on these sites.

Coastal Montane Thuja forests (T3)

This community type has the largest mean total basal area (187.3
m^2/ha) within the Thuja group; the mean maximum tree height is 42 m
(Table 24). These forests are dominated by Thuja plicata followed by
Tsuga heterophylla and Abies amabilis. All species are regenerating
well, except possibly Thuja plicata (Table 24). The species poor shrub
stratum has a high coverage, with large contributions by 1 m high Gaul-
theria shallon and 2.5 m high Vaccinium species. The herb layer is the
richest within the Thuja group, but Blechnum spicant remains the dominant
species. The rich bryophyte-lichen layer is characteristic of the Thuja
group, but otherwise is not distinctive (Table 25).

The coastal montane <u>Thuja</u> forests are found only near the coast from mid-to high elevations, mostly on mid-slope topographic positions of very strong to steep slopes (Fig. 8b). They occur on deep, well to poorly drained soils. The organic horizons are thick (average of 14 cm) and rooting is mostly limited to these horizons (Appendix 2). The soils, mostly Gleyed or Orthic Ferro-Humic Podzols, or Humic Gleysols, have developed on a variety of materials (Table 29). Traces of fire disturbance were not found, but many stands show signs of wind disturbance in the form of isolated uprooted trees. This community type is very similar to the coastal <u>Thuja</u> forests (T4) which are found at lower elevations on similar sites (Figs. 8a and b, 13 and 14; Tables 24 and 25). Both types intergrade along an elevation gradient (Fig. 8b) and present similar visual aspects, except for a greater abundance of <u>Abies</u> <u>amabilis</u> (particularly in the sapling and seedling strata) in the coastal montane <u>Thuja</u> forests (Table 24).

The coastal montane <u>Thuja</u> forests do not appear to have been described previously.

Coastal <u>Thuja</u> forests (T4) (Fig. 18d)

The coastal <u>Thuja</u> forests have an impressive mean total basal area of 180.4 m^2/ha (Table 24). <u>Thuja</u> <u>plicata</u> dominates, with <u>Tsuga</u> <u>heterophylla</u> and <u>Abies</u> <u>amabilis</u> as second and third dominants, respectively. These species are regenerating well, although not abundantly in the case of <u>Thuja</u> <u>plicata</u> (Table 24). The shrub stratum is well developed, with a large coverage of <u>Gaultheria</u> <u>shallon</u> close to 2 m in height, and several

Vaccinium species over 3 m in height (Fig. 18d). The herb layer, one of the poorest in the Thuja group, is strongly dominated by Blechnum spicant (Fig. 18d). The bryophyte-lichen stratum is relatively rich and is characteristic of the Thuja group (Table 25).

The coastal Thuja forests are found near the coast from low to mid-elevations on a variety of topographical positions except ridges (Fig. 8b). This community type occurs on deep, generally imperfectly drained soils, situated on level to strongly sloping terrain. The organic horizons are very thick (average of 20 cm) and most of the root mass is restricted to them (Appendix 2). The soils almost invariably show signs of B horizon gleying and cementation. They are mostly Humic Gleysols, with some Ferro-Humic Podzols, Ortstein and Duric Humo-Ferric Podzols (Table 29). Because of the frequent cementation of the mineral horizons, most seepage occurs in the organic horizons (this was observed once during a rainstorm). Plot 24, although not coastal, receives abundant seepage water and supports vegetation typical of coastal sites. Very few stands showed traces of fire, but most had evidence of wind disturbance by uprooted individual trees. This community type is similar to the coastal montane Thuja forests (T3), found at higher elevations on similar sites (Figs. 8a and b, 13 and 14; Tables 24 and 25).

No detailed description of the coastal Thuja forests of the west coast of Vancouver Island seems to have been published. Klinka et al. (1979) list the major species and ecological characteristics of forests described as stands of "decadent" old-growth trees, with very dense and tall shrub layers. In the Estevan Submontane Wetter Maritime Coastal

Western Hemlock biogeoclimatic subzone variant these stands are nearly at climatic climax because of the virtual absence of forest fires (Klinka et al., 1979). These authors also note the considerable relief of the forest floor in these forests caused by the continual windthrow of individual trees. Forests of a similar nature are probably found all along the coast of British Columbia and Washington. Hines (1971) describes a Tsuga-Picea/Gaultheria/Blechnum community type for north coastal Oregon which appears similar to the Coastal Thuja forests of Vancouver Island, especially in the shrub and herb strata, where the dominants are identical. The more southerly location (and thus drier climate) of the Oregon stands may explain why they contain so little Thuja plicata as compared to the Vancouver Island plots.

Coastal wet Thuja forests (T5)

This community type has one of the lowest mean total basal areas of the Thuja group (87.7 m^2/ha), and it also has the lowest mean maximum tree height (24 m). The mean tree density (855 trees/ha) is the highest in the study area and results from a large number of small trees (Table 24). Thuja plicata dominates the tree stratum with Tsuga heterophylla and Pinus contorta as co-dominants. Taxus brevifolia is always present. Thuja plicata and Tsuga heterophylla are regenerating well (Table 24). A nearly impenetrable and continuous shrub layer is dominated by 2 m high Gaultheria shallon and Vaccinium ovatum. Pyrus fusca, essentially restricted to this community type, often reaches 4 to 6 m in height. The relatively rich herb stratum has a large coverage and is dominated by Blechnum spicant. The rich bryophyte-lichen stratum is characteristic of the Thuja group (Table 25).

The coastal wet Thuja forests occur very near the coast, close to sea level, always on level sites (Fig. 8b). They are found on deep, poorly drained soils on morainal or fluvial deposits. The organic horizons are very thick (average of 20 cm) and contain most of the root mass (Appendix 2). Most soils are Humic Gleysols (Table 29). Evidence of disturbance by fire or wind was found in some stands. This community type has close vegetational similarities with the coastal dry Thuja forests (T1), but these two types occur in markedly different habitats (Fig... 8a and b). The coastal wet Thuja forests also have similarities with the coastal Thuja forests (Figs. 8a and b, 13 and 14; Tables 24 and 25).

Communities very similar in appearance to the Coastal wet Thuja forests are described as Coastal forested swamps by Franklin and Dyrness (1973) for western Washington's coastal plain. Klinka et al. (1979) ·report that, on the west coast of Vancouver Island, Thuja plicata and Pinus contorta are the major species on flat areas and on the lower parts of gentle slopes when there is a large water surplus.

4. ABIES VEGETATION GROUP

Montane Tsuga-Abies-Gaultheria forests (A1)

This community type has a large mean total basal area (121 m^2/ha) and a high mean tree density (700 trees/ha), but the smallest mean maximum tree height (44 m) within the Abies group (Table 26). The tree stratum, the richest within the Abies group, is dominated by Tsuga heterophylla, Pseudotsuga menziesii and Abies amabilis, of which only Pseudotsuga menziesii is not regenerating (Table 26). A continuous shrub layer over 1 m high, the richest within the Abies group, is dominated by Vaccinium alaskaense, Gaultheria shallon and V. parvifolium. The herb stratum is the poorest in species and the smallest in total coverage within the study area. The bryophyte-lichen layer is well developed and is dominated by Rhytidiadelphus loreus (Table 27).

The montane Tsuga-Abies-Gaultheria forests are found mostly within the central part of the study area. They occur on generally south facing, strong to extreme slopes, from mid- to high elevations, mostly on upper-slope topographical positions (Fig. 9b). The deep, rapidly to well drained soils are formed mostly of colluvial material. The organic horizons are moderately thick (average of 9.3 cm) and rooting is shallow (mean effective rooting depth of 19 cm) (Appendix 2). The soils are Orthic Humo-Ferric Podzols (Table 29). All the stands show evidence of fire disturbance, some only as reflected by the abundance of Pseudotsuga menziesii, and some by charcoal in the soil. This community type has environmental similarities to the montane Tsuga-Gaultheria forests (P7) and the montane Tsuga forests (P6) (Figs. 7b, 9b and 14), but it differs

vegetationally from them in the abundance of <u>Abies amabilis</u> and <u>Vaccinium alaskaense</u>. Within the <u>Abies</u> group it is not particularly similar to other types, except for the presence of <u>Abies amabilis</u> regeneration (Figs. 9a and b, 13 and 14; Tables 26 and 27).

The montane <u>Tsuga-Abies-Gaultheria</u> forests are similar to the <u>Chamaecyparis</u>/<u>Gaultheria</u> habitat type described for eastern Vancouver Island by Beese (1981). In this habitat type <u>Abies amabilis</u> is rare in the tree stratum, but seedlings are relatively abundant and <u>Gaultheria shallon</u> dominates the shrub layer. The <u>Abies amabilis</u>/<u>Gaultheria shallon</u> association, described by Franklin and Dyrness (1973) for the <u>Abies amabilis</u> Zone in southern Washington, is somewhat related with a high <u>G. shallon</u> coverage and a very poorly developed herb stratum.

Montane <u>Abies-Tsuga</u> forests (A2)

These forests have a high mean total basal area (146.5 m^2/ha) and the lowest mean tree density (280 trees/ha) in the study area (Table 26). Small trees (not including saplings) are scarce and most trees are found within a narrow range of size-classes. <u>Tsuga heterophylla</u>, <u>Abies amabilis</u> and <u>Thuja plicata</u> dominate the tree stratum with the former two species having equal dominance in sapling and seedling layers (Table 26). The shrub stratum has a large coverage and is dominated by <u>Vaccinium alaskaense</u> over 1 m in height. The herb layer, relatively rich and of high coverage for the <u>Abies</u> group, is characterized by <u>Blechnum spicant</u>. The bryophyte-lichen stratum has a small coverage and is made up of species generally found within the <u>Abies</u> group (Table 27).

This community type is found above 500 m in elevation in the central part of the study area (Fig. 9b). It occurs on upper-slope positions of extreme slopes, over deep deposits of colluvial or morainal material. The soils are moderately well to imperfectly drained Gleyed Ferro-Humic Podzols (Table 29). The organic horizons are moderately thick (average of 10.5 cm) and contain almost all of the roots (Appendix 2). A disturbance origin (fire or wind) of the stands is suspected because of the even-sized structure of the tree stratum. This community type has similarities to the montane Tsuga-Abies forests (A3), which are found on better drained sites, but in wetter coastal areas (Figs. 9a and b, and 14; Tables 26 and 27).

The montane Abies-Tsuga forests correspond to the Rhytidiadelphus-Oval-leaved & Alaskan Blueberry-Amabilis Fir-Western Hemlock biogeocoenotic type of the West Vancouver Island Montane Wetter Maritime CWH subzone variant (Klinka et al., 1979). Klinka et al. (1979) report that Rhytidiopsis robusta, Gaultheria shallon and Vaccinium parvifolium are more common in stands of drier sites at the upper limit of the variant, and in stands situated the farthest inland. Both stands sampled are found at the eastern limit of the subzone variant mentioned.

Montane Tsuga-Abies forests (A3)

This community type has the lowest mean total basal area (79.5 m^2/ha) within the Abies group (Table 26). The species poor tree stratum consists entirely of Tsuga heterophylla and Abies amabilis, with Tsuga heterophylla showing the most abundant regeneration (Table 26). The

sparse and species poor shrub layer is dominated by Vaccinium parvi-folium. The herb stratum is equally poor and sparse, with Blechnum spicant accounting for most of the coverage. The bryophyte-lichen layer is typical of the Abies group (Table 27).

The montane Tsuga-Abies forests are most often found at mid to high elevations near the coast (only once in the central part of the study area). They occur mostly on upper-slope topographic positions of generally north facing, very strong to steep slopes (Fig. 9b). The deep and well drained soils are mostly formed of colluvial material. The organic horizons are thick (average of 15 cm) and contain most of the roots (Appendix 2). The soils are classified as Orthic Humo-Ferric Podzols (Table 29). Most stands show evidence of wind disturbance, but only one shows evidence of fire. Although this community type is found at, or near, the well drained crests of mountains nearest to the coast, it has no similarities with the community types of the Thuja group, found on adjacent lower topographical positions (montane coastal Thuja forests (T3) or coastal Thuja forests (T4). This type has some similarities to the more coastal montane Abies-Tsuga forests (A2), and to the cooler and wetter montane Abies-Streptopus forests (A4) (Figs. 9a and b, and 14; Tables 26 and 27).

The montane Tsuga-Abies forests have similarities to the Rhyti-diadelphus-Red Huckleberry & Alaskan Blueberry-Amabilis Fir-Western Hemlock biogeocoenotic type of the West Vancouver Island Submontane Wetter Maritime CWH subzone variant (Klinka et al., 1979). Klinka et al. (1979) report that the most frequent disturbance in these communities is caused by southerly, or westerly, gale force winds. Such disturbance,

particularly on exposed upper-slopes and crests, is responsible for the development of nearly even-aged stands of Tsuga-heterophylla and Abies amabilis (Klinka et al., 1979). In the Montane Tsuga-Abies forests such a structure is frequently observed, giving the impression of a two-tiered forest comprising an upper tier of mature trees and a lower tier of saplings.

Montane Abies-Streptopus forests (A4)

These forests have a high mean total basal area (122 m^2/ha) as well as a high mean maximum tree height (53 m (Table 26)). Only Abies amabilis, the dominant species, and Tsuga heterophylla form the tree stratum. Abies amabilis shows the best regeneration (Table 26). The coverage of the shrub stratum, the poorest in species within the study area, is almost entirely made up by Vaccinium alaskaense. Oplopanax horridus is nearly always present. The herb layer, with the largest coverage and number of species within the Abies group, is characterised by Rubus pedatus, Streptopus roseus and S. streptopoides. Several fern species, indicative of moist and nutrient-rich soils, are present (Adiantum pedatum, Athyrium filix-femina and Gymnocarpium dryopteris). The sparse bryophyte-lichen layer is characteristic of the Abies group, except for the only occurrence within the study area of Eurhynchium pulchellum in two stands on limestone bedrock (Table 27). This moss is usually found on calcareous substrata (Schofield, 1976).

This community type is found in the central part of the study area above 600 m. It occurs on mid-slope and upper-slope topographic positions

of very strong, generally north facing slopes (Fig. 9b). Soils are deep,

moderately well to imperfectly drained, and have formed from colluvial

material. The organic horizons are very thick (average of 21 cm) and

contain most of the roots (Appendix 2). The soils belong to various

types (Table 29), but most are gleyed as a result of constant see-

page (as the presence of Oplopanax horridus indicates). No evidence of

fire disturbance was found, but wind disturbance was noticed in the two

stands nearest to the ocean. This community type is environmentally

quite different from other community types, but is perhaps closest to

the montane Abies-Tsuga forests (A2) or to the montane Tsuga-Abies fo-

rests (A3) (Figs. 9a and b, 13 and 14; Tables 26 and 27). The montane

Abies-Streptopus forests are quite similar in composition to the lowland

Abies forests (A5), although they occur at totally different elevations

(Fig. 9a and b).

The Abies/Vaccinium alaskaense/Streptopus habitat type described

for eastern Vancouver Island by Beese (1981) corresponds nearly exactly

to the Montane Abies-Streptopus forests. These forests also are similar

to the Streptopo-Abietum association described by Brooke et al. (1970)

for the Coastal Subalpine Mountain Hemlock Zone. This association is

characterized by constant seepage (Brooke et al., 1970). Kojima and

Krajina (1975) pointed out the resemblance of the Streptopo-Abietum asso-

ciation with their Vaccinium alaskaense association situated at lower

elevations. In this study area, the Abies-Streptopus forests and the

lowland Abies forests (comparable to the V. alaskaense association) also

are floristically similar (Fig. 9a and b; Tables 26 and 27). The Abies

amabilis/Streptopus roseus association described by Franklin and Dyrness

(1973) for the Abies amabilis zone of Washington also is related.

Lowland _Abies_ forests (A5) (Fig. 18f)

The lowland _Abies_ forests have a low mean total basal area
(107.7 m^2/ha) but an excellent mean maximum tree height (54 m) compared
to other community types of the _Abies_ group (Table 26). _Abies amabilis_
achieves its highest dominance in the study area (Fig. 18f), and _Tsuga_
heterophylla is the second dominant in a two species tree stratum. Both
species are regenerating (Table 26). The moderately developed shrub
layer is made up of _Vaccinium alaskaense_ and _V. parvifolium_ averaging
2 m in height. The herb stratum is marked by the abundance of _Blechnum_
spicant, _Dryopteris austriaca_ and _Tiarella trifoliata_. The well developed
bryophyte-lichen stratum, although the richest within the _Abies_ group,
has no particularly characteristic species.

The lowland _Abies_ forests occur throughout the study area, except
for the coastal plain and the driest inland areas. They occur at low to
mid-elevations, on the lower-slopes or terraces of narrow river valleys;
aspects most often are north facing (Fig. 9b). The topographic location
suggests that the sites are subjected to cold air drainage (Miller _et al._,
1983) or snow accumulation (Kojima and Krajina, 1975). The lowland _Abies_
forests are generally found on strong slopes, with deep, moderately well
drained soils formed from a variety of materials (colluvial, morainal,
fluvial). The organic horizons are thick (average of 15 cm) and half of
the root mass is found within them (Appendix 2). Evidence of wind dis-
turbance was found in less than half of the stands, and fire disturbance
was found in only two stands. This community type shows environmental
similarities with the _Tsuga-Blechnum-Polystichum_ forests (A7) and the

coastal Tsuga-Blechnum-Polystichum forests (T2) (Figs. 13 and 14). Vege-
tationally, it is most similar to the montane Abies-Streptopus forests
(A4), although this type occurs at a much higher elevation (Figs. 9a and
b, 13 and 14; Tables 26 and 27).

The lowland Abies forests fit closely the description given by
Kojima and Krajina (1975) of the Vaccinium alaskaense association found
in Strathcona Provincial Park. These authors indicate that most of
their stands were found on terraces close to the bottom of protected
valleys, or on the gentle slopes of hillsides. They suggest that snow
accumulation may explain the presence of this association which usually
occurs at higher elevations. In the present study area, stands of the
lowland Abies forests were found in very similar sites to those described
by Kojima and Krajina (1975). On eastern Vancouver Island, the Abies/
Vaccinium alaskaense-V. parvifolium habitat type described by Beese (1981)
has similarities with the lowland Abies forests. Franklin and Dyrness
(1973) report that the climatic climax community for the Abies amabilis
Zone (600-1300 m) of the northern Washington Cascade Range is an Abies
amabilis/Vaccinium alaskaense association with an abundance of mesic
herbs and Rubus pedatus. However, the lowland Abies forests described
here are not considered zonal plant communities because of the particular
topographic factors influencing their microclimate.

Tsuga-Gaultheria-Blechnum forests (A6)

This community type has a low mean total basal area (116.5 m^2/ha)
and a low mean maximum tree height (46 m), relative to the other types

within the Abies group (Table 26). Tsuga heterophylla strongly dominates

the tree stratum and is the major regenerating species. Abies amabilis

is the second dominant, but is not regenerating abundantly (Table 26).

The species poor shrub stratum has a large coverage, dominated by Gaul-

theria shallon (over 1 m high) and Vaccinium parvifolium (2 to 3 m high).

The herb layer is the most species-poor within the study area and is

entirely dominated by Blechnum spicant. The bryophyte-lichen stratum,

with the highest coverage within the Abies group, is characterized by

an abundance of Stokesiella oregana (Table 27).

The Tsuga-Gaultheria-Blechnum forests were found on the coast

and in the central part of the study area, on low elevation mid- and

lower-slope topographic positions (Fig. 9b). The soils are deep, modera-

tely well drained, Gleyed Humo-Ferric Podzols formed from morainal mate-

rial (Table 29). The organic horizons are moderately thick (average of

11.5 cm), and roots are abundant in the upper mineral horizons (Appen-

dix 2). No evidence of fire was found, but one stand did show signs of

wind disturbance. This community type has environmental similarities

with several other community types, (Figs. 13 and 14), but is relati-

vely distinct vegetationally, except for some similarities with some

types of the Thuja group (Fig. 9a; Tables 24, 25, 26 and 27).

Tsuga-Blechnum-Polystichum forests (A7) (Fig. 18e)

This community type has the highest mean total basal area .

(185.2 m^2/ha) and the highest mean maximum tree height (64 m) of the

Abies group (Table 26). Tsuga heterophylla dominates the tree stratum

in all stands and is the only species regenerating. Pseudotsuga menzie-
sii, Thuja plicata and Picea sitchensis are the second dominants depen-
ding on the stand (Table 26). The shrub layer is the most species-poor
within the study area. Dominance of the herb stratum is shared equally
by Blechnum spicant and Polystichum munitum (Fig. 18e). The bryophyte-
lichen layer is sparse, but generally characteristic of the Abies group
(Table 26).

This community type is found from the coast to the central part
of the study area, but is absent from the dry inland sector. These
forests occur on the lower and mid-slope topographic positions of very
strong slopes, mostly at low elevations (Fig. 9b). The soils are deep
and well to moderately well drained. In most cases soils have formed
from morainal material, except those of two coastal stands which have
developed from colluvial material originating from ancient land slides.
Better drainage on the colluvium may account for the vegetational simi-
larities between the coastal and the inland stands of this type. The
organic horizons are thick (average of 13 cm) and contain most of the
root mass (Appendix 2). Most soils are Orthic Humo-Ferric Podzols; also
represented are a Gleyed Humo-Ferric Podzol and a Gleyed Ferro-Humic
Podzol (Table 29). Evidence of fire disturbance was found in two of the
central stands, and land slides were at the origin of the two coastal
stands. This community type is most similar to the coastal Tsuga-
Blechnum-Polystichum forests (T2) (Fig. 14; Tables 24, 25, 26 and 27).
The difference is mostly one of geographical location, resulting in a
wetter soil moisture regime for the coastal type because of higher amounts
of precipitation. This is reflected by a lesser amount of Pseudotsuga

menziesii and Polystichum munitum, and a higher amount of Abies amabilis
and Blechnum spicant in the coastal Tsuga-Blechnum-Polystichum forests
(T2), than in the Tsuga-Blechnum-Polystichum forests.

The Tsuga-Blechnum-Polystichum forests are very similar to the
better drained and most productive stands of the Rhytidiadelphus-Red
Huckleberry & Alaskan Blueberry-Amabilis Fir-Western Hemlock biogeo-
coenotic type within the West Vancouver Island Submontane Wetter Maritime
CWH Subzone variant (Klinka et al., 1979); however the Tsuga-Blechnum-
Polystichum forests described here probably have a drier soil moisture
regime as indicated by the predominance of Tsuga heterophylla and Pseudo-
tsuga menziesii over Abies amabilis (Table 26).

5. FLOODPLAIN VEGETATION GROUP

Floodplain forests (Fl)

Floodplain forests possess the largest mean total basal area in
the study area (246.2 m^2/ha), as well as a high mean maximum tree height
(60 m (Table 24)). The dominant tree is most often Picea sitchensis,
but Thuja plicata and even Pseudotsuga menziesii dominate in some of the
plots. Tsuga heterophylla is, on average, the second dominant and is
the only species regenerating well (Table 24). Rubus spectabilis, Ribes
bracteosum and Vaccinium species often form a continuous shrub layer
over 2 m in height. The herb stratum, the richest in the study area, is
dominated by Polystichum munitum and Athyrium filix-femina which form a
continuous, one metre high layer in some stands. Many herb species such
as Trautvetteria caroliniensis, Melica subulata, Luzula parviflora and
Aruncus sylvester are restricted to this community type. Leucolepis
menziesii, Plagiomnium insigne and Stokesiella praelonga characterize
the bryophyte-lichen stratum (Table 25).

This community type is found at low elevations throughout the
study area on the floodplains of major rivers. The shrub stratum is
often absent or weakly developed in younger stands, or stands situated
on the most active floodplains. In contrast, such stands have a well
developed herb stratum with up to 85 % coverage of Polystichum munitum.
Older stands, or stands on less active floodplains, have a dense shrub
layer (mainly Rubus spectabilis) and usually have a few very large Picea
sitchensis. The soils are deep, well drained loams of alluvial or flu-
vial nature and contain very few coarse fragments; the organic horizons

are thin and tree roots penetrate deeply into the mineral soil (Appendix 2). The water table was not encountered in any of the soil pits; however, the soils remain moist owing to their fine texture and the level terrain. The soils are mostly Gleyed Sombric Brunisols (Table 29). Signs of wind disturbance, mostly in the form of uprooted large *Picea sitchensis*, were found in half of the stands; a few stands contained evidence of fire. Floodplain forests have few similarities to other types described for the study area. Their closest affinity is with the *Thuja* group (Figs. 5, 13 and 14; Tables 24 and 25).

Floodplain forests correspond closely in vegetation composition and ecological characteristics to the *Picea sitchensis-Polystichum munitum-Leucolepis menziesii* forest type described by Cordes (1972) for floodplains of the west coast of Vancouver Island. First and second river terrace communities described by Fonda (1974) for the Olympic National Park, Washington State, also have similarities with the floodplain forests. The former differ from the latter by having a lesser coverage of *Rubus spectabilis* (probably because of elk browsing) and an abundance of *Oxalis oregana* in the understory. Phytogeographically, the *Picea sitchensis* dominated floodplain forests range along the coast from southern Alaska to southern Oregon where they merge with the Redwood forests (Fonda, 1974). *Oxalis oregana* is a characteristic element of these forests in Washington, Oregon, and California, but it was found only near the Klanawa River (plots 170 et 171) within the study area. The phytogeography of this species in British Columbia has recently been discussed by Ogilvie *et al.* (1984).

Floodplain forests (Lysichitum variant) (F2)

This community type has a structure similar to the typical flood-
plain forests (F1), with a very large mean total basal area (236.5 m^2/ha)
and a high mean tree height (56 m (Table 24)). Picea sitchensis and
Thuja plicata share dominance equally. Tsuga heterophylla is the third
dominant and is the only species regenerating well (Table 24). The
dense and almost continuous shrub stratum (over 3 m high) is dominated
by Gaultheria shallon, Rubus spectabilis and Vaccinium species. The
high coverage herb layer is dominated nearly equally by Blechnum spicant,
Lysichitum americanum and Polystichum munitum. The bryophyte-lichen
stratum is similar in composition to that of the typical floodplain
forests (F1).

The Lysichitum variant of the floodplain forests was found in only
one area near the coast, on the alluvial plain of a small river. The
soils are very poorly drained Humic Gleysols formed from alluvial deposits
(Table 29). The organic horizons are thin, and the effective rooting
depth (averaging 80 cm) is restricted by a shallow water table (Appendix 2).
Evidence of fire and wind disturbance was found. Apart from the poorer
drainage and heavier soil texture, this community type is similar to the
typical floodplain forests (Figs. 5 and 14; Tables 24 and 25).

The Lysichitum variant of the floodplain forests is very similar,
floristically and ecologically, to the Picea sitchensis-Lysichitum ame-
ricanum forest type described by Cordes (1972) for the west coast of
Vancouver Island.

6. <u>SUBALPINE VEGETATION GROUP</u> (SA)

The subalpine vegetation group is formed by an heterogeneous assemblage of eleven plots ranging in elevation from 485 m to 1050 m (mean = 789 m). Most plots of this group probably represent low elevation extensions of vegetation types more common above the upper elevation limit set for this study; therefore, the description of this group is general.

<u>Tsuga</u> <u>heterophylla</u> dominates the tree stratum; <u>Abies</u> <u>amabilis</u> is the second dominant and also is the most abundantly regenerating species (Table 28). <u>Tsuga</u> <u>mertensiana</u> and <u>Chamaecyparis</u> <u>nootkatensis</u> also are important in the tree stratum. Both of these species are characteristic of high elevation coastal forests (Krajina, 1969; Brooke <u>et</u> <u>al</u>., 1970; Klinka <u>et</u> <u>al</u>., 1979). <u>Pseudotsuga</u> <u>menziesii</u> is relatively abundant in many stands, presumably because of past fire disturbance. A general pattern also can be described for the understory strata. Most stands have a shrub layer strongly dominated by <u>Vaccinium</u> <u>alaskaense</u> (up to 50 % coverage). The herb stratum is generally sparse and is characterized by species such as <u>Clintonia</u> <u>unifolia</u>, <u>Rubus</u> <u>pedatus</u>, <u>Tiarella</u> <u>unifolia</u> and <u>Veratrum</u> <u>viride</u>. The bryophyte-lichen layer is usually well developed, with total coverages of up to 75 %, and is always strongly dominated by <u>Rhytidiopsis</u> <u>robusta</u>. Other species, such as <u>Vaccinium</u> <u>membranaceum</u>, <u>Gaultheria</u> <u>ovatifolia</u>, <u>Phyllodoce</u> <u>empetriformis</u> and <u>Viola</u> <u>orbiculata</u>, were found most often within this group. <u>Rhododendron</u> <u>albiflorum</u> and <u>Fritillaria</u> <u>camschatcensis</u> were found only in plots of the subalpine vegetation group.

The environmental conditions (mainly the soil moisture and nutrient status) appear to vary widely in this group (Appendix 2). Associations within the subalpine Mountain Hemlock Zone of coastal British Columbia have been described by Brooke et al. (1970). Klinka et al. (1979) describe eastern and western variants within a Maritime Forested Mountain Hemlock biogeoclimatic subzone for Vancouver Island. Fonda and Bliss (1969) discuss an Abies amabilis-Tsuga mertensiana community type for the Olympic Mountains of Washington. Franklin and Dyrness (1973) also discuss the communities of the Tsuga mertensiana Zone of the Pacific Northwest States.

D. VEGETATION STRATA HOMOGENEITY AND

SPECIES RICHNESS WITHIN TYPES

The average homogeneity coefficients and the average species richness values of vegetation strata in fourteen community types are summarized in Table 31. The seedling stratum, followed closely by the tree and sapling strata, are, on average over all types, the most homogeneous in the study area. Most community types are composed of old-growth stands with closed canopies where seedling establishment is restricted almost entirely to a few shade tolerant species; thus, a high degree of uniformity within the seedling stratum is to be expected. Community types with open canopies, such as the dry Pinus-Pseudotsuga forests (D1), the coastal dry Pinus forests (D2), and some stands within the Floodplain forests (F1) show a much lower homogeneity in their seedling strata. The lower homogeneity of the tree stratum may reflect variation in the type and intensity of disturbances at the origin of the stands. The tree stratum often contains large proportions of long-lived, shade intolerant species (eg. Pseudotsuga menziesii) which are usually absent in seedling strata.

The shrub stratum is less homogeneous than the tree, sapling, and seedling strata, but is, on average, more homogeneous than the herb and bryophyte-lichen layers (Table 31). The coastal wet Thuja forests (T5) have the most homogeneous and one of the most species-rich shrub strata. The least homogeneous shrub stratum is found in the Floodplain forests (F1) and may reflect variations in flooding regime or stand age (see Chapter 4. C, section 5).

The most homogeneous herb strata occur in the Thuja group commu-
nity types, because of the strong dominance of Blechnum spicant growing
profusely on the thick organic horizons to the exclusion of nearly all
other herbs. The least homogeneous herb strata are found in the montane
Tsuga forests (P6) and the montane Tsuga-Gaultheria forests (P7). The
herb strata of these two types (P6 and P7) have very low total coverages
and, although average species richness is low, the total number of spe-
cies encountered is relatively high (Table 23), resulting in herb stratum
heterogeneity within the types.

The bryophyte-lichen layer is overall the least homogeneous of
all the vegetation strata, possibly because it reflects varying micro-
site conditions from stand to stand (microtopography, number of fallen
logs, area of bare rock surfaces, etc.).

The average homogeneities of community types over all strata are
also shown in Table 31. The coastal Thuja forests (T4) and the coastal
wet Thuja forests (T5) have the most homogeneous vegetation; the Flood-
plain forests (F1) have the least homogeneous vegetation. Thuja types
T4 and T5 occur at low elevation very near to the coast where the climate
and other environmental conditions are more uniform (no dry summer period,
no freezing, abundant seepage, thick organic layers, etc.), and where
fire disturbances are unusual (see fire index for Thuja types in Table 31)
and wind disturbances not as frequent as at high elevations. The combi-
nation of these factors may be responsible for the extremely homogeneous
vegetation. By contrast, numerous tree species can grow very success-
fully on floodplains where nutrients and moisture are abundant. The

establishment of seedlings following a major disturbance on a floodplain
is probably mostly a result of stochastic events and proximity of seed
sources, rather than environmental factors, leading to the lack of homogeneity
in the tree stratum. Further heterogeneity is introduced by the flooding
regime which may favor or hinder the development of a particular under-
story species or stratum.

There does not appear to be a clear, general relationship between
the mean richness of a stratum and its homogeneity. The shrub layer tends
to be slightly more homogeneous with increasing richness ($r = .349$), but
the herb layer tends to be slightly less homogeneous with increasing
richness ($r = -.349$). Herb and shrub layers also tend to be less homo-
geneous with increasing fire index values (herbs, $r = -.589$; shrubs,
$r = -.425$), while the tree stratum tends to be more homogeneous ($r = .358$).
The interpretation of the fire index values is limited because they do
not include information on fire intensity or frequency. The fire index
values do indicate that fires have occurred predominantly in dry Pinus-
Pseudotsuga forests (D1) and in all Pseudotsuga types (P3 to P7 in table
31). Fire may be said to be a rare occurrence in types where the fire
index value is smaller than its standard deviation (an estimate of the
variability).

E.   TREE SIZE-CLASS STRUCTURE OF COMMUNITY TYPES

The size-class distributions of tree species can offer some insight into community dynamics so long as certain limitations of this approach are borne in mind (Harper, 1977).   Individuals of a single tree species which become established on a site following a disturbance usually will not have the same size, even when the time of establishment is identical.   Within site differences in nutrient or water availability, and presence of competing neighbours may cause size differences between trees of identical age.   In addition, the establishment of trees following a disturbance is often spread over several years, during which time conditions of resource availability and competition may also vary.   For these reasons, even typically seral species will show a wide range of sizes (although a peak number of stems is usually found in one size-class) in stands that owe their origin to a single disturbance in the past.   This effect is amplified here because data from several plots were compiled for each community type; thus apart from the likely environmental differences between plots, the time and intensity of the disturbance also may vary.   Nevertheless, the graphs (Figs. 15-17) do illustrate differences in size class structure between seral tree species, whose presence results from past disturbance, and shade tolerant species, whose regeneration is not strictly linked to disturbance.   Shade tolerant or "climax" species, will be referred to as "primary" species in the terminology of Brokaw (1980).   Stem numbers in the size-class distribution figures (Figs. 15, 16 and 17) are on a logarithmic scale. It is noted that the classical, reversed "J"-shaped curve remains characteristic of primary species, while a bell-shaped distribution of sizes is associated with seral or pioneer species.

1. PSEUDOTSUGA TYPES

The size-class distribution curves of major tree species in different community types of the Pseudotsuga group are generally similar (Fig. 15). Pseudotsuga menziesii, with most of its stems in the larger size-classes, is characteristic of a seral species; however, this trend is less obvious in community types restricted to the driest, low elevation, inland part of the study area (types D1, P1, P2 and P3). Only in the dry Pinus-Pseudotsuga forests (D1), on rock outcrops, does the size-class distribution of Pseudotsuga menziesii appear characteristic of a primary species. In all types where they are important, Tsuga heterophylla and Thúja plicata have size-class distributions characteristic of primary species. In community types with progressively greater soil moisture supply (types P3 to P5, and the higher elevation type P6), Tsuga heterophylla is increasingly found in larger size-classes. In the montane Tsuga forests (P6), the size-class containing most Pseudotsuga menziesii stems also contains an equivalent number of Tsuga heterophylla stems. This contrasts with the drier, lower elevation Pseudotsuga-Berberis forests (P4), where the size-class with the most Pseudotsuga menziesii stems has very few Tsuga heterophylla stems (Fig. 15). This difference could be caused by a cooler and wetter climate at higher elevations allowing Tsuga heterophylla to grow as rapidly as Pseudotsuga menziesii after a disturbance. Double peaks can be seen in the size-class distribution curves of Pseudotsuga menziesii in types P2 and P7. Because the plots of the Pseudotsuga-Thuja-Acer forests (P2) are very similar environmentally (Appendix 2) and are spatially close (within a 2 km

radius of the Dog Mountain peninsula on Sproat Lake, Fig. 1), it is proposed that the two peaks correspond to two distinct fire disturbances in the past. The largest _Pseudotsuga_ _menziesii_ trees all have fire charred bark. The double _Pseudotsuga_ _menziesii_ peaks in type P7 cannot be interpreted similarly with equal confidence since the plots are scattered spatially.

2. THUJA TYPES

Pinus contorta, in the coastal wet Thuja forests (T5), is the only example of a seral species size-class distribution within the Thuja group (Fig. 16). In the coastal dry Pinus forests (D2) Pinus contorta appears to be a primary species. Abies amabilis, Tsuga heterophylla, and Thuja plicata all have size-class distributions characteristic of primary species (Fig. 16). In the coastal montane Thuja forests (T3) and the coastal Thuja forests (T4), the curves for Thuja plicata are strongly skewed toward the larger size-classes (Fig. 16). This particular size-class distribution may reflect the very large sizes attained by Thuja plicata as well as its impressive longevity of approximately 1000 years, which is twice that of Tsuga heterophylla and Abies amabilis (Waring and Franklin, 1979). Thuja plicata also shows low mortality when mature because of its high resistance to fungal and insect attack (Minore, 1979).

3. ABIES TYPES

In most of the community types presented in Fig. 17, Abies ama-
bilis and Tsuga heterophylla are considered primary species able to
regenerate in the understory; however, wind disturbance may cause the
occasional pulse-like establishment of trees, indicated by peaks in the
larger size-classes of some community types (A3, A4, A5 and T2).

Abies amabilis presents a size-class distribution curve charac-
teristic of a primary species in the A1, A4, and A5 community types.
Tsuga heterophylla may also be considered a primary species in the A1,
A7, and T2 types; however its distribution curves have peaks in the
larger size-classes of the A3, A4 and A5 types, suggesting that distur-
bance may partly explain its presence in these types. The montane
Tsuga-Abies forests (A3), situated on upper mountain slopes and ridges
near the coast, are particularly susceptible to wind disturbance causing
partial or total blowdowns. Stands of this community type have been
observed in various stages of recovery following wind disturbance. A two-
tiered structure caused by wind disturbance in coastal mountain Abies
amabilis and Tsuga heterophylla forests has been described by Klinka
et al. (1979). The upper layer consists of mostly even-sized, dominant
trees; numerous small trees and saplings characterize the understory. Pseu-
dotsuga menziesii's size-class distribution curve in the montane Tsuga-
Abies-Gaultheria forests (A1) is characteristically seral (Fig. 17).

F. TREE SEEDLING ABUNDANCE ON UNDECOMPOSED

WOOD AND FOREST FLOOR SUBSTRATA

The abundance patterns of seedlings of the major tree species on undecomposed wood and forest floor substrata vary greatly within the study area (Table 32). The abundance of _Tsuga heterophylla_ seedlings on undecomposed wood is almost always significantly higher than on the forest floor in the community types studied (Table 32). In community types of the _Thuja_ group, _Thuja plicata_ seedlings are always significantly more abundant on undecomposed wood (Table 32); however, in the drier, inland types (P4 and P6), _Thuja plicata_ seedlings, although of low densities, are equally abundant on both substratum classes (Table 32). _Abies amabilis_ seedlings are, in general, equally abundant on undecomposed wood and forest floor substrata. _Pseudotsuga menziesii_ seedlings occur in equal amounts on both substratum classes in the two community types (P4 and P6) where there were sufficient data for analysis (Table 32). _Pseudotsuga menziesii_ is a long-lived, seral species in these closed canopy, old-growth forests, and is absent from the sapling size-class (Fig. 15). Seedling establishment conditions for this shade-intolerant species are poor, as reflected by low seedling densities (Table 32). Patterns of _Pseudotsuga menziesii_ seedling abundance on organic or mineral soil substrata are likely to be different in a more open environment following a forest fire.

CHAPTER 5

DISCUSSION

A. VEGETATION ANALYSIS

1. GENERAL VEGETATION PATTERNS

The interpretation of the 172 and 140 plots ordinations (Figs. 5 and 6) supports the first two hypotheses formulated in the Introduction. These hypotheses proposed that, in order of decreasing importance, macroclimatic and soil parent material factors would correlate most strongly with the vegetation patterns. In the 172 plots ordination, an elevation macro-climatic gradient is reflected in the vegetation pattern expressed along the first and second axes (Fig. 5), leading to the isolation of a group of subalpine vegetation plots. Low elevation plots, belonging to the floodplain vegetation group and the Pinus contorta vegetation group of rock outcrops, also are isolated on the first axis of this ordination, reflecting a soil parent material gradient, secondary in importance to the macro-climatic gradient which is reflected on two axes (Fig. 5).

The highest elevations represent the cooler end of the macroclimatic gradient, where continuous snow accumulation occurs during winter months. This, in turn, has a marked effect on organic horizons structure, and on tree seedling establishment and survival (Brooke et al., 1970; Klinka et al., 1979). Abies amabilis seedlings are reportedly superior to Tsuga heterophylla seedlings at resisting mechanical damage caused by litter debris accumulating in winter snow packs (Thornburg, 1969).

The larger size of the Abies amabilis seedling (Schopmeyer, 1974) is probably very important in this aspect. Abies amabilis is undoubtedly regenerating the most successfully of all the tree species within the subalpine vegetation group (Table 28).

The parent material gradient separating the floodplain vegetation group from the Pinus contorta group contrasts the droughty, nutrient poor residual soils of rock outcrops, against the moist, nutrient rich alluvial soils of floodplains. Species such as Pinus contorta, Arbutus menziesii, Rhacomitrium lanuginosum and Vaccinium ovatum characterize the rock outcrops (Table 3), and are either tolerant of drought and poor soil nutrient conditions, or they are shade intolerant (Minore, 1979). Arbutus menziesii and Arctostaphylos columbiana are found only on the dry and hot microclimates of rock outcrops near the northern boundaries of their ranges. Rock outcrops of the interior of the study area also represent the only habitats where Pseudotsuga menziesii regenerates within the study area (Table 22).

The characteristic species of floodplains, such as Picea sitchensis, Rubus spectabilis, Ribes bracteosum, Polystichum munitum and Trautvetteria carolinensis, likely have high edaphic requirements, such as abundant moisture and high soil nutrient levels, combined with good drainage. Polystichum munitum probably requires relatively high levels of soil nutrients based on the high potassium (2 %) content of its leaves (Klinka, 1974). Rubus spectabilis and Ribes bracteosum, along with other floodplain species such as Adenocaulon bicolor, Athyrium filix-femina and Melica subulata (Table 25) are known as "nitrate accumulators" from the easily

detectable nitrates in their leaves (Krajina et al., 1982, p. 57). Picea
sitchensis is also beleived to require relatively high soil nutrient
levels (Krajina et al., 1982; Minore, 1979).

The Pseudotsuga, Thuja and Abies vegetation groups were differen-
tiated within an ordination of 140 plots after the removal of plots from
previously identified groups (Fig. 6). Strong correlations with distance
from the coast, on both the first and second axes (Table 6), indicate
that a macro-climatic gradient is again linked to the vegetation patterns
expressed in this ordination. Plots of the Pseudotsuga group are found
in the part of the study area farthest from the coast, while plots of the
Thuja group are found only near the coast. Coastal areas receive 50 %
more annual precipitation than the Port Alberni surroundings (Fig. 2).
The effect of this steep rainfall gradient on the vegetation is explored
further in section 6 (The climatic master gradient). Plots of the Abies
group do not have particular geographical affinities, and although a few
are intermediate in geographical location between plots of the Pseudotsuga
and Thuja groups, most are associated with high elevations or otherwise
micro-climatically cooler sites, such as the bottom of steep-walled
valleys subjected to cold air drainage or delayed snowmelt, or to the
base of steep north-facing slopes (Fig. 9b).

A canonical analysis of the six vegetation groups reveals a clear
separation of the groups based on environmental data (Fig. 13). However,
the floodplain group, the Pinus contorta group and the subalpine group
are not as well separated as in the reciprocal averaging vegetation ordi-
nation (Fig. 5). This is probably results from the abundance of edaphic
variables and the lack of direct climatic variables in the environmental

data matrix used in the canonical analysis (Table 1). In this case, the ordination based on vegetation data is believed to reflect relationships more accurately (Fig. 5). Predictably, the canonical analysis reveals that the vegetation group most environmentally similar to the subalpine group is the Abies group (Table 16). Within the three larger vegetation groups, the Pseudotsuga and Thuja groups are the least environmentally similar (Table 16). Important macro-climatic differences between coastal areas (Thuja group) and more inland areas (Pseudotsuga group) are reflected in these results based on non-climatic variables. Several edaphic variables, such as organic horizons thickness, rooting characteristics, percent carbon and nitrogen in B horizons, and type of disturbance vary along the distance from the coast gradient (Table 6), and are directly or indirectly related to climate. A gradual change occurs from a fire domi-nated disturbance regime inland, towards the coast where fire is virtually absent and the main disturbance factor is wind. In several plots of the Thuja group, windthrow of a few individual trees was the most frequently observed disturbance, although a few large scale wind disturbances were seen (e.g. plots 72 and 151). All of the dominant tree species in the Thuja group, such as Thuja plicata, Tsuga heterophylla and Abies amabilis are characteristically shallow rooting (Minore, 1979); conversely, Pseudo-tsuga menziesii is a deep rooting species (Minore, 1979). The root distri-bution recorded in soil profiles (Appendix 2) reflects forest composition, which is linked in turn to disturbance type, and both are related to climate. The shallow rooting habit of trees near the coast, where the strongest winds occur, may increase the incidence of windthrow. Thuja plicata, the dominant tree species in forests near the coast, is regarded

as being more wind-resistant than Abies amabilis and Tsuga heterophylla (Minore, 1979). Pseudotsuga menziesii, the dominant tree species inland, is considered the most fire resistant of the coastal tree species, and Thuja plicata the least (Minore, 1979). Some community types within the Abies group, such as the montane Abies-Streptopusforests (A4) and the lowland Abies forests (A5), show little disturbance by either fire or wind. Montane Abies-Streptopus forests (A4) occur on steep, but moist, high elevation sites away from the coast, where strong winds and forest fires are infrequent. The montane Tsuga-Abies forests (A3), however, are situated in relatively high elevation sites near the coast and show abundant windthrow.

Soil organic matter accumulation is greatest in forests near the coast, where plant production is nearly continuous owing to the mild climate and plentiful soil moisture (Valentine, 1971). Nutrient cycling may occur predominantly in the thick H horizon of these forests through the intermediary of a recently discovered indigenous earthworm (Spiers et al., 1984). This phenomenon seems closely linked to the presence of most of the tree root mass within the organic horizons of these forests (Spiers et al., 1984). Thuja plicata roots are apparently more numerous in organic layers, when these are thick, than in the underlying soil (Ross, 1932).

Percent carbon is also higher in the mineral B_1 horizons of stands closest to the coast. This reflects a climatically controlled soil gradient from a predominance of Humo-Ferric Podzols inland to a predominance of Ferro-Humic Podzols near the coast (Jungen and Lewis, 1978).

Other environmental variables, such as elevation, percent slope and drainage quality decrease towards the coast, and parent material is more frequently morainal than colluvial (Table 6). These environmental factors are likely associated with changing topography and not related to climate. An exception might be drainage, because it is partially defined on annual duration of soil saturation (correlated with amount of soil mottling), which could be different for identical sites depending on the total amount of precipitation and evapotranspiration. Morainal surficial material, predominant near the coast, has slower drainage than colluvial material, prevalent inland.

2. THE PSEUDOTSUGA GROUP

Within the area where plots of the Pseudotsuga group are found, macro-climate and soil parent material are fairly homogeneous. The environmental factors most closely associated with vegetation patterns appear to be at the scale of meso-climate and soil moisture (Figs. 7a and b, Table 8). These observations support hypotheses 1c and 1d formulated in the Introduction. Meso-climate and soil moisture have been found repeatedly to play a major role in the distribution of vegetation in mountainous areas when macro-climate and parent material were uniform (Whittaker, 1956; 1960; Whittaker and Niering, 1965). The direct ordination of the Pseudotsuga group shows a clear relationship between vegetation patterns and elevation (= meso-climate) and topographic-moisture gradients (Fig. 7b). Low elevation sites with abundant soil moisture, often at the base of mountain slopes, are most frequently occupied by Tsuga-Pseudotsuga-Polystichum forests (P5). Dry sites at higher elevations (500-800 m), such as crests, ridges and steep upper-slopes, are occupied by the montane Tsuga-Gaultheria forests (P7). On sites of intermediate moisture regime, an altitudinal gradient can be followed through the low elevation, warmest Pseudotsuga-Thuja-Acer forests (P2), to the mid-elevation Pseudotsuga-Berberis forests (P4), and to the cooler montane Tsuga forests (P6) (Fig. 7a and b).

Dry Pseudotsuga forests (P1), Pseudotsuga-Linnaea forests (P3) and Pseudotsuga-Thuja-Acer forests (P2) are clearly differentiated vegetationally (Fig. 7a, Tables 22 and 23) but appear similar environ-mentally in the canonical analyses (Figs. 13 and 14). This discrepancy

may be explained by a combination of fire disturbance and soil moisture differences, unaccounted for by the environmental variables used in the canonical analyses, but nevertheless reflected by the vegetation. The dry _Pseudotsuga_ forests (P1), because of the almost exclusive presence of large, scattered _Pseudotsuga menziesii_ trees with charred bark, appear to have had the most recent fires. _Pseudotsuga-Thuja-Acer_ forests (P2) appear to be environmentally very similar to the _Pseudotsuga-Linnaea_ forests (P3) according to the canonical analysis results (Table 17). However, these two community types are distinctly separated on the ordination based on vegetation data (Fig. 7a). The _Pseudotsuga-Linnaea_ forests (P3) contain numerous species associated with dry sites, such as _Gaultheria shallon_ and _Linnaea borealis_, whereas the _Pseudotsuga-Thuja-Acer_ forests (P2) have a higher abundance of species more characteristic of mesic habitats, such as _Polystichum munitum_ and _Tiarella trifoliata_ (Table 23). Increased soil moisture, through seepage, is probably responsible for the observed vegetational differences between the two community types, although fire history also may be important. The environmental variables recorded (Table 1) do not measure soil seepage and would contribute little to the differentiation of the two community types in the canonical analyses (Figs. 13 and 14). Also, only the occurrence of forest fire was recorded, and not its intensity or actual date of occurrence.

The dry _Pinus-Pseudotsuga_ forests (D1) form the dry end of the soil moisture gradient on low elevation rock outcrops (Fig. 7b).

Environmentally, the two most dissimilar community types of the Pseudotsuga group are the Pseudotsuga-Thuja-Acer forests (P2) and the Tsuga-Pseudotsuga-Polystichum forests (P5) (Table 17). The environmental variables most strongly correlated with this difference are topographical position, maximum soil depth and LFH pH (Table 21). The higher soil moisture conditions associated with lower-slopes and level topography, as well as deep soils, are characteristic of the Tsuga-Pseudotsuga-Polystichum forests (P5). Polystichum munitum is a dominant understory component in these forests, and Tsuga heterophylla is regenerating abundantly (Tables 7, 22 and 23). The Pseudotsuga-Thuja-Acer forests (P2) are found only in the warmest and driest sector of the study area, and are characterized by a relative abundance of Thuja plicata, Cornus nuttallii and Acer macrophyllum (Tables 7 and 22). The abundance of these tree species appears linked to soil seepage conditions. The higher pH of the organic layer of these forests probably can be explained by the calcium rich litter of Thuja plicata (Minore, 1979), as well as that from the deciduous species Acer macrophyllum and Cornus nuttallii[1]. The low LFH pH in the Tsuga-Pseudotsuga-Polystichum forests (P5) is probably linked to the abundance of Tsuga heterophylla and the acidifying effects of its litter.

From its central position in both the reciprocal averaging ordination and the direct ordination of the Pseudotsuga group, the Pseudotsuga-Berberis forests (P4) appear to represent the characteristic mesic,

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(1) Cornus florida, closely related to C. nuttallii, has high concentrations of calcium in its leaves (Thomas, 1969).

mid-slope community type of the inland part of the study area (Fig. 7a and b).

The hypotheses put forward in the Introduction concerning the close relationship between vegetation and environmental patterns in old-growth forests, and the possible role of major disturbances (hypotheses 2a and 2b), are well illustrated in the Pseudotsuga group. In general, vegetation patterns closely match the environmental patterns, except for community types P1, P2 and P3 where the relationship is weak (Figs. 13 and 14). These three community types are found in the warmest and driest areas where the Pseudotsuga group occurs, and where forest fire recurrence is probably highest. The strong dominance of Pseudotsuga menziesii in most stands, the abundance of charred bark on trees and charcoal in the soil, all present direct evidence in support of this assumption. Thus, different fire histories, rather than edaphic factors, may be the cause of vegetational differences between some of the community types within the Pseudotsuga group.

3. THE THUJA GROUP

While macro-climate is relatively uniform within the coastal sector where most of the plots from the Thuja vegetation group are found, the same cannot be said of soil parent material. Surficial deposits vary from poorly drained marine clays or sands, to imperfectly drained cemented tills and to well drained colluvium. Considering the variety of parent materials, a soil nutrient gradient very likely influences the vegetation pattern within the Thuja group. This is supported by the numerous correlations between the first reciprocal averaging ordination axis of the Thuja group and soil nutrient variables, such as percent nitrogen in LFH and B_1 horizons, and C/N ratio in the LFH (Table 10). This soil nutrient gradient appears to be linked to a site productivity gradient which, in the direction of increasing productivity, is reflected in the vegetation by increasing maximum tree height, decreasing tree species richness and decreasing total coverage of the shrub and bryophyte strata (Table 10). Species richness is expected to decrease towards more productive environments, through increased competitive interaction between species (Del Moral, 1983). The increased amount of light·resulting from the sparse overstory of poor sites, seems especially favourable to the development of a very dense shrub layer, where Gaultheria shallon and Vaccinium ovatum are particularly important. Two community types of the Thuja group, the coastal dry Thuja forests (T1) and the coastal wet Thuja forests (T5), although at opposite ends of the moisture gradient (Fig. 8b) are grouped together at the nutrient-poor end of the soil nutrient gradient reflected on the first axis of the vegetation ordination (Fig. 8a). Coastal Tsuga-Blechnum-Polystichum forests (T2) have the best soil nutrient and

drainage characteristics, and are probably the most productive forest communities within the Thuja group. Half of the plots of this community type occurred on ancient landslides, which may have improved soil drainage and nutrient conditions. Coastal Tsuga-Blechnum-Polystichum forests are also found at mid-elevations on mountain slopes (Fig. 8b), several kilometers away from the coast. Summer fogs rarely occur at these mid-elevations, and this may permit greater productivity through increased solar radiation. The effects of summer sea fogs on solar radiation and moisture have been described for the coast of California (Azevedo and Morgan, 1974).

An altitudinal gradient was also detected in the Thuja vegetation group. The low elevation, widespread coastal Thuja forests (T4) inter-grade at higher elevations with the coastal montane Thuja forests (T3), characterized by an increased importance of Abies amabilis in the tree, sapling and seedling layers (Table 24). Along a soil moisture gradient, the driest sites are rock outcrops where only the coastal dry Pinus forests (D2) are found (Fig. 8b).

Although a direct ordination separated the various community types or the Thuja group on altitudinal and topography-moisture gradients (Fig. 8b), these same gradients are not distinctly reflected in the indirect ordi-nation based on vegetation data alone (Fig. 8a). Moreover, elevation does not seem to exert the strongest influence on vegetation, as was hypothesized in the Introduction (hypothesis 1c). Instead a soil nutrient gradient appears to be most closely linked with the main vegetation variation (Table 10). Soil moisture appears to have little influence

on vegetation patterns, probably because precipitation exceeds 3 000 mm

annually and soil water deficits are non-existent (Fig. 2).

Elevation is clearly the second most important environmental

gradient in the canonical analysis of the Thuja group (Fig. 13, Table 21),

but an outlier plot (no. 85) tends to obscure the relationship with

elevation in the indirect ordination (Fig. 8a, Table 10). Also strongly

correlated with the second canonical axis is percent slope (Fig. 13,

Table 21), suggesting a link between vegetation patterns and a gradient

in soil moisture, from saturated soils at low elevations to better drained

soils at higher elevations. This could occur through better drainage

(increased slope) and absence of fog at higher elevations.

It should be noted also that previous studies demonstrating the

strong correlation of elevation (hypothesis 1c) and moisture (hypothesis

1d) gradients with the vegetation patterns of mountainous areas were

carried out in drier climates, where summer soil moisture deficits occur

frequently (Whittaker, 1956; 1960; Whittaker and Niering, 1965; Peet,

1981). Thus slope aspect and topographical position are expected to

influence vegetation patterns wherever soil moisture is limited. In the

coastal part of this study area, where soil moisture is probably abundant

year round on all slope aspects and most topographical positions, the

influence of soil moisture on vegetation patterns may be greatly reduced

or nullified.

Large scale disturbance by fire is absent from areas near the coast,

large scale windthrow is infrequent and natural landslides rarely occur.

Thus, it would appear than in this relatively stable environment, old-growth

forests have become closely attuned to their environments and vegetation accurately reflects environmental gradients (hypothesis 2a), based on the results obtained from canonical analyses (Figs. 13 and 14, Tables 18 and 20).

4. THE ABIES GROUP

The Abies vegetation group is not associated with a specific
geographical area; therefore, macro-climate (mostly precipitation) is
less homogeneous than in the Pseudotsuga and Thuja groups. The Abies
group is characterized by the dominance of Abies amabilis or Tsuga
heterophylla, or both (Table 26). Environmentally, the majority of
community types recognized within the group are found in sites with cool
micro-climates. The lowland Abies forests (A5) are generally found at
the bottom of steep valleys, often on north-facing slopes or on the upper
terraces near rivers. In the drier parts of the study area, lowland
Abies forests (A5) were encountered most frequently in river valleys
at the base of steep north-facing slopes, while Tsuga-Pseudotsuga-
Polystichum forests (P5) occupied the opposite south-facing slopes
(plots 29 and 27, Figs. 1, 7b and 9b). Such a distribution may be
explained by a cooler micro-climate on the northern aspect, where a lesser
amount of solar radiation leads to lower evapotranspiration rates, higher
soil moisture levels, and delayed snow melt in the spring. Cold air
drainage also may be involved in the case of some narrow valleys.

In northern Washington, Abies amabilis forests predominate between
600 to 1300 m in elevation, where temperatures are cool, precipitation
is high and snowpack is deep (Teskey et al., 1984). Low summer water
deficits and low air temperatures have been reported as characteristic
of areas where Abies amabilis is dominant (Waring et al., 1972). The
montane Abies-Streptopus forests (A4) are all found above 600 m in eleva-
tion on north-facing slopes, inland within the study area (Fig. 9b).

This community type probably has the coldest environmental conditions of all those studied, except for the subalpine vegetation group. At lower elevations, but near the summit of small mountains near the coast, are found the montane Tsuga-Abies forests (A3). This community type usually occurs immediately above stands of the coastal montane Thuja forests (T3), on steeper slopes with faster drainage, and higher probabilities of wind disturbance. Plot 151 was sampled in a dense stand of Tsuga heterophylla and Abies amabilis originating from a complete windthrow of the previous forest (Fig. 9a and b). The montane Abies-Tsuga forests (A2) occur in similar topographical situations as the montane Tsuga-Abies forests (A3), but at higher average elevation inland, where snowpack is probably deeper and of longer duration. The higher relative densities of Abies amabilis seedlings and saplings in type A2, as compared to type A3, indirectly support this suggestion.

The Tsuga-Blechnum-Polystichum forests (A7) are one of the two community types within the Abies group to be almost entirely dominated by Tsuga heterophylla. This is strictly a low elevation community type, where relatively recent disturbances (100-200 years) may have played an important role in the strong Tsuga heterophylla dominance. However, the Tsuga-Gaultheria-Blechnum forests (A6), also dominated by Tsuga heterophylla, appear to be climatically controlled and probably represent an intermediate community type along a precipitation gradient beginning with the coastal Thuja forests (T4) and ending in the driest inland sector around Port Alberni, with community types of the Pseudotsuga group. Finally, the montane Tsuga-Abies-Gaultheria forests (A1) occupy the driest habitats within the Abies vegetation group (Fig. 9b).

In terms of the major environmental gradients correlated with vegetation patterns in the Abies group, hypotheses formulated earlier appear to be confirmed (1c and 1d), although the precondition that macro-climate be uniform is not held. It is possible that strong micro-climatic effects override macro-climate in the case of the Abies group. The Abies community types found in the interior of the study area, may avoid soil moisture deficits and high temperatures because they occupy habitats with characteristically cool and moist micro-climates (types A2, A4 and A5). A climatic gradient, from the cool climates where community types A4, A5 and A2 are found to the milder climates where the A7, A6 and A3 community types are found, is reflected in the first axis of the reci-procal averaging ordination (Fig. 9a). The third axis separates the only community type of dry habitats (A1) from the other types. The direct ordination of the plots also illustrates these gradients of meso-climate (linked to elevation) and soil moisture (linked to slope aspect and topographical position). a finer topographical position scale would probably resolve the overlap between types A7 and A5 (Fig. 9b).

The interpretation of the canonical analysis of the Abies group is limited because only four environmental variables were used. Never-theless, low elevation community types (A5, A6, A7) are separated from higher elevation community types (A4, A2, A3), and those occurring on steep slopes (A2, A3) are separated from those occurring on gentle slopes or level terrain (A5, A6) (Fig. 13, Table 21). Increasing organic horizons thickness, positively correlated with the first canonical axis (Table 21), is characteristic of the montane Abies-Streptopus forests (A4), where cooler temperatures and long snowpack duration are expected

to impede organic matter decomposition. It is surprising to note how similar vegetationably the montane _Abies-Streptopus_ forests (A4) are to the lowland _Abies_ forests (A5), but how dissimilar they are environmentally (Figs. 9a and 14, Tables 19, 20, 26 and 27). Environmental similarity would undoubtedly increase if climatic variables were available to include in the analyses, allowing micro-climatic similarities between the two types to surface.

5. VEGETATION CLASSIFICATION

Classification of individual plots into broad vegetation groups,
as well as into more narrowly defined community types was acheived using
successive ordinations of the vegetation data (Peet, 1980). Overall,
the community types and vegetation groups defined following this approach
also differ environmentally. This is demonstrated by the canonical
analysis of all community types and the subalpine vegetation group based
solely on environmental data (Fig. 14). These results generally indicate
that differences at the plant community level are paralleled by diffe-
rences at the environmental level within the study area (hypothesis 2a).
Such a close vegetation – environment correspondance was expected at the
outset of this study because of the sampling of "old-growth" forests.

The effects of fire disturbance are probably at least partially
responsible for the weaker matching between vegetational and environmental
differences encountered in some community types within the Pseudotsuga
group: (types P1, P2 and P3). Differing fire disturbance histories are
hypothesized to be the cause of the difference in vegetation composition
between these particular community types. Soil seepage, unaccounted for
in the set of measured environmental variables, also may explain why the
Pseudotsuga-Thuja-Acer forests (P2), with a characteristically mesic
vegetation, are grouped environmentally with the Pseudotsuga-Linnaea
forests (P3) of drier habitats in Fig. 14. However, these results
(Fig. 14) represent only the first two canonical axes. When Mahalanobis
squared distances accounting for all dimensions are inspected, we find
that the dry Pseudotsuga forests (P1) are much more environmentally

similar to the Pseudotsuga-Linnaea forests (P3), than this latter community type is to the Pseudotsuga-Thuja-Acer forests (P2) (Table 20). Therefore, community types P1 and P3 are the most likely to have vegetational differences based on differing fire histories because they are the most environmentally similar . The Pseudotsuga-Thuja-Acer forests (P2) are thus more likely to show vegetational differences from types P1 and P3 on the basis of the presence of unrecorded soil seepage.

Evidence from discriminant analyses also suggests a weaker relationship between environmental characteristics and vegetation composition in the Pseudotsuga group. Using discriminant functions based on environmental data to re-classify plots into community types (originally defined by composition) it was found that a correct re-classification was obtained for 62.5 % of the plots from the Pseudotsuga group. In the Thuja vegetation group the re-classification success was 69.4 %. Re-classification success for all community types analyzed together was 72.5 % (Appendix 4). This shows a lower concordance between environmental characteristics and vegetation composition in the Pseudotsuga group, subjected to large scale fire disturbances, as compared to the Thuja group where disturbances are less prevalent, or to the entire study area. Thus, the hypothesis formulated earlier regarding the effect of disturbance seems to hold (Introduction, 2b).

High environmental similarities between community types of different vegetation groups is observable between the T2 type of the Thuja group and the A7 type of the Abies group, as well as between the A1 type of the Abies group and the P6 and P7 types of the Pseudotsuga group (Fig. 14,

Table 20). In both cases these community types are environmentally more
similar to types of another vegetation group, than to community types
within their own vegetation group. This resulted from the separation
of plots for further analyses through successive ordinations; these
particular community types being near the edges of separated plot
clusters on the ordination diagrams. This situation can be seen as a
reflection of the continuous nature of vegetation, and an excellent
example of the difficulty encountered in attempts at partitionning this
continuum for classification purposes. The vegetational and environ-
mental differences between these community types are sufficient to maintain
their separate status. However, the coastal Tsuga-Blechnum-Polystichum
forests (T2) might fit just as well with the Abies vegetation group;
similarly, the montane Tsuga-Abies-Gaultheria forests (A1) could be
included with the Pseudotsuga group (Fig. 14, Table 20).

Environmental differences detected through the canonical analyses
are sometimes slight between two community types which are differentiated
vegetationally along only one major environmental gradient, such as ele-
vation. This is particularly evident in the case of the Pseudotsuga-
Berberis forests (P4) and the montane Tsuga forests (P6), adjacent
community types along an elevation gradient of mesic sites on inland
mountain slopes (Figs. 7a, 7b and 14, Table 20).

Environmental relationships between community types of the three
larger vegetation groups were analyzed individually within each group
(Fig. 13). The results are similar to those obtained in a global analysis
of all community types from all vegetation groups (Fig. 14). The latter

analysis has the advantage of showing the relationships between community types of different vegetation groups, as well as possibly improving the characterization of within group relationships through increased total variation in the environmental variables employed.

6. THE CLIMATIC MASTER GRADIENT

The successive vegetation ordination approach has revealed a variety of environmental gradients correlated with vegetation variation in each set of plots analysed. A macro-climatic gradient from low elevation vegetation to subalpine forests was detected in the first ordination, as well as a parent material gradient from floodplains to rock outcrops (Fig. 5). A subsequent ordination detected what appeared to be a general gradient of increasing distance from the coast, linked with macro-climate (Fig. 6). In other ordination of smaller groups of plots, gradients of elevation (meso-climate), soil moisture (topography) and soil nutrient factors were correlated with vegetation patterns. The major macro-climatic gradient of precipitation occurring in the study area had not been clearly identified in the vegetation ordinations, except perhaps in the one using 140 plots (Fig. 6). Thus, an ordination of modal plots was done in order to assess the importance of this macro-climatic gradient on the general vegetation patterns within the entire study area. The modal plots were selected from all the sampled plots with the objective of producing a data set in which edaphic and meso-climatic variations would be minimized. Such a technique has been called the "functional approach to plant community ecology" (Austin et al., 1984) and assumes that if certain factors known to influence vegetation are held constant, in this case through data manipulation, the relationship between vegetation and the factor allowed to vary can be analyzed. Plots located at both extremities of the edaphic gradients of soil moisture and soil nutrients were eliminated, as well as plots at the cooler end of meso-climatic or micro-climatic gradients. Modal plots represent low-

to mid-elevation sites of intermediate edaphic conditions throughout the study area. Because of the selection criteria, very few plots were included from the Abies vegetation group. The majority of modal plots come from the Pseudotsuga and Thuja vegetation groups, both occurring in geographically distinct areas.

The results of the reciprocal averaging ordination of the modal plots show that the vegetation pattern expressed on the first two axes is strongly correlated with the distance from the coast (Fig. 10, Table 14). It is assumed that the distance from the coast gradient is closely linked to a steep precipitation gradient. Evidence for this major climatic gradient is easily obtained (Figs. 2 and 12). Precipitation decreases from an average of over 3 000 mm annually to less than 2 000 mm within a 60 km distance from the coast (Fig. 2). The same trend can be seen during the growing season (fig. 12), when soil water deficits are most likely to occur inland (Fig. 2). The steepness of this precipitation gradient is a result of orographic precipitation and rain shadow effects caused by the interception of moisture laden air masses by high mountains parallel to the coast. Even though the annual mean temperature is only slightly higher inland than on the coast (Fig. 2), this difference translates into 200-300 extra effective growing degree-days annually for the inland areas (Fig. 12). Therefore, more heat is available inland for the growth of plants. However, soil moisture deficits may be encountered inland during July or August (Fig. 2).

The precipitation gradient directly influences a disturbance type gradient. Fire disturbance is undoubtedly predominant in its scale and its effect on vegetation at the low precipitation end of the gradient

(Table 14). Towards the coast, with increasing precipitation and the absence of soil moisture deficits, forest fires rarely occur and the main disturbances are caused by wind (Klinka et al., 1979). Improving drainage away from the coast reflects a natural change in topography to steeper slopes and more abundant colluvial material, as well as a much shorter annual period of soil saturation (Table 14). Numerous other soil attributes vary along the distance from the coast-precipitation gradient (Table 14). The strongest correlation is with the organic horizons thickness/effective rooting depth ratio. This ratio decreases inland, where trees are more deeply rooted into the mineral soil, and increases towards a value of 1 near the coast, where the effective rooting depth often coincides with the thickness of the organic horizons (Table 14, Fig. 12). The thickness of the organic horizons is, in turn, probably related to climate. Plentiful moisture and mild temperatures lead to abundant and nearly continuous plant growth on the coast, and to the accumulation of thick organic soil horizons (Valentine, 1971). Decomposition may be slowed by a heat deficit, compared to inland areas. Plant productivity is probably reduced inland by summer soil moisture deficits and by colder winter temperatures, leading to a lesser accumulation of litter. Decomposition of this litter probably proceeds faster than on the coast because of higher summer temperatures. Organic horizons thickness is also partially related to the type of vegetation and the type of litter produced, influencing decomposition rates and by-products (acidity, nutrients). However, vegetation itself is also closely related to the precipitation gradient. Whether the climate or the vegetation exerts the strongest influence on organic horizons thickness may be difficult to assess.

Different tree species are known to have distinct rooting depth patterns (Minore, 1979; Eis, 1974; McMinn, 1963; Strong and La Roi, 1983). Pseudotsuga menziesii, dominant inland, is known to be a deep rooting species (Minore, 1979). Thuja plicata, Tsuga heterophylla and Abies amabilis, dominants near the coast, are known to be shallow rooting (Minore, 1979). Shallow effective rooting near the coast also may result partially from increased waterlogging of the soil as a product of high precipitation. Whatever the cause, it remains that the tree root mass is often restricted to the organic horizons in natural forest communities near the coast. As distance from the coast increases, the tree root mass occupies more and more of the mineral soil. This tendency is correlated with increasing dominance by Pseudotsuga menziesii and decreasing precipitation (Figs. 11 and 12). Total tree basal area tends to increase towards the coast and may indicate an increase in forest productivity linked with the precipitation gradient (Table 14). Maximum tree height decreases near the coast, possibly reflecting the change in dominant tree species (Waring and Franklin, 1979) or increasing wind disturbance, or both (Table 14).

The vegetation pattern and changing environmental variables along the precipitation gradient are documented by the ordination of modal plots (Fig. 10) and by correlations between site variables and ordination axes (Table 14). Also of interest is the graph showing the distribution patterns of major tree species along this same gradient (Fig. 11). Pseudotsuga menziesii and Thuja plicata each attain their maximum and minimum basal areas, at opposite ends of the gradient (Fig. 11). Although not indicated in the graph, Thuja plicata is present in small amounts at

the dry end of the gradient, but the polynomial curve follows the best fit of the more abundant data near the wetter end of the gradient. The presence of a Pseudotsuga menziesii peak at the dry end of the gradient is not surprising in light of this species' well known adaptation to fire (Franklin and Dyrness, 1973; Minore, 1979). Other species, such as Tsuga heterophylla, Thuja plicata and Abies amabilis, possess thin bark and are usually killed by fire. These species are also more tolerant of cooler temperatures (or less heat available for growth) as can be inferred from their northern distributions along the coast, whereas Pseudotsuga menziesii reaches its northern coastal distribution limit on Vancouver Island (Krajina et al., 1982). The slight decrease in Pseudotsuga menziesii and increase in Tsuga heterophylla basal areas past the 50 km mark may be a response to increasing orographic precipitation caused by a second major ridge of mountains just west of Port Alberni (Fig. 11).

Towards the wet end of the gradient Thuja plicata reaches an average basal area of 120 m^2/hectare in modal vegetation 10-15 km from the coast, then declines to less than 80 m^2/ha within 5 km of the coast. This decline could reflect a lowered forest productivity near the coast due to the high frequency of summer fogs. These fogs reduce the amount of solar radiation reaching the forest canopy, thus reducing photo-synthesis and impeding evapotranspiration rates. Although low produc-tivity sometimes results from low soil nutrient levels, this seems unlikely here since percent soil nitrogen increases towards the coast, in both the organic LFH and mineral B_1 horizons (Table 14). Abies amabilis basal area increases linearly in modal vegetation towards the coast (Fig. 11), in agreement with the general autecological characteristics ascribed to this species (Minore, 1979; Krajina et al., 1982).

The relationship between basal area and distance from the coast is more complex in Tsuga heterophylla than in the other species examined (the polynomial equation for T. heterophylla has the lowest r^2 value, Fig. 11). Toward the dry end of the gradient, the observed drop in basal area may reflect a combination of fire disturbance and sub-optimal moisture conditions. Toward the coast, the decline and slight rise in Tsuga heterophylla basal area coincide with an opposite trend in Thuja plicata. This is suggestive of a comptetitive interaction between the two species (possibly for space which is occupied for greater periods by the longer lived Thuja plicata (Waring and Franklin, 1979)) since abiotic conditions near the coast are unlikely to impair the growth of Tsuga heterophylla. In only a small segment of the gradient does Tsuga heterophylla become the dominant tree in terms of basal area (29 to 31 km from the coast). This region appears to represent a transition zone between coastal and inland forest types where, perhaps, decreased competition from the other dominants permits better growth in Tsuga heterophylla.

The organic horizons thickness/effective rooting depth ratio also varies with distance from the coast (Figs. 11 and 12). The ratio is lowest toward the dry end of the gradient, in the region of Pseudotsuga menziesii's peak in basal area, and increases towards the wetter end of the gradient. This ratio reflects the different utilization of the soil horizons (organic vs. mineral) by the roots of the changing assemblage of tree species along this major climatic gradient (Pseudotsuga menziesii vs. Thuja plicata).

The results illustrated by Figure 11 have major implications for forest management. Because of its economic desirability, Pseudotsuga menziesii has been for many years the preferred species for replanting after

logging in this area. Yet the data presented here show that Pseudotsuga menziesii is not an important species within 25 km of the coast, and that it is totally absent within 15 km of the coast on modal sites (Fig. 11). Pseudotsuga menziesii is present near the coast, however, in a few non-modal sites such as rock outcrops (e.g. the coastal dry Pinus forests, Table 24), although such sites are unproductive and are not usually logged. Other more productive sites, which may be considered modal, have been replanted with Pseudotsuga menziesii after logging. These sites, often very near to the coast, previously would have supported mature stands of Thuja plicata, Tsuga heterophylla and Abies amabilis. The absence of Pseudotsuga menziesii from the natural modal vegetation could be attributed simply to the lack of forest fires, although other types of disturbances, such as blowdowns and landslides, occasionally occur which would create openings for this species. A few Pseudotsuga menziesii trees have indeed been found near the coast on steep slopes of old landslide colluvium in the Cypre River valley and near Kennedy Lake. Nevertheless, the question remains why Pseudotsuga menziesii is not a more widespread and important species in the immediate vicinity of the coast.

The answer to this question may have been found recently by Spiers et al. (1983) studying Pseudotsuga menziesii plantations near the coast. The trees in these plantations are starting to show serious growth defects, 20 to 30 years after planting. Abnormally high levels of arsenic have been detected in the leaders of planted Pseudotsuga menziesii, while levels in adjacent, naturally regenerating species were near background levels (Spiers et al., 1983). These authors have suggested that arsenic is found in an arsenate form (Sadiq et al., 1983), analogous to a form of phosphate

absorbed by plants, in the frequently waterlogged mineral soil. Anaerobic and reducing conditions encountered in saturated soils may hinder also the natural physiological processes of selective soil nutrient uptake by *Pseudotsuga menziesii* roots, leading to the uptake of potentially toxic arsenate along with the nutrient phosphate. High arsenic concentrations in the meristems of the tree could possibly cause growth defects by interfering with the synthesis of plant growth hormones (Spiers et al., 1983). The delay in the appearance of symptoms probably is related to the time required by the deep, rooting *Pseudotsuga menziesii* to reach the satured lower horizons where arsenic will occur in the arsenate form. The delay also could be related to a slow accumulation of arsenic up to a critical point when toxicity occurs. Soil saturation is probably highest in the spring when active growth is taking place (Spiers et al., 1983). Waterlogging is probably increased on the plantation sites following the removal of the original vegetation which removes large amounts of soil moisture through evapotranspiration. These excessive soil moisture conditions at greater depths are avoided by *Thuja plicata*, *Tsuga heterophylla* and *Abies amabilis* because of their shallow rooting habits. Avoidance of saturated soil horizons probably occurs also for *Pseudotsuga menziesii* on the rapidly drained sites, such as rock outcrops and old landslide colluvium, where it is found near the coast. Carter et al. (1984) have described growth abnormalities, identical to those reported by Spiers et al. (1983), in other coastal plantations of *Pseudotsuga menziesii*. They tentatively diagnosed a boron deficiency from tissue and soil analyses, although arsenic concentrations were not reported.

An increase in alpha diversity of vascular plants (species richness) with increasing continentality, or distance from the coast, was observed by Whittaker (1960) in the forest vegetation of south-coastal Oregon. Del Moral and Watson (1978) reported similar findings for the Washington Cascades. Oksanen (1983) describes an increase in alpha diversity of lichens and vascular plants with increasing continentality in Finland. These trends were observed also in western Vancouver Island, supporting hypothesis 1e formulated in the Introduction. The alpha diversity gradient is particularly steep in the case of vascular plants, with fewer than 16 species occurring on average in the 0.05 ha plots near the coast, increasing to an average of more than 26 species in inland plots (Fig. 12). Bryophyte species richness appears to increase towards the wetter coastal areas, while vascular species richness increases towards the more continental and drier areas, particularly the herb layer (Table 19).

Numerous factors have been proposed to account for gradients in vascular plant diversity, but a synthesis of the causes underlying the patterns at different scales has not yet been acheived. At the micro-scale level, Del Moral's (1983) experimental results, based on the theoretical and conceptual frameworks of Grime (1980), Tilman (1980) and Huston (1979), demonstrate the effects of a combined interaction of site productivity, disturbance level and moisture stress on species diversity in subalpine meadows. On a larger regional scale, Whittaker (1975) suggested that site productivity and moisture levels were not the major controls of vascular plant alpha diversity, but that heat (possibly measured by growing degree-days) may represent the key factor. Recent experimental results indicate that the most productive sites have lower

alpha diversity than sites with intermediate productivity (Del Moral, 1983).

The explanation offered in this case is that competitive interactions

between species tend to reduce diversity in productive sites. Extreme

physical stress also tends to reduce diversity, but it enhances it at

intermediate levels by again preventing or reducing competitive inter-

actions (Del Moral, 1983). Disturbance plays a major role in increasing

diversity, and the more productive the site the more frequent the dis-

turbances must be in order to prevent the competitive exclusion of several

species by one or a few dominants (Del Moral, 1983). Thus, it may be

that the more frequent large scale forest fire disturbances of the interior

part of the study area enhance vascular plant alpha diversity. On the

other hand, the relatively stable environment of the coastal sector may

allow strong competitive interactions to take place and reduce diversity.

Dominance concentration (Whittaker, 1975; Peet, 1974) is also much higher

in the shrub and herb strata of the community types of the Thuja group than

of the Pseudotsuga group (Tables 23 and 25). High dominance concentration

(= low equitability) implies that a stratum, or community, is strongly

dominated by one or a few species (Whittaker, 1975).

Beta diversity also has been observed to increase from coastal to

more continental areas (Whittaker, 1960; Del Moral and Watson, 1978). As

used here, beta diversity [1], refers to the number of half-changes in

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1 Beta diversity = (log a − log z)/log 2, where a = replicate plots

 similarity, and z = extreme plots similarity. Plot similarities were

 measured using the cosine function which reflects quantitative changes

 in species representation.

compositional similarity that occur along distinct environmental gradients (Whittaker and Woodwell, 1978). This measure was useful for comparing vegetation-environment relationships in two geographically distinct groups of plots along the major rainfall gradient : (1) the Pseudotsuga vegetation group representing the drier, more continental interior sector, and (2) the Thuja group representing the very humid, coastal sector. Beta diversity along a soil moisture gradient (at low elevation) was 4.8 in the Pseudotsuga group (endpoints : plots 110 and 17, Fig. 7b); in the Thuja group (endpoints : plots 53 and 50, Fig. 8b) beta diversity was 0.7. Along an elevation gradient, values of 4.7 in the Pseudotsuga group (endpoints : plots 13 and 139, Fig. 7b) and 0.3 in the Thuja group (endpoints : 50 and 152, Fig. 8b) were obtained. Difference in total lengths of the elevation gradients concerned (800 m in the Pseudotsuga group and 600 m in the Thuja group) are considered insufficient to explain the large discrepancy in the beta diversity values calculated. The decline in temperatures with increasing elevation probably leads to greater moisture availability through reduced evapotranspiration, thus superimposing a soil moisture gradient on elevation. This could explain the high beta diversity of the Pseudotsuga group along the elevation gradient, since soil moisture conditions would be expected to vary more widely with elevation here than in the Thuja group. Evapotranspiration would not be expected to differ significantly between high and low elevations in the Thuja group, because of the frequent occurrence of summer fogs at low elevation.

The higher beta diversity of the Pseudotsuga group along the soil moisture gradient at low elevation probably reflects the greater length of this gradient in the drier interior sector. Differences between dry

and wet habitats are greater in absolute terms in dry areas (vegetation growing on rock outcrops experiences longer periods of drought in dry areas than in areas of high precipitation). On the other hand, wet habitats would be similar in terms of absolute soil moisture availability, in wet or dry areas. Slope aspect effects on soil moisture and on the amount of heat available for growth are also likely to be stronger in the drier, interior sector.

Thus, the trends in beta diversity identified here are in general agreement with results from other studies on coastal forests (Whittaker, 1960; Del Moral and Watson, 1978). The same trend applies along both the environmental gradients of soil moisture and elevation.

7. HOMOGENEITY AND SPECIES RICHNESS OF STRATA

The investigation of homogeneity in separate strata of fourteen community types supports the third hypothesis formulated in the Introduction (Table 31). The community types of the Pseudotsuga vegetation group have, on average, a vegetation homogeneity of 0.72, while community types of the Thuja vegetation group have, on average, a vegetation homogeneity of 0.84. The high mean fire indices within the Pseudotsuga group indicate that fire is a common form of disturbance (Table 31); the opposite is true for the community types of the Thuja group (Table 31). Thus, it appears that large scale disturbances such as fire may tend to reduce vegetation homogeneity. If the vegetation of the two groups is compared on a stratum by stratum basis, few differences are seen for the tree, seedling and bryophyte-lichen layers (Table 31). The largest difference occurs at the level of the herb stratum, with an average homogeneity of 0.96 in the Thuja group and 0.47 in the Pseudotsuga group. The shrub and sapling layers are also markedly more homogeneous in the Thuja vegetation group. Interestingly, a significant positive correlation exists, over all types, between increasing fire index values and decreasing homogeneity of the herb and shrub strata ($r = -.589$ and $-.425$). The reverse occurs in the tree stratum, where homogeneity increases with increasing fire index values ($r = .358$). This result reflects the abundance of homogeneous post-fire stands strongly dominated by Pseudotsuga menziesii, the only major tree species of the study area well adapted to forest fire disturbances.

The seedling stratum is generally the most homogeneous within the entire study area (Table 31). The explanation for this may be that most communities have closed canopies permitting only shade tolerant tree seedlings to germinate and become established. In support of this hypothesis, it can be seen that rock outcrop communities, with open canopies and mixtures of shade tolerant and intolerant seedlings, have lower seedling layer homogeneities. Floodplain forests (Fl), often relatively open and with ideal germination and early growth conditions (ample moisture and soil nutrients), have the lowest seedling stratum homogeneity of the community types studied (Table 31). The least homogeneous vegetation layer is by far the bryophyte-lichen layer. This stratum is strongly influenced by the micro-heterogeneity of the forest floor. An exception is found in the very homogeneous bryophyte-lichen layer of the Pseudotsuga-Linnaea forests (P3). This community type is characterized by a nearly complete cover of Hylocomium splendens giving it the highest dominance concentration (= lowest $1/\lambda$ value or highest λ value) for this layer in all the community types described (Tables 23, 25 and 27). In fact, as a general rule it appears that any vegetation stratum with a high homogeneity is likely to have a strong dominance concentration, which means that one species has a much higher coverage, or relative density, than other species in the layer. The extremely homogeneous shrub and herb layers of the coastal Thuja forests (T4) are a good example (Tables 25 and 31), as are the sapling and seedling layers of the Tsuga-Blechnum-Polystichum forests (A7) (Tables 26 and 31).

The two most homogeneous community types are the coastal wet Thuja forests (T5) and the coastal Thuja forests (T4) (Table 31). The coastal

wet Thuja forests(T5) have extremely homogeneous vegetation strata, all
above 0.9 except for the bryophyte layer. This community type is found
only within a narrow range of environmental conditions, disturbances are
rare, and it is not very widespread (Fig. 8b). The coastal Thuja forests
(T4), on the other hand, occupy a wider range of environments near the
coast (Fig. 8b). This, and the fact that the 19 plots used to calculate
the homogeneity values came from a relatively large area, amplifies the
extraordinary homogeneity of these forests. The herb stratum is remarkable
with its homogeneity of 0.98. This undoubtedly results from the nearly
exclusive dominance of Blechnum spicant, growing profusely on the thick,
forest floor organic horizons characteristic of this community type
(Table 25). The reasons for such high homogeneity may lie in the relatively
uniform climate, with no extreme temperatures, abundant moisture and a
very low frequency of major disturbances. Fire is virtually absent, and
major windthrow is unusual at the low elevations where these forests
occur. Occasionaly, individual trees are blown down, but such occurrences
do not appear to initiate significant changes in understory conditions
because of the naturally open nature of the canopy of very large and
widely spaced Thuja plicata trees. This combination of minimal disturbance
and optimal plant growth conditions seems, in large part, responsible for
the low species richness and diversity, and the concentration of dominance
in a small number of species in each stratum. In the coastal Thuja forests
(T4) the increasing homogeneity through seedling, sapling, and tree layers,
suggests that a process of elimination (through competition?) takes place
during the development of the forest canopy (Table 31). This may be related
to the longevity of Thuja plicata, whose life span is twice that of

co-dominant tree species (Waring and Franklin, 1979). This inference of a monopolization of space by a long-lived species corresponds to the inhibition model of Connell and Slatyer (1977).

The least homogeneous community type are the floodplain forests (F1) (Table 31). Colonization of floodplains after disturbance is more likely linked to stochastic events and available seed sources than to the ecological tolerances of species. The differing ages of formation of the floodplains sampled, as well as their differing flooding regimes, add to the observed heterogeneity. Compared with other community types, the surficial materials of floodplains are much younger and are subject to a higher disturbance frequency in the form of floodings (mechanical damage or new sediment deposition). The high species richness of the herb stratum of the floodplain forests (F1) appears largely linked to this more or less regular and frequent disturbance regime as well, because a low species richness would be predicted for such productive sites (Table 31). Del Moral (1983) has shown that with increasing site productivity, disturbance regime had to increase as well to maintain species diversity by reducing the occurrence of competitive interactions. Floodplain forests (F1) have the highest species richness of community types of mesic habitats within the study area (Table 30).

No distinct relationship was found between species richness and homogeneity of vegetation strata when all community types and all strata were considered, possibly because the data were too heterogeneous for any clear trends to emerge.

B. COMMUNITY DYNAMICS

Since the publication of a seminal paper by Henry and Swan (1974) there has been a growing recognition of the importance of natural disturbances in the composition, structure and dynamics of nearly all natural vegetation (White, 1979). Even though the coastal forests of Vancouver Island are uniquely imposing in stature and age, they share a common feature with many other vegetation types (e.g. Grimm, 1984) in that disturbance has played a major role in their development. In fact, continuous small or large scale disturbances may be essential to their maintenance.

1. PSEUDOTSUGA COMMUNITY TYPES

Fire is undoubtedly the most noticeable form of disturbance within the study area. It has permitted Pseudotsuga menziesii to remain the dominant tree species in most community types of the drier interior sector of the study area. Because of its thick bark, Pseudotsuga menziesii is considered the most fire resistant of all coastal tree species (Minore, 1979). However, its seedlings are incapable of establishing themselves under the shade of its canopy, except perhaps in the driest parts of coastal British Columbia (Krajina, 1969; Krajina et al., 1982). Thus, the bell-shaped distribution curves of Pseudotsuga menziesii stems in most community types are characteristic of a seral species (Fig. 15) which depends entirely on the occurrence of a major disturbance, fire in this case, for its establishment. In the dry Pinus-Pseudotsuga forests (D1) of rock outcrops, the dry Pseudotsuga forests (P1), and the Pseudotsuga-Linnaea forests (P3), the seral role of Pseudotsuga menziesii is not as obvious because some regeneration appears to occur (Fig. 15). However, only on the rock outcrop communities (type D1) of the interior of the study area does Pseudotsuga's size-class distribution curve appear characteristic of a primary species (Fig. 15).

It has been suggested that Pseudotsuga menziesii cannot regenerate in the moist coastal forests because its seedlings or saplings cannot transpire sufficiently in the shade to rid themselves of excess moisture (Krajina, 1969; Krajina et al., 1982). Thus, Krajina (1969) argues that P. menziesii becomes "shade tolerant", or has the ability to regenerate under a canopy, only on dry sites near the Coast. Conversely, Tsuga

heterophylla requires shade to germinate on dry sites, and even then the
saplings or young trees will likely die following a drought (Krajina,
1969). Viewed differently, it may be that Pseudotsuga menziesii is the
most shade tolerant of the tree species that can grow in climatically
dry areas or edaphically dry sites on Vancouver Island. Tsuga hetero-
phylla is more shade tolerant, in an absolute sense, than Pseudotsuga
menziesii, but it is probably incapable of surviving on the driest sites,
as observed by Krajina (1969). On such dry sites (or areas), the rela-
tively shade intolerant Pseudotsuga menziesii will then become the
dominant tree species, because it is the most shade tolerant of all the
other species capable of growing there (i.e. Arbutus menziesii, Pinus
contorta). This concept has been proposed by Daubenmire in his habitat
type approach to vegetation (Daubenmire and Daubenmire, 1968). In all
community types of the Pseudotsuga group, except those of the driest
environments (types D1 and P1), Tsuga heterophylla and Thuja plicata are
clearly primary, or climax, species (Fig. 15). Both are easily killed
by fires (Minore, 1979).

Tsuga heterophylla seedlings are commonly found growing on unde-
composed wood substrata on the forest floor of Pseudotsuga community types
(Table 32). In the community type where the relationship was not signi-
ficant, the mean seedling density was still the highest on the undecom-
posed wood substrata (Table 32). Christy and Mack (1984) have shown
that Tsuga heterophylla "juveniles" are almost exclusively restricted to
decaying logs, predominantly those in intermediate stages of decomposition.
These partially decomposed "nurse logs" are regarded as presenting an
optimal compromise of litter-shedding characteristics (best in youngest

logs) and substratum conditions (best in oldest logs) that permits the successful germination and establishment of tree seedlings (Christy and Mack, 1984). It is assumed that litter accumulation represents an important impediment to the establishment of Tsuga heterophylla seedlings, and that the nurse logs provide the necessary elevated "safe sites" (sensu Harper et al., 1965) within the community. Nurse logs with hundreds of Tsuga heterophylla seedlings and saplings were frequently observed within the Pseudotsuga group. In Tsuga-Pseudotsuga-Polystichum forests (P5), seedlings, saplings and small Tsuga heterophylla trees were often seen growing on or very near the bases of the large Pseudotsuga menziesii dominants. This location may be the only place free from litter in forests where logs are rare. Pseudotsuga menziesii seedlings are not statistically associated with a particular substratum (Table 32), but this could be an artifact of the very low seedling densities encountered under the dense canopy of the community types analyzed.

Tsuga heterophylla occurs in increasingly larger size-classes along a moisture gradient within the Pseudotsuga group (community types P3 < P4 < P5 = P6, Fig. 15). In the cool and moist conditions of the montane Tsuga forests (P6), Tsuga heterophylla probably grows as fast as Pseudotsuga menziesii following a disturbance, and may thus be a good species for reforestation, either alone or in mixture with Pseudotsuga menziesii. This may be particularly advantageous if a relatively short planting to harvest rotation is planned (80 to 100 years); otherwise, the superior, long-term size potential of Pseudotsuga menziesii negates the use of Tsuga heterophylla. On the poor and shallow soils of the montane Tsuga-Gaultheria forests (P7), Tsuga heterophylla may also be the most appropriate

choice for reforestation. In all other community types at lower ele-
vations (P1, P2, P3, P4 and P5), Pseudotsuga menziesii would appear to
be the most ideally suited species for reforestation. The frequency of
droughts causing mortality would preclude any use of Tsuga heterophylla
as a viable reforestation species in most of these community types, parti-
cularly those with the driest moisture regimes (P1 and P3). The Pseudo-
tsuga-Thuja-Acer forests (P2) are the only community type within the
Pseudotsuga group which has more Thuja plicata stems per hectare than
Tsuga heterophylla stems (Fig. 15). The hypothesized presence of soil
seepage would also explain this discrepancy. Tsuga heterophylla regene-
ration is reportedly poor in these nutrient rich sites, occurring only
on decaying wood; conversely, Thuja plicata does well in the same sites
(Krajina, 1969).

The double peaks in the size-class distribution curve of Pseudo-
tsuga menziesii within the Pseudotsuga-Thuja-Acer forests (P2) are inter-
preted as resulting from two periods of establishment, following two
distinct forest fires (Fig. 15). The close geographical proximity of
all the plots permits such an explanation, since their fire disturbance
history may be assumed to be identical. Fires usually occur on a rela-
tively large scale in coastal forests, but with a low frequency of once
every few hundred years. Indirect evidence of this is found in the
dominance of vast areas by Pseudotsuga menziesii, a species which can
establish quickly in openings cleared by fire, as well as avoid damage
from surface fires because of the thick, fire resistant bark of mature
trees (Minore, 1979). Historically, large conflagrations were likely in
the heavy fuel loads of coastal forests following periods of unusually

hot and dry weather. A recent forest fire, fought without much success with modern equipment and techniques, burned almost the entire south-facing slopes of the Sproat Lake valley. This example provides an indication of the minimum areal extent of forest fires which have occurred in the drier coastal areas of British Columbia.

An alternative to the two fires hypotheses is that all Pseudotsuga menziesii trees belong to the same cohort in which a size hierarchy has developed through intraspecific competition (Harper, 1977). When such a hierarchy of sizes is created through competition however, the smaller individuals are always more numerous. This is not supported by the data in Fig. 15 and the competition hypothesis is therefore rejected. More likely, the second fire following which the smaller (i.e. younger) Pseudotsuga trees got established, was of a lighter intensity than the first burn. Many already established Pseudotsuga trees would have survived the second fire, while almost all trees of other species would have been killed. All the larger Pseudotsuga menziesii trees found in plots of the Pseudotsuga-Thuja-Acer forests (P2) have fire charred bark. A sufficiently large sample of increment cores from the Pseudotsuga menziesii population of the area would permit the validation of the two fires hypothesis.

2. THUJA COMMUNITY TYPES

Wind disturbance, causing major blowdowns over large areas or the isolated falling of single trees, is regarded as the second most prevalent type of forest disturbance within the study area. Wind related effects increase towards the coast where the forests are more directly exposed to storms. Large scale blowdown is probably the major factor initiating secondary forest succession on the coast, as forest fires are believed to be extremely rare. The prevalence and extent of wind disturbance also appears to be linked with elevation. Extensive blowdowns are most frequently observed on the ridges or summits of mountains nearest to the coast (e.g. plot 151, Figs. 1 and 9), where the montane Tsuga-Abies forests (A3) are usually found. In valleys or on plains closer to sea level, where the coastal Thuja forests (T4) predominate, isolated tree falls triggered by wind tend to be the most frequent form of disturbance. Landslides also influence the development of some coastal community types, but their frequency and areal extent are small. The bare areas with improved drainage created by landslides would be rapidly colonized by light demanding or fast growing species such as Pseudotsuga menziesii and Picea sitchensis. Apart from rock outcrops, old landslides appear to be the only suitable environment for Pseudotsuga menziesii near the coast. Plot 87 on the upper-slope of the Cypre River valley and plot 155 on upper-slopes near Kennedy Lake are examples of such sites. Picea sitchensis also occurs on old landslides near the coast, but only at the base of slopes where moisture and nutrient levels are probably higher (plots 91 and 69).

Daubenmire and Daubenmire (1968; p. 55) have summarized an observation common to all who have studied forests dominated by Thuja plicata : "Thuja plicata is distinctive from the other trees in that younger age-classes often seem inadequate to guarantee replacement of larger individuals...". This can be seen in the coastal montane Thuja forests (T3) and the coastal Thuja forests (T4), where the size-class distribution curve of Thuja plicata dips far below the curves of Tsuga heterophylla and Abies amabilis in the smaller size-classes, but extends much further into the larger size-classes (Fig. 16). Daubenmire and Daubenmire (1968) have suggested that the longevity of individuals and the layering habit of Thuja plicata were probably a key to understanding its persistence. Each individual needs only to leave one successfull offspring to maintain the population density, "thus, the longer it lives, the more sparse the reproduction can be and yet suffice" (Daubenmire and Daubenmire, 1968; p. 55). Indeed, Thuja plicata has a potential longevity of over 1,000 years, at least double that of the co-dominants Tsuga heterophylla and Abies amabilis (Waring and Franklin, 1979). If layering does occur, the longevity of the "genetic" individual may be much longer. The coastal Thuja forests (T4) may thus represent an ideal example of Connell and Slatyer's (1977) inhibition model, where the largest and longest-lived species eventually achieves dominance as succession proceeds. Young coastal forests developing after extensive wind damage, however, are strongly dominated by Tsuga heterophylla and Abies amabilis (e.g. plot 151). Also, the coastal Tsuga-Blechnum-Polystichum forests (T2), which are suspected of having had a large disturbance at their origin, have very little Thuja plicata (Table 24). In most plots of the coastal Thuja

forests (T4), where Thuja plicata is the first dominant, no important

disturbance could be detected, and it is possible that such stands have

had no major disturbance in several hundreds, if not thousands of years.

Thuja plicata's dominance in the low elevation coastal areas would

be threatened if its trees, otherwise long-lived, were frequently felled

or fatally damaged by wind, before the time necessary for their successful

regeneration. Thus, two hypotheses can be put forward to explain the

presence of apparently stable Thuja plicata communities near the coast :

the first states that strong winds very rarely occur in areas where Thuja

plicata is the present dominant; the second states that Thuja plicata is

less susceptible than other tree species to wind damage. The first hypo-

tehsis appears untenable, because strong winds occasionally do occur even

at low elevations near the coast. On the other hand, several lines of

circumstantial evidence appear to support the second hypothesis. Thuja

plicata is indeed considered the most wind resistant coastal tree, after

Pseudotsuga menziesii, possibly because of its very dense and extensive

root system (Minore, 1979; Klinka and Feller, 1984). Some mechanical

resistance to wind-toppling may also be gained by the fluted and buttressed

bases of large Thuja plicata trees (Putz et al., 1983). Also, mechanical

resistance to bole snapping by wind may be increased by the fact that the

trunks of old Thuja plicata trees are almost always hollow, perhaps con-

ferring the enhanced stress resisting characteristics of hollow cylinders.

Some evidence for a superior resistance to wind by large Thuja plicata

trees was found in several plots. For example in plot 72, large indi-

viduals of Thuja plicata were observed still standing while almost all

Tsuga heterophylla and Abies amabilis trees had been blown down in

approximately the same direction, apparently during the same storm.

Large Thuja plicata trees may be able to lose their leader and uppermost

branches during storms without fatal consequences, partly because of a

high resistance to rot-causing fungi and to insect attack (Minore, 1979).

The so called "candelabra" appearance of large Thuja trees near the coast,

seems to be caused by the death of the leader and upper-crown branches,

and by the shared apical dominance of several large lateral branches.

This particular candelabra shape has not been noticed in Thuja plicata

trees elsewhere than in the wettest areas nearest to the coast. This shape

may develop with increasing age of the individuals; however, ancient Thuja

trees can be found, in moist pockets even in the driest and most fire prone

areas, that do not possess the characteristic candelabra shape. The

possibility of a distinct genetic race, restricted to a narrow coastal

band, seems to be discounted by the high genetic uniformity of Thuja

plicata (Copes, 1981). The most likely explanation is that a particular

set of environmental factors (abundant moisture, mild temperatures,

occasional strong winds, lack of fire) combine with the genetic charac-

teristics of the species (resistance to rot and insects, weak apical

dominance, longevity) to produce the observed candelabra shape in old

Thuja plicata trees near the coast.

Germination and establishment sites for seedlings appear to be

almost entirely restricted to undecomposed wood substrata, mostly large

logs, in the Thuja group (T2, T3 and T4, Table 32). These logs represent

"safe sites" with particular combinations of ecological factors (abiotic

and biotic) which permit the successful germination of seeds and establish-

ment of seedlings (Harper et al., 1965). It has been frequently observed

that Tsuga heterophylla and Thuja plicata regenerate on fallen trees, or "nurse logs", in coastal forests (Franklin and Dyrness, 1973). Both of these species have small seeds, producing small and fragile seedlings that are likely to be susceptible to mechanical damage by burial. Abies amabilis, on the other hand, has larger seeds and produces large, robust seedlings (Schopmeyer, 1974), which are not expected to be as strongly affected by litter accumulation. This could explain why the distribution of Abies amabilis seedlings is unrelated to the occurrence of undecomposed wood in most of the community types analyzed (Table 32). The importance of undecomposed wood for the germination and establishment of Thuja plicata seedlings can be seen in the eighteen-fold increase in the number of seedlings found on undecomposed wood compared to forest floor sites in Thuja forests (T3 and T4, Table 32). Thuja plicata logs may provide the "safest" sites for seedling establishment and development to maturity. The decay rate of Thuja plicata logs appears to be extremely slow, compared to that of Abies amabilis and Tsuga heterophylla logs (Foster and Lang, 1982; Graham, 1981). Abies amabilis appeared to have the fastest decay rate in the field; it is probably comparable to the decay rate of Abies balsamea (Foster and Lang, 1982). The discovery, in plot 73, of a large Thuja plicata tree, approximately 400 years old by a growth-ring count, growing on top of a Thuja log of similar size illustrates the slow decay rate of Thuja plicata. Indeed, this log was still sound and not in contact with the soil along some of its length. Where systematic observations were made (some plots of the coastal Thuja forests), it was found that almost all seedlings, saplings and young trees of Thuja plicata and Tsuga heterophylla were rooted on decaying fallen trees, stumps or even

on the bases of living trees. This was not as obvious for larger and older trees, whose nurse logs may have had eventually rotted away.

The fourth hypothesis stated in the Introduction, that Thuja plicata is able to maintain itself in all of the coastal forests it presently dominates, appears very plausible. The extent to which vegetative regeneration of Thuja plicata contributes towards its total regeneration remains to be assessed. Schmidt (1955) reported that vegetative regeneration might be as important as regeneration from seed in high density stands. Vegetative regeneration may occur through the layering of low branches pinned under litter, from the rooting of broken live branches, or fallen live boles (Schmidt, 1955). Such occurrences were not observed in the coastal montane Thuja forests (T3), or in the coastal Thuja forests (T4).

Reforestation within the community types of the Thuja group can be effectively carried out using several species. For short rotations on productive sites (T2 > T3 > T4), both Tsuga heterophylla and Abies amabilis could be recommended, with perhaps some Picea sitchensis only on the best sites. Pseudotsuga menziesii cannot be recommended as a viable reforestation species in the area occupied by the Thuja vegetation group (Spiers et al., 1983; Carter et al., 1984). The sites near the coast where this species appears to grow successfully are very limited. On the poorest sites (T1 and T5), the best growth might be acheived by Thuja plicata, or by the faster growing Pinus contorta. Thuja plicata represents the climax species in dry (D2, T1) as well as wet (T5) nutrient-poor sites (Fig. 16). Definitely seral in the coastal wet Thuja forests

(T5), _Pinus_ _contorta_ may be capable of self-regeneration in the very open,
coastal dry _Pinus_ forests (D2) (Fig. 16). The presence of understory
fern species could serve as useful indicators of site productivity near
the coast. _Polystichum_ _munitum_ was most abundant in productive sites
where access to mineral soil was not restricted by thick organic horizons.
Conversely, _Blechnum_ _spicant_ dominates on thick organic horizons found
on the less productive sites.

3. ABIES COMMUNITY TYPES

Because of its high shade tolerance, large seed size, and capa-
bility to withstand long periods of suppression under a forest canopy,
Abies amabilis is considered a climax or primary species. It has this
role in all of the community types within the Abies group (except for
type A7) and in many within the Thuja group (Figs. 16 and 17).

The importance of disturbance in producing the tree size-class
structures of community types within the Abies group can be inferred
from the irregular shapes of the distribution curves shown in Fig. 17.
For example, community type A3 is found on mountain ridges near the
coast, where wind disturbance appears to maintain a two-tiered arborescent
structure. This is characterized by a lower layer of suppressed trees and
saplings and a highly discontinous upper layer consisting of trees
released from competition after the last wind disturbance. This parti-
cular forest structure was also observed by Klinka et al. (1979), and
its origin may be similar to the wind driven wave-regeneration phenomenon
described for high elevation Abies balsamea forests of the northeastern
United States (Sprugel and Bormann, 1981). A similar interpretation could
be made for the montane Abies-Tsuga forests (A2).

The coastal Tsuga-Blechnum-Polystichum forests (T2) have a size-
class structure which is also heavily skewed towards the larger size-
classes (Fig. 17). Landslide disturbance is suspected to have been at
the origin of at least half of the stands of this community type, and
evidence of wind disturbance was found in the remaining stands. It could
be argued that the coastal Tsuga-Blechnum-Polystichum forests (T2) are

actually long-duration seral communities which occur near the coast after

major disturbances have improved seedling establishment conditions, soil

drainage or soil nutrient availability. The slow accumulation of organic

matter on the forest floor of these communities may eventually direct

their development towards community types dominated by Thuja plicata

(T3 or T4). This hypothetical successional sequence may never be entirely

completed on old landslides because of the profound modification of the

site drainage.

The Tsuga-Blechnum-Polystichum forests (A7) show evidence of past

disturbance in the form of landslides in the two coastal plots, and fire

in the inland plots. The shape of the size-class distribution curve of

Tsuga heterophylla, characteristic of a climax species (Fig. 17), and the

small importance of seral species (Table 26), may suggest that the original

disturbances are very old. Alternatively, it is possible that Tsuga hete-

rophylla, because of particular environmental conditions, established

itself with more success than the usual seral species following the

disturbance.

The montane Abies-Streptopus forests (A4) and the lowland Abies

forests (A5) not only have floristic similarities, but are also similar

in tree size-class structure (Fig. 17). Abies amabilis has a size-class

distribution curve characteristic of a primary species in both community

types, whereas Tsuga heterophylla's size-class distribution curve has a

peak in the larger size- classes (Fig. 17). The occurrence of past

disturbances was not frequently recorded in these community types, except

for the occasional tree blown down by wind. In fact, partly decayed,

standing dead tree boles were often observed. The role of Tsuga hetero-
phylla, in these two community types, may be that of an opportunistic,
gap-regenerator which invades openings following the removal of a large
canopy tree.

In the montane Tsuga-Abies-Gaultheria forests (A1), fire has been
the major type of disturbance, as confirmed by the presence of Pseudotsuga
menziesii with its characteristically seral size-class distribution
curve (Fig. 17).

For reforestation purposes within the Abies group, Abies amabilis
and Tsuga heterophylla may be equally appropriate in most of the montane
community types (A2, A3 and A4), and in the lowland Abies forests (A5).
Pseudotsuga menziesii could represent a viable species for the montane
Tsuga-Abies-Gaultheria forests (A1) and some inland stands of the Tsuga-
Blechnum-Polystichum forests (A7). Coastal stands of the same community
type would be excellent sites for Picea sitchensis.

4. FLOODPLAIN COMMUNITY TYPES

The dynamics of the floodplain communities sampled in this study appear to correspond generally to previous accounts by Cordes (1972) for Vancouver Island and by Fonda (1974) for the Olympic Peninsula. Very young floodplains dominated by Alnus rubra (Fonda, 1974) were not sampled, but they were frequently observed along all major rivers. The youngest stand sampled is probably plot 171, near the Klanawa River. This plot consisted of a dense grove of Picea sitchensis with a shrubless under-story nearly completely covered by Polystichum munitum. Further away from the edge of the Klanawa River, plot 170 occupies an older, less frequently inundated floodplain. Here, Tsuga heterophylla was more abun-dant than Picea sitchensis in the tree stratum. In increasingly older floodplains, only a few large Picea sitchensis individuals remain. Tree species regeneration occurs almost exclusively on Picea logs, and is dominated by Tsuga heterophylla (Tables 24 and 32). Again, the fallen logs provide safe sites against burial by litter and mechanical damage during floods. The canopy of the older stands is always sparse, which probably explains the presence of an extremely dense and tall shrub layer, dominated by Rubus spectabilis and Ribes bracteosum. In the Olympic Peninsula such an extensive shrub layer never develops (Fonda, 1974), possibly because of a strong browsing pressure by elk.

The large sizes of trees of different species growing on flood-plains indicates the high growth potential of these habitats (Table 24). Some of the largest Pseudotsuga menziesii trees encountered during the study (181 cm DBH) were found on an old floodplain situated near Nahmint

Lake (plot 122). Thus, since environmental factors on floodplains may be considered to be non-limiting (except perhaps tolerance to flooding), the original tree species composition is likely to depend mainly on stochastic events, such as seed dispersal or the availability of local seed sources, when a major disturbance releases a floodplain for colonization.

Fast growing trees which can exploit fully the ideal growth conditions of floodplains should be selected for reforestation. _Picea sitchensis_ probably remains the best suited species on all sites, but _Pseudotsuga menziesii_ may be an alternative choice on older floodplain terraces in the interior of the study area.

CHAPTER 6.

CONCLUSIONS

The analysis of vegetation-environment relationships in old-growth forests of a large sector of the west coast of Vancouver Island was the prime objective of this study. Macro-climate appears to have the strongest influence on vegetation over the whole study area; variation in soil parent material is ranked second in importance. Within areas of relatively uniform macro-climate and soil parent material, stronger relationships with other environmental factors were found.

In the Pseudotsuga group, characteristic of the drier inland section of the study area, vegetation is correlated with meso-climate (elevation) and soil moisture gradients. Large scale fire disturbances have played a major role in the determination of the vegetation composition and structure in this group. Also, homogeneity of the vegetation, between environmentally similar sites, was generally the highest in areas where fire disturbance was absent or infrequent, as in the Thuja group. However, different trends were observed for individual vegetation strata. The herb and shrub strata increased in homogeneity with decreasing fire disturbance, but the opposite trend was observed in the tree layer. This trend is linked to the presence of very homogeneous, almost mono-specific, post-fire stands dominated by Pseudotsuga menziesii.

The Thuja group, found exclusively near the coast, displays variation mainly along gradients of soil nutrients and meso-climate

(elevation). The importance of soil nutrients is probably related to the large variability in parent material found in the Thuja group. Moreover, the extremely abundant precipitation probably explains the absence of a major soil moisture gradient. The longevity of Thuja plicata, and its apparently high resistance to wind damage, are features thought to be important in maintaining the high dominance of this species in forests nearest to the coast.

The Abies group was found over a range of coastal and more inland sites; thus, affinities with macro-climate were difficult to deduce. Vegetation appeared mainly related to meso-climate (elevation) and soil moisture gradients. The cool, moist micro-climates associated with several community types within the Abies group may have nullified the influence of macro-climate.

Alpha and beta diversity were found to increase towards the interior of the study area. These diversity increases may be caused by the increasing amount of heat available for plant growth, by the decreasing productivity brought on by moisture deficits, by the increasing frequency and severity of large scale fire disturbances, or, most likely, by a combination of all of these factors.

Analyses of tree species size-class distributions confirm the essentially seral role of Pseudotsuga menziesii in most community types, while Tsuga heterophylla, Abies amabilis and Thuja plicata are the major potential "climax" species. The eventual dominance of a particular species, or combination of species, is linked to a complex interplay of disturbance regime and ecological site characteristics.

Finally, a gradient analysis approach to resource inventory and management may represent an advantage over more traditional methods, in its relative freedom from resource mapping and complex integration of diverse resource maps. The vegetation patterns of a sector can instead be modelled through multiple regression equations using a few ecological factors, previously identified as strongly linked to vegetation variation. This information would then form a useful basis for forest management decisions bearing on harvesting, post-harvesting treatments, and species selection for reforestation.

The selection of appropriate tree species for reforestation is one of the most important steps in forest management. Within the area studied, it appears that _Pseudotsuga menziesii_ constitutes the most appropriate choice in many situations. Possible exceptions are high elevation and nutrient poor sites where other species, such as _Tsuga heterophylla_, may grow as fast or faster. However, reforestation with _Pseudotsuga menziesii_ on coastal sites, within the area occupied by the _Thuja_ group, should be strictly avoided because of severe growth problems, likely caused by arsenic accumulation.

Integral conservation of particular sites or areas also should be part of a comprehensive and ecological forest management program. As forest management techniques develop, intensive management will be increasingly directed towards the most productive sites, with easiest access and gentle terrain. This represents a desirable trend if it allows forests to be used as a truly renewable resource, with better reforestation, control of soil erosion and minimal nutrient loss. As a

result, less logging pressure should be felt by less productive sites. Already, sites characterized as unproductive, such as rock outcrops, very steep slopes and some high elevation sites, are neglected in most logging operations. These sites are particularly suited for integral conservation; they are rich in species, usually occur at the extremeties of ecological gradients, and therefore represent ideal sites for the conservation of genetic variation (e.g. community types D1, D2, P7, T1, T5 and A1). The maintenance of genetic diversity within populations of economically valuable tree species is a duty of the forest industry and of the relevant governmental agencies. Thus, through the conservation of particular habitats, or entire areas, the forest industry could contribute towards this goal.

Another ecological aspect of importance to forest management is the prevalence of natural fire disturbance in the interior sector of the study area, and its virtual absence in the coastal sector. Therefore, the use of fire as a forest management tool may recreate naturally occurring phenomena in the _Pseudotsuga_ forests, to which the biota is adapted, but unexpected ecological problems may be created in _Thuja_ forests near the coast, where nutrient cycling appears to occur mostly within organic soil horizons, which may be partly or totally destroyed during burns.

It is hoped that the information contained in this thesis will contribute to improved forest management, and will not acquire an historical value too soon.

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Table 1 : List of environmental variables.

I. TOPOGRAPHIC

    1. elevation (m)
    2. aspects ($0°-180°$, NNE to SSW)
    3. slope (%)
    4. position : 1 – crest
                    2 – upper-slope
                    3 – mid-slope
                    4 – lower-slope
                    5 – level
                    6 – depression

II. EDAPHIC

    (a) physical

    5. drainage : 1 – very rapid
                    2 – rapid
                    3 – well
                    4 – moderately well
                    5 – imperfect
                    6 – poor
                    7 – very poor

    6. effective rooting depth (cm)
    7. root restricting depth (cm)
    8. soil depth (cm)
    9. material : 0 – rock
                    1 – colluvial
                    2 – morainal
                    3 – fluvial
                    4 – alluvial

    10. LFH tickness (cm)
    11. B_1 % coarse fragments
    12. B_1 texture: 1 – sand
                        2 – loamy sand
                        3 – sandy loam
                        4 – loam
                        5 – sandy clay loam
                        6 – silt loam
                        7 – silt
                        8 – sandy clay
                        9 – clay loam
                       10 – silty clay loam
                       11 – silty clay
                       12 – clay
    13. V6/V7
    14. V6/V8
    15. V10/V6

II. EDAPHIC

    (b) chemical

    16. LFH pH (H_2O)
    17. LFH pH ($CaCl_2$)
    18. LFH % C
    19. LFH % N
    20. LFH C/N
    21. A pH (H_2O)
    22. A pH ($CaCl_2$)
    23. B_1 pH (H_2O)
    24. B_1 pH ($CaCl_2$)
    25. B_1 % C
    26. B_1 % N
    27. B_1 C/N
    28. B_2 pH (H_2O)
    29. B_2 pH ($CaCl_2$)

III. GEOGRAPHIC

    30. distance from coast

IV. DISTURBANCE

    31. fire : 0 – no evidence
                 1 – charcoal
                      or scars
    32. wind : 0 – no evidence
                 1 – blowdowns

Table 2 : List of community characteristics.

I. RICHNESS

    1. tree species
    2. shrub species
    3. herb species
    4. bryophyte and lichen species
    5. understory vascular species
    6. vascular species
    7. total species

II. COVERAGE (%)

    8. understory strata
    9. shrub stratum
    10. herb stratum
    11. bryophyte and lichen stratum

III. TREE STRATUM

    12. tree basal area (m^2/ha)
    13. tree density (stems/ha)
    14. maximum tree height (m)

Table 3 : Species with the ten largest positive and negative eigenvector
          coefficients on axes one and two of the reciprocal averaging
          ordination of the 172 plots.

Axis 1 (% variance = 11.0)

Pinus contorta (sap.)	.387	Abies amabilis (tree)	-.168
P. contorta (tree)	.384	A. amabilis (sap.)	-.138
Pseudotsuga menziesii (seed.)	.330	A. amabilis (seed.)	-.126
P. menziesii (sap.)	.217	Tsuga heterophylla (seed.)	-.123
Acer macrophyllum (seed.)	.179	T. heterophylla (tree)	-.110
P. menziesii (tree)	.177	Vaccinium alaskaense	-.106
Arbutus menziesii (tree)	.163	T. heterophylla (sap.)	-.099
P. contorta (seed.)	.162	Blechnum spicant	-.098
Rhacomitrium lanuginosum	.157	Rubus pedatus	-.065
Vaccinium ovatum	.155	Picea sitchensis (tree)	-.055

Axis 2 (% variance = 8.8)

Abies amabilis (sap.)	.301	Picea sitchensis (tree)	-.351
A. amabilis (tree)	.192	P. sitchensis (seed.)	-.346
A. amabilis (seed.)	.190	Rubus spectabilis	-.276
Vaccinium alaskaense	.172	Ribes bracteosum	-.222
Rhytidiopsis robusta	.157	Polystichum munitum	-.212
Tsuga mertensiana (tree)	.143	Athyrium filix-femina	-.158
Chamaecyparis nootkatensis (sap.)	.127	Rubus parviflorus	-.154
C. nootkatensis (tree)	.110	Trautvetteria carolinensis	-.149
P. contorta (tree)	.104	Sambucus racemosa	-.142
Rubus pedatus	.094	A. macrophyllum (sap.)	-.131

Table 4 : Product moment correlations between environmental variables, community characteristics, and reciprocal averaging axes of the 172 plots (n = 172; ** = p $\leqslant$ .01; * = .01 < p $\leqslant$ .05).

	axis 1	axis 2
axis 2	-.279**	–
elevation	-.347**	.656**
aspect	.299**	-.100
position	-.269**	-.299**
drainage	-.386**	-.014
soil depth	-.279**	-.036
material	-.213**	-.205**
LFH pH (H_2O)	.292**	-.413**
LFH pH ($CaCl_2$)	.331**	-.432**
LFH thickness	-.293**	.180*
LFH % N	-.231**	.051
LFH C/N	.244**	.007
B_1 pH (H_2O)	.039	-.215**
B_1 pH ($CaCl_2$)	.023	-.202**
B_1 % coarse fragments	.235**	.201
effective rooting depth	.158*	-.199**
eff. r. d./soil depth	.453**	-.123
LFH thick./eff. r. d.	-.257**	.212**
fire disturbance	.301**	-.087
tree spp. richness	.304**	.005
shrub spp. richness	.247**	-.219**
understory coverage	.129	-.218**
herb coverage	-.150*	-.254**
bryo. coverage	.408**	-.102
tree basal area	-.205**	-.264**
tree height	-.191*	-.240**

Table 5 : Species with the ten largest positive and negative eigenvector
coefficients on axes one and two of the reciprocal averaging
ordination of the 140 plots.

Axis 1 (% variance = 13.6)

Pseudotsuga menziesii (tree)	.339	Abies amabilis (sap.)	-.361
P. menziesii (seed.)	.238	A. amabilis (tree)	-.336
Acer macrophyllum (sap.)	.221	A. amabilis (seed.)	-.266
Cornus nuttallii (sap.)	.188	Vaccinium alaskaense	-.190
Hylocomium splendens	.187	Rubus pedatus	-.169
C. nuttallii (seed.)	.173	Blechnum spicant	-.139
A. macrophyllum (seed.)	.169	Plagiothecium undulatum	-.089
Berberis nervosa	.150	Streptopus streptopoides	-.087
Linnaea borealis	.146	Rhizomnium glabrescens	-.072
Thuja plicata (sap.)	.133	Rhytidiadelphus loreus	-.072

Axis 2 (% variance = 9.8)

Gaultheria shallon	.333	Abies amabilis (seed.)	-.223
T. plicata (seed.)	.310	A. amabilis (tree)	-.216
Vaccinium ovatum	.285	A. amabilis (sap.)	-.190
Blechnum spicant	.277	P. menziesii (tree)	-.181
T. plicata (tree)	.275	Rubus pedatus	-.157
T. plicata (sap.)	.239	A. macrophyllum	-.145
Pinus contorta (tree)	.142	C. nuttallii (sap.)	-.136
Carex obnupta	.138	C. nuttallii (seed.)	-.113
Pyrus fusca	.114	Polystichum munitum	-.110
Cornus canadensis	.102	A. macrophyllum (seed.)	-.110

Table 6 : Product moment correlations between environmental
variables, community characteristics, and reciprocal
averaging axes of the 140 plots (n = 140; ** = $p \leq .01$;
* = $.01 < p \leq .05$).

	axis 1	axis 2
axis 2	-.408*	-
elevation	-.005	-.496**
aspect	.290**	-.140
slope	.182*	-.307**
drainage	-.532**	.469**
material	-.300**	.356**
LFH pH (H_2O)	.240**	.116
LFH pH ($CaCl_2$)	.311**	.084
LFH thickness	-.483**	.358**
LFH % N	-.314**	.061
LFH C/N	.252**	-.135
B_1 % coarse fragments	.372**	-.345**
B_1 % C	-.252**	.112
B_1 % N	-.316**	.118
effective rooting depth	.395**	-.285**
root restricting depth	.213*	-.264**
eff. r. d./soil depth	.513**	-.230**
LFH thick./eff. r. d.	-.537**	.388**
fire disturbance	.578**	-.441**
wind disturbance	-.437**	.591**
distance from coast	.501**	-.728**
tree spp. richness	.268**	-.020
shrub spp. richness	-.050	.223**
herb spp. richness	.217**	-.436**
bryo. spp. richness	-.198**	.231**
vascular spp. richness	.208*	-.310**
understory coverage	-.153	.456**
shrub coverage	-.236**	.463**
herb coverage	-.254**	.363**
bryo. coverage	.360**	-.075
tree height	.225**	-.472**

Table 7 : Species with the ten largest positive and negative eigenvector
coefficients on axes one and two of the reciprocal averaging
ordination of the Pseudotsuga group.

Axis 1 (% variance = 14.4)

Tsuga heterophylla (sap.)	.265	Acer macrophyllum (sap.)	-.378
T. heterophylla (seed.)	.253	Cornus nuttallii (seed.)	-.274
T. heterophylla (tree)	.225	Pseudotsuga menziesii (seed.)	-.270
Blechnum spicant	.112	A. macrophyllum (seed.)	-.255
Polystichum munitum	.089	C. nuttallii (sap.)	-.236
Vaccinium parvifolium	.075	Thuja plicata (sap.)	-.187
Scapania bolanderi	.072	P. menziesii (sap.)	-.179
Rhytidiopsis robusta	.071	Rhytidiadelphus triquetrus	-.174
Abies amabilis (sap.)	.059	C. nuttallii (tree)	-.172
Plagiothecium undulatum	.054	Linnaea borealis	-.153

Axis 2 (% variance = 9.6)

Polystichum munitum	.379	Gaultheria shallon	-.489
C. nuttallii (seed.)	.188	Hylocomium splendens	-.355
C. nuttallii (sap.)	.184	P. menziesii (seed.)	-.174
T. plicata (seed.)	.178	Pinus monticola (seed.)	-.117
A. macrophyllum (sap.)	.176	Rhytidiopsis robusta	-.114
Blechnum spicant	.160	Vaccinium alaskaense	-.110
A. macrophyllum (seed.)	.156	Rhytidiadelphus loreus	-.092
Taxus brevifolia (sap.)	.134	Vaccinium ovatum	-.090
Rubus ursinus	.120	Linnaea borealis	-.090
Isothecium stoloniferum	.111	Chimaphila umbellata	-.084

Table 8 : Product moment correlations between environmental variables, community characteristics, and reciprocal averaging axes of the Pseudotsuga group (n = 59; ** = p ⩽ .01; * = .01 < p ⩽ .05).

	axis 1	axis 2
axis 2	.283*	—
elevation	.197	-.372**
slope	.185	.268**
position	.238	.640**
soil depth	.371**	.227
LFH pH (H_2O)	-.483**	-.070
LFH pH ($CaCl_2$)	-.534**	-.099
LFH thickness	.336**	-.059
B_1 % N	.186	.364**
B_1 C/N	-.104	-.434**
eff. r. d./soil depth	-.277*	-.238
distance from coast	-.431**	-.373**
tree spp. richness	-.463**	-.117.
shrub spp. richness	-.423**	.034
herb spp. richness	-.432**	.071
vascular spp. richness	-.512**	.045
understory coverage	-.454**	-.527**
shrub coverage	-.289*	-.726**
herb coverage	-.136	.390**
bryo. coverage	-.408**	-.528**
tree basal area	.069	.622**
tree height	.049	.588**

Table 9 : Species with the ten largest positive and negative eigenvector
coefficients on axes one and two of the reciprocal averaging
ordination of the Thuja group.

Axis 1 (% variance = 23.4)			
Abies amabilis (sap.)	.309	Vaccinum ovatum	-.401
A. amabilis (tree)	.288	Thuja plicata (sap.)	-.350
Tsuga heterophylla (seed.)	.283	T. plicata (seed.)	-.288
Polystichum munitum	.146	Carex obnupta	-.191
T. heterophylla (sap.)	.130	Pinus contorta (tree)	-.183
A. amabilis (seed.)	.127	Linnaea borealis	-.179
Scapania bolanderi	.088	Gaultheria shallon	-.155
Vaccinium alaskaense	.078	Pyrus fusca	-.136
Blechnum spicant	.073	Sphagnum girgensohnii	-.119
T. heterophylla (tree)	.068	Hylocomium splendens	-.118

Axis 2 (%variance = 13.5)			
Linnaea borealis	.402	Vaccinium ovatum	-.252
Carex obnupta	.378	Pseudotsuga menziesii (tree)	-.175
A. amabilis (sap.)	.351	T. heterophylla (sap.)	-.146
Coptis asplenifolia	.295	Gaultheria shallon	-.125
Calamagrostis nutkaensis	.255	T. plicata (sap.)	-.118
Maianthemum dilatatum	.204	T. heterophylla (tree)	-.109
Lysichitum americanum	.169	P. menziesii (seed.)	-.092
Rubus spectabilis	.161	Polystichum munitum	-.085
Vaccinium ovalifolium	.141	Taxus brevifolia (sap.)	-.080
Cornus canadensis	.130	Isothecium stoloniferum	-.072

Table 10 : Product moment correlations between environmental
variables, community characteristics, and reciprocal
averaging axes of the <u>Thuja</u> group (n = 40; ** = p ≤ .01;
* = .01 < p ≤ .05).

	axis 1	axis 2
axis 2	.210	–
elevation	.453**	.393*
drainage	–.013	.385*
soil depth	.428**	.283
LFH pH (H_2O)	.050	.361*
LFH % N	.550**	.195
LFH C/N	–.473**	–.189
B_1 % C	.449**	.078
B_1 % N	.516**	–.061
B_1 C/N	.220	.448**
root restricting depth	.356*	.383*
tree spp. richness	–.581**	.180
shrub spp. richness	–.448**	.133
herb spp. richness	.018	.640**
vascular spp. richness	–.187	.568**
understory coverage	–.803**	.091
shrub coverage	–.808**	–.246
herb coverage	–.159	.483**
bryo. coverage	–.512**	.011
tree height	.647**	–.083

Table 11 : Species with the ten largest positive and negative eigenvector
coefficients on axes one and three of the reciprocal averaging
ordination of the _Abies_ group.

Axis 1 (% variance = 16.7)

Tsuga heterophylla (sap.)	.339	Abies amabilis (sap.)	-.356
T. heterophylla (seed.)	.257	Rubus pedatus	-.347
Pseudotsuga menziesii (tree)	.222	A. amabilis (seed.)	-.344
Polystichum munitum	.213	A. amabilis (tree)	-.285
T. heterophylla (tree)	.186	Streptopus streptopoides	-.188
Gaultheria shallon	.131	Vaccinium alaskaense	-.180
Thuja plicata (tree)	.112	Rhytididelphus loreus	-.155
Vaccinium parvifolium	.110	Streptopus roseus	-.134
Blechnum spicant	.099	Athyrium filix-femina	-.102
Stokesiella oregana	.087	Tiarella trifoliata	-.095

Axis 3 (% variance = 10.3)

Gaultheria shallon	.359	Sphagnum girgensohnii	-.258
A. amabilis (seed.)	.257	A. amabilis (tree)	-.242
Rhytidiopsis robusta	.237	Achlys triphylla	-.231
A. amabilis (sap.)	.218	Polystichum munitum	-.219
P. menziesii (tree)	.206	Tiarella trifoliata	-.213
T. heterophylla (tree)	.164	Blechnum spicant	-.200
Vaccinium alaskaense	.162	T. heterophylla (sap.)	-.178
Taxus brevifolia (sap.)	.139	Rubus pedatus	-.152
Chamaecyparis nootkatensis (tree)	.118	T. heterophylla (seed.)	-.149
Vaccinium parvifolium	.104	Dryopteris austriaca	-.133

Table 12 : Product moment correlations between environmental variables, community characteristics, and reciprocal averaging axes of the <u>Abies</u> group (n = 40; ** = p $\leqslant$ .01; * = .01 < p $\leqslant$ .05).

	axis 1	axis 3
axis 3	-.499**	-
elevation	-.421**	.595**
position	.071	-.500**
LFH % C	-.436**	.314**
LFH C/N	-.169	.470**
B_1 pH (H_2O)	.349*	-.166
B_1 pH ($CaCl_2$)	.364*	-.180
B_1 C/N	-.065	.369*
fire disturbance	.098	.411**
distance from coast	-.488**	.345*
tree spp. richness	-.197	.509**
herb spp. richness	-.330*	.024
bryo. spp. richness	-.073	-.312*
vascular spp. richness	-.331*	.117
Herb coverage	-.067	-.360*
tree height	.210	-.409**

Table 13 : Species with the ten largest positive and negative eigenvector
coefficients on axes one and two of the reciprocal averaging
ordination of the 105 modal plots.

Axis 1 (% variance = 15.0)

Pseudotsuga menziesii (tree)	.353	Blechnum spicant	-.292
P. menziesii (seed.)	.263	Abies amabilis (sap.)	-.283
Acer macrophyllum (sap.)	.263	A. amabilis (tree)	-.206
Cornus nuttallii (sap.)	.214	Thuja plicata (tree)	-.168
C. nuttallii (seed.)	.201	A. amabilis (seed.)	-.140
A. macrophyllum (seed.)	.195	Vaccinium alaskaense	-.094
Hylocomium splendens	.193	Gaultheria shallon	-.093
Linnaea borealis	.174	Rhizomnium glabrescens	-.081
Berberis nervosa	.161	Tsuga heterophylla (tree)	-.070
Achlys triphylla	.143	Plagiothecium undulatum	-.067

Axis 2 (% variance = 8.8)

Tsuga heterophylla (sap.)	.333	Gaultheria shallon	-.299
T. heterophylla (seed.)	.280	T. plicata (tree)	-.257
T. heterophylla (tree)	.235	Blechnum spicant	-.235
Polystichum munitum	.213	A. macrophyllum (sap.)	-.227
P. menziesii (tree)	.128	T. plicata (seed.)	-.224
Picea sitchensis (tree)	.128	A. amabilis (sap.)	-.223
Rhytidiopsis robusta	.086	T. plicata (sap.)	-.189
Hypnum circinale	.080	C. nuttallii (seed.)	-.159
Isothecium stoloniferum	.071	A. macrophyllum (seed.)	-.136
Polypodium glycyrrhiza	.058	C. nuttallii (sap.)	-.113

Table 14 : Product moment correlations between environmental
variables, community characteristics, and reciprocal
averaging axes of the 105 modal plots (n = 105;
** = p ⩽ .01; * = .01 < p ⩽ .05).

	axis 1	axis 2
axis 2	.670**	–
elevation	.222*	.296*
slope	.150	.459**
drainage	-.621**	-.699**
material	-.378**	-.452**
LFH thickness	-.528**	-.493**
LFH % N	-.296**	-.196*
LFH C/N	.294**	.179
B % coarse fragments	.372**	.294**
B % C	-.359**	-.208*
B % N	-.419**	-.134
effective rooting depth	.393**	.267**
root restricting depth	.201*	.267**
eff. r. d./soil depth	.586**	.280**
LFH thick./eff. r. d.	-.608**	-.468**
fire disturbance	.717**	.543**
wind disturbance	-.711**	-.652**
distance from coast	.805**	.621**
tree spp. richness	.318**	-.101
shrub spp. richness	-.030	-.284**
herb spp. richness	.559**	.324**
bryo. spp. richness	-.266**	-.207**
vascular spp. richness	.488**	.171
understory coverage	-.170**	-.638**
shrub coverage	-.254**	-.584**
herb coverage	-.416**	-.415**
bryo. coverage	-.463**	-.176
tree basal area	-.390**	-.265*
tree height	.291**	.492**

Table 15 : Names of community types and vegetation groups.

Vegetation groups (code)	Community types (code)
Pinus contorta (D)	Dry Pinus-Pseudotsuga forests (D1)
	Coastal dry Pinus forests (D2)
Floodplain (F)	Floodplain forests (F1)
	Floodplain forests (Lysichitum variant) (F2)
Pseudotsuga (P)	Dry Pseudotsuga forests (P1)
	Pseudotsuga-Thuja-Acer forests (P2)
	Pseudotsuga-Linnaea forests (P3)
	Pseudotsuga-Berberis forests (P4)
	Tsuga-Pseudotsuga-Polystichum forests (P5)
	Montane Tsuga forests (P6)
	Montane Tsuga-Gaultheria forests (P7)
Thuja (T)	Coastal dry Thuja forests (T1)
	Coastal Tsuga-Blechnum-Polystichum forests (T2)
	Coastal montane Thuja forests (T3)
	Coastal Thuja forests (T4)
	Coastal wet Thuja forests (T5)
Abies (A)	Montane Tsuga-Abies-Gaultheria forests (A1)
	Montane Abies-Tsuga forests (A2)
	Montane Tsuga-Abies forests (A3)
	Montane Abies-Streptopus forests (A4)
	Lowland Abies forests (A5)
	Tsuga-Gaultheria-Blechnum forests (A6)
	Tsuga-Blechnum-Polystichum forests (A7)
Subalpine (SA)	(no community types differentiated)

Table 16 : Canonical analysis results of vegetation groups based
on environmental data.

Mahalanobis squared distances between groups :

Subalpine	–					
Floodplain	41.1	–				
Pinus contorta	67.7	106.9	–			
Pseudotsuga	16.5	36.6	51.2	–		
Thuja	23.5	33.9	66.0	16.1	–	
Abies	12.5	38.2	54.5	9.6	5.7	–
	SA	F	D	P	T	A

Table 17 : Canonical analysis results of Pseudotsuga group community
types based on environmental data (community type codes
are listed in table 15).

Mahalanobis squared distances between types :

P1	–						
P2	15.9	–					
P3	23.5	25.6	–				
P4	19.4	20.7	26.1	–			
P5	69.4	70.7	62.5	30.1	–		
P6	32.9	39.9	32.8	11.7	19.1	–	
P7	34.2	36.6	38.4	16.5	49.7	18.4	–
	P1	P2	P3	P4	P5	P6	P7

Table 18 : Canonical analysis results of <u>Thuja</u> group community types based on environmental data (community type codes are listed in table 15).

Mahalanobis squared distances between types :

	T2	T3	T4	T5
T2	–			
T3	262.8	–		
T4	140.3	82.0	–	
T5	206.1	196.1	53.1	–

Table 19 : Canonical analysis results of <u>Abies</u> group community types based on environmental data (community type codes are listed in table 15).

Mahalanobis squared distances between types :

	A1	A2	A3	A4	A5	A6	A7
A1	–						
A2	1.8	–					
A3	5.3	6.2	–				
A4	20.9	20.2	36.8	–			
A5	7.0	14.7	11.6	26.0	–		
A6	5.5	11.5	9.6	31.7	2.1	–	
A7	7.8	13.6	4.2	44.5	5.4	3.5	–

Table 20 : Canonical analysis results of all community types based on environmental data (community type codes are listed in table 15, coastal dry <u>Thuja</u> forests (Tl) are not included in this analysis).

Mahalanobis squared distances between types :

	SA	F1	F2	D1	D2	P1	P2	P3	P4	P5
SA	–									
F1	73.2	–								
F2	89.3	38.3	–							
D1	82.0	139.7	156.0	–						
D2	124.3	154.9	185.8	54.4	–					
P1	51.8	77.0	82.5	58.9	81.0	–				
P2	58.4	56.7	70.5	57.5	69.5	15.2	–			
P3	43.1	57.3	68.8	72.9	103.8	9.9	16.4	–		
P4	33.8	52.3	73.3	55.3	81.5	12.4	12.6	17.3	–	
P5	36.4	61.6	85.0	85.1	108.5	30.6	28.7	36.0	12.7	–
P6	19.7	59.3	82.2	65.7	92.2	19.4	23.6	23.1	7.9	11.5
P7	18.4	64.4	82.7	51.6	79.0	27.9	29.0	30.8	12.2	27.2
T2	44.7	68.7	75.7	82.2	88.0	51.3	45.6	55.0	31.4	20.1
T3	34.4	69.4	59.2	103.6	124.2	52.2	52.3	47.9	36.7	34.0
T4	45.3	52.8	50.4	94.0	111.1	46.1	40.4	43.5	29.0	31.3
T5	52.8	45.3	38.9	114.7	132.2	50.4	44.4	45.9	38.3	47.0
A1	25.6	82.8	94.2	55.5	93.0	27.2	33.2	34.1	21.1	28.6
A2	34.1	110.1	96.5	108.9	139.6	61.6	65.3	60.0	49.5	41.5
A3	46.5	107.5	118.6	92.1	106.5	70.5	72.6	78.8	44.0	36.2
A4	27.4	109.5	113.1	115.8	121.1	82.8	83.0	80.1	58.2	50.7
A5	33.8	50.2	68.2	85.8	103.8	44.5	43.9	47.0	22.8	17.6
A6	49.3	78.0	85.5	104.8	108.2	50.9	53.3	61.8	35.4	25.6
A7	41.7	69.1	85.9	87.3	107.7	40.7	44.3	47.7	21.7	15.5

	P6	P7	T2	T3	T4	T5	A1	A2	A3
P7	9.3	–							
T2	33.1	35.2	–						
T3	35.3	33.5	22.1	–					
T4	36.6	33.5	16.5	11.2	–				
T5	44.9	45.9	46.9	28.6	14.6	–			
A1	12.5	18.4	42.4	50.3	44.1	53.1	–		
A2	38.8	48.1	35.3	26.0	35.1	57.7	35.8	–	
A3	41.9	39.8	28.9	24.8	37.7	63.6	61.4	47.0	–
A4	46.9	37.8	36.0	23.1	36.5	52.5	58.1	35.9	25.3
A5	25.4	29.1	16.4	19.7	14.1	27.6	35.6	40.1	29.3
A6	35.8	42.3	21.7	22.9	21.3	36.5	46.5	40.6	30.4
A7	23.8	33.9	15.4	26.4	21.5	42.8	32.4	29.5	29.9

	A4	A5	A6	A7
A5	34.9	–		
A6	33.0	11.9	–	
A7	43.7	11.7	18.7	–

Table 21 : Correlations between canonical variates and environmental variables (see Figs. 13 and 14).

Environmental variables	Vegetation groups		All types		Pseudotsuga		Thuja		Abies	
	CV1	CV2	CV1	CV2	CV1	CV2	CV1	CV2	CV1	CV2
Elevation	.32	−.02	.28	−.56	.12	.60	−.25	−.76	.74	.63
Aspect	.41	−.00	.41	−.14	.15	.09	−.01	−.17		
Slope	.43	−.13	.34	−.51	.30	−.07	.06	−.73	.05	.91
Position	−.63	.34	−.56	.52	.58	−.47	−.12	.48		
Drainage	−.83	−.10	−.82	.21	.03	.05	−.35	.41		
Eff. root. depth	.15	.43	.19	.19	.03	−.03	−.08	−.19		
Root rest. depth	.05	.36	.02	.02	.41	.14	−.12	−.31		
Soil depth	−.30	.11	−.37	−.08	.48	.12	−.06	−.19		
Material	−.71	.25	−.59	.52	−.05	.06	−.25	.35		
LFH thickness	−.36	−.47	−.53	−.32	.38	.23	−.02	.28	.40	−.18
B_1 % coarse frag.	.52	−.18	.43	−.31	−.01	−.14	.01	−.21		
Texture	−.26	−.08	−.26	.03	−.06	.10	−.01	.04	−.03	.19
Eff. r. d./r rest. d.	.18	.19	.29	.27	−.42	−.22	.04	.15		
Eff. r. d./soil d.	.51	.28	.60	.21	−.46	−.20	.05	−.03		
LFH thick./eff. r. d.	−.34	−.58	−.50	−.38	.24	.23	−.19	.26		
LFH pH (H_2O)	−.10	.42	.10	.67	−.38	−.52	−.28	−.01		
LFH pH ($CaCl_2$)	−.07	.49	.16	.70	−.44	−.51	−.22	.07		
LFH % C	.23	−.21	.12	−.38	.16	.20	.33	−.10		
LFH % N	−.25	−.38	−.44	−.35	.39	−.36	−.03	−.26		
LFH C/N	.41	.22	.54	.11	−.25	−.46	.23	.12		
B_1 pH (H_2O)	.06	.34	.17	.46	−.04	−.54	−.02	.31		
B_1 pH ($CaCl_2$)	.05	.24	.13	.34	.02	−.55	−.02	.21		
B_1 % C	−.08	−.34	−.09	−.17	−.01	−.45	.24	−.42		
B_1 % N	−.22	−.28	−.27	−.09	.42	−.43	.39	−.42		
B_1 % C/N	.25	−.01	.34	−.08	−.30	−.00	−.27	−.11		
Fire disturbance	.53	.39	.65	.14	−.07	−.38	−.01	.42		
Wind disturbance	−.58	−.39	−.62	−.05	−.08	.34	−.18	−.09		

Vegetation groups : n = 157, r at .01 = .21;

Pseudotsuga : n = 56, r at .01 = .34;   Thuja : n = 36, r at .01 = .34;

Abies : n = 32, r at .01 = .45

All types : n = 149, r at .01 = .21;

Table 22 : <u>Pseudotsuga</u> group and community type D1 tree strata summary table
(see table 15 for community type codes).

Community types	D1	P1	P2	P3	P4	P5	P6	P7	D1	P1	P2	P3	P4	P5	P6	P7
Number of plots	3	4	4	5	11	17	12	7								

Trees (> 10 cm DBH)	Mean relative importance value (%)								Constancy (%)							
Acer macrophyllum			6	+	+	+					100	20	9	5		
Arbutus menziesii	13	4							100	50						
Cornus nuttallii			6	1	1						100	20	27			
Pinus contorta	66	1							100	25						
Pseudotsuga menziesii	20	93	67	69	50	42	33	30	100	100	100	100	100	100	100	100
Thuja plicata	1	1	12	9	12	11	12	14	33	25	50	60	72	65	75	71
Tsuga heterophylla		1	8	17	34	44	54	55		25	75	100	100	100	100	100

Saplings (0–10 cm DBH)	Mean relative density (%)															
Acer macrophyllum			29	3	+						100	20	9			
Arbutus menziesii	25	13							66	25						
Cornus nuttallii		5	17	1	15					50	75	20	36			
Pinus contorta	53	31							100	25						
Pseudotsuga menziesii	22	35	10	5		+			100	75	75	20		5		
Thuja plicata		1	24	12	13	1	10	12		25	100	40	27	17	33	71
Tsuga heterophylla		13	17	68	66	94	82	73		25	100	100	90	100	100	100

Seedlings (below BH)	Mean relative density (%)															
Abies amabilis				5	1	1	4	+				20	18	17	58	14
Acer macrophyllum	4	2	18		+	2	+		100	50	100		36	11	8	
Arbutus menziesii	18	26							33	50						
Cornus nuttallii		2	20	1	2	+	+			50	100	20	45	5	16	
Pinus contorta	9								100							
Pseudotsuga menziesii	67	64	26	41	10	1	3	7	100	100	100	100	100	52	75	71
Thuja plicata		2	15	3	8	12	6	7		50	75	40	72	52	75	85
Tsuga heterophylla	2	3	19	48	77	83	85	83	33	25	100	100	100	100	100	100

Table 22 (continued)

Community types	D1	P1	P2	P3	P4	P5	P6	P7
Species richness[1] (.05 ha)	4.3	4.2	5.7	4.2	4.4	3.7	3.9	3.8
	(0.6)[2]	(2.2)	(0.9)	(0.8)	(1.1)	(0.9)	(0.9)	(1.4)
Total species[1]	6	8	8	10	9	8	9	7
Species diversity[3] : Exp (H')[5]	2.5	1.4	2.9	2.7	3.1	3.0	2.7	2.8
$1/\lambda$[6]	2.0	1.1	2.1	1.9	2.6	2.6	2.4	2.4
Mean basal area (m^2/ha)[4]	30.7	86.2	132.5	89.4	138.4	158.4	114.5	86.0
	(6.5)	(24.5)	(20.5)	(20.3)	(43.5)	(52.9)	(31.1)	(13.4)
Mean density(trees/ha)[3]	700	300	340	420	485	414	388	634
	(87)	(73)	(157)	(136)	(104)	(118)	(122)	(288)
Mean max. height (m)	18	44	64	48	58	61	50	41
	(7)	(7)	(8)	(10)	(10)	(8)	(8)	(16)

[1] Includes tree, sapling and seedling strata

[2] (standard deviation)

[3] Includes tree stratum only

[4] Includes trees and saplings

[5] Antilog of Shannon's Index

[6] Reciprocal of Simpson's Index

Table 23 : <u>Pseudotsuga</u> group and community type D1 understory strata summary table
(see table 15 for community type codes).

Community types	D1	P1	P2	P3	P4	P5	P6	P7	D1	P1	P2	P3	P4	P5	P6	P7
Number of plots	3	4	4	5	11	17	12	7								

Shrubs			Mean coverage (%)									Constancy (%)				
Amelanchier alnifolia	+	+	+	+	+	+	+		66	50	25	40	18	5	16	
Arctostaphylos columbiana	7	+							100	25						
Berberis nervosa	5	12	13	10	11	3	6	4	100	100	100	100	100	58	58	57
Gaultheria shallon	13	60	13	44	10	+	4	75	100	100	75	100	90	35	66	100
Holodiscus discolor	+	3	+	2	+				33	50	25	40	9			
Rosa gymnocarpa	+	1	2	3	+	+	+	1	100	75	100	80	54	11	16	14
Rubus ursinus	1	2	8	1	1	+	+	1	100	75	100	60	72	35	16	28
Symphoricarpos spp.		+	+	1	+					50	50	40	18			
Vaccinium alaskaense		2		+	3	1	5	8		25		20	36	65	50	14
Vaccinium ovatum	18	11	+	1	+	+		4	66	50	25	20	18	11		14
Vaccinium parvifolium	+	7	2	10	12	7	20	7		100	100	100	100	100	100	100

Herbs																
Achillea millefolium	+								66							
Achlys triphylla	+	2	11	12	4	3	4	+	33	100	100	100	100	100	75	42
Adenocaulon bicolor			+	+	+	+					50	20	18	17		
Allotropa virgata		+		+	+		+	+		50		40	27		16	14
Apocynum androsaemifolium	+	+				+			66	50					8	
Arenaria macrophylla	+	+		+	+				33	50		20	9			
Blechnum spicant					+	3	2	+					9	52	58	28
Boschniakia hookeri		+		+	+			+		100		60	9			42
Bromus vulgaris			+	+	·	+					50	20		5		
Calypso bulbosa			+	+	+						50	40	27			
Campanula scouleri		+	+	+	+		+			75	50	40	9		16	
Chimaphila menziesii		+	+	+	+	+	+			50	75	80	63	17	50	

Table 23 (continued)

Community types	D1	P1	P2	P3	P4	P5	P6	P7	D1	P1	P2	P3	P4	P5	P6	P7
Herbs (continued)																
Chimaphila umbellata	+	6	+	2	+	+	+	+	33	100	50	100	54	5	41	42
Corallorhiza maculata			+	+			+	+			25	60			8	14
Corallorhiza mertensiana				+	+	+	+	+				60	27	11	50	28
Cryptogramma crispa	+								66							
Danthonia spicata	4	1							100	50						
Festuca occidentalis	+	3	2	1	+		+	+	66	100	50	40	9		8	14
Festuca ovina	1								66							
Festuca subuliflora		+	3	2	+	+	+	1		50	100	100	36	35	16	28
Fragaria virginiana	+	+							66	50						
Galium triflorum			+			+					50			29		
Goodyera oblongifolia	+	+	+	+	+	+	+	+	100	100	100	100	81	35	33	42
Hieracium albiflorum	+	1	+	+			+	+	100	75	25	20			16	14
Hypochaeris radicata	+	+							66	50						
Lathyrus nevadensis			+	1							25	60				
Linnaea borealis	1	8	10	20	8	2	1	3	33	100	100	100	81	29	33	28
Listera cordata	+	+	+	+	+	+	+	+	66	75	75	80	54	17	50	85
Madia madioides		1								50						
Montia parviflora			+		+	+					50		9	17		
Polypodium glycyrrhiza	+	+	1	+	+	+	+	+	66	100	100	40	36	35	25	14
Polystichum munitum	+	+	18	4	8	29	3	+	66	100	100	100	100	100	75	57
Pteridium aquilinum		6	+	+	+	+	+	+		100	75	60	63	23	8	14
Saxifraga ferruginea	+								66							
Selaginella wallacei	5	+		+		+			100	25		20		5		
Tiarella laciniata			+	+	+	+	+				25	20	54	41	41	
Tiarella trifoliata			1	+	1	2	1				50	20	63	88	33	
Trientalis latifolia	+	2	4	2	+	+	+	+	66	100	100	80	81	17	33	28
Trillium ovatum			+		+	+	+				25		54	76	58	
Viola sempervirens	+	+	1	2	2	+	+		33	75	75	80	54	17	25	

Table 23 (continued)

Community types	D1	P1	P2	P3	P4	P5	P6	P7	D1	P1	P2	P3	P4	P5	P6	P7
Bryophytes & lichens																
Cladina impexa	1								66							
Cladina rangiferina	5	+						+	100	50						14
Cladonia bellidiflora	1	+						+	100	25						14
Cladonia multiformis	3	+							100	50						
Cladonia gracilis	1	+							66	25						
Dicranum fuscescens	+	2	1	1	+	+	1	2	33	100	100	100	90	58	58	100
Dicranum scoparium	10	2	+	+					66	50	25	20				
Heterocladium macounii					1	1	+						27	52	33	
Hylocomium splendens	2	21	22	52	23	2	14	35	100	100	100	100	100	76	91	100
Hypnum circinale		+	+	+	1	3	3	1		50	50	40	81	94	100	85
Isopterygium elegans	+			+	+	+	+		33			20	27	76	58	
Isothecium stoloniferum	2	3	3	+	2	5	4	+	33	75	75	20	81	94	83	42
Leucolepis menziesii			3	+	+	+	+				75	60	18	11	8	
Peltigera leucophlebia	1	+						+	66	75						28
Peltigera membranacea	+	1			+	+	+	+	33	75			18	5	16	14
Peltigera polydactyla					+	+	+	+					18	17	50	14
Plagiothecium undulatum	+	+	+	1	+	2	2	+	33	25	50	60	45	70	50	57
Pogonatum contortum			1	3	+	+	+	+			50	100	9	29	50	28
Polytrichum commune	1	+							100	25						
Polytrichum juniperinum	4	2		+					100	100		20				
Rhacomitrium canescens	3	2							100	75						
Rhizomnium glabrescens			+	+	+	+	+	+			25	20	54	65	41	14
Rhytidiadelphus loreus	+	+	2	4	6	4	4	15	66	100	75	100	90	76	83	85
Rhytidiadelphus triquetrus	1	+	6	1	+	+		1	66	75	75	80	18	5		28
Rhytidiopsis robusta	+			1	2	+	9	5	33			40	63	17	66	71
Scapania americana	+								66							
Scapania bolanderi			+	1	1	2	4	2			50	100	81	94	100	85
Stereocaulon tomentosum	1								66							
Stokesiella oregana	4	28	24	6	20	13	10	10	100	100	100	100	100	94	91	71
Trachybryum megaptilum	1	1		1	+	+	1	1	33	100		40	45	5	50	71
Rock	28	2	9	1	2	10	8	2	100	50	50	20	54	88	75	28

Table 23 (continued)

Community types	D1	P1	P2	P3	P4	P5	P6	P7
Strata mean coverage (%)								
Shrubs	45	98	38	72	39	12	36	102
	(7)[1]	(35)	(12)	(46)	(24)	(11)	(32)	(12)
Herbs	24	35	54	49	26	44	13	7
	(26)	(10)	(28)	(28)	(25)	(29)	(15)	(8)
Bryo. & lichens	54	64	64	73	59	35	55	73
	(5)	(14)	(9)	(31)	(25)	(19)	(24)	(38)
Total understory	123	197	157	195	125	91	105	182
	(22)	(24)	(36)	(54)	(48)	(37)	(46)	(51)
Species richness (.05 ha)								
Shrubs	8.7	7.8	6.8	6.4	5.7	4.5	3.8	3.6
	(1.5)	(0.3)	(1.5)	(1.5)	(2.4)	(2.5)	(1.4)	(1.3)
Herbs	17.3	20.3	18.5	17.4	14.3	11.7	10.4	6.9
	(7)	(0.9)	(4.4)	(6.2)	(2.8)	(6.2)	(5.5)	(5.7)
Bryo. & lichens	18.7	13.8	9.5	11.0	10.8	11.0	12.0	9.9
	(3.2)	(3.4)	(3.3)	(2.0)	(2.4)	(2.5)	(2.3)	(2.3)
Total species : Shrubs	12	14	12	12	15	17	12	9
Herbs	32	33	36	35	41	54	42	25
Bryo. & lichens	31	23	17	20	26	27	29	21
Species diversity								
Shrubs & herbs Exp. (H')[2]	9.6	15.5	15.2	15.0	14.7	8.7	8.9	5.7
$1/\lambda$[3]	18.1	8.7	13.8	9.1	11.5	6.0	8.8	2.9
Bryo. & lichens Exp. (H')[2]	20.6	9.0	6.6	7.1	8.4	10.7	12.8	8.3
$1/\lambda$[3]	16.2	5.4	4.5	3.9	5.6	7.5	10.0	6.3

[1] (standard deviation)   [2] Antilog of Shannon's Index   [3] Reciprocal of Simpson's Index

Table 24 : <u>Thuja</u> group and community types D2, F1 and F2 tree strata summary table
(see table 15 for community type codes).

Community types	D2	T1	T2	T3	T4	T5	F2	F1	D2	T1	T2	T3	T4	T5	F2	F1
Number of plots	4	3	6	7	19	4	2	8								
Trees (> 10 cm DBH)	Mean relative importance value (%)								Constancy (%)							
Abies amabilis		1	28	18	12		4	9		33	100	100	89		50	12
Chamaecyparis nootkatensis	15	4		5					100	33		28				
Picea sitchensis		1	5		+		37	35		33	16		5		100	62
Pinus contorta	28					11			100					75		
Pinus monticola	4				+	1			75				5	25		
Pseudotsuga menziesii	17	11	3					5	100	66	16					12
Taxus brevifolia		3		1	+	6	1			100		42	15	100	50	
Thuja plicata	17	47	18	51	54	53	37	21	75	100	50	100	100	100	100	62
Tsuga heterophylla	19	34	46	25	33	29	21	26	100	100	100	100	100	100	100	87
Saplings (0–10 cm DBH)	Mean relative density (%)															
Abies amabilis			4	64	13	+	14	1		83	100		57	25	50	25
Chamaecyparis nootkatensis	35			+					100		14					
Pinus contorta	14					1			100					50		
Pinus monticola	1					1			75					25		
Taxus brevifolia	1	4			8	6			25	33			57	75		
Thuja plicata	27	54		6	7	49		2	100	100		57	63	100		12
Tsuga heterophylla	21	42	96	30	72	42	86	85	100	100	100	85	100	100	100	87
Seedlings (below BH)	Mean relative density (%)															
Abies amabilis			5	11	5			3		83	100	74				25
Chamaecyparis nootkatensis	24			2					100		14					
Picea sitchensis					+		15	23					15		100	62
Pinus contorta	12								100							
Pinus monticola	1					1			75					25		
Pseudotsuga menziesii	4	5						1	100	66						12
Thuja plicata	29	50	6	24	27	70	30	10	100	100	50	100	94	100	100	25
Tsuga heterophylla	28	41	89	63	67	29	55	49	100	100	100	100	100	100	100	100

Table 24 (continued)

Community types	D2	T1	T2	T3	T4	T5	F2	F1
Species richness[1]	6.5	4.7	3.0	3.8	3.8	4.2	4.0	3.9
	(1.0)[2]	(0.5)	(0.6)	(0.7)	(0.7)	(0.5)	(-)	(1.8)
Total species[1]	8	7	5	5	6	6	5	8
Species diversity[3]: Exp (H')[5]	5.4	3.6	3.6	3.3	2.7	3.2	3.4	4.8
$1/\lambda$[6]	5.1	2.8	3.1	2.8	2.4	2.6	3.1	4.1
Mean basal area (m^2/ha)[4]	30.2	86.0	142.3	187.3	180.4	87.7	236.5	246.2
	(10.2)	(9.5)	(47.4)	(81.5)	(54.8)	(21.6)	(14.8)	(124.9)
Mean density (trees/ha)[3]	695	740	407	583	455	855	330	315
	(213)	(250)	(93)	(195)	(148)	(209)	(19)	(124)
Mean max. height (m)	17	30	52	42	43	24	56	60
	(10)	(4)	⟨(7)	(9)	(6)	(1)	(-)	(9)

[1] Includes tree, sapling and seedling strata

[2] (standard deviation)

[3] Includes tree stratum only

[4] Includes trees and saplings

[5] Antilog of Shannon's Index

[6] Reciprocal of Simpson's Index

Table 25 :   Thuja group and community types D2, F1 et F2 understory strata summary table
(see table 15 for community type codes).

Community types	D2	T1	T2	T3	T4	T5	F2	F1		D2	T1	T2	T3	T4	T5	F2	F1
Number of plots	4	3	6	7	19	4	2	8									

Shrubs			Mean	coverage	(%)							Constancy	(%)				
Gaultheria shallon	45	64	9	45	57	75	33	1		100	100	83	100	100	100	100	37
Menziesia ferruginea	1	2	+	4	2	5	5	+		50	100	33	85	94	100	100	12
Pyrus fusca	+				+	8		+		25				5	100		12
Ribes bracteosum								5									62
Rubus spectabilis		+	+	+	2	2	21	23			33	83	57	78	75	100	100
Vaccinium alaskaense	2	+	5	15	11	6	7	1		50	66	83	100	100	100	100	75
Vaccinium ovalifolium	+		+	2	1	+	4	1		25		66	71	57	25	100	37
Vaccinium ovatum	25	50	+		1	34	2			75	100	16		57	100	100	
Vaccinium parvifolium	6	7	13	14	13	13	13	5		100	100	100	100	100	100	100	100

Herbs																	
Achlys triphylla					+			5						5			50
Adenocaulon bicolor						1		+								50	50
Adiantum pedatum								+									50
Agrostis scabra	+									75							
Aruncus sylvester								+									62
Athyrium filix-femina			+		+		1	13				33		10		100	100
Blechnum spicant	+	32	46	48	61	65	29	6		26	100	100	100	100	100	100	62
Boschniakia hookeri	+	+			+	+				75	66			5	50		
Boykinia elata				+			+	+					28			100	25
Bromus vulgaris								+									50
Calamagrostis nutkaensis						1									50		
Carex obnupta					+	5	3	+						10	75	100	12
Coptis asplenifolia				3	+			+					57	5			12

Table 25 (continued)

Community types	D2	T1	T2	T3	T4	T5	F2	F1	D2	T1	T2	T3	T4	T5	F2	F1
Herbs (continued)																
Danthonia spicata	+								75							
Dryopteris austriaca			+					+			50					50
Galium triflorum					+		+	1					5		50	87
Goodyera oblongifolia	+			+	+			+	75			28	15			12
Linnaea borealis	4	1		1	+	5			100	66		42	10	100		
Listera caurina			+	+	+						33	71	5			
Listera cordata		+	+	+	+	+				33	16	85	47	25		
Luzula parviflora			+					+			16					75
Lysichitum americanum					2	+	26	+					10	25	100	12
Maianthemum dilatatum	+	+		2	+	2	1	3	50	33		71	57	100	100	100
Melica subulata								1								62
Polystichum munitum			12	1	+		23	45			100	42	26		100	100
Rubus pedatus				3								57				
Saxifraga ferruginea	+								75							
Selaginella wallacei	+								50							
Streptopus amplexifolius			+	+	+	+	+	+			33	85	10	25	100	75
Tiarella laciniata			+	1	+		2	+			66	85	21		100	62
Tiarella trifoliata			+	1	+		5	9			66	85	26		100	100
Trautvetteria caroliniensis								10								100
Trisetum cernuum							+	+							100	25
Trillium ovatum			+	+	+			1			50	42	36			75
Veratrum viride				+	+	+	+	+				28	5	50	50	37
Viola glabella				+			+	+				14			100	50
Bryophytes & lichens																
Andreaea rupestris	+								50							
Blepharostoma trichophyllum		+			+	1	+			33			21	50	50	
Calypogeia muellerana		+	+		+			1		33	50		26			50

Table 25 (continued)

Community types	D2	T1	T2	T3	T4	T5	F2	F1	D2	T1	T2	T3	T4	T5	F2	F1
Bryophytes & lichens (continued)																
Campylopus atrovirens	+								50							
Cephalozia bicuspidata		1	2	2	2	2	+	+		33	66	71	57	75	50	12
Cladina impexa	3								100							
Cladina rangiferina	9								100							
Cladonia bellidiflora	+								100							
Cladonia multiformis	+								50							
Cladonia gracilis	1								100							
Cladonia uncialis	1								100							
Dicranum fuscescens	+	+	+	+	+	+		+	25	100	16	42	36	25		12
Dicranum scoparium	7					+		+	100					75		12
Diplophyllum albicans	+	1		+	+	+		+	25	33		14	26	75		12
Diplophyllum plicatum		1			+	1				33			10	50		
Hebertus aduncus	+				+	1			75				15	75		
Heterocladium macounii		+	+					+		66	33					25
Hookeria lucens		+	+	+	+	+	1	+		100	66	100	84	100	100	62
Hylocomium splendens	7	14	+	4	7	8	2	2	100	100	16	85	100	100	100	87
Hypnum circinale		+	1	+	+	+		+		66	83	85	26	25		37
Isopterygium elegans		+	1	+	+		+	1		33	100	57	10		50	50
Isothecium stoloniferum	+	5	3	3	1		1	1	25	100	83	100	89		50	75
Leucolepis menziesii					+		10	6					10		100	75
Mylia taylorii	+		+	+	+	+			25		16	14	5	50		
Pellia neesiana			+	+	+		3	+			33	57	15		100	50
Plagiochila porelloides		+	+	+	+	+	3	+		33	33	42	63	75	100	62
Plagiomnium insigne							+	2							100	75
Plagiothecium undulatum	+	2	6	4	4	4	4	2	100	100	83	100	100	100	100	62
Pleurozium schreberi	1								75							
Polytrichum commune	+								75							
Polytrichum juniperinum	+								50							
Polytrichum piliferum	+								50							

Table 25 (continued)

Community types	D2	T1	T2	T3	T4	T5	F2	F1	D2	T1	T2	T3	T4	T5	F2	F1
Bryophytes & lichens																
(continued)																
Rhacomitrium heterostichum	6								50							
Rhacomitrium lanuginosum	7								75							
Rhizomnium glabrescens	+	+	2	4	5	1	15	2	50	100	100	100	94	100	100	100
Rhytidiadelphus loreus	11	20	1	11	6	12	3	5	100	100	83	100	94	100	100	100
Scapania bolanderi	2	2	5	6	3	2	2	+	75	33	100	100	78	25	100	87
Sphagnum girgensohnii	1	2		+	+	3			50	66		28	10	75		
Sphagnum henryense					+	+	+						5	25	100	
Stereocaulon subcoralloides	+								100							
Stokesiella oregana	2	13	3	6	13	17	+	9	75	100	100	100	100	75	50	62
Stokesiella praelonga						3	17	6						25	100	50
Rock	26	1	1	1				1	100	33	66	28				12

Table   25 (continued)

Community types	D2	T1	T2	T3	T4	T5	F2	F1
Strata mean coverage (%)								
Shrubs	79	125	29	80	87	143	86	46
	(30)[1]	(31)	(28)	(35)	(30)	(9)	(25)	(44)
Herbs	9	34	60	66	65	88	94	119
	(7)	(32)	(27)	(19)	(14)	(14)	(28)	(34)
Bryo. & lichens	62	63	27	42	47	58	62	39
	(22)	(26)	(9)	(20)	(20)	(21)	(-)	(21)
Total understory	150	221	116	188	199	289	242	204
Species richness (.05 ha)	(47)	(45)	(23)	(45)	(42)	(15)	(3)	(52)
Shrubs	5.3	5.0	4.7	5.3	6.1	7.3	7.0	5.9
	(0.9)	(1.0)	(1.4)	(1.1)	(1.3)	(0.5)	(-)	(1.8)
Herbs	9.0	3.7	6.2	11.3	4.8	7.5	14.5	20.1
	(1.8)	(0.6)	(3.0)	(4.5)	(3.1)	(1.9)	(3.5)	(5.2)
Bryo. & lichens	20.5	13.0	11.7	13.4	12.4	13.5	16.0	12.1
	(1.3)	(1.0)	(2.0)	(1.6)	(1.9)	(1.3)	(2.8)	(2.0)
Total species : Shrubs	11	6	7	7	10	9	7	16
Herbs	20	7	14	24	24	13	17	49
Bryo. & lichens	32	20	22	25	36	22	20	26
Species diversity								
Shrubs & herbs : Exp (H')[2]	5.3	4.6	5.5	9.6	5.4	8.8	13.3	19.7
$1/\lambda$[3]	6.3	3.8	3.8	6.4	3.7	6.2	10.6	11.7
Bryo. & lichens : Exp (H')[2]	18.7	10.1	11.6	11.5	12.7	12.8	12.1	14.5
$1/\lambda$[3]	14.6	7.6	8.8	9.2	9.3	9.7	9.4	11.4

[1] (standard deviation)   [2] Antilog of Shannon's Index   [3] Reciprocal of Simpson's Index

Table 26 : *Abies* group tree strata summary table (see table 15 for community type codes).

Community types	A1	A2	A3	A4	A5	A6	A7		A1	A2	A3	A4	A5	A6	A7
Number of plots	3	2	4	4	12	2	5								

Tree (> 10 cm DBH)	Mean relative importance value (%)								Constancy (%)						
Abies amabilis	12	25	45	65	74	25	4		66	100	100	100	100	100	40
Chamaecyparis nootkatensis	2								66						
Picea sitchensis							9								20
Pseudotsuga menziesii	25	7					17		100	50					60
Thuja plicata	8	22			3	11	13		60	100			16	50	40
Tsuga heterophylla	52	45	55	35	23	64	57		100	100	100	100	91	100	100

Saplings (0-10 cm DBH)	Mean relative density (%)														
Abies amabilis	44	39	27	80	46	1	1		100	100	100	100	100	50	20
Thuja plicata	3	2			+		1		33	50			8		20
Tsuga heterophylla	48	58	73	19	54	99	98		100	100	100	50	100	100	100

Seedlings (below BH)	Mean relative density (%)														
Abies amabilis	41	30	12	48	27	5	3		100	100	100	100	100	100	40
Thuja plicata	3	8	1	3	6		2		66	50	50	50	33		40
Tsuga heterophylla	54	62	87	49	67	95	94		66	100	100	100	100	100	100

Table 26 (continued)

Community types	A1	A2	A3	A4	A5	A6	A7
Species richness[1]	5.0	3.0	2.7	3.5	2.5	2.5	2.8
	(1.0)[2]	(1.4)	(0.9)	(1.9)	(0.8)	(0.7)	(0.4)
Total species[1]	6	4	4	4	5	3	5
Species diversity[3]: Exp (H')[5]	3.4	3.4	2.0	2.0	1.9	2.4	3.4
$1/\lambda$[6]	2.8	3.1	2.0	1.9	1.7	2.1	2.6
Mean basal area (m^2/ha)[4]	121.0	146.5	79.5	121.9	107.7	116.5	185.2
	(44.5)	(47.4)	(11.9)	(29.6)	(20.4)	(43.1)	(37.4)
Mean density (trees/ha)[3]	700	280	435	420	517	420	348
	(295)	(28)	(153)	(140)	(149)	(56)	(114)
Mean max. height (m)	44	50	53	53	54	46	64
	(12)	(-)	(6)	(3)	(6)	(9)	(4)

[1] Includes tree, sapling and seedling strata

[2] (standard deviation)

[3] Includes tree stratum only

[4] Includes trees and saplings

[5] Antilog of Shannon's Index

[6] Reciprocal of Simpson's Index

Table 27 : <u>Abies</u> group understory strata summary table (see table 15 for community type codes).

Community types	A1	A2	A3	A4	A5	A6	A7		A1	A2	A3	A4	A5	A6	A7
Number of plots	3	2	4	4	12	2	5								

Shrubs			Mean coverage (%)								Constancy (%)				
Gaultheria shallon	34	2	+		1	43	+		100	50	50		41	100	40
Menziesia ferruginea	+	+	+			+	2		66	50	25		41	50	
Oplopanax horridus				1	+							75	16		
Rubus spectabilis		+	2	+	1		+			50	100	25	91		80
Sorbus sitchensis	+								66						
Vaccinium alaskaense	41	43	2	31	25	6	5		100	100	100	100	100	100	100
Vaccinium ovalifolium	1	1		+	3				66	50		25	66		
Vaccinium parvifolium	27	14	22	4	10	28	9		100	100	100	100	100	100	100

Herbs															
Achlys triphylla	+	4	+	4	3	+	+		33	50	25	100	50	50	40
Adiantum pedatum				1	+		+					50	16		20
Athyrium filix-femina		+		3	+	+	+			50		75	50	50	60
Blechnum spicant	1	16	11	7	17	15	25		33	100	75	100	100	100	100
Clintonia uniflora				1	+							50	16		
Cornus canadensis	1	+		+	+				33	50		50	16		
Dryopteris austriaca			+	1	2		+				25	50	66		60
Gymnocarpium dryopteris				1	+							75	25		
Hypopitys monotropa	+		+	+	+				33		50	25	25		
Listera caurina		+	+	+	+					100	50	75	16		
Listera cordata	+	+				+	+		66	50				50	20
Maianthemum dilatatum	+	+	+	1	+		+		33	50	25	50	41		20
Polystichum munitum	+	4	2	2	3	+	29		33	50	100	75	83	100	100
Rubus pedatus		1		31	3					50		75	50		
Streptopus amplexifolius		+	+		+		+			50	75		41		60

Table 27 (continued)

Community types	A1	A2	A3	A4	A5	A6	A7	A1	A2	A3	A4	A5	A6	A7
Herbs (continued)														
Streptopus roseus	+	+		5	+		+	33	50		100	25		20
Streptopus streptopoides				8	+						100	8		
Tiarella laciniata		+	+	+	+	+	+		50	50	75	50	50	60
Tiarella trifoliata		3	+	3	4	+	+		50	25	75	91	50	80
Trautvetteria caroliniensis				1	+	+					50	33	50	
Trillium ovatum	+	1	+	+	+	+	+	33	50	75	100	58	50	60
Bryophytes & lichens														
Cephalozia bicuspidata			2	1	3		1			50	25	83		80
Dicranum fuscescens	1	1	+	+	+		+	100	100	50	100	33		20
Diplophyllum albicans			2		1					50		16		
Eurhynchium pulchellum				+							50			
Heterocladium macounii			2		+		+			25		8		80
Hookeria lucens		+	+	+	1	+	+		50	75	50	75	50	80
Hylocomium splendens	3	+	1	+	3	7	+	100	50	25	25	83	50	20
Hypnum circinale	2	3	2	3	+	+	1	66	100	75	100	25	100	80
Isopterygium elegans		+	2	+	1	+	1		50	100	25	66	50	40
Isothecium stoloniferum	2	1	2	1	2	2	4	66	100	75	100	83	100	100
Lepidozia reptans	+	+	+		+	3		33	50	75		8	50	
Plagiochila porelloides				+	+	+	+				50	58	100	20
Plagiothecium undulatum	+	4	5	8	8	11	4	33	100	100	100	100	100	80
Rhizomnium glabrescens		1	4	1	7	6	2		50	75	75	100	100	80
Rhytidiadelphus loreus	17	6	3	11	17	1	2	100	100	50	75	100	100	80
Rhytidiopsis robusta	3	3		1				66	100		100			
Scapania bolanderi	3	4	6	2	2	7	4	100	100	75	100	91	100	100
Stokesiella oregana	5	+	+	+	7	24	2	66	50	25	25	75	100	100
Rock			1	3	+		5			50	25	33		60

Table 27 (continued)

Community types	A1	A2	A3	A4	A5	A6	A7
Strata mean coverage (%)							
Shrubs	104	61	25	36	40	80	15
	(34)[1]	(33)	(25)	(30)	(21)	(29)	(8)
Herbs	3	31	14	70	35	16	56
	(1)	(42)	(9)	(60)	(31)	(20)	(27)
Bryo. & lichens	39	25	33	30	54	61	22
	(16)	(12)	(18)	(20)	(17)	(11)	(7)
Total understory	147	116	72	137	129	158	93
	(44)	(88)	(18)	(73)	(48)	(20)	(22)
Species richness (.05 ha)							
Shrubs	5.3	4.0	3.8	3.3	4.8	3.5	3.4
	(1.1)	(2.8)	(0.5)	(1.0)	(1.0)	(0.7)	(0.9)
Herbs	5.0	11.0	7.0	15.0	10.9	6.0	7.8
	(2.6)	(2.7)	(5.4)	(5.1)	(7.1)	(5.6)	(2.5)
Bryo. & lichens	7.3	10.5	11.3	11.0	12.7	11.0	11.4
	(2.1)	(4.9)	(2.9)	(2.9)	(2.5)	(-)	(3.6)
Total species : Shrubs	7	6	5	5	9	4	5
Herbs	14	20	16	25	41	10	17
Bryo. & lichens	10	14	23	19	30	14	21
Species diversity							
Shrubs & herbs : Exp (H')[2]	4.9	6.3	4.8	9.8	9.8	4.5	5.5
$1/\lambda$[3]	3.8	3.7	3.4	8.0	6.4	3.6	4.7
Bryo. & lichens : Exp (H')[2]	8.5	8.1	13.0	9.7	12.2	7.6	11.9
$1/\lambda$[3]	7.4	6.6	10.4	7.7	8.8	6.1	9.4

[1] (standard deviation)　　[2] Antilog of Shannon's Index　　[3] Reciprocal of Simpson's Index

Table 28 : Subalpine vegetation group tree strata summary table.

	Mean relative importance value (%)	Constancy (11 plots) (%)
Trees (> 10 cm DBH)		
Abies amabilis	14	82
Chamaecyparis nootkatensis	7	36
Pseudotsuga menziesii	10	64
Thuja plicata	8	36
Tsuga heterophylla	51	91
Tsuga mertensiana	10	45
Saplings (0-10 cm DBH)	Mean rel. density (%)	
Abies amabilis	78	100
Chamaecyparis nootkatensis	3	27
Pseudotsuga menziesii	+	9
Thuja plicata	3	45
Tsuga heterophylla	13	82
Tsuga mertensiana	3	45
Seedlings (below BH)	Mean rel. density (%)	
Abies amabilis	46	100
Chamaecyparis nootkatensis	3	45
Pseudotsuga menziesii	1	54
Thuja plicata	3	36
Tsuga heterophylla	42	91
Tsuga mertensiana	5	18

Mean basal area (m^2/ha) : 113.2 (26.3)

Mean density (trees/ha) : 520 (243)

Table 29 : Classification of community type soils to the subgroup level (see table 15 for community type codes).

Soil subgroups (C.S.S.C., 1978)

Community types	ODB EDB	GDB	OHFP OTHFP DUHFP	GHFP	OFHP	GFHP	HG	GSB	CR	OR
SA[1]	1		7	1		1	1			
D1										3
D2	1									3
F1	1							6	1	
F2							2			
P1	3		1							
P2	1		3							
P3			5							
P4	2		9							
P5	2		12			1				2
P6	1		10							1
P7	1		6							
T1			1							2[2]
T2			1		4	1				
T3			1	1	1	2	2			
T4			3	2	3	4	7			
T5						1	3			
A1			3							
A2						2				
A3			4							
A4			1	1		1	1			
A5	1	1	6	1		2			1	
A6				2						
A7			3	1		1				

DB : Dystric Brunisol	SB : Sombric Brunisol	E : Eluviated
HFP : Humo-Ferric Podzol	CR : Cumulic Regosol	G : Gleyed
FHP : Ferro-Humic Podzol	OR : Orthic Regosol	OT : Ortstein
HG : Humic Gleysol	O : Orthic	DU : Duric

[1] SA : Subalpine vegetation group
[2] Typic Folisols

Table 30 : Mean species richness of community types (for .05 ha).

| Community types | Mean species richness | |
	vascular	total[2]
D1 Dry Pinus-Pseudotsuga forests	30.3 (8.6)[1]	49.0 (6.0)
D2 Coastal dry Pinus forests	20.7 (1.2)	41.2 (0.9)
F1 Floodplain forests	29.9 (7.8)	42.0 (6.9)
F2 Floodplain forests (Lysichitum variant)	25.5 (3.5)	41.5 (0.7)
P1 Dry Pseudotsuga forests	32.2 (3.9)	46.0 (2.1)
P2 Pseudotsuga-Thuja-Acer forests	31.0 (4.2)	39.7 (6.2)
P3 Pseudotsuga-Linnaea forests	28.0 (7.7)	39.0 (8.5)
P4 Pseudotsuga-Berberis forests	24.4 (4.9)	35.2 (6.7)
P5 Tsuga-Pseudotsuga-Polystichum forests	19.8 (7.6)	30.8 (9.1)
P6 Montane Tsuga forests	18.1 (6.6)	30.1 (7.2)
P7 Montane Tsuga-Gaultheria forests	14.3 (7.6)	24.1 (8.2)
T1 Coastal dry Thuja forests	13.3 (1.5)	26.3 (2.3)
T2 Coastal Tsuga-Blechnum-Polystichum forests	13.8 (3.8)	25.5 (5.1)
T3 Coastal montane Thuja forests	20.4 (5.3)	33.8 (5.0)
T4 Coastal Thuja forests	14.6 (4.4)	27.0 (5.7)
T5 Coastal wet Thuja forests	19.0 (2.6)	32.5 (2.4)
A1 Montane Tsuga-Abies-Gaultheria forests	15.3 (2.9)	22.7 (2.1)
A2 Montane Abies-Tsuga forests	18.0 (17.0)	28.5 (21.9)
A3 Montane Tsuga-Abies forests	13.5 (5.8)	24.7 (8.3)
A4 Montane Abies-Streptopus forests	21.7 (5.4)	32.7 (7.9)
A5 Lowland Abies forests	18.2 (7.6)	30.8 (9.3)
A6 Tsuga-Gaultheria-Blechnum forests	12.0 (5.6)	23.0 (5.6)
A7 Tsuga-Blechnum-Polystichum forests	14.0 (2.5)	25.4 (9.3)

[1] (standard deviation)

[2] also includes bryophytes and lichens

Table 31 : Homogeneity and richness of vegetation strata within community types compared with a fire disturbance index (see table 15 for community type codes).

Community types (plots)		trees	sap-lings	seed-lings	shrubs	herbs	bryo. & lichens	all strata avg.	fire[3] index
D1 (3)	hom.[1]	.87	.85	.66	–	.49	.22	.62	1.0
	rich.[2]	3.3	2.7	3.3	8.7	17.3	18.7		(-)
P3 (5)	hom.	.92	.75	.85	.66	.50	.88	.76	1.0
	rich.	3.8	2.2	3.2	6.4	17.4	11.0		(-)
P4 (11)	hom.	.89	.51	.93	.72	.50	.65	.70	0.9
	rich.	3.4	2.0	4.1	5.7	14.3	10.8		(0.3)
P5 (17)	hom.	.81	.97	.91	.63	.92	.57	.80	0.8
	rich.	3.0	1.6	2.6	4.5	11.7	11.0		(0.4)
P6 (12)	hom.	.88	.87	.98	.58	.24	.44	.66	0.9
	rich.	3.1	1.6	3.5	3.8	10.4	12.0		(0.3)
P7 (7)	hom.	.79	.76	.97	.84	.20	.56	.69	0.6
	rich.	3.0	2.3	3.3	3.6	6.9	9.9		(0.5)
D2 (4)	hom.	.64	.55	.67	.88	.64	.63	.67	0
	rich.	5.5	5.0	6.3	5.3	9.0	20.5		(-)
T2 (6)	hom.	.66	.99	.98	.76	.96	.56	.82	0
	rich.	2.8	1.8	2.3	4.7	6.2	11.7		(-)
T3 (7)	hom.	.90	.87	.82	.85	.93	.55	.82	0
	rich.	3.7	2.6	3.4	5.3	11.3	13.4		(-)
T4 (19)	hom.	.92	.88	.83	.86	.98	.68	.86	0.1
	rich.	3.1	2.8	2.9	6.1	4.8	12.4		(0.3)
T5 (4)	hom.	.95	.95	.92	.95	.97	.50	.87	0.5
	rich.	4.0	3.8	2.3	7.3	7.5	13.5		(0.6)
F1 (8)	hom.	.40	.67	.54	.48	.65	.31	.51	0.3
	rich.	2.8	1.9	3.0	5.9	20.1	12.1		(0.5)
A5 (12)	hom.	.90	.77	.72	.83	.76	.56	.76	0.2
	rich.	2.1	2.1	2.5	4.8	10.9	12.7		(0.4)
A7 (5)	hom.	.75	.99	.99	.56	.95	.50	.79	0.4
	rich.	2.6	1.4	2.2	3.4	7.8	11.4		(0.5)
stratum avg. (all types)		.81	.81	.84	.74	.69	.54	.74	

[1] Homogeneity coefficient

[2] Species richness, average for .05 ha

[3] Fire : 0 = absence, 1 = presence (S.D.)

Table 32 : Tree seedling abundance on undecomposed wood and forest floor
substrata within community types (see table 15 for community
type codes).

Community types		Mean seedling density/m^2 (S.D.)			
Substrata types		Tsuga heterophylla	Thuja plicata	Abies amabilis	Pseudotsuga menziesii
P4 (5)[1]	wood (33)[2]	2.82 (6.13)	0.09 (0.38)		0.06 (0.24)
	floor (67)	1.10 (4.93)	0.10 (0.53)		0.10 (0.47)
	z[3]	1.40	0.15		0.62
	sig.[4]	n.s.	n.s.		n.s.
P5 (13)	wood (111)	3.22 (7.31)	0.37 (1.57)		
	floor (149)	0.70 (2.57)	0.09 (0.51)		
	z	3.47	1.82		
	sig.	***	*		
P6 (10)	wood (86)	17.74 (27.25)	0.80 (1.99)		0.13 (0.50)
	floor (114)	6.36 (11.60)	0.59 (1.35)		0.14 (0.55)
	z	3.63	0.85		0.17
	sig.	***	n.s.		n.s.
T2 (6)	wood (63)	6.60 (9.94)	0.71 (1.90)	0.27 (1.01)	
	floor (57)	1.88 (3.84)	0.16 (0.53)	0.21 (0.67)	
	z	3.50	2.23	0.37	
	sig.	***	**	n.s.	
T3 (6)	wood (66)	9.05 (15.27)	5.20 (10.47)	0.82 (2.20)	
	floor (54)	1.56 (4.82)	0.30 (1.25)	0.24 (0.97)	
	z	3.76	3.77	1.92	
	sig.	***	***	*	
T4 (8)	wood (80)	1.00 (1.92)	0.73 (2.23)	0.05 (0.22)	
	floor (80)	0.18 (0.69)	0.04 (0.19)	0.04 (0.19)	
	z	3.62	2.74	0.36	
	sig.	***	**	n.s.	
A5 (7)	wood (88)	5.60 (10.97)		3.98 (6.94)	
	floor (52)	1.79 (3.37)		4.19 (7.28)	
	z	3.03		0.27	
	sig.	**		n.s.	
F1 (7)	wood (41)	0.78 (1.85)			
	floor (99)	0.07 (0.38)			
	z	2.43			
	sig.	**			

[1] Number of plots; [2] Number of microplots; [3] z-value of two sample z-test
[4] *** = $p \leqslant .001$; ** = $.001 < p \leqslant .01$; * = $.01 < p \leqslant .05$; n.s. = $p > .05$

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Figure 1 :   Study area and plot location map.

234
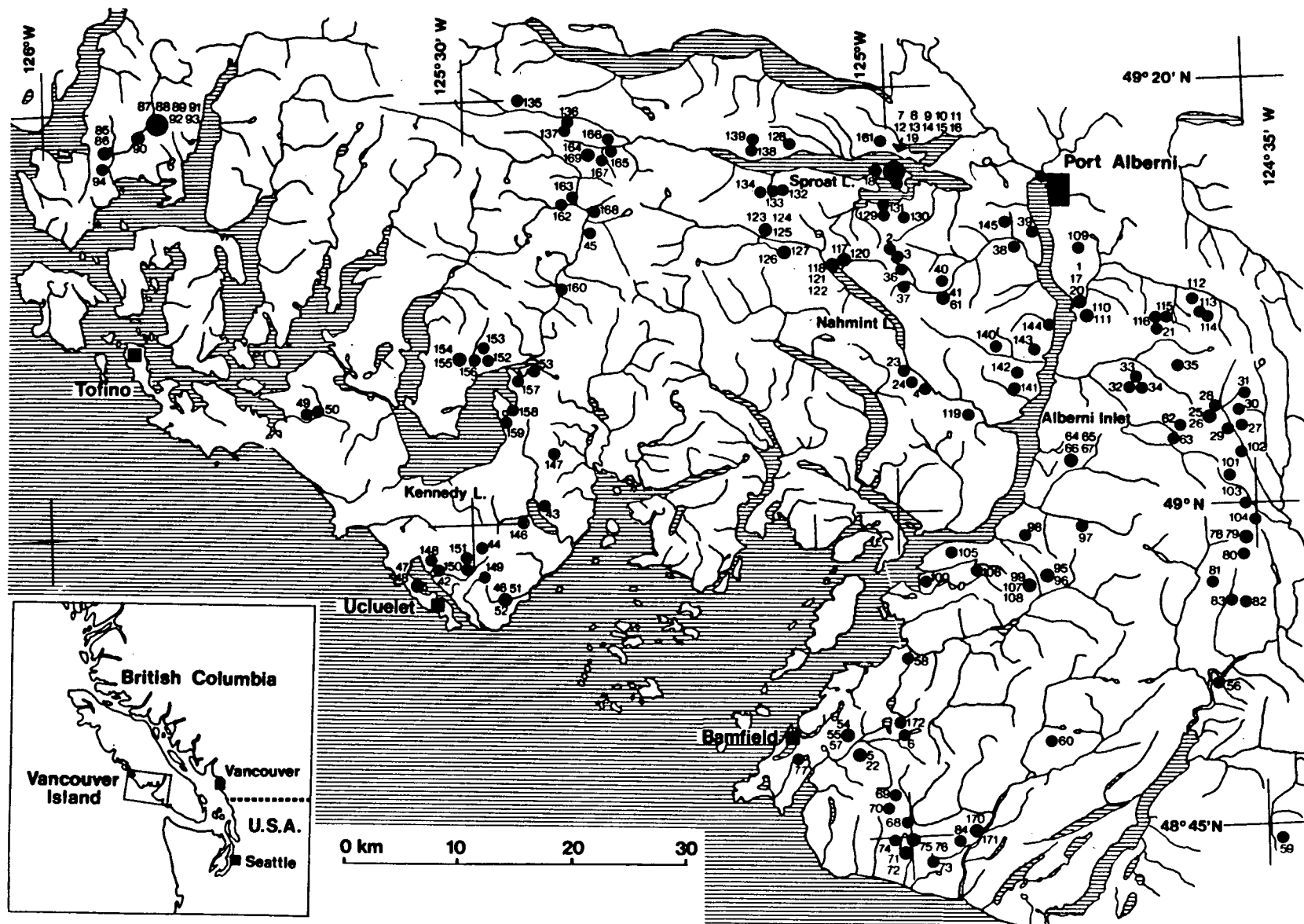
Figure 2 : Climate diagrams.

Abscissa in months, ordinate with one division

to 10° C or 20 mm precipitation (except 100 mm

at top of diagram),

A = elevation above sea level,

B = distance drom the coast,

C = length of record,

D = mean annual temperature ($^{\circ}$C),

E = mean annual precipitation (mm),

F = highest temperature on record,

G = mean daily maximum of the warmest month (July),

H = mean daily minimum of the coldest month (January),

I = lowest temperature on record,

J = mean monthly precipitation curve,

K = mean monthly temperature curve,

L   (vertical shading, two scales) = relative humid

    season,

M   (dotted shading) = relative period of drought,

N   (neutral shading) = months with mean daily

    minimum below 0° C,

O   (diagonal shading) = months with lowest temperature

    on record below 0° C,

P = frost-free period.

    [following Walter and Lieth (1967), data from

        Atmospheric Environment Service (Anon. 1982)].

Tofino A 49°5'N 125°46'W

20m^A 2km^B 25yrs^C   8.9°^D 3288^E

Alberni Lupsi Cupsi 49°15'N 124°49'W

9m 57km 25yrs   9.5° 1929
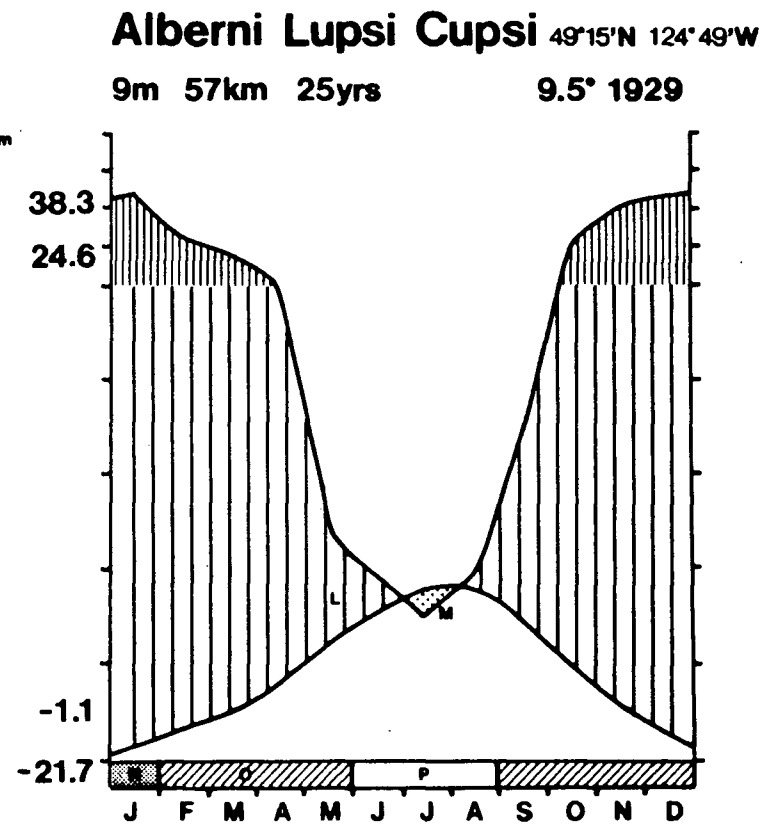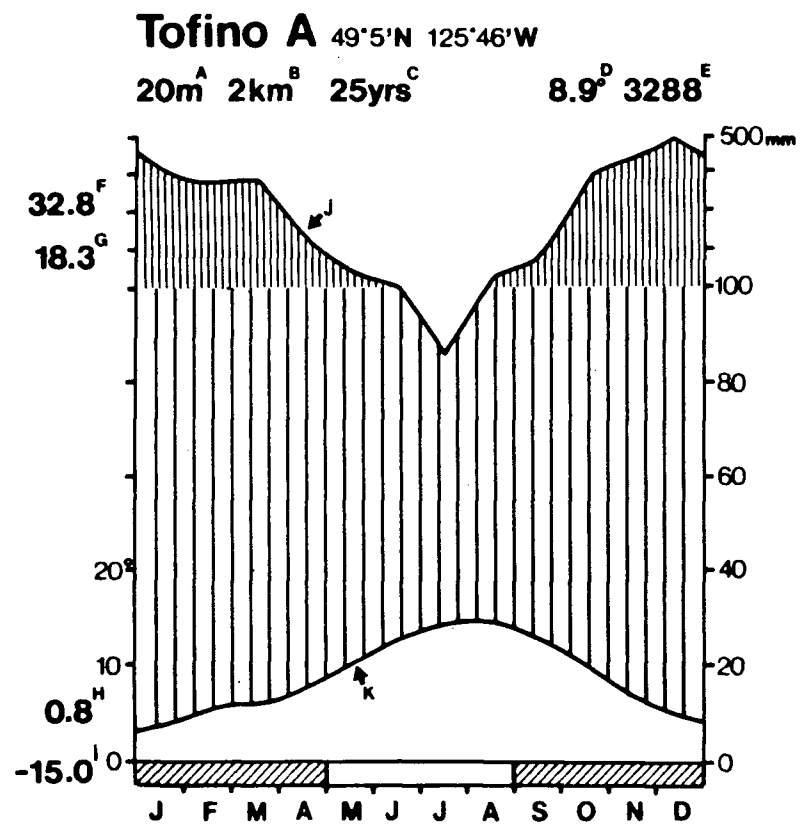
Figure 3 : Watersheds sampled in the study area.

1. Sproat Lake;

2. Cous Creek;

3. Nahmint Lake;

4. Kennedy River;

5. Estevan;

6. Cypre River;

7. China Creek;

8. Museum Creek;

9. Coleman Creek;

10. Nitinat River;

11. Sarita River;

12. Pachena River;

13. Klanawa River.
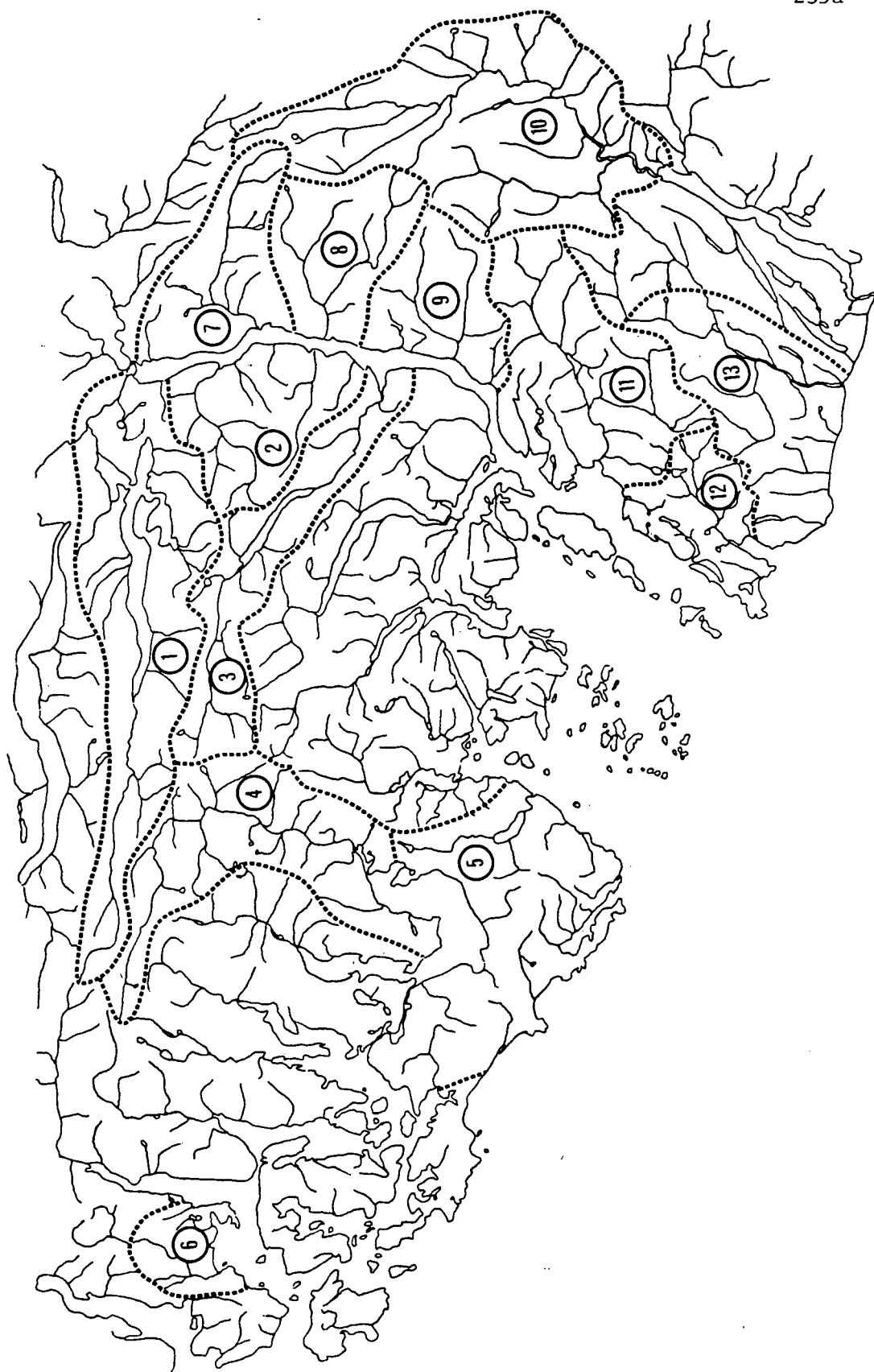
Figure 4 : Microplot sampling designs.

      a)   systematic microplot placement within 500 m^2 plot;

      b)   stratified random microplot placement within plot;

      c)   cover classes used in conjunction with microplots.

500 m² plot

25.2m upslope

flagging

microplots

0 12.6m 25.2 m

25.2 m

downslope

(a)

(b)

1m² microplot

		2
5	4	3
6	7	

(c)
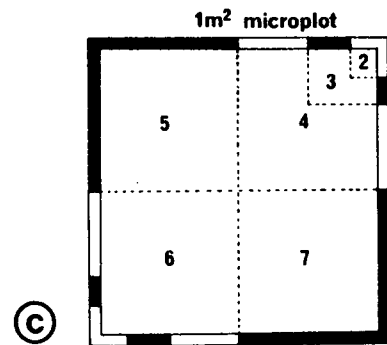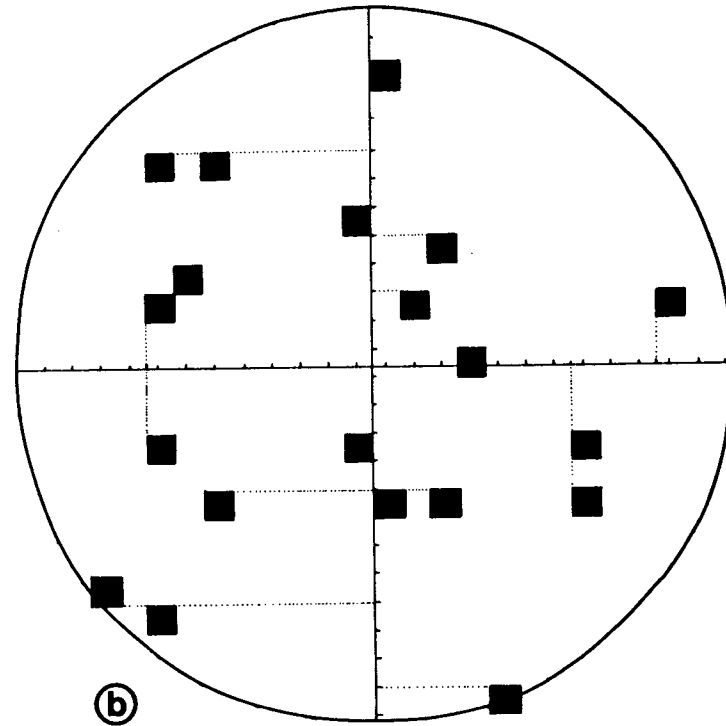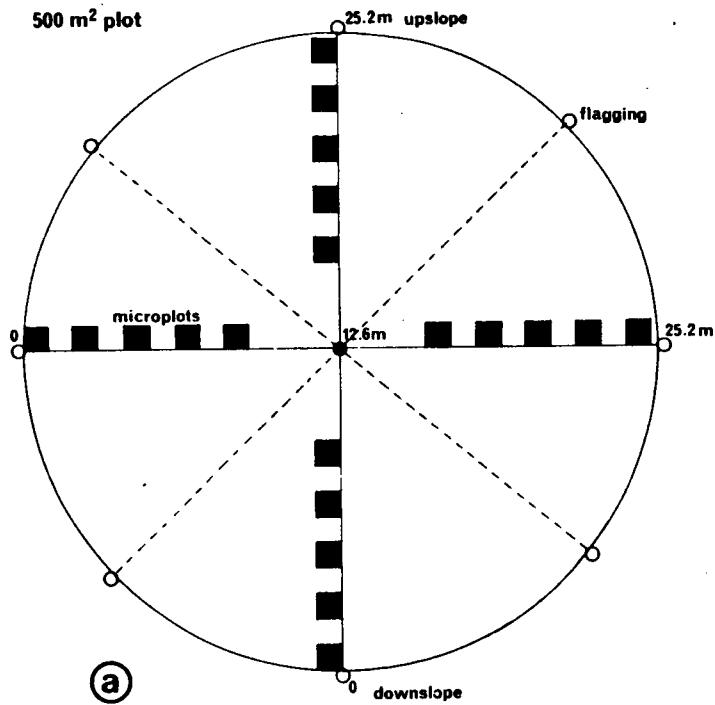
cover scale

1 : present outside microplots
2 :   0 - 1%
3 :   1 - 5
4 :   5 - 25
5 :   25 - 50
6 :   50 - 75
7 :   75 - 100
8 :   100

Figure 5 :   Reciprocal averaging ordination of forest vegetation

data from 172 plots.

Variance explained is 11.0 % by the first axis and

8.8 % by the second axis.   Solid triangles (▲)

indicate plots from the subalpine vegetation group,

squares indicate plots from the floodplain vegetation

group and circles indicate plots from the Pinus con-

torta vegetation group.   Community types : floodplain

forests (F1), ■ ; floodplain forests (Lysichitum

variant) (F2),□ ; dry Pinus-Pseudotsuga forests

(D1),● ; coastal dry Pinus forests (D2), ○ ; dry

Pseudotsuga forests (P1), △ .   Species names are

approximately located where they appear in the

species ordination also produced by RA.   Non-

classified plots are represented by small dots.
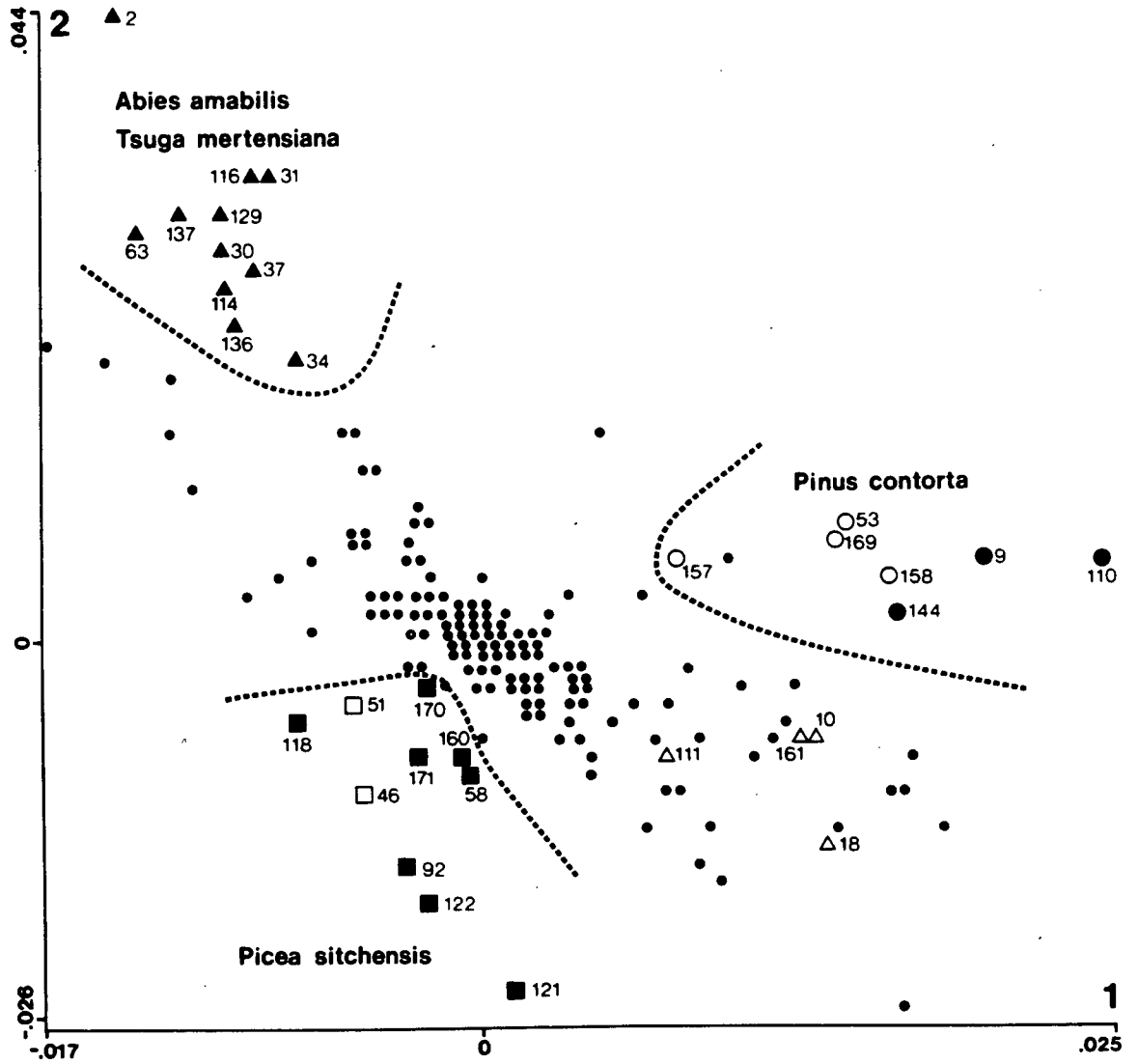
Figure 6 : Reciprocal averaging ordination of forest vegetation

data from 140 plots.

Variance explained is 13.6 % by the first axis

and 9.8 % by the second axis. Circles (●)

indicate plots from the Pseudotsuga group,

squares (□) indicate plots from the Abies group,

and triangles (▲) indicate plots from the Thuja

group. Species names are approximately located

where they appear in the species ordination also

produced by RA. A single non-classified plot is

represented by a small dot.
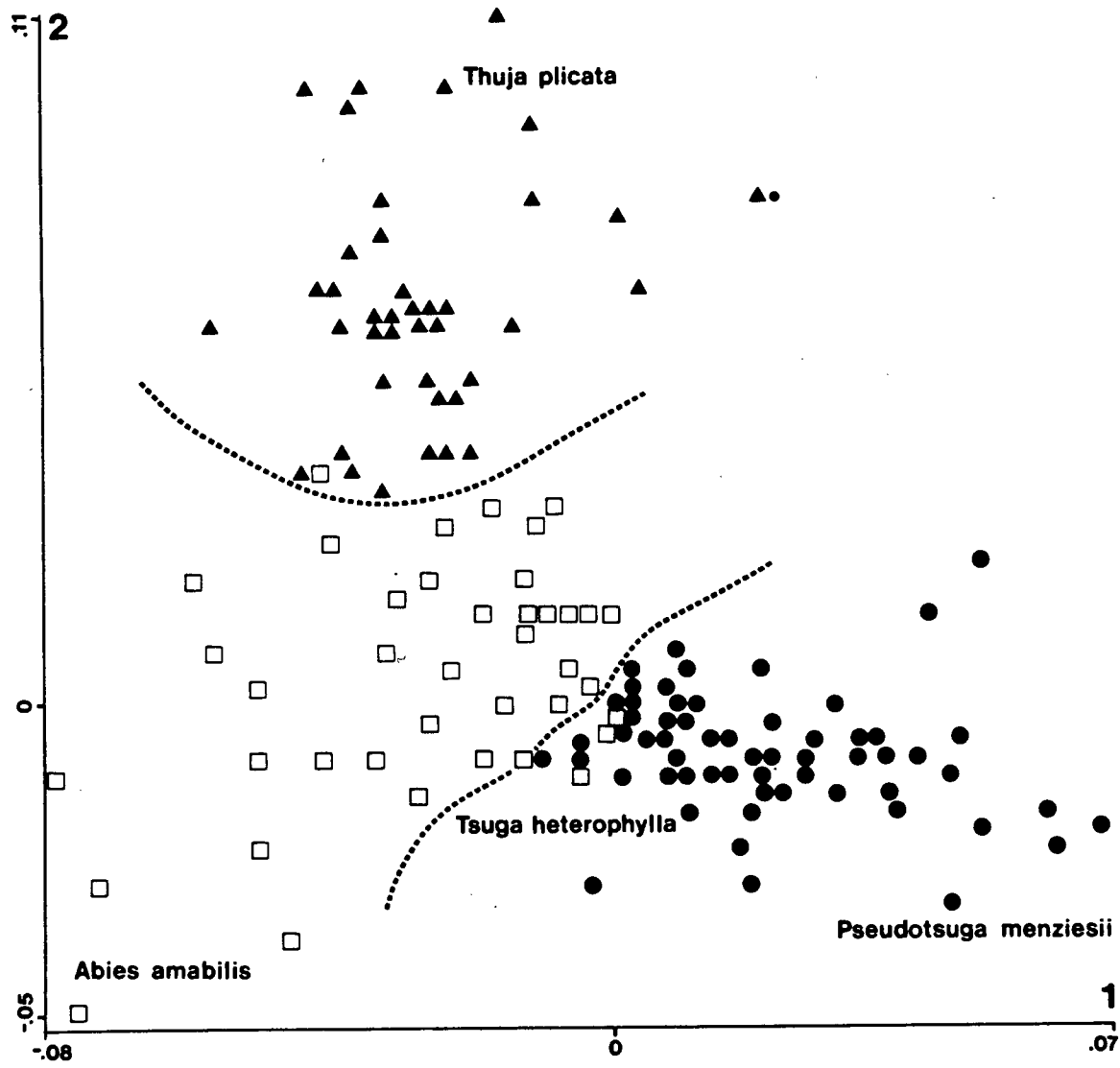
Figure 7 :   Reciprocal averaging ordination (a) and direct ordination

(b) of 59 plots from the Pseudotsuga vegetation group.

Variance explained is 14.4 % by the first axis and

9.6 % by the second axis. Community types :

Pseudotsuga-Thuja-Acer forests (P2), ■ ;

Pseudotsuga-Linnaea forests (P3), ○ ;

Pseudotsuga-Berberis forests (P4), △ ;

Tsuga-Pseudotsuga-Polystichum forests (P5), □ ;

montane Tsuga forests (P6), ▲ ;

montane Tsuga-Gaultheria forests (P7), ● ; added to

the direct ordination, dry Pinus-Pseudotsuga

forests (D1), ◆ . Species names are approximately

located where they appear in the species ordination

also produced by RA. Non-classified plots are

represented by small dots. The topographical

gradient is modified from Whittaker (1960).

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Figure 8 : Reciprocal averaging ordination (a) and direct ordination

(b) of 40 plots from the Thuja vegetation group.

Variance explained is 23.4 % by the first axis

and 13.5 % by the second axis. Community types :

coastal dry Thuja forests (T1), ● ;

coastal Tsuga-Blechnum-Polystichum forests (T2), □ ;

coastal montane Thuja forests (T3), △ ;

coastal Thuja forests (T4), ▲ ;

coastal wet Thuja forests (T5), ○ ;

added to the direct ordination, coastal dry Pinus

forests (D2), ◇ . Species names are approximately

located where they appear in the species ordination

also produced by RA. A single non-classified plot

is represented by a small dot. The topographical

gradient is modified from Whittaker (1960).
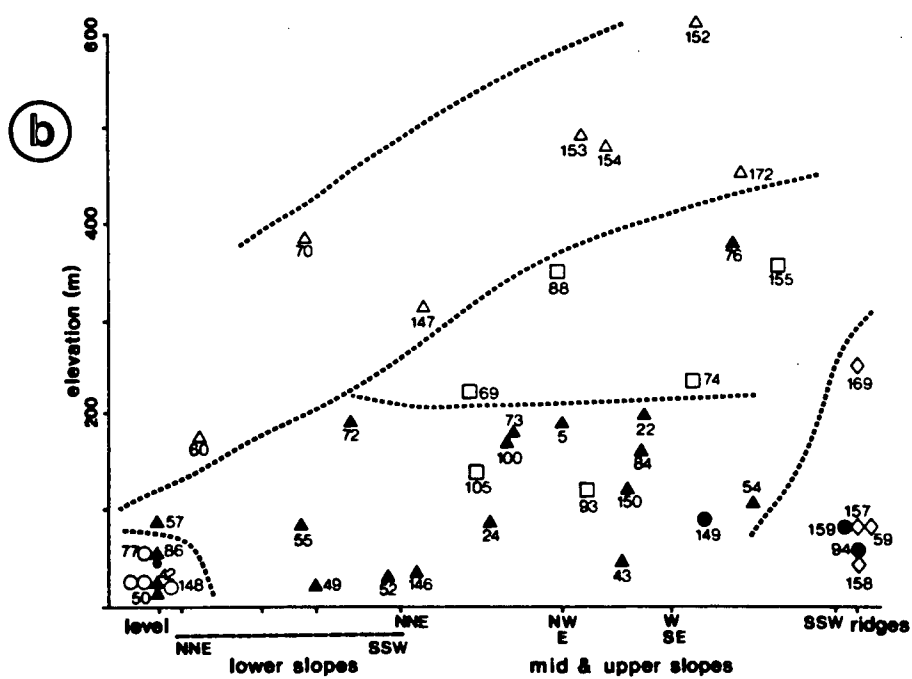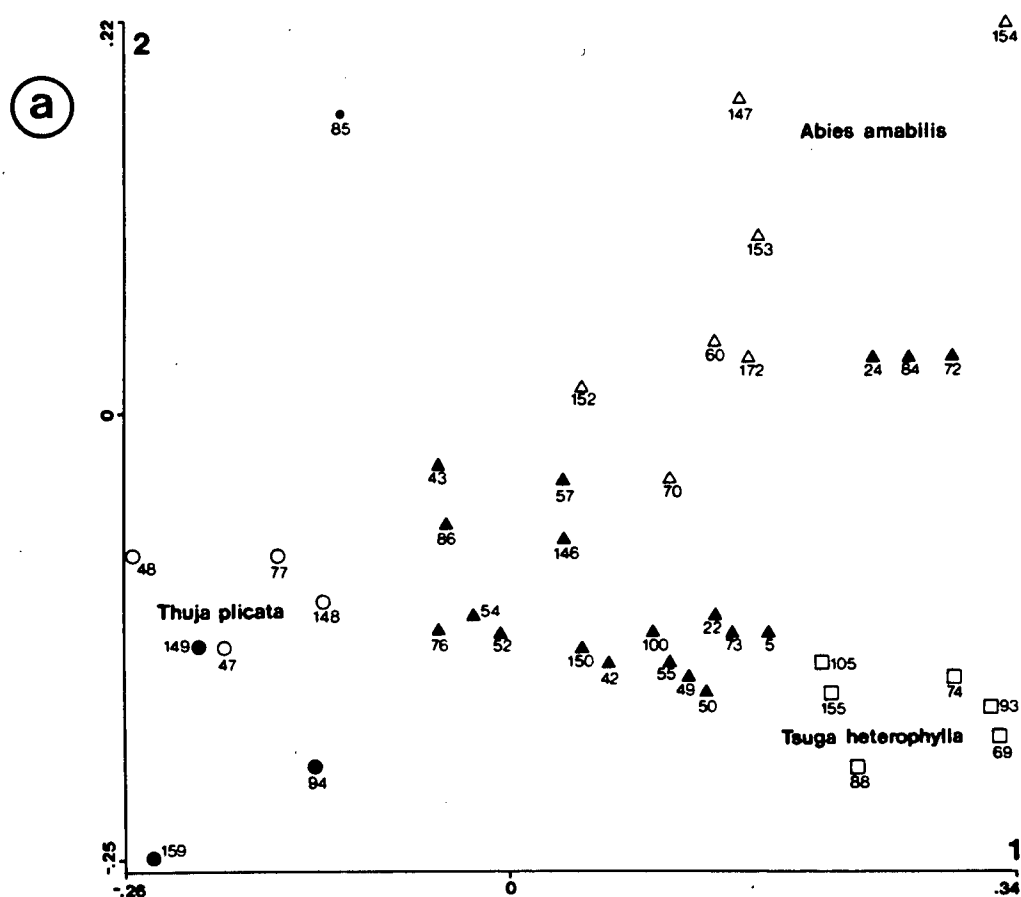
Figure 9 : Reciprocal averaging ordination (a) and direct ordination

(b) of 40 plots from the <u>Abies</u> vegetation group.

Variance explained is 16.7 % by the first axis

and 10.3 % by the third axis. Community types :

montane <u>Tsuga-Abies-Gaultheria</u> forests (A1), ◆ ;

montane <u>Abies-Tsuga</u> forests (A2), △ ;

montane <u>Tsuga-Abies</u> forests (A3), ▲ ;

montane <u>Abies-Streptopus</u> forests (A4), ■ ;

lowland <u>Abies</u> forests (A5), □ ;

<u>Tsuga-Gaultheria-Blechnum</u> forests (A6), ○ ;

<u>Tsuga-Blechnum-Polystichum</u> forests (A7), ● .

Species names are approximately located where they

appear in the species ordination also produced by

RA. Non-classified plots are represented by small

dots. The topographical gradient is modified from

Whittaker (1960).
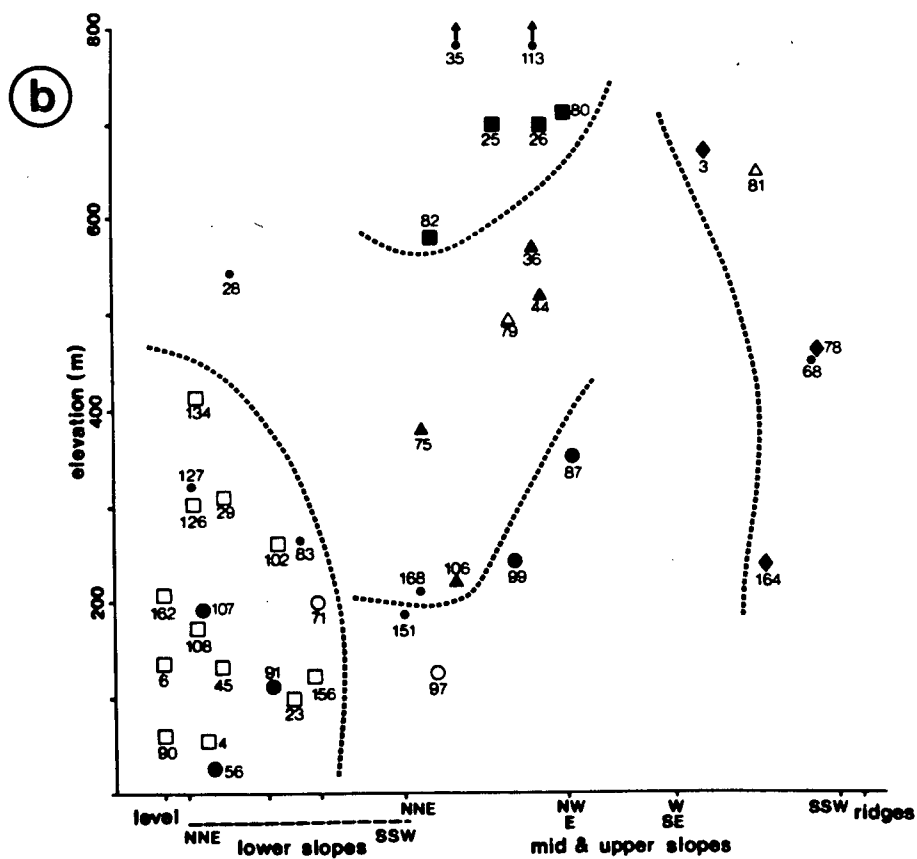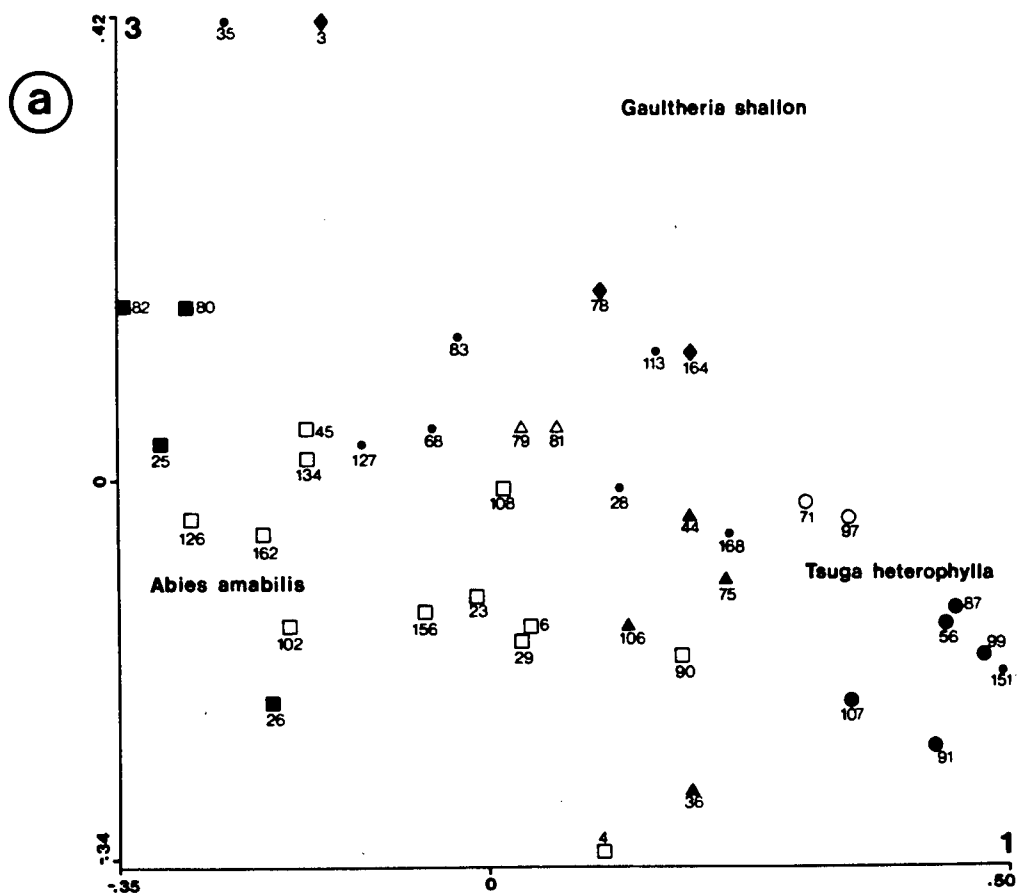
Figure 10 : Reciprocal averaging ordination of 105 modal vegetation

plots.

Variance explained is 15.0 % by the first axis

and 8.8 % by the second axis. Circles are modal

plots from the Pseudotsuga group, squares are modal

plots from the Abies group, and triangles are modal

plots from the Thuja group. Modal plots not clas-

sified into community types are represented by

small dots. Community types : P2, ◑ ; P3, ◒ ;

P4, ◐ ; P5, ● ; P6, ○ ; P7, ◒ ; T2, ▲ ; T3, △ ;

T4, ▲ ; A3, ◧ ; A6, □ ; A7, ■ (see table 15 for

community type codes).

Figure 11 : Relationships between species basal areas, LFH thickness/
effective rooting depth ratios, and distance from the
coast in 105 modal vegetation plots.

Polynomial regression equations for basal area (m^2/ha)
of species :

P. menziesii = $- 4.202 \cdot D + 0.261 \cdot D^2 - 0.003 \cdot D^3 + 16.629$
($P = .0001$, $F = 20.8$);

T. plicata = $29.204 \cdot D - 1.801 \cdot D^2 + 0.039 \cdot D^3 - 0.00029 \cdot D^4$
$- 34.556$ ($P = .0001$, $F = 18.2$);

A. amabilis = $- 0.419 \cdot D + 21.76$ ($P = .0001$, $F = 29.9$);

T. heterophylla = $- 9.538 \cdot D + 0.692 \cdot D^2 - 0.0174 \cdot D^3 +$
$0.00014 \cdot D^4 + 67.189$ ($P = .021$, $F = 3.03$);

LFH/E.R.D. ratio = $- 6.185 \cdot D + 0.552 \cdot D^2 - 0.0167 \cdot D^3$
$+ 0.0015 \cdot D^4 + 79.906$ ($P = .0001$, $F = 13.1$).

D = distance from the coast in km.
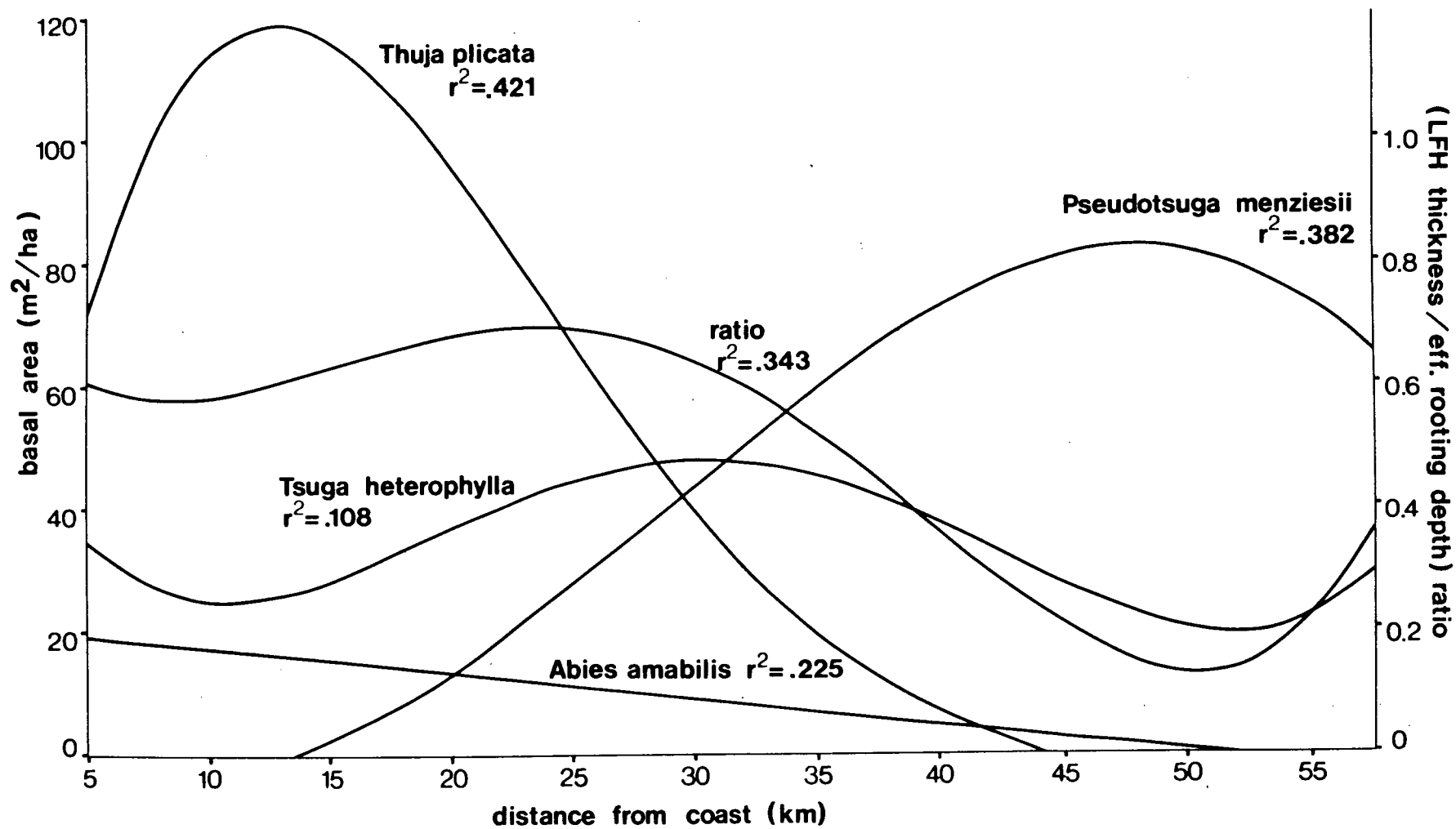
Figure 12 : Isoline maps of vascular species richness, LFH thickness/
effective rooting depth ratio, and climate variables
within the study area [climate maps adapted from
Colidago (1980)].

Vascular species richness isolines (S / 0.05 ha)

Average May to Sept. precipitation isolines (mm)

Ratio of (LFH thickness / effective rooting depth) isolines

Average effective growing degree - days isolines (°C day)

244a
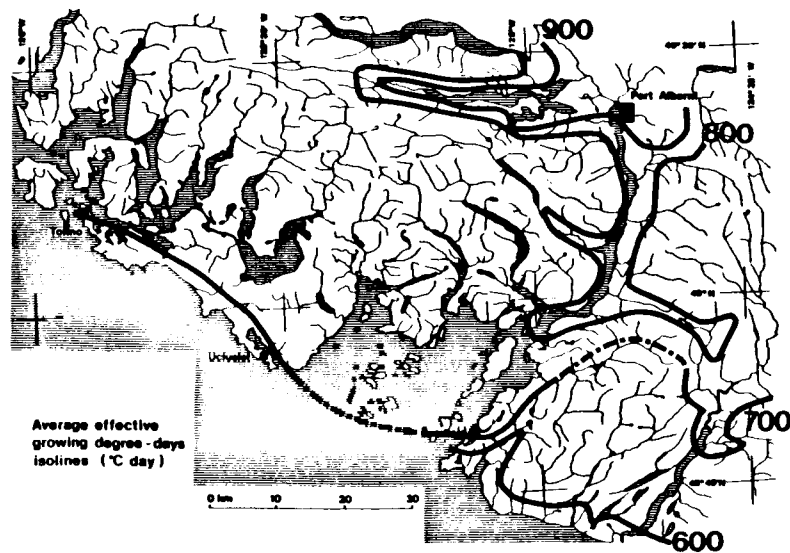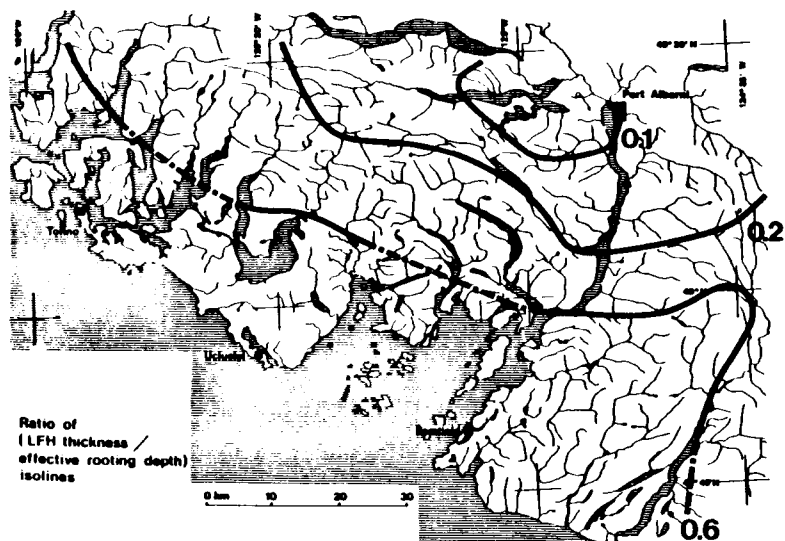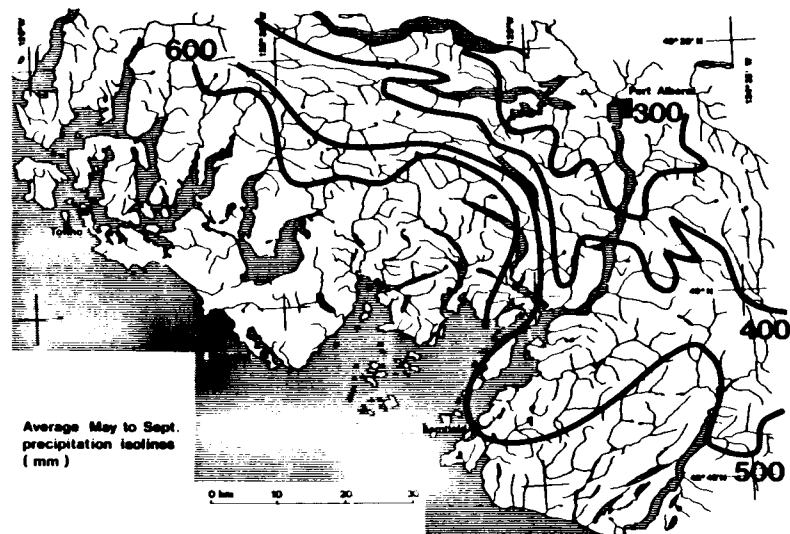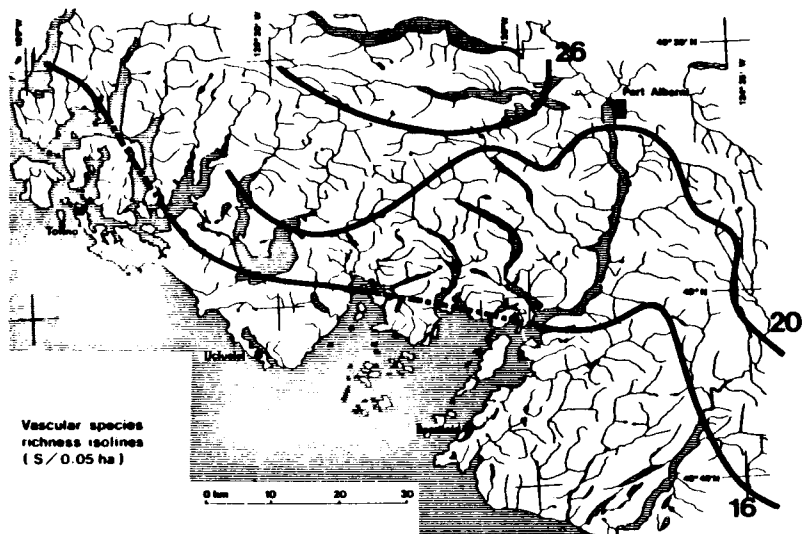
Figure 13 : Canonical analyses of vegetation groups, and community
types within three groups, based on environmental data.

Shown are means of plot scores, and 90 % confidence
circles, on the first two canonical axes. Codes to
vegetation groups and community types are listed in
Table 15.
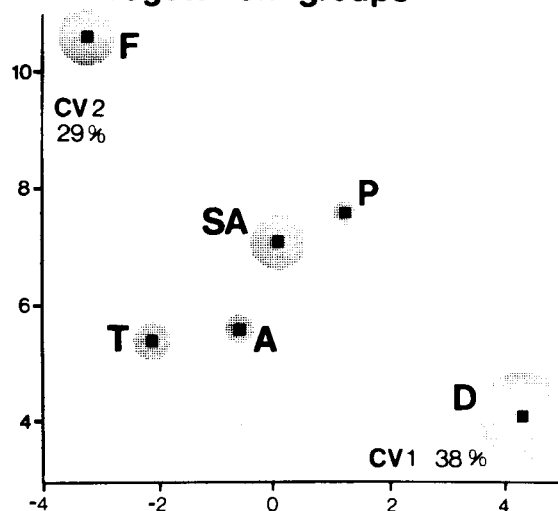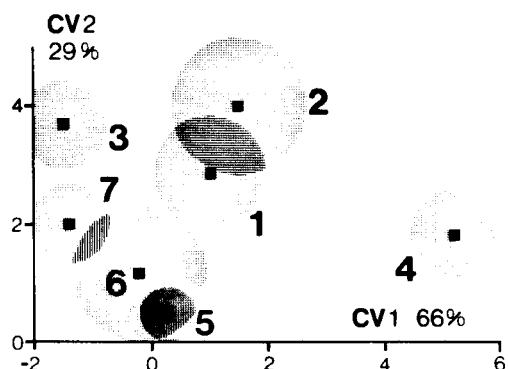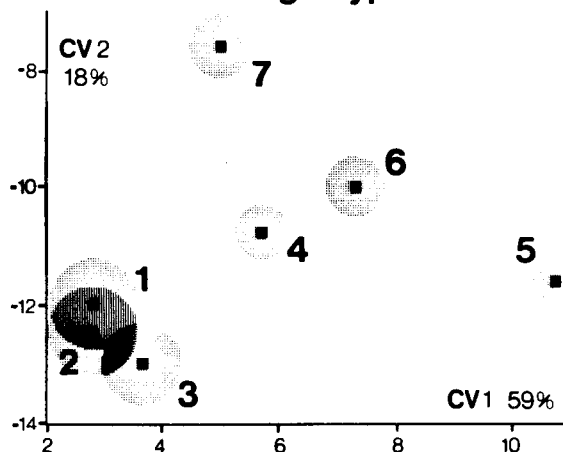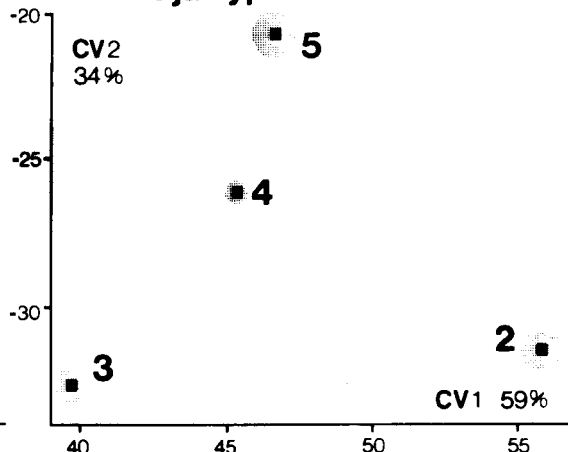
Figure 14 : Canonical analysis of twenty-two community types and the subalpine group based on environmental data.

Shown are means of plot scores, and 90 % confidence circles, on the first two canonical axes. Codes to community types and group are listed in Table 15.
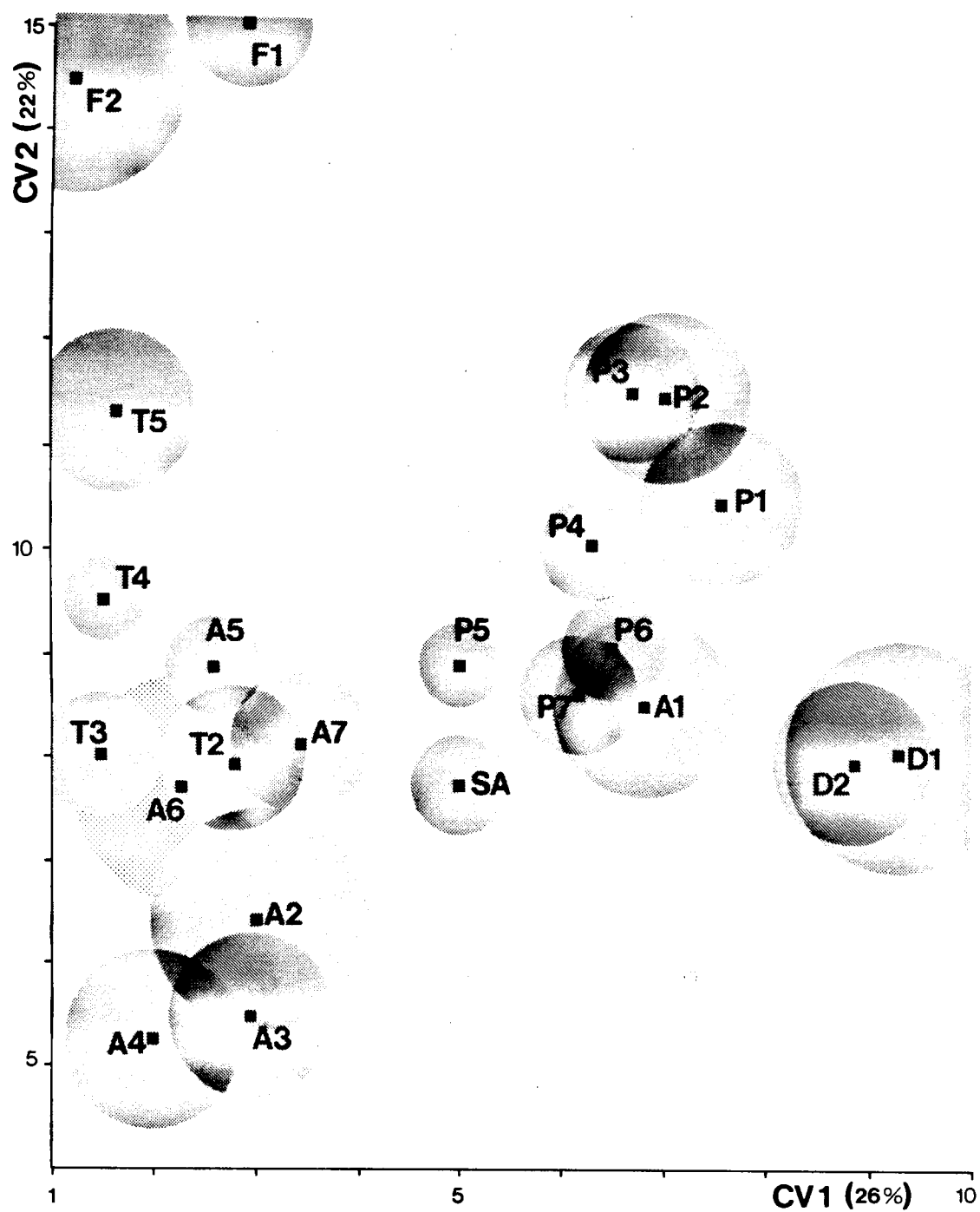
Figure 15 : Tree size-class structure : <u>Pseudotsuga</u> group community
types and dry <u>Pinus-Pseudotsuga</u> forests (D1).

Hand-fitted and smoothed curves from the data of all
plots within each community type. Codes to community
types are listed in Table 15.

Ps = <u>Pseudotsuga menziesii</u>,

Ts = <u>Tsuga heterophylla</u>,

Th = <u>Thuja plicata</u>,

Pi = <u>Pinus contorta</u>.

P1

P2

P3

P4

P5

10^4

10^3

10^2

10

1

stems / ha

Ps

Ts

Th

Ts

Ps

Th

Ts

Ps

Th

Ts

Th

Ps

Ts

Th

Ps

se. 5 15   45   75   105   135   165   195   225

P6

P7

D1

Ts

Th

Ps

Ts

Ps

Pi

Ps

seedlings & size-classes (10 cm)
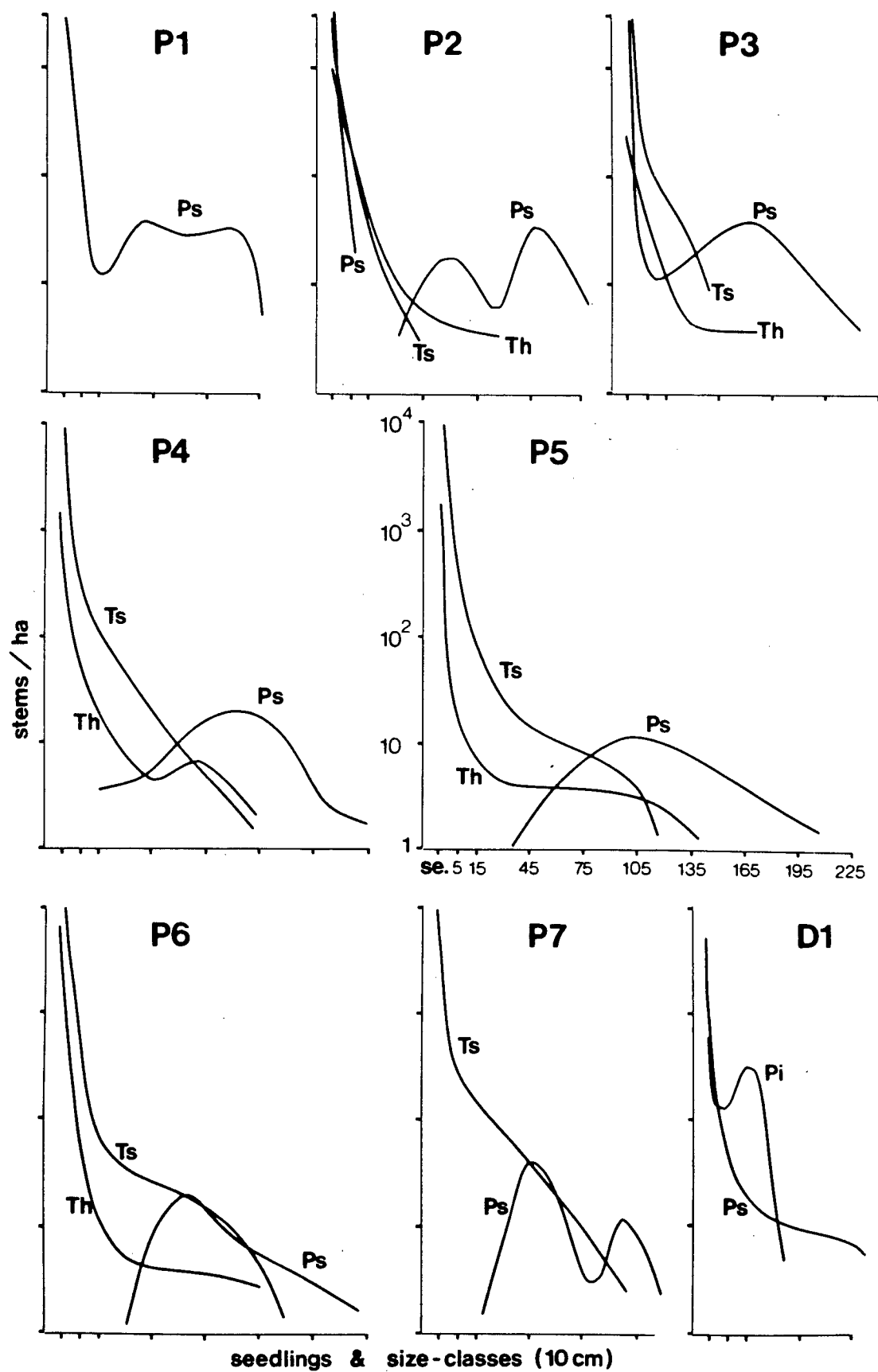
Figure 16 : Tree size-class structure : <u>Thuja</u> group community
types and coastal dry <u>Pinus</u> forests (D2).

Hand-fitted and smoothed curves from the data of
all plots within each community type. Codes to
community types are listed in Table 15.

Th = <u>Thuja</u> <u>plicata</u>,

Ts = <u>Tsuga</u> <u>heterophylla</u>,

Ab = <u>Abies</u> <u>amabilis</u>,

Pi = <u>Pinus</u> <u>contorta</u>.
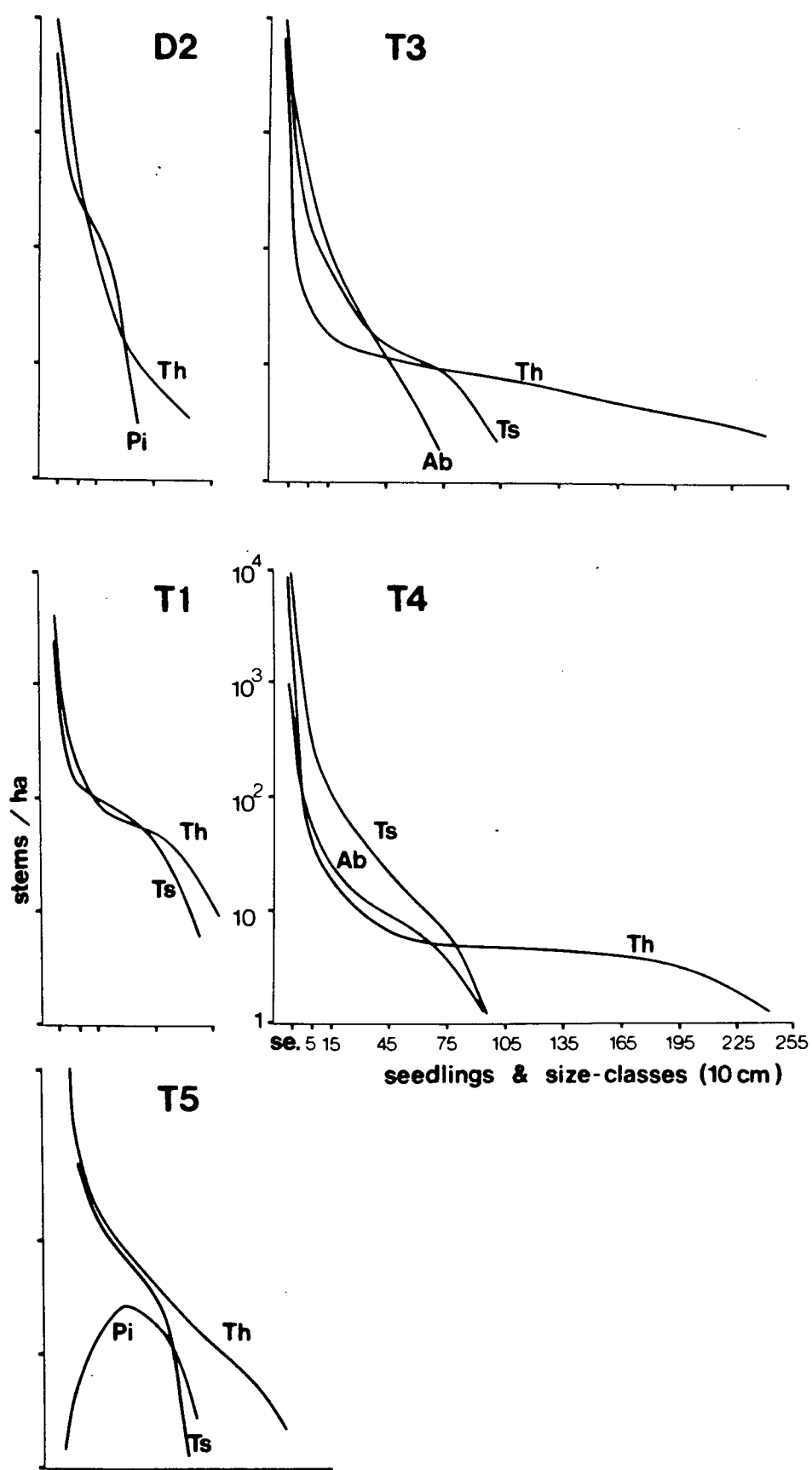
Figure 17 : Tree size-class structure : <u>Abies</u> group community

types and coastal <u>Tsuga</u>-<u>Blechnum</u>-<u>Polystichum</u>

forests (T2).

Hand-fitted and smoothed curves from the data of

all plots within each community type. Codes to

community types are listed in Table 15.

Ab = <u>Abies</u> <u>amabilis</u>,

Ts = <u>Tsuga</u> <u>heterophylla</u>,

Ps = <u>Pseudotsuga</u> <u>menziesii</u>.
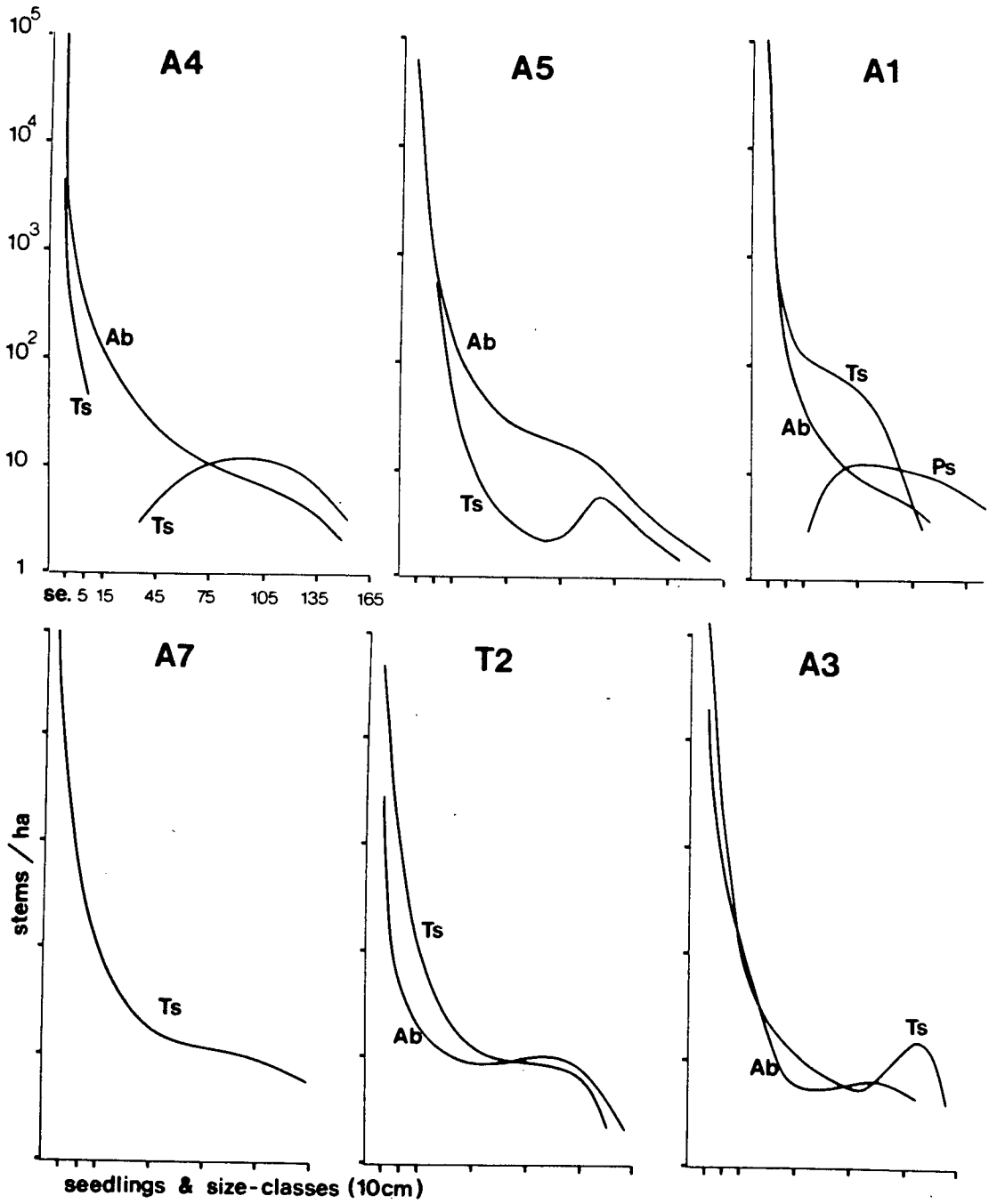
Figure 18 : Community type photographs.

a) montane <u>Tsuga</u>-<u>Gaultheria</u> forests (P7, plot 32);

b) <u>Pseudotsuga</u>-<u>Berberis</u> forests (P4, plot 123);

c) <u>Tsuga</u>-<u>Pseudotsuga</u>-<u>Polystichum</u> forests (P5, plot 124);

d) coastal <u>Thuja</u> forests (T4, plot 49);

e) <u>Tsuga</u>-<u>Blechnum</u>-<u>Polystichum</u> forests (A7, plot 91);

f) lowland <u>Abies</u> forests (A5, plot 162).

Appendix 1 : List and constancy of species found in vegetation plots.

Life-form divisions used for shrubs and herbs
(following Scoggan 1978-1979) :

Phanerophytes
(woody stems, perennating buds above 25 cm from ground)

Ms   Mesophanerophytes, 8-30 m in height
Mc   Microphanerophytes, 2-8 m in height
N   Nanophanerophytes, 25 cm to 2 m in height

Chamaephytes

Ch   (woody stems, perennating buds within 25 cm of ground)

Hemicryptophytes
(perennating buds at ground surface)

Hp   Protohemicryptophyte without runners
Hpr   Protohemicryptophyte with runners
Hs   Hemicryptophyte, semi-rosette, without runners
Hsr   Hemicryptophyte, semi-rosette, with runners
Hr   Hemicryptophyte, rosette, without runners
Hrr   Hemicryptophyte, rosette, with runners

Cryptophytes
(perennating buds or structure under ground surface)

Gp   Saprophytic or parasitic geophyte
Grh   Rhizome geophyte, perennating bud terminating a deep rhizome
Gst   Stem-tuber geophyte, perennating by tubers or corms
Grt   Root-tuber geophyte, perennating by tuberous roots
Gb   Bulb geophyte, perennating by a bulb or bulbs
Hel   Helophyte, perennating buds and lower part of plant
        submersed or in mud

Therophytes
(perennating as a seed)

T   Therophyte, plant annual

Trees	Constancy (%)			
Abbr. Species	All plots (172)[1]	Pse.[2] (59)	Thu. (40)	Abies (40)
ABA Abies amabilis (Dougl.) Forbes	59.3	30.5	82.5	92.5
ABG Abies grandis (Dougl.) Forbes	2.3	5.0		
ACM Acer macrophyllum Pursh	13.3	22.0		2.5
ALR Alnus rubra Bong.	4.6	8.5	2.5	
ARB Arbutus menziesii Pursh	3.4			
CHN Chamaecyparis nootkatensis (D.Don) Spach	11.6	6.8	7.5	5.0
COR Cornus nuttallii Aud.	9.3	22.0		
PIS Picea sitchensis (Bong.) Carr.	8.1		12.5	2.5
PIC Pinus contorta Dougl.	7.5		10.0	
PIM Pinus monticola Dougl.	9.8	11.8	7.5	
PSE Pseudotsuga menziesii (Mirbel) Franco	55.2	98.3	10.0	30.0
TAX Taxus brevifolia Nutt.	22.6	11.8	60.0	7.5
THU Thuja plicata Donn.	73.2	81.3	95.0	55.0
TSH Tsuga heterophylla (Raf.) Sarg.	96.5	100.0	100.0	100.0
TSM Tsuga mertensiana (Bong.) Carr.	5.8	3.3		
TOTAL TREE Species	15	12	10	8

1 number of plots

2 vegetation groups

Shrubs			Constancy (%)			
Abbr.	Species	Life-forms	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
ACGL	_Acer glabrum_ Torr.	Mc	2.9	6.7		
AMAL	_Amelanchier alnifolia_ Nutt.	N	8.1	13.5		
ARCO	_Arctostaphylos columbiana_ Piper	N	2.3			
BENE	_Berberis nervosa_ Pursh	N	32.5	72.8		7.5
COST	_Cornus stolonifera_ Michx.	N	0.5			
GASH	_Gaultheria shallon_ Pursh	N (Mc)	68.6	69.4	97.5	50.0
HODI	_Holodiscus discolor_ (Pursh) Maxim.	N (Mc)	4.6	6.7		
LOCI	_Lonicera ciliosa_ (Pursh) DC.	N (Mc)	1.1	1.6		
MEFE	_Menziesia ferruginea_ Smith	N (Mc)	34.3	5.0	85.0	35.0
OPHO	_Oplopanax horridus_ (Smith) Miq.	N (Mc)	6.9	3.3		17.5
PAMY	_Pachistima myrsinites_ (Pursh) Raf.	N	1.7			
PHYS	_Physocarpus opulifolius_ (L.) Maxim.	Mc	0.5			
PYUS	_Pyrus fusca_ Raf.	Mc (Ms)	4.6		15.0	
RHAM	_Rhamnus purshiana_ DC.	Mc (Ms)	2.9	1.6	10.0	
RHHA	_Rhododendron albiflorum_ Hook.	N	0.5			
RIBB	_Ribes bracteosum_ Dougl.	N (Mc)	4.0	1.6		2.5
RIBL	_Ribes lacustre_ (Pers.) Poir.	N	2.3	5.0		
ROGY	_Rosa gymnocarpa_ Nutt.	N	17.4	32.2	5.0	2.5
RUPA	_Rubus parviflorus_ Nutt.	Hp	4.6	5.0		2.5
RUSP	_Rubus spectabilis_ Pursh	Hpr	43.6	16.9	72.5	65.0
RUUR	_Rubus ursinus_ Cham. & Schlecht.	Hpr	19.7	44.0		
SALI	_Salix_ sp.	Mc	1.7			

Shrubs		Constancy (%)				
		Life-forms	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
SAMR	Sambucus racemosa L.	Mc	3.4	3.3		5.0
SOSI	Sorbus sitchensis Roemer	Mc	3.4		2.5	7.5
SYAL	Symphoricarpos albus (L.) Blake	N	5.2	11.8		
	+					
	Symphoricarpos mollis Nutt.	Ch				
VAAL	Vaccinium alaskaense Howell	N	70.3	38.9	95.0	95.0
VAME	Vaccinium membranaceum Dougl.	N	4.0	3.3		2.5
VAOL	Vaccinium ovalifolium Smith	N	33.1	11.8	55.0	40.0
VAOT	Vaccinium ovatum Pursh	N (Mc)	21.5	13.5	47.5	
VAPA	Vaccinium parvifolium Smith	N (Mc)	99.4	100	100	100
	TOTAL SHRUB Species		31	23	11	14

Herbs		Constancy (%)			
Abbr. Species	Life-forms	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
ACHI Achillea millefolium L.	Hsr	1.1			
ACTR Achlys triphylla (Smith) DC.	Grh	51.7	86.4	2.5	52.5
ADBI Adenocaulon bicolor Hook.	Hs	10.4	13.5		12.5
ADPE Adiantum pedatum L.	Grh	12.7	18.6		15.0
AGAL Agrostis sp.	Hs	1.1			
AGSC Agrostis hyemalis (Walt.) BSP.	Hs	2.3			
ALVI Allotropa virgata T. & G.	Gp	5.8	13.5		
ANLY Anemone lyallii Britt.	Grh	2.3	5.0		
ANNE Antennaria neglecta Greene	Ch	0.5			
APAN Apocynum androsaemifolium L.	Grh (Hp)	2.9	1.6		
ARCE Arceuthobium campylopodum Engelm.	parasite	——	——	——	——
ARUV Arctostaphylos uva-ursi (L.) Spreng.	Ch	1.1			
AREN Arenaria macrophylla Hook.	Hpr	2.9	3.3		
ARUY Aruncus sylvester Kostel	Hp	3.4	1.6		
ASTR Asplenium trichomanes L.	Hr	0.5	1.6		
ATFI Athyrium filix-femina (L.) Roth.	Hr	22.0	11.8	10.0	40.0
BLSP Blechnum spicant (L.) Roth.	Hr	63.9	33.8	100	87.5
BOHO Boschniakia hookeri Walpers	Gp	11.0	11.8	12.5	
BOMU Botrychium multifidum (Gmel.) Trevis	Grh	0.5		2.5	
BOVI Botrychium virginianum (L.) Swartz	Grh	0.5	1.6		
BOYE Boykinia elata (Nutt.) Greene	Hs	5.8	1.6	5.0	7.5
BROV Bromus vulgaris (Hook.) Shear	Hs	4.6	6.7		
CALA Calamagrostis nutkaensis (Presl) Steud.	Hsr	1.7		7.5	

Herbs		Life-forms	Constancy (%)			
			All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
CALY	Calypso bulbosa (L.) Oakes	Gst	4.6	11.8		
CAMP	Campanula scouleri Hook.	Hpr	5.8	11.8		
CARD	Carex deweyana Schw.	Hs	0.5			
CARH	Carex hendersonii Bailey	Hs	1.7	1.6		
CARI	Carex laeviculmis Meinsh.	Hs	0.5		2.5	
CARL	Carex leptalea Wahl.	Hsr	0.5		2.5	
CARM	Carex mertensii Prescott	Grh	0.5			2.5
CARO	Carex obnupta Bailey	Grh	5.2		15.0	
CARR	Carex sp. 1		0.5		2.5	
CARS	Carex sp. 2		0.5		2.5	
CHME	Chimaphila menziesii (R.Br.) Spreng.	Hpr	22.0	40.6		12.5
CHUM	Chimaphila umbellata (L.) Bart.	Hpr	20.3	37.2		10.0
CIRC	Circaea alpina L.	Grh	0.5			
CLUN	Clintonia uniflora (Schult.) Kunth.	Grh	6.3	1.6		10.0
COAA	Collomia heterophylla Hook.	T	0.5			
COAS	Coptis asplenifolia Salisb.	Hrr	6.9		15.0	12.5
COMA	Corallorhiza maculata Raf.	Grh	6.9	10.1		7.5
COME	Corallorhiza mertensiana Bong.	Grh	13.9	27.1	2.5	5.0
CORN	Cornus canadensis L.	Hpr	23.8	6.7	45.0	27.5
CRCR	Cryptogramma crispa (L.) R. Br.	Hr	1.7			
CYST	Cystopteris fragilis (L.) Bernh.	Hr	0.5			2.5
DASP	Danthonia spicata (L.) Beauv.	Hs	4.6			
DESC	Deschampsia caespitosa (L.) Beauv.	Hs	0.5		2.5	

Herbs		Constancy (%)				
	Life-forms	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
DICE	_Dicentra formosa_ (Andr.) Walp.	Grh	0.5	1.6		
DIHO	_Disporum hookeri_ (Torr.) Nicholson	Grh	8.1	15.2		5.0
DISM	_Disporum smithii_ (Hook.) Piper	Grh	1.7	1.6		5.0
DRAU	_Dryopteris austriaca_ (Jacq.) Woynar	Hr (Grh)	16.8	10.1	7.5	37.5
EQTE	_Equisetum telmateia_ Ehrh.	Grh	1.1		5.0	
ERLA	_Eriophyllum lanatum_ (Pursh) Forbes	Hp	0.5			
FEOC	_Festuca occidentalis_ Hook.	Hs	7.5	11.8		
FEOV	_Festuca ovina_ L.	Hs	1.1			
FESA	_Festuca subulata_ Trin.	Hs	1.7			
FESU	_Festuca subuliflora_ Scribn.	Hs	17.4	42.3	2.5	2.5
FRAG	_Fragaria virginiana_ Duchesne	Hrr	2.3			
FRIT	_Fritillaria camschatcensis_ (L.) Ker-Gawl.	Gb	1.1			
GALI	_Galium triflorum_ Michx.	Hp	13.3	11.8	5.0	15.0
GAOV	_Gaultheria ovatifolia_ Gray	Ch	3.4	3.3		2.5
GOOB	_Goodyera oblongifolia_ Raf.	Hrr	37.7	55.9	12.5	15.0
GYDR	_Gymnocarpium dryopteris_ (L.) Newm.	Grh	7.5			20.0
HADI	_Habenaria dilatata_ (Pursh) Hook.	Grt	0.5			2.5
HAEL	_Habenaria elegans_ (Lindl.) Boland.	Grt	0.5			
HASA	_Habenaria saccata_ Greene	Grt	0.5		2.5	
HASP	_Habenaria_ sp.	Grt	0.5			
HECO	_Hemitomes congestum_ Gray	Gp	7.5	13.5		5.0
HEMI	_Heuchera micrantha_ Dougl.	Hr	0.5	1.6		
HIAL	_Hieracium albiflorum_ Hook.	Hs	6.9	8.4		
HYPA	_Hypochaeris radicata_ L.		2.3			

Herbs		Life-forms	Constancy (%)			
			All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
HYPO	Hypopitys monotropa Crantz	Gp	19.1	23.7		25.0
LAMU	Lactuca muralis (L.) Fresen.		12.7	27.1		5.0
LANE	Lathyrus nevadensis Wats.	Grh	2.3	6.7		
LIAO	Lilium columbianum Hanson	Gb	2.9	1.6		
LIBO	Linnaea borealis L.	Ch	35.4	50.8	30.0	7.5
LICA	Listera caurina Piper	Grh	23.8	15.2	20.0	40.0
LICO	Listera cordata (L.) R. Br.	Grh	39.5	49.1	45.0	22.5
LUPI	Lupinus sp.		0.5			
LUZC	Luzula campestris (L.) DC.	Hs	1.1			
LUZP	Luzula parviflora (Ehrh.) Desv.	Hs	8.1	1.6	2.5	10.0
LYCL	Lycopodium clavatum L.	Ch	4.0	3.3	5.0	2.5
LYSE	Lycopodium selago L.	Ch	2.9	1.6	2.5	2.5
LYSI	Lysichitum americanum Hulten & St.John	Grh	6.3		17.5	2.5
MAAD	Madia madioides (Nutt.) Greene	Hs	1.1			
MADI	Maianthemum dilatatum (Wood) Nels. & Macbr.	Grh	31.3	8.4	55.0	35.0
MECU	Melica subulata (Griseb.) Scribn.	Gst	3.4	1.6		
MIOV	Mitella ovalis Greene	Hrr	2.9		5.0	2.5
MONE	Moneses uniflora (L.) Gray	Hr	4.6	3.3	5.0	10.0
MONO	Monotropa uniflora L.	Gp	6.9	16.9		2.5
MOPA	Montia parvifolia (Moc.) Greene	Hsr	4.0	10.1		
MOSI	Montia sibirica (L.) Howell	T (Hs)	3.4	5.0		2.5
NEPH	Nephrophyllidium crista-galli (Menzies) Gilg.	Grh (Hel)	0.5		2.5	

Herbs		Life-forms	Constancy (%)			
			All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
OXOR	Oxalis oregana Nutt.		1.1			
PAOC	Panicum occidentale Scribn.	Hs	0.5			
PEDI	Pedicularis racemosa Dougl.	Hp	1.1	1.6		
PENS	Penstemon davidsonii Greene	Ch	0.5			
PENT	Penstemon serrulatus Menzies	Hp (Ch)	0.5			2.5
PHYL	Phyllodoce empetriformis (Sw.) D.Don	Ch	1.1			
PLER	Pleuropogon refractus (Gray) Benth.	Hs	0.5			
POAM	Poa marcida Hitchc.	Hs	2.9			5.0
POLY	Polypodium glycyrrhiza D.C. Eat.	Grh	20.3	33.8	7.5	2.5
POMU	Polystichum munitum (Kaulf.) Presl	Hr	71.5	89.8	35.0	80.0
PRAL	Prenanthes alata (Hook.) D. Dietr.	Hp	1.7		2.5	5.0
PRUN	Prunella vulgaris L.	Hsr	1.1		2.5	
PTAQ	Pteridium aquilinum (L.) Kuhn	Grh	16.2	33.8		5.0
PTEA	Pterospora andromedea Nutt.	Gp	2.3	6.7		
PYAP	Pyrola aphylla Smith	Hrr	1.1	3.3		
PYAS	Pyrola asarifolia Michx.	Hrr	2.3	1.6		2.5
PYPI	Pyrola picta Smith	Hrr	9.8	18.6		5.0
PYSE	Pyrola secunda L.	Hrr	8.7	3.3		15.0
RUNI	Rubus nivalis Dougl.	Hpr	0.5	1.6		
RUPE	Rubus pedatus J.E. Smith	Hpr	16.8	1.6	10.0	37.5
SAXF	Saxifraga ferruginea Graham	Hr	2.9			
SEWA	Selaginella wallacei Hieron.	Ch	4.6	3.3		
SMRA	Smilacina racemosa (L.) Desf.	Grh	4.0	10.1		

Herbs		Life-forms	Constancy (%)			
			All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
SMST	Smilacina stellata (L.) Desf.	Grh	4.0	5.0		7.5
STAC	Stachys cooleyae Heller	Gst	2.3	1.6		
STEN	Stenanthium occidentale Gray	Gb	0.5	1.6		
STRA	Streptopus amplexifolius (L.) DC.	Grh	23.2	6.7	27.5	35.0
STRR	Streptopus roseus Michx.	Grh	13.3	5.0		35.0
STRS	Streptopus streptopoides (Ledeb.) Frye & Rigg	Grh	6.9			17.5
TILA	Tiarella laciniata Hook.	Hsr	40.1	35.5	37.5	52.5
TITR	Tiarella trifoliata L.	Hsr	51.1	49.1	40.0	67.5
TIUN	Tiarella unifoliata Hook.	Hsr	1.1			2.5
TOME	Tolmiea menziesii (Pursh) T. & G.	Hsr	1.1			
TRAU	Trautvetteria caroliniensis (Walt.) Vail	Grh	10.4	1.6		22.5
TRIE	Trientalis arctica Fisch.	Hpr	0.5		2.5	
TRLA	Trientalis latifolia Hook.	Gst	20.3	45.7		
TROV	Trillium ovatum Pursh	Grh	45.9	47.4	32.5	65.0
TRMA	Trisetum canescens Buckl.	Hs	0.5			
TRMC	Trisetum cernuum Trin.	Hs	2.3			
VEVI	Veratrum viride Ait.	Grh	10.4		15.0	7.5
VIGL	Viola glabella Nutt.	Hsr	6.3	1.6	5.0	5.0
VIOR	Viola orbiculata Geyer	Hs	1.7			2.5
VISE	Viola sempervirens Greene	Hsr	22.0	33.8	5.0	15.0
ZYVE	Zigadenus venenosus Wats.	Gb	0.5			
	TOTAL HERB Species		135	78	47	63

Mosses		Constancy (%)			
Abbr.	Species	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
ANDR	Andreaea rupestris Hedw.	1.1			
ANTI	Antitrichia curtipendula (Hedw.) Brid.	1.1		2.5	2.5
BUXB	Buxbaumia piperi Best	1.7	1.6		
CAMY	Campylopus atrovirens De Not.	1.1			
CLOA	Claopodium crispifolium (Hook.) Ren. & Card.	4.6	8.4		5.0
DICF	Dicranum fuscescens Turn.	59.3	77.9	40.0	52.5
DICM	Dicranum majus Sm.	1.1		5.0	
DICS	Dicranum scoparium Hedw.	8.1	3.3	7.5	
DITR	Ditrichum sp.	0.5			
EURP	Eurhynchium pulchellum (Hedw.) Jenn. var. barnesii (Ren. & Card.) Crum, Steere & Anders.	2.3			7.5
HETE	Heterocladium macounii Best	17.4	28.8	10.0	15.0
HETP	Heterocladium procurrens (Mitt.) Rau & Herv.	1.1	1.6		
HOLU	Hookeria lucens (Hedw.) Sm.	43.0	11.8	87.5	60.0
HYLO	Hylocomium splendens (Hedw.) B.S.G.	78.4	89.8	85.0	55.0
HYPU	Hypnum circinale Hook.	64.5	84.7	47.5	65.0
HYPV	Hypnum dieckii Ren. & Card. ex Roell.	0.5		2.5	
HYPP	Hypopterygium fauriei Besch.	1.1	1.6		2.5
ISOP	Isopterygium elegans (Brid.) Lindb.	43.0	44.0	32.5	52.5
ISST	Isothecium stoloniferum Brid.	72.0	74.5	80.0	87.5
LEME	Leucolepis menziesii (Hook.) Steere ex L. Koch	16.2	20.3	5.0	12.5

Mosses		Constancy (%)			
		All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
META	Metaneckera menziesii (Hook. ex Drumm.) Steere	0.5	1.6		
MNIU	Mnium spinulosum B.S.G.	13.3	25.4		2.5
MNIV	Mnium thompsonii Schimp.	0.5			2.5
PLIN	Plagiomnium insigne (Mitt.) Kop.	8.1	8.4		2.5
PLUN	Plagiothecium undulatum (Hedw.) B.S.G.	75.5	57.6	97.5	92.5
PLZS	Pleurozium schreberi (Brid.) Mitt.	3.4	1.6		
POGM	Pogonatum alpinum (Hedw.) Rohl. var. sylvaticum (Hoppe) Lawt.	20.9	37.2	5.0	15.0
POGC	Pogonatum contortum (Brid.) Lesq.	6.9	1.6	7.5	17.5
PONC	Polytrichum commune Hedw.	4.0			
PONF	Polytrichum formosum Hedw.	0.5			2.5
PONJ	Polytrichum juniperinum Hedw.	5.8	1.6		
PONP	Polytrichum piliferum Hedw.	2.9	1.6		
PORO	Porotrichum bigelovii (Sull.) Kindb.	0.5			2.5
RHAA	Rhacomitrium aquaticum (Brid. ex Schrad.) Brid.	1.7		2.5	2.5
RHAC	Rhacomitrium canescens (Hedw.) Brid.	3.4			
RHAH	Rhacomitrium heterostichum (Hedw.) Brid.	6.9	5.0		5.0
RHAL	Rhacomitrium lanuginosum (Hedw.) Brid.	2.3			
RHGL	Rhizomnium glabrescens (Kindb.) Kop.	67.4	47.4	97.5	80.0
RHLO	Rhytidiadelphus loreus (Hedw.) Warnst.	88.9	83.0	95.0	85.0
RHTR	Rhytidiadelphus triquetrus (Hedw.) Warnst.	9.8	20.3		
RHYT	Rhytidiopsis robusta (Hook.) Broth.	28.4	44.0		27.5
ROEL	Roellia roellii (Broth.) Andr. ex Crum	0.5			2.5

Mosses		Constancy (%)			
		All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
SCLE	Scleropodium tourettei (Brid.) L. Koch	0.5			
SPHF	Sphagnum fallax (Klinggr.) Klinggr.	0.5		2.5	
SPHG	Sphagnum girgensohnii Russ.	9.3		22.5	12.5
SPHH	Sphagnum henryense Warnst.	2.3		5.0	
SPHP	Sphagnum papillosum Lindb.	0.5		2.5	
SPHS	Sphagnum squarrosum Crome	0.5		2.5	
STOR	Stokesiella oregana (Sull.) Robins.	79.6	93.2	97.5	62.5
STPR	Stokesiella praelonga (Hedw.) Robins.	4.0		2.5	
TIMM	Timmia austriaca Hedw.	0.5	1.6		
TAME	Trachybryum megaptilum (Sull.) Schof.	15.6	32.2		2.5
	TOTAL MOSS Species	52	30	25	29

Liverworts		Constancy (%)			
Abbr.	Species	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
BAZZ	Bazzania denudata (Torr. ex Gott.) Trev.	12.7	3.3	32.5	15.0
BLET	Blepharostoma trichophyllum (L.) Dum.	10.4	3.3	20.0	15.0
CALF	Calypogeia fissa (L.) Raddi	0.5		2.5	
CALM	Calypogeia muellerana (Schiffn.) K. Muell.	8.7	1.6	22.5	10.0
CEPH	Cephalozia bicuspidata (L.) Dum.	31.3	11.8	60.0	50.0
COCO	Conocephalum conicum (L.) Dum. ex Lindb.	3.4		2.5	5.0
DIPA	Diplophyllum albicans (L.) Dum.	11.6	1.6	27.5	12.5
DIPP	Diplophyllum plicatum Lindb.	2.9		12.5	
HEBA	Herbertus aduncus (Dicks.) S. Gray	6.3	1.6	17.5	
JULE	Jungermannia leiantha Grolle	1.1		5.0	
KURZ	Kurzia sp.	1.7		7.5	
LEDO	Lepidozia reptans (L.) Dum.	9.3	10.1	5.0	17.5
MARS	Marsupella emarginata (Ehrh.) Dum.	0.5			
METZ	Metzgeria conjugata Lindb.	1.1	1.6	2.5	
MYTA	Mylia taylorii (Hook.) S. Gray	3.4		12.5	
NASC	Nardia scalaris S. Gray	1.7		5.0	
PELI	Pellia neesiana (Gott.) Limpr.	12.7		25.0	12.5
PLAG	Plagiochila porelloides (Torr. ex Nees) Lindenb.	30.8	11.8	52.5	42.5
PORE	Porella roellii Steph.	0.5		2.5	
PTIC	Ptilidium californicum (Aust.) Underw.	1.1	1.6		2.5
PTIP	Ptilidium pulcherrinum (G. Web.) Hampe	0.5			
RICL	Riccardia latifrons Lindb.	10.4		30.0	10.0

Liverworts	Constancy (%)			
	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
RICM Riccardia multifida (L.) S. Gray	0.5		2.5	
SCAA Scapania americana K. Muell.	1.1			
SCAB Scapania bolanderi Aust.	83.1	89.8	77.5	90.0
SCAP Scapania paludosa (K. Muell.) K. Muell.	0.5		2.5	
TOTAL LIVERWORT Species	26	11	22	12

Lichens	Constancy (%)			
Abbr. Species	All plots (172)	Pse. (59)	Thu. (40)	Abies (40)
CLAS Cladina impexa (Harm.) B. de Lesd.	3.4	3.3		
CLAR Cladina rangiferina (L.) Harm.	5.8	1.6		
CLEA Cladonia acuminata (Ach.) Norrl.	0.5	1.6		
CLDB Cladonia bellidiflora (Ach.) Schaer.	5.2	1.6		
CLDP Cladonia chlorophaea (Flk.) Spreng.	0.5			
CLEC Cladonia furcata (Huds.) Schrad.	0.5			
CLDG Cladonia gracilis (L.) Willd.	4.0			
CLDF Cladonia multiformis Merr.	4.0			
CLEB Cladonia pyxidata (L.) Hoffm.	0.5			
CLDS Cladonia squamosa (Scop.) Hoffm.	1.1			
CLDU Cladonia uncialis (L.) Wigg.	2.9			
LOBA Lobaria linita (Ach.) Rabh.	2.3			5.0
Lobaria oregana (Müll. Arg.) Hale	0.5	1.6		
Peltigera aphtosa (L.) Willd.	1.7			
PELO Peltigera leucophlebia (Nyl.) Gyeln.	5.2	5.0		2.5
Peltigera membranacea (Ach.) Nyl.	6.9	10.1		5.0
PELT Peltigera polydactyla (Neck.) Hoffm.	11.6	20.3		10.0
Peltigera praetextata (Somm.) Vain.	0.5	2.5		
STEO Stereocaulon subcoralloides Nyl.	2.9			
STET Stereocaulon tomentosum Fr.	1.1			
TOTAL LICHEN Species	20	9	0	4
TOTAL VASCULAR PLANT Species	181	113	68	85
TOTAL NON-VASCULAR PLANT Species	98	50	47	45
TOTAL PLANT Species	279	163	115	130

Appendix 2 : Environmental data descriptive statistics for vegetation
groups and community types.

List of variables
(refer to Table 1 for definitions of classes for discrete variables*) :

1 - elevation (m)
2 - aspect (0 - 180 , NNE to SSW)
3 - slope (%)
4 - topographic position (1-6)*
5 - drainage (1-7)*
6 - effective rooting depth (cm)
7 - root restricting depth (cm)
8 - soil depth (cm)
9 - surficial material (0-4)*
10 - effective rooting depth/root restricting depth
11 - effective rooting depth/soil depth
12 - LFH thickness/effective rooting depth
13 - fire disturbance (0-1)*
14 - wind disturbance (0-1)*
15 - worms (0-3)*
16 - LFH pH (H_2O)
17 - LFH pH ($CaCl_2$)
18 - LFH thickness (cm)
19 - A pH (H_2O)
20 - A pH ($CaCl_2$)
21 - B_1 pH (H_2O)
22 - B_1 pH ($CaCl_2$)
23 - B_1 % coarse fragments
24 - B_1 texture (1-12)*
25 - B_1 % N
26 - B_1 % C
27 - B_1 C/N ratio
28 - B_2 pH (H_2O)
29 - B_2 pH ($CaCl_2$)
30 - LFH % C
31 - LFH % N
32 - LFH C/N ratio

Slope classes (C.S.S.C., 1978)

% slope	terminology
< 2.5	level
2-5	very gentle slopes
6-9	gentle slopes
10-15	moderate slopes
16-30	strong slopes
31-45	very strong slopes
46-70	extreme slopes
71-100	steep slopes
> 100	very steep slopes

(Note : variable 15 cannot be interpreted from these data since it was not
recorded in 1980 plots, and these are included in these statistics)

Appendix 2 : Subalpine vegetation group (SA)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	11	485.00	1050.0	788.91	188.44
2.ASPECT	11	18.000	156.00	71.000	41.156
3.SLOPE	11	27.000	60.000	41.000	12.141
4.POSIT	11	2.0000	3.0000	2.7273	.46710
5.DRAINAGE	11	2.0000	5.0000	3.1818	.98165
6.EROOTDEP	11	13.000	69.000	40.364	17.996
7.ROOTDEP	11	19.000	104.00	63.545	24.039
8.SOILDEP	11	19.000	148.00	85.364	36.211
9.MATERIAL	11	1.0000	2.0000	1.4545	.52223
10.RATIO1	11	.15000	1.0000	.70182	.29549
11.RATIO2	11	.90000 -1	1.0000	.56273	.29018
12.RATIO3	11	.60000 -1	1.0000	.38455	.39853
13.FIRE	11	0.	1.0000	.72727	.46710
14.WIND	11	0.	1.0000	.90909 -1	.30151
15.WORMS	11	0.	2.0000	.81818	.98165
16.ORGPHWAT	10	3.4000	4.3000	3.7300	.24967
17.ORGPHCAL	10	2.9000	3.8000	3.2400	.25906
18.ORGTHICK	11	2.0000	35.000	11.818	10.177
19.APHWAT	3	3.5000	3.9000	3.7333	.20817
20.APHCAL	3	2.9000	3.4000	3.2000	.26458
21.B1PHWAT	10	3.8000	4.9000	4.4100	.37845
22.B1PHCAL	10	3.2000	4.4000	3.9100	.37845
23.COARSE%	11	20.000	90.000	50.455	23.922
24.TEXTURE	10	3.0000	9.0000	4.5000	1.9579
25.B1%N	10	.90000 -1	.22000	.13700	.39735 -1
26.B1%C	10	2.3000	14.030	5.5280	3.2535
27.B1CNRAT	10	25.800	63.200	38.210	10.598
28.B2PHWAT	8	4.6000	5.3000	5.0125	.26424
29.B2PHCAL	8	4.1000	5.0000	4.5375	.29731
30.ORG%C	10	37.600	52.200	47.743	4.4627
31.ORG%N	10	.64000	1.3200	.91000	.21970
32.ORGCNRAT	10	35.800	70.200	54.420	10.024

Appendix 2 : <u>Pinus</u> <u>contorta</u> vegetation group (D)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	7	45.000	322.00	156.71	117.01
2.ASPECT	7	46.000	167.00	103.86	41.611
3.SLOPE	7	10.000	65.000	37.143	19.334
4.POSIT	7	1.0000	1.0000	1.0000	
5.DRAINAGE	7	1.0000	1.0000	1.0000	
6.EROOTDEP	7	3.0000	23.000	12.857	8.4346
7.ROOTDEP	7	3.0000	23.000	12.857	8.4346
8.SOILDEP	7	3.0000	23.000	12.857	8.4346
9.MATERIAL	7	0.	1.0000	.28571	.48795
10.RATIO1	7	1.0000	1.0000	1.0000	
11.RATIO2	7	1.0000	1.0000	1.0000	
12.RATIO3	7	.13000	1.0000	.46857	.38133
13.FIRE	7	0.	1.0000	.42857	.53452
14.WIND	7	0.	1.0000	.42857	.53452
15.WORMS	7	0.	0.	0.	
16.ORGPHWAT	7	3.8000	4.4000	4.0429	.19881
17.ORGPHCAL	7	3.3000	4.0000	3.6143	.25448
18.ORGTHICK	7	1.0000	14.000	4.4286	4.4668
19.APHWAT	1	3.8000	3.8000	3.8000	
20.APHCAL	1	3.2000	3.2000	3.2000	
21.B1PHWAT	5	4.2000	5.4000	4.7600	.43359
22.B1PHCAL	5	3.7000	4.7000	4.1800	.38987
23.COARSE%	7	0.	95.000	40.571	41.016
24.TEXTURE	5	2.0000	6.0000	4.2000	1.7889
25.B1%N	5	.20000	.36000	.28000	.58310 -1
26.B1%C	5	3.1000	15.620	8.3240	4.7100
27.B1CNRAT	5	15.300	43.500	28.080	11.107
28.B2PHWAT	0				
29.B2PHCAL	0				
30.ORG%C	7	36.150	49.760	44.830	4.7782
31.ORG%N	7	.48000	.88000	.63571	.13794
32.ORGCNRAT	7	48.200	100.10	73.871	19.842

Appendix 2 : Floodplain vegetation group (F)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	10	15.000	95.000	47.900	37.563
2.ASPECT	10	0.	107.00	19.300	40.988
3.SLOPE	10	0.	5.0000	2.1000	2.0790
4.POSIT	10	5.0000	5.0000	5.0000	
5.DRAINAGE	10	4.0000	7.0000	4.9000	1.1972
6.EROOTDEP	10	11.000	113.00	55.000	29.728
7.ROOTDEP	10	11.000	130.00	72.500	42.009
8.SOILDEP	10	62.000	130.00	96.100	18.947
9.MATERIAL	10	3.0000	4.0000	3.5000	.52705
10.RATIO1	10	.61000	1.0000	.82600	.16304
11.RATIO2	10	.10000	.87000	.56000	.22730
12.RATIO3	10	.30000 -1	.19000	.77000 -1	.61653 -1
13.FIRE	10	0.	1.0000	.30000	.48305
14.WIND	10	0.	1.0000	.50000	.52705
15.WORMS	10	0.	3.0000	2.0000	1.0541
16.ORGPHWAT	10	4.2000	5.6000	4.7900	.38427
17.ORGPHCAL	10	3.9000	5.1000	4.4000	.35277
18.ORGTHICK	10	1.0000	10.000	3.4000	2.6750
19.APHWAT	8	4.0000	5.7000	4.8375	.63005
20.APHCAL	8	3.6000	5.4000	4.4000	.62564
21.B1PHWAT	10	4.3000	5.9000	5.1600	.51467
22.B1PHCAL	10	3.7000	5.4000	4.4800	.49621
23.COARSE%	10	0.	10.000	1.0000	3.1623
24.TEXTURE	10	3.0000	10.000	5.3000	2.8304
25.B1%N	10	.60000 -1	.30000	.20800	.79833 -1
26.B1%C	10	1.0200	7.2000	4.2130	2.0890
27.B1CNRAT	10	16.700	28.200	19.860	4.1743
28.B2PHWAT	10	4.5000	6.1000	5.2900	.45570
29.B2PHCAL	10	3.9000	5.5000	4.6200	.48028
30.ORG%C	10	25.210	49.200	38.552	6.8562
31.ORG%N	10	.48000	1.0000	.71200	.16295
32.ORGCNRAT	10	34.200	70.400	55.770	11.652

Appendix 2 : <u>Pseudotsuga</u> vegetation group (P)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	59	15.000	805.00	344.71	195.15
2.ASPECT	59	0.	178.00	108.88	58.283
3.SLOPE	59	4.0000	80.000	46.085	20.761
4.POSIT	59	1.0000	5.0000	3.1525	.73844
5.DRAINAGE	59	1.0000	4.0000	2.4746	.79559
6.EROOTDEP	59	8.0000	128.00	57.932	32.400
7.ROOTDEP	59	15.000	128.00	78.644	26.835
8.SOILDEP	59	15.000	164.00	86.508	31.111
9.MATERIAL	59	0.	3.0000	1.3051	.70109
10.RATIO1	59	.10000	1.0000	.74119	.27768
11.RATIO2	59	.60000 -1	1.0000	.70153	.29389
12.RATIO3	59	.30000 -1	1.0000	.22458	.22897
13.FIRE	59	0.	1.0000	.83051	.37841
14.WIND	59	0.	1.0000	.16949 -1	.13019
15.WORMS	59	0.	3.0000	.94915	1.0073
16.ORGPHWAT	58	3.2000	5.7000	4.1138	.59011
17.ORGPHCAL	58	2.7000	5.4000	3.6534	.61991
18.ORGTHICK	59	1.0000	23.000	8.4407	4.6024
19.APHWAT	7	3.8000	5.2000	4.3000	.54772
20.APHCAL	7	3.2000	4.8000	3.7286	.56484
21.B1PHWAT	56	3.5000	6.0000	4.9143	.43918
22.B1PHCAL	56	3.0000	5.4000	4.3214	.40842
23.COARSE%	59	5.0000	100.00	60.169	23.717
24.TEXTURE	56	1.0000	10.000	3.9286	1.9896
25.B1%N	56	.40000 -1	.35000	.14018	.70362 -1
26.B1%C	56	1.3000	14.440	4.6812	2.3227
27.B1CNRAT	56	15.300	94.300	36.668	17.234
28.B2PHWAT	49	4.6000	6.6000	5.1959	.39049
29.B2PHCAL	49	4.1000	5.7000	4.6184	.38225
30.ORG%C	58	27.010	56.200	45.255	5.9177
31.ORG%N	58	.48000	1.5600	.86517	.21904
32.ORGCNRAT	58	32.000	104.40	55.093	14.307

Appendix 2 : <u>Thuja</u> vegetation group (T)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	40	15.000	610.00	173.00	155.56
2.ASPECT	40	0.	169.00	76.450	53.926
3.SLOPE	40	0.	96.000	29.900	20.836
4.POSIT	40	1.0000	6.0000	3.5000	1.1094
5.DRAINAGE	40	1.0000	7.0000	4.5500	1.4667
6.EROOTDEP	40	5.0000	110.00	31.025	22.564
7.ROOTDEP	40	10.000	133.00	54.575	30.609
8.SOILDEP	40	10.000	158.00	85.325	37.376
9.MATERIAL	40	0.	4.0000	2.0500	.87560
10.RATIO1	40	.60000 -1	1.0000	.64550	.30860
11.RATIO2	40	.40000 -1	1.0000	.41225	.25414
12.RATIO3	40	.50000 -1	1.0000	.65650	.33312
13.FIRE	40	0.	1.0000	.12500	.33493
14.WIND	40	0.	1.0000	.82500	.38481
15.WORMS	40	0.	3.0000	1.2500	1.0064
16.ORGPHWAT	40	3.5000	4.8000	4.0875	.36033
17.ORGPHCAL	40	2.9000	4.4000	3.5650	.37795
18.ORGTHICK	40	1.0000	43.000	16.775	9.6383
19.APHWAT	19	3.8000	5.5000	4.3263	.50973
20.APHCAL	19	3.1000	5.2000	3.7947	.52332
21.B1PHWAT	38	3.8000	6.0000	4.6816	.39171
22.B1PHCAL	38	3.5000	5.4000	4.1447	.38952
23.COARSE%	40	0.	95.000	36.650	25.081
24.TEXTURE	37	2.0000	12.000	4.9459	2.2724
25.B1%N	38	.20000 -1	.86000	.21395	.13689
26.B1%C	38	.18000	24.410	6.8100	4.1899
27.B1CNRAT	38	10.000	52.900	31.679	8.1741
28.B2PHWAT	32	4.2000	5.3000	4.8781	.28707
29.B2PHCAL	32	3.7000	5.2000	4.3844	.38530
30.ORG%C	40	32.300	51.950	43.891	5.1019
31.ORG%N	40	.54000	1.5400	.99700	.23247
32.ORGCNRAT	40	27.800	77.600	46.367	12.291

Appendix 2 : <u>Abies</u> vegetation group (A)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	40	25.000	915.00	355.72	235.33
2.ASPECT	40	0.	172.00	57.925	51.816
3.SLOPE	40	3.0000	80.000	38.800	22.253
4.POSIT	40	2.0000	5.0000	3.4250	.81296
5.DRAINAGE	40	2.0000	6.0000	3.6500	1.0754
6.EROOTDEP	40	5.0000	109.00	33.350	25.077
7.ROOTDEP	40	11.000	134.00	61.400	29.846
8.SOILDEP	40	17.000	196.00	96.400	32.762
9.MATERIAL	40	1.0000	3.0000	1.7250	.71567
10.RATIO1	40	.12000	1.0000	.57850	.30590
11.RATIO2	40	.50000 -1	1.0000	.38250	.28372
12.RATIO3	40	.40000 -1	1.0000	.58375	.34013
13.FIRE	40	0.	1.0000	.30000	.46410
14.WIND	40	0.	1.0000	.40000	.49614
15.WORMS	40	0.	3.0000	1.1750	1.1297
16.ORGPHWAT	40	3.0000	6.2000	3.7500	.53060
17.ORGPHCAL	40	2.4000	5.4000	3.1875	.53166
18.ORGTHICK	40	3.0000	27.000	13.225	5.8287
19.APHWAT	20	3.5000	6.2000	3.9750	.62228
20.APHCAL	20	3.0000	5.4000	3.3800	.56345
21.B1PHWAT	40	3.8000	6.3000	4.6725	.46243
22.B1PHCAL	40	3.5000	5.6000	4.1900	.44133
23.COARSE%	40	5.0000	95.000	46.625	23.949
24.TEXTURE	40	3.0000	9.0000	4.7500	1.7209
25.B1%N	40	.80000 -1	.38000	.20700	.76902 -1
26.B1%C	40	2.4000	12.670	5.9607	2.5819
27.B1CNRAT	40	12.500	51.100	29.462	8.8890
28.B2PHWAT	36	4.3000	6.5000	5.0194	.40905
29.B2PHCAL	36	3.8000	5.6000	4.5389	.40162
30.ORG%C	40	30.100	53.300	45.826	5.4391
31.ORG%N	40	.66000	1.6800	1.0892	.28331
32.ORGCNRAT	40	23.500	74.500	44.655	11.825

Appendix 2 : Dry <u>Pinus</u>-<u>Pseudotsuga</u> forests (D1)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	3	60.000	322.00	215.67	137.79
2.ASPECT	3	117.00	167.00	135.00	27.785
3.SLOPE	3	10.000	60.000	31.667	25.658
4.POSIT	3	1.0000	1.0000	1.0000	
5.DRAINAGE	3	1.0000	1.0000	1.0000	
6.EROOTDEP	3	3.0000	23.000	15.333	10.786
7.ROOTDEP	3	3.0000	23.000	15.333	10.786
8.SOILDEP	3	3.0000	23.000	15.333	10.786
9.MATERIAL	3	0.	1.0000	.66667	.57735
10.RATIO1	3	1.0000	1.0000	1.0000	
11.RATIO2	3	1.0000	1.0000	1.0000	
12.RATIO3	3	.13000	1.0000	.54333	.43662
13.FIRE	3	1.0000	1.0000	1.0000	
14.WIND	3	0.	1.0000	.66667	.57735
15.WORMS	3	0.	0.	0.	
16.ORGPHWAT	3	4.0000	4.4000	4.2000	.20000
17.ORGPHCAL	3	3.3000	4.0000	3.7000	.36056
18.ORGTHICK	3	3.0000	4.0000	3.3333	.57735
19.APHWAT	0				
20.APHCAL	0				
21.B1PHWAT	2	4.8000	4.8000	4.8000	
22.B1PHCAL	2	4.3000	4.3000	4.3000	
23.COARSE%	3	0.	95.000	58.000	50.863
24.TEXTURE	2	6.0000	6.0000	6.0000	
25.B1%N	2	.20000	.28000	.24000	.56569 -1
26.B1%C	2	3.1000	9.7500	6.4250	4.7023
27.B1CNRAT	2	15.300	34.900	25.100	13.859
28.B2PHWAT	0				
29.B2PHCAL	0				
30.ORG%C	3	36.150	47.840	43.030	6.1137
31.ORG%N	3	.61000	.88000	.74667	.13503
32.ORGCNRAT	3	48.200	78.400	59.300	16.614

Appendix 2 : Coastal dry <u>Pinus</u> forests (D2)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	4	45.000	250.00	112.50	92.961
2.ASPECT	4	46.000	129.00	80.500	35.369
3.SLOPE	4	30.000	65.000	41.250	16.008
4.POSIT	4	1.0000	1.0000	1.0000	
5.DRAINAGE	4	1.0000	1.0000	1.0000	
6.EROOTDEP	4	5.0000	20.000	11.000	7.3485
7.ROOTDEP	4	5.0000	20.000	11.000	7.3485
8.SOILDEP	4	5.0000	20.000	11.000	7.3485
9.MATERIAL	4	O.	O.	O.	
10.RATIO1	4	1.0000	1.0000	1.0000	
11.RATIO2	4	1.0000	1.0000	1.0000	
12.RATIO3	4	.20000	1.0000	.41250	.39238
13.FIRE	4	O.	O.	O.	
14.WIND	4	O.	1.0000	.25000	.50000
15.WORMS	4	O.	O.	O.	
16.ORGPHWAT	4	3.8000	4.0000	3.9250	.95743 -1
17.ORGPHCAL	4	3.4000	3.7000	3.5500	.17321
18.ORGTHICK	4	1.0000	14.000	5.2500	6.1305
19.APHWAT	1	3.8000	3.8000	3.8000	
20.APHCAL	1	3.2000	3.2000	3.2000	
21.B1PHWAT	3	4.2000	5.4000	4.7333	.61101
22.B1PHCAL	3	3.7000	4.7000	4.1000	.52915
23.COARSE%	4	O.	75.000	27.500	33.292
24.TEXTURE	3	2.0000	4.0000	3.0000	1.0000
25.B1%N	3	.26000	.36000	.30667	.50332 -1
26.B1%C	3	6.4000	15.620	9.5900	5.2251
27.B1CNRAT	3	22.600	43.500	30.067	11.658
28.B2PHWAT	O				
29.B2PHCAL	O				
30.ORG%C	4	40.800	49.760	46.180	3.8826
31.ORG%N	4	.48000	.63000	.55250	.66018 -1
32.ORGCNRAT	4	70.300	100.10	84.800	15.227

Appendix 2 : Floodplain forests (F1)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	8	15.000	95.000	54.375	39.681
2.ASPECT	8	0.	107.00	24.125	45.022
3.SLOPE	8	0.	5.0000	2.6250	1.9955
4.POSIT	8	5.0000	5.0000	5.0000	
5.DRAINAGE	8	4.0000	5.0000	4.3750	.51755
6.EROOTDEP	8	11.000	113.00	58.125	31.809
7.ROOTDEP	8	11.000	130.00	76.625	43.948
8.SOILDEP	8	62.000	130.00	99.250	20.105
9.MATERIAL	8	3.0000	4.0000	3.3750	.51755
10.RATIO1	8	.61000	1.0000	.82250	.16369
11.RATIO2	8	.10000	.87000	.57375	.23790
12.RATIO3	8	.30000 -1	.18000	.61250 -1	.52491 -1
13.FIRE	8	0.	1.0000	.25000	.46291
14.WIND	8	0.	1.0000	.50000	.53452
15.WORMS	8	1.0000	3.0000	2.2500	.88641
16.ORGPHWAT	8	4.2000	5.6000	4.8625	.39619
17.ORGPHCAL	8	3.9000	5.1000	4.4750	.35355
18.ORGTHICK	8	1.0000	10.000	3.0000	2.8785
19.APHWAT	6	4.4000	5.7000	5.1167	.42622
20.APHCAL	6	3.9000	5.4000	4.6500	.49699
21.B1PHWAT	8	4.9000	5.9000	5.3625	.32486
22.B1PHCAL	8	4.3000	5.4000	4.6625	.35431
23.COARSE%	8	0.	10.000	1.2500	3.5355
24.TEXTURE	8	3.0000	6.0000	4.1250	1.5526
25.B1%N	8	.60000 -1	.30000	.19375	.83826 -1
26.B1%C	8	1.0200	7.1200	3.8162	2.0375
27.B1CNRAT	8	17.100	28.200	19.350	3.6320
28.B2PHWAT	8	5.0000	6.1000	5.4625	.30677
29.B2PHCAL	8	4.2000	5.5000	4.7875	.36815
30.ORG%C	8	25.210	49.200	38.490	7.7256
31.ORG%N	8	.48000	1.0000	.68875	.16703
32.ORGCNRAT	8	34.200	70.400	57.525	12.311

Appendix 2 : Floodplain forests (<u>Lysichitum</u> variant) (F2)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	2	22.000	22.000	22.000	
2.ASPECT	2	0.	0.	0.	
3.SLOPE	2	0.	0.	0.	
4.POSIT	2	5.0000	5.0000	5.0000	
5.DRAINAGE	2	7.0000	7.0000	7.0000	
6.EROOTDEP	2	27.000	58.000	42.500	21.920
7.ROOTDEP	2	27.000	85.000	56.000	41.012
8.SOILDEP	2	82.000	85.000	83.500	2.1213
9.MATERIAL	2	4.0000	4.0000	4.0000	
10.RATIO1	2	.68000	1.0000	.84000	.22627
11.RATIO2	2	.33000	.68000	.50500	.24749
12.RATIO3	2	.90000 -1	.19000	.14000	.70711 -1
13.FIRE	2	0.	1.0000	.50000	.70711
14.WIND	2	0.	1.0000	.50000	.70711
15.WORMS	2	0.	2.0000	1.0000	1.4142
16.ORGPHWAT	2	4.4000	4.6000	4.5000	.14142
17.ORGPHCAL	2	4.0000	4.2000	4.1000	.14142
18.ORGTHICK	2	5.0000	5.0000	5.0000	
19.APHWAT	2	4.0000	4.0000	4.0000	
20.APHCAL	2	3.6000	3.7000	3.6500	.70711 -1
21.B1PHWAT	2	4.3000	4.4000	4.3500	.70711 -1
22.B1PHCAL	2	3.7000	3.8000	3.7500	.70711 -1
23.COARSE%	2	0.	0.	0.	
24.TEXTURE	2	10.000	10.000	10.000	
25.B1%N	2	.26000	.27000	.26500	.70711 -2
26.B1%C	2	4.4000	7.2000	5.8000	1.9799
27.B1CNRAT	2	16.700	27.100	21.900	7.3539
28.B2PHWAT	2	4.5000	4.7000	4.6000	.14142
29.B2PHCAL	2	3.9000	4.0000	3.9500	.70711 -1
30.ORG%C	2	37.200	40.400	38.800	2.2627
31.ORG%N	2	.70000	.91000	.80500	.14849
32.ORGCNRAT	2	44.400	53.100	48.750	6.1518

Appendix 2 : Dry _Pseudotsuga_ forests (P1)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	4	100.00	325.00	214.50	95.870
2.ASPECT	4	32.000	149.00	110.25	53.984
3.SLOPE	4	20.000	65.000	43.500	18.448
4.POSIT	4	2.0000	3.0000	2.7500	.50000
5.DRAINAGE	4	1.0000	3.0000	1.7500	.95743
6.EROOTDEP	4	34.000	68.000	48.000	16.892
7.ROOTDEP	4	34.000	68.000	54.250	14.431
8.SOILDEP	4	34.000	68.000	54.250	14.431
9.MATERIAL	4	1.0000	1.0000	1.0000	
10.RATIO1	4	.58000	1.0000	.89500	.21000
11.RATIO2	4	.58000	1.0000	.89500	.21000
12.RATIO3	4	.20000 -1	.12000	.80000 -1	.48990 -1
13.FIRE	4	1.0000	1.0000	1.0000	
14.WIND	4	0.	0.	0.	
15.WORMS	4	0.	1.0000	.25000	.50000
16.ORGPHWAT	4	4.3000	4.6000	4.4000	.14142
17.ORGPHCAL	4	3.9000	4.2000	4.0250	.12583
18.ORGTHICK	4	1.0000	4.0000	3.2500	1.5000
19.APHWAT	0				
20.APHCAL	0				
21.B1PHWAT	4	4.6000	5.1000	4.9000	.21602
22.B1PHCAL	4	4.1000	4.6000	4.3500	.20817
23.COARSE%	4	41.000	85.000	69.000	19.253
24.TEXTURE	4	3.0000	6.0000	4.2500	1.2583
25.B1%N	4	.10000	.22000	.14750	.52520 -1
26.B1%C	4	4.7000	11.700	7.7300	3.0746
27.B1CNRAT	4	38.200	111.40	57.200	36.140
28.B2PHWAT	3	4.8000	4.9000	4.8333	.57735 -1
29.B2PHCAL	3	4.2000	4.4000	4.3000	.10000
30.ORG%C	4	33.320	44.500	40.030	4.7833
31.ORG%N	4	.66000	.85000	.76000	.89815 -1
32.ORGCNRAT	4	46.900	63.500	53.050	7.7328

Appendix 2 : <u>Pseudotsuga</u>-<u>Thuja</u>-<u>Acer</u> forests (P.2)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	4	15.000	195.00	134.50	81.000
2.ASPECT	4	14.000	162.00	118.50	69.979
3.SLOPE	4	25.000	61.000	43.250	14.975
4.POSIT	4	3.0000	3.0000	3.0000	
5.DRAINAGE	4	2.0000	4.0000	2.7500	.95743
6.EROOTDEP	4	29.000	84.000	55.750	25.591
7.ROOTDEP	4	29.000	107.00	65.250	36.900
8.SOILDEP	4	29.000	107.00	65.250	36.900
9.MATERIAL	4	1.0000	1.0000	1.0000	
10.RATIO1	4	.78000	1.0000	.90000	.11662
11.RATIO2	4	.78000	1.0000	.90000	.11662
12.RATIO3	4	.30000 -1	.80000 -1	.57500 -1	.26300 -1
13.FIRE	4	1.0000	1.0000	1.0000	
14.WIND	4	0.	0.	0.	
15.WORMS	4	0.	2.0000	.50000	1.0000
16.ORGPHWAT	4	4.3000	5.1000	4.7750	.34034
17.ORGPHCAL	4	4.0000	4.7000	4.3500	.28868
18.ORGTHICK	4	1.0000	7.0000	3.5000	2.5166
19.APHWAT	1	5.2000	5.2000	5.2000	
20.APHCAL	1	4.8000	4.8000	4.8000	
21.B1PHWAT	4	4.8000	5.6000	5.2250	.33040
22.B1PHCAL	4	4.3000	5.1000	4.6000	.34641
23.COARSE%	4	20.000	90.000	62.500	32.275
24.TEXTURE	4	1.0000	4.0000	3.2500	1.5000
25.B1%N	4	.90000 -1	.15000	.11750	.27538 -1
26.B1%C	4	2.6000	4.0000	3.3600	.71536
27.B1CNRAT	4	26.300	30.800	28.750	1.8520
28.B2PHWAT	3	4.9000	5.2000	5.0667	.15275
29.B2PHCAL	3	4.3000	4.6000	4.4667	.15275
30.ORG%C	4	35.000	49.500	44.265	6.4213
31.ORG%N	4	.60000	1.0100	.72750	.19259
32.ORGCNRAT	4	49.000	77.600	62.600	12.067

Appendix 2 : <u>Pseudotsuga-Linnaea</u> forests (P3)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	5	200.00	590.00	324.00	157.26
2.ASPECT	5	13.000	157.00	80.400	67.859
3.SLOPE	5	15.000	60.000	37.800	17.880
4.POSIT	5	2.0000	3.0000	2.8000	.44721
5.DRAINAGE	5	2.0000	4.0000	2.6000	.89443
6.EROOTDEP	5	15.000	99.000	55.400	40.955
7.ROOTDEP	5	15.000	99.000	59.600	40.698
8.SOILDEP	5	15.000	125.00	64.800	47.997
9.MATERIAL	5	1.0000	3.0000	1.4000	.89443
10.RATIO1	5	.68000	1.0000	.93600	.14311
11.RATIO2	5	.68000	1.0000	.89400	.15027
12.RATIO3	5	.50000 -1	.33000	.19000	.11979
13.FIRE	5	1.0000	1.0000	1.0000	
14.WIND	5	O.	O.	O.	
15.WORMS	5	O.	2.0000	.60000	.89443
16.ORGPHWAT	5	4.0000	5.7000	4.9000	.73824
17.ORGPHCAL	5	3.5000	5.4000	4.5400	.78294
18.ORGTHICK	5	5.0000	11.000	6.8000	2.6833
19.APHWAT	O				
20.APHCAL	O				
21.B1PHWAT	5	4.6000	6.0000	5.2000	.68920
22.B1PHCAL	5	4.1000	5.3000	4.6000	.51962
23.COARSE%	5	40.000	77.000	56.400	13.686
24.TEXTURE	5	3.0000	4.0000	3.6000	.54772
25.B1%N	5	.70000 -1	.20000	.15000	.54314 -1
26.B1%C	5	4.6000	14.440	8.0220	3.8233
27.B1CNRAT	5	30.400	84.400	56.440	21.380
28.B2PHWAT	3	4.9000	6.6000	5.8667	.87369
29.B2PHCAL	3	4.3000	5.6000	5.1333	.72342
30.ORG%C	5	35.630	49.880	43.402	6.4640
31.ORG%N	5	.77000	1.2900	.95000	.20087
32.ORGCNRAT	5	36.300	64.800	47.260	12.608

Appendix 2 : <u>Pseudotsuga-Berberis</u> forests (P4)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	11	150.00	465.00	252.00	107.99
2.ASPECT	11	37.000	173.00	108.27	51.219
3.SLOPE	11	5.0000	60.000	40.909	18.987
4.POSIT	11	3.0000	4.0000	3.1818	.40452
5.DRAINAGE	11	1.0000	3.0000	2.2727	.64667
6.EROOTDEP	11	26.000	117.00	67.455	29.784
7.ROOTDEP	11	29.000	117.00	78.364	27.332
8.SOILDEP	11	29.000	117.00	79.273	26.710
9.MATERIAL	11	1.0000	3.0000	1.5455	.82020
10.RATIO1	11	.31000	1.0000	.86909	.21925
11.RATIO2	11	.31000	1.0000	.85545	.21491
12.RATIO3	11	.30000 -1	.40000	.15818	.11957
13.FIRE	11	O.	1.0000	.90909	.30151
14.WIND	11	O.	O.	O.	
15.WORMS	11	O.	2.0000	.63636	.92442
16.ORGPHWAT	11	3.6000	5.6000	4.1545	.62508
17.ORGPHCAL	11	3.3000	5.3000	3.7364	.63918
18.ORGTHICK	11	3.0000	23.000	8.6364	5.4639
19.APHWAT	2	3.9000	4.8000	4.3500	.63640
20.APHCAL	2	3.2000	4.0000	3.6000	.56569
21.B1PHWAT	11	4.6000	5.4000	4.9727	.26492
22.B1PHCAL	11	4.0000	4.8000	4.2909	.25082
23.COARSE%	11	50.000	84.000	71.636	10.828
24.TEXTURE	11	2.0000	9.0000	3.8182	1.9400
25.B1%N	11	.40000 -1	.25000	.11636	.56617 -1
26.B1%C	11	1.5600	6.7000	3.6164	1.7445
27.B1CNRAT	11	18.000	77.300	33.145	15.870
28.B2PHWAT	9	4.8000	5.8000	5.1667	.36056
29.B2PHCAL	9	4.2000	5.0000	4.4778	.29059
30.ORG%C	11	27.010	51.800	44.104	7.5492
31.ORG%N	11	.54000	1.3200	.87273	.22055
32.ORGCNRAT	11	37.500	82.300	52.473	12.859

Appendix 2 : <u>Tsuga</u>–<u>Pseudotsuga</u>–<u>Polystichum</u> forests (P5)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	17	70.000	500.00	284.59	123.24
2.ASPECT	17	0.	177.00	119.18	61.647
3.SLOPE	17	4.0000	80.000	52.824	21.924
4.POSIT	17	3.0000	5.0000	3.8235	.52859
5.DRAINAGE	17	1.0000	4.0000	2.2941	.84887
6.EROOTDEP	17	8.0000	128.00	60.941	37.641
7.ROOTDEP	17	61.000	128.00	89.471	22.867
8.SOILDEP	17	61.000	164.00	100.59	28.483
9.MATERIAL	17	1.0000	3.0000	1.2353	.66421
10.RATIO1	17	.10000	1.0000	.65529	.28577
11.RATIO2	17	.60000 -1	1.0000	.59941	.28137
12.RATIO3	17	.60000 -1	1.0000	.24353	.22271
13.FIRE	17	0.	1.0000	.76471	.43724
14.WIND	17	0.	0.	0.	
15.WORMS	17	0.	2.0000	1.1176	.92752
16.ORGPHWAT	16	3.2000	4.8000	3.9687	.47570
17.ORGPHCAL	16	2.7000	4.3000	3.4625	.47452
18.ORGTHICK	17	5.0000	20.000	9.8824	3.7730
19.APHWAT	1	3.8000	3.8000	3.8000	
20.APHCAL	1	3.5000	3.5000	3.5000	
21.B1PHWAT	15	4.1000	6.0000	4.9733	.44476
22.B1PHCAL	15	3.3000	5.4000	4.4200	.46782
23.COARSE%	17	5.0000	100.00	64.118	30.116
24.TEXTURE	15	1.0000	10.000	4.0000	2.6458
25.B1%N	15	.60000 -1	.35000	.20067	.84386 -1
26.B1%C	15	2.2700	11.390	5.3353	2.1659
27.B1CNRAT	15	18.300	40.600	28.313	7.0625
28.B2PHWAT	15	4.6000	6.2000	5.2933	.38999
29.B2PHCAL	15	4.1000	5.7000	4.7600	.41884
30.ORG%C	16	27.490	56.200	46.123	6.6850
31.ORG%N	16	.76000	1.5600	1.0225	.21212
32.ORGCNRAT	16	32.000	60.000	46.162	8.4686

Appendix 2 : Montane <u>Tsuga</u> forests (P6)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	12	102.00	795.00	486.00	195.36
2.ASPECT	12	27.000	177.00	116.67	50.869
3.SLOPE	12	14.000	75.000	52.083	19.374
4.POSIT	12	2.0000	4.0000	3.0000	.42640
5.DRAINAGE	12	1.0000	3.0000	2.4167	.66856
6.EROOTDEP	12	10.000	95.000	51.250	28.661
7.ROOTDEP	12	43.000	111.00	75.667	20.169
8.SOILDEP	12	43.000	120.00	85.583	26.919
9.MATERIAL	12	1.0000	2.0000	1.1667	.38925
10.RATIO1	12	.15000	1.0000	.68083	.32520
11.RATIO2	12	.11000	1.0000	.64833	.35022
12.RATIO3	12	.50000 -1	1.0000	.31000	.34351
13.FIRE	12	0.	1.0000	.91667	.28868
14.WIND	12	0.	0.	0.	
15.WORMS	12	0.	3.0000	1.2500	1.1382
16.ORGPHWAT	12	3.5000	4.7000	3.8250	.37447
17.ORGPHCAL	12	2.9000	4.1000	3.3333	.39158
18.ORGTHICK	12	4.0000	18.000	8.5000	4.1010
19.APHWAT	0				
20.APHCAL	0				
21.B1PHWAT	11	4.5000	5.1000	4.8182	.19400
22.B1PHCAL	11	4.0000	4.5000	4.2727	.17373
23.COARSE%	12	20.000	90.000	53.750	21.440
24.TEXTURE	11	2.0000	6.0000	3.5455	1.2933
25.B1%N	11	.50000 -1	.20000	.11818	.44004 -1
26.B1%C	11	2.2400	7.1700	4.9145	1.6014
27.B1CNRAT	11	27.000	94.300	45.882	22.196
28.B2PHWAT	10	5.0000	5.4000	5.1500	.12693
29.B2PHCAL	10	4.3000	5.2000	4.6100	.25582
30.ORG%C	12	39.200	50.110	45.880	3.7412
31.ORG%N	12	.48000	1.1800	.77667	.19690
32.ORGCNRAT	12	37.500	104.40	63.025	18.709

Appendix 2 : Montane <u>Tsuga</u>-<u>Gaultheria</u> forests (P7)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	7	220.00	805.00	538.57	210.79
2.ASPECT	7	31.000	178.00	118.86	58.724
3.SLOPE	7	10.000	70.000	39.286	26.011
4.POSIT	7	1.0000	3.0000	2.1429	1.0690
5.DRAINAGE	7	2.0000	4.0000	2.5714	.78680
6.EROOTDEP	7	17.000	104.00	53.000	33.481
7.ROOTDEP	7	32.000	105.00	79.143	27.492
8.SOILDEP	7	32.000	105.00	82.714	26.183
9.MATERIAL	7	0.	3.0000	1.2857	.95119
10.RATIO1	7	.18000	1.0000	.68000	.30589
11.RATIO2	7	.18000	1.0000	.66143	.32749
12.RATIO3	7	.40000 -1	.69000	.29714	.26336
13.FIRE	7	0.	1.0000	.57143	.53452
14.WIND	7	0.	1.0000	.14286	.37796
15.WORMS	7	0.	2.0000	.85714	1.0690
16.ORGPHWAT	7	3.4000	4.2000	3.8429	.35989
17.ORGPHCAL	7	3.0000	3.8000	3.4000	.35590
18.ORGTHICK	7	4.0000	22.000	9.8571	6.7683
19.APHWAT	3	3.8000	4.5000	4.1333	.35119
20.APHCAL	3	3.2000	3.9000	3.5333	.35119
21.B1PHWAT	7	3.5000	5.2000	4.4571	.52870
22.B1PHCAL	7	3.0000	4.5000	3.9143	.45251
23.COARSE%	7	25.000	70.000	54.286	19.670
24.TEXTURE	7	3.0000	6.0000	4.1429	1.3452
25.B1%N	7	.60000 -1	.11000	.84286 -1	.15119 -1
26.B1%C	7	1.3000	4.9600	3.2714	1.1335
27.B1CNRAT	7	15.300	58.800	40.743	16.044
28.B2PHWAT	6	4.6000	5.1000	4.8833	.17224
29.B2PHCAL	6	4.2000	4.8000	4.3500	.23452
30.ORG%C	7	42.370	55.700	46.823	4.7138
31.ORG%N	7	.56000	.79000	.70429	.83438 -1
32.ORGCNRAT	7	59.600	83.000	67.014	7.9134

Appendix 2 : Coastal dry <u>Thuja</u> forests (T1)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	3	60.000	90.000	76.667	15.275
2.ASPECT	3	59.000	137.00	107.33	42.218
3.SLOPE	3	40.000	54.000	46.333	7.0946
4.POSIT	3	1.0000	3.0000	1.6667	1.1547
5.DRAINAGE	3	1.0000	3.0000	1.6667	1.1547
6.EROOTDEP	3	10.000	18.000	13.333	4.1633
7.ROOTDEP	3	10.000	27.000	16.333	9.2916
8.SOILDEP	3	10.000	27.000	16.333	9.2916
9.MATERIAL	3	0.	2.0000	.66667	1.1547
10.RATIO1	3	.67000	1.0000	.89000	.19053
11.RATIO2	3	.67000	1.0000	.89000	.19053
12.RATIO3	3	.17000	1.0000	.72333	.47920
13.FIRE	3	0.	0.	0.	
14.WIND	3	1.0000	1.0000	1.0000	
15.WORMS	3	0.	2.0000	1.0000	1.0000
16.ORGPHWAT	3	4.1000	4.5000	4.3000	.20000
17.ORGPHCAL	3	3.8000	4.1000	3.9333	.15275
18.ORGTHICK	3	3.0000	12.000	8.3333	4.7258
19.APHWAT	1	4.1000	4.1000	4.1000	
20.APHCAL	1	3.5000	3.5000	3.5000	
21.B1PHWAT	1	5.1000	5.1000	5.1000	
22.B1PHCAL	1	4.6000	4.6000	4.6000	
23.COARSE%	3	0.	10.000	3.3333	5.7735
24.TEXTURE	0				
25.B1%N	1	.13000	.13000	.13000	
26.B1%C	1	4.3800	4.3800	4.3800	
27.B1CNRAT	1	32.400	32.400	32.400	
28.B2PHWAT	0				
29.B2PHCAL	0				
30.ORG%C	3	40.020	49.400	46.153	5.3147
31.ORG%N	3	.54000	.86000	.70667	.16042
32.ORGCNRAT	3	57.000	74.100	66.567	8.7295

Appendix 2 : Coastal <u>Tsuga</u>-<u>Blechnum</u>-<u>Polystichum</u> forests (T2)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	6	120.00	358.00	238.00	100.65
2.ASPECT	6	29.000	157.00	80.500	50.425
3.SLOPE	6	34.000	60.000	46.667	11.343
4.POSIT	6	3.0000	3.0000	3.0000	
5.DRAINAGE	6	3.0000	4.0000	3.5000	.54772
6.EROOTDEP	6	6.0000	70.000	33.833	23.241
7.ROOTDEP	6	26.000	118.00	59.833	32.474
8.SOILDEP	6	26.000	158.00	92.333	53.377
9.MATERIAL	6	1.0000	3.0000	1.5000	.83666
10.RATIO1	6	.23000	1.0000	.61667	.41994
11.RATIO2	6	.18000	1.0000	.41167	.31301
12.RATIO3	6	.21000	1.0000	.46500	.28836
13.FIRE	6	0.	0.	0.	
14.WIND	6	0.	1.0000	.66667	.51640
15.WORMS	6	0.	3.0000	1.6667	1.0328
16.ORGPHWAT	6	3.5000	4.2000	3.8500	.23452
17.ORGPHCAL	6	2.9000	3.8000	3.3167	.29269
18.ORGTHICK	6	3.0000	40.000	14.667	13.501
19.APHWAT	0				
20.APHCAL	0				
21.B1PHWAT	6	4.3000	4.9000	4.5333	.22509
22.B1PHCAL	6	3.8000	4.3000	4.0333	.21602
23.COARSE%	6	10.000	60.000	43.333	20.656
24.TEXTURE	6	4.0000	6.0000	5.0000	1.0954
25.B1%N	6	.17000	.86000	.37333	.24476
26.B1%C	6	5.6500	24.410	10.502	7.0714
27.B1CNRAT	6	20.300	32.600	28.217	4.8139
28.B2PHWAT	5	4.4000	5.0000	4.6600	.27019
29.B2PHCAL	5	4.0000	4.7000	4.1800	.29496
30.ORG%C	6	41.200	51.950	47.207	4.2463
31.ORG%N	6	.69000	1.4800	1.0650	.25665
32.ORGCNRAT	6	27.800	74.900	47.400	16.017

Appendix 2 : Coastal montane <u>Thuja</u> forests (T3)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	7	175.00	610.00	415.00	141.07
2.ASPECT	7	11.000	142.00	80.000	50.695
3.SLOPE	7	30.000	96.000	47.286	23.056
4.POSIT	7	3.0000	4.0000	3.2857	.48795
5.DRAINAGE	7	3.0000	6.0000	4.7143	.95119
6.EROOTDEP	7	14.000	110.00	42.000	42.579
7.ROOTDEP	7	15.000	133.00	74.000	43.317
8.SOILDEP	7	40.000	135.00	99.143	36.108
9.MATERIAL	7	1.0000	3.0000	2.0000	.57735
10.RATIO1	7	.13000	1.0000	.57571	.34476
11.RATIO2	7	.11000	.81000	.39143	.27961
12.RATIO3	7	.12000	1.0000	.61857	.41071
13.FIRE	7	0.	0.	0.	
14.WIND	7	0.	1.0000	.85714	.37796
15.WORMS	7	0.	2.0000	1.4286	.78680
16.ORGPHWAT	7	3.8000	4.8000	4.1571	.34087
17.ORGPHCAL	7	3.2000	4.2000	3.5429	.33094
18.ORGTHICK	7	5.0000	22.000	14.000	5.0662
19.APHWAT	4	3.9000	4.9000	4.4250	.41130
20.APHCAL	4	3.6000	4.4000	3.9750	.35000
21.B1PHWAT	7	3.8000	4.8000	4.5286	.34983
22.B1PHCAL	7	3.5000	4.2000	4.0286	.26277
23.COARSE%	7	20.000	70.000	41.429	15.736
24.TEXTURE	7	3.0000	10.000	5.2857	2.5635
25.B1%N	7	.17000	.33000	.21000	.55976 -1
26.B1%C	7	4.9200	11.200	7.5929	2.4972
27.B1CNRAT	7	26.600	52.900	35.886	8.8048
28.B2PHWAT	6	4.2000	5.2000	4.8167	.38687
29.B2PHCAL	6	3.7000	4.7000	4.3167	.36009
30.ORG%C	7	36.550	49.100	41.927	4.5254
31.ORG%N	7	.74000	1.5400	1.0871	.31658
32.ORGCNRAT	7	28.500	53.700	40.700	9.3016

Appendix 2 : Coastal _Thuja_ forests (T4)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	19	15.000	380.00	115.11	90.941
2.ASPECT	19	0.	169.00	81.526	53.127
3.SLOPE	19	0.	50.000	22.632	14.415
4.POSIT	19	2.0000	6.0000	3.6842	1.1082
5.DRAINAGE	19	3.0000	7.0000	4.8947	1.2425
6.EROOTDEP	19	5.0000	60.000	30.105	15.051
7.ROOTDEP	19	20.000	100.00	55.211	24.503
8.SOILDEP	19	41.000	138.00	92.632	26.790
9.MATERIAL	19	1.0000	4.0000	2.3158	.74927
10.RATIO1	19	.60000 -1	1.0000	.62789	.29293
11.RATIO2	19	.40000 -1	.77000	.34737	.18113
12.RATIO3	19	.31000	1.0000	.73421	.29615
13.FIRE	19	0.	1.0000	.10526	.31530
14.WIND	19	0.	1.0000	.89474	.31530
15.WORMS	19	0.	3.0000	1.3158	1.0569
16.ORGPHWAT	19	3.7000	4.8000	4.1263	.37095
17.ORGPHCAL	19	3.1000	4.4000	3.6105	.37401
18.ORGTHICK	19	3.0000	43.000	19.842	9.4473
19.APHWAT	9	3.8000	5.4000	4.2222	.48419
20.APHCAL	9	3.1000	4.6000	3.6556	.40961
21.B1PHWAT	19	4.2000	6.0000	4.7105	.40537
22.B1PHCAL	19	3.6000	5.4000	4.1632	.41394
23.COARSE%	19	0.	95.000	42.053	28.415
24.TEXTURE	19	2.0000	12.000	4.5789	2.1938
25.B1%N	19	.20000 -1	.32000	.20316	.81789 -1
26.B1%C	19	.18000	13.400	6.4284	3.1632
27.B1CNRAT	19	10.000	44.200	30.700	8.0325
28.B2PHWAT	17	4.5000	5.3000	4.9176	.24808
29.B2PHCAL	17	3.8000	5.2000	4.4471	.41400
30.ORG%C	19	32.300	49.100	43.278	5.1703
31.ORG%N	19	.67000	1.3000	1.0347	.17302
32.ORGCNRAT	19	33.900	56.300	42.642	6.9708

Appendix 2 : Coastal wet <u>Thuja</u> forests (T5)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	4	20.000	55.000	31.250	16.008
2.ASPECT	4	0.	142.00	35.500	71.000
3.SLOPE	4	0.	8.0000	2.0000	4.0000
4.POSIT	4	4.0000	5.0000	4.7500	.50000
5.DRAINAGE	4	5.0000	6.0000	5.7500	.50000
6.EROOTDEP	4	22.000	39.000	27.750	7.6757
7.ROOTDEP	4	24.000	59.000	39.250	17.076
8.SOILDEP	4	51.000	100.00	71.250	21.608
9.MATERIAL	4	2.0000	3.0000	2.5000	.57735
10.RATIO1	4	.50000	1.0000	.77000	.23123
11.RATIO2	4	.22000	.66000	.42750	.19619
12.RATIO3	4	.55000	1.0000	.74250	.18822
13.FIRE	4	0.	1.0000	.50000	.57735
14.WIND	4	0.	1.0000	.50000	.57735
15.WORMS	4	0.	2.0000	.50000	1.0000
16.ORGPHWAT	4	3.5000	4.7000	3.9250	.53151
17.ORGPHCAL	4	3.0000	4.2000	3.4000	.54160
18.ORGTHICK	4	12.000	27.000	20.500	6.5574
19.APHWAT	4	3.8000	5.5000	4.3750	.76757
20.APHCAL	4	3.3000	5.2000	3.8500	.90370
21.B1PHWAT	4	4.3000	5.7000	4.9000	.58878
22.B1PHCAL	4	3.9000	5.3000	4.2750	.68496
23.COARSE%	4	2.0000	35.000	19.250	15.777
24.TEXTURE	4	3.0000	10.000	6.2500	3.7749
25.B1%N	4	.20000 -1	.13000	.80000 -1	.58310 -1
26.B1%C	4	.44000	5.7500	2.8725	2.6090
27.B1CNRAT	4	20.900	46.000	31.025	11.163
28.B2PHWAT	3	4.9000	5.1000	5.0000	.10000
29.B2PHCAL	3	3.9000	4.9000	4.4333	.50332
30.ORG%C	4	32.950	46.700	42.517	6.4175
31.ORG%N	4	.80000	.97000	.87000	.71647 -1
32.ORGCNRAT	4	33.900	56.600	49.475	10.484

Appendix 2 : Montane <u>Tsuga-Abies-Gaultheria</u> forests (A1)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	3	238.00	670.00	457.00	216.06
2.ASPECT	3	125.00	172.00	149.00	23.516
3.SLOPE	3	15.000	65.000	44.000	25.942
4.POSIT	3	2.0000	3.0000	2.6667	.57735
5.DRAINAGE	3	2.0000	3.0000	2.6667	.57735
6.EROOTDEP	3	17.000	23.000	19.000	3.4641
7.ROOTDEP	3	17.000	62.000	42.667	23.159
8.SOILDEP	3	17.000	128.00	86.000	60.225
9.MATERIAL	3	1.0000	2.0000	1.3333	.57735
10.RATIO1	3	.35000	1.0000	.57333	.36964
11.RATIO2	3	.13000	1.0000	.44333	.48336
12.RATIO3	3	.13000	1.0000	.53333	.43844
13.FIRE	3	1.0000	1.0000	1.0000	
14.WIND	3	O.	O.	O.	
15.WORMS	3	O.	2.0000	1.0000	1.0000
16.ORGPHWAT	3	3.5000	3.6000	3.5667	.57735 -1
17.ORGPHCAL	3	2.9000	3.2000	3.0333	.15275
18.ORGTHICK	3	3.0000	17.000	9.3333	7.0946
19.APHWAT	2	3.6000	3.6000	3.6000	
20.APHCAL	2	3.0000	3.0000	3.0000	
21.B1PHWAT	3	3.9000	4.9000	4.4000	.50000
22.B1PHCAL	3	3.5000	4.4000	4.0000	.45826
23.COARSE%	3	30.000	50.000	38.333	10.408
24.TEXTURE	3	3.0000	9.0000	5.0000	3.4641
25.B1%N	3	.90000 -1	.10000	.96667 -1	.57735 -2
26.B1%C	3	3.4000	4.6000	4.1133	.63129
27.B1CNRAT	3	38.600	44.700	42.500	3.3867
28.B2PHWAT	2	4.3000	5.0000	4.6500	.49497
29.B2PHCAL	2	3.8000	4.8000	4.3000	.70711
30.ORG%C	3	46.120	50.110	48.477	2.0910
31.ORG%N	3	.66000	.89000	.76667	.11590
32.ORGCNRAT	3	56.300	74.500	64.100	9.3744

Appendix 2 : Montane <u>Abies-Tsuga</u> forests (A2)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	2	497.00	650.00	573.50	108.19
2.ASPECT	2	42.000	147.00	94.500	74.246
3.SLOPE	2	60.000	65.000	62.500	3.5355
4.POSIT	2	3.0000	3.0000	3.0000	
5.DRAINAGE	2	4.0000	5.0000	4.5000	.70711
6.EROOTDEP	2	16.000	17.000	16.500	.70711
7.ROOTDEP	2	19.000	55.000	37.000	25.456
8.SOILDEP	2	106.00	125.00	115.50	13.435
9.MATERIAL	2	1.0000	2.0000	1.5000	.70711
10.RATIO1	2	.31000	.84000	.57500	.37477
11.RATIO2	2	.14000	.15000	.14500	.70711 -2
12.RATIO3	2	.71000	1.0000	.85500	.20506
13.FIRE	2	0.	1.0000	.50000	.70711
14.WIND	2	0.	1.0000	.50000	.70711
15.WORMS	2	0.	3.0000	1.5000	2.1213
16.ORGPHWAT	2	3.4000	3.7000	3.5500	.21213
17.ORGPHCAL	2	2.9000	3.1000	3.0000	.14142
18.ORGTHICK	2	9.0000	12.000	10.500	2.1213
19.APHWAT	2	3.7000	3.8000	3.7500	.70711 -1
20.APHCAL	2	3.1000	3.3000	3.2000	.14142
21.B1PHWAT	2	4.4000	4.5000	4.4500	.70711 -1
22.B1PHCAL	2	4.0000	4.1000	4.0500	.70711 -1
23.COARSE%	2	50.000	75.000	62.500	17.678
24.TEXTURE	2	3.0000	6.0000	4.5000	2.1213
25.B1%N	2	.22000	.23000	.22500	.70711 -2
26.B1%C	2	8.5300	8.5400	8.5350	.70711 -2
27.B1CNRAT	2	37.800	39.300	38.550	1.0607
28.B2PHWAT	2	4.8000	5.2000	5.0000	.28284
29.B2PHCAL	2	4.2000	5.0000	4.6000	.56569
30.ORG%C	2	48.480	51.510	49.995	2.1425
31.ORG%N	2	.86000	1.1600	1.0100	.21213
32.ORGCNRAT	2	41.800	59.900	50.850	12.799

Appendix 2 : Montane Tsuga-Abies forests (A3)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV	
1.ELEV	4	220.00	570.00	422.50	157.14	
2.ASPECT	4	7.0000	57.000	34.500	24.406	
3.SLOPE	4	45.000	80.000	65.500	15.631	
4.POSIT	4	2.0000	3.0000	2.7500	.50000	
5.DRAINAGE	4	2.0000	3.0000	2.7500	.50000	
6.EROOTDEP	4	12.000	86.000	44.500	35.529	
7.ROOTDEP	4	62.000	103.00	87.000	18.092	
8.SOILDEP	4	86.000	123.00	106.50	16.783	
9.MATERIAL	4	1.0000	2.0000	1.2500	.50000	
10.RATIO1	4	.12000	1.0000	.57250	.49406	
11.RATIO2	4	.10000	1.0000	.46750	.42531	
12.RATIO3	4	.70000 -1	1.0000	.61500	.46336	
13.FIRE	4	0.	1.0000	.25000	.50000	
14.WIND	4	0.	1.0000	.75000	.50000	
15.WORMS	4	0.	2.0000	1.0000	1.1547	
16.ORGPHWAT	4	3.4000	3.7000	3.5250	.12583	
17.ORGPHCAL	4	2.4000	3.2000	2.9000	.35590	
18.ORGTHICK	4	6.0000	24.000	15.000	7.7460	
19.APHWAT	2	3.9000	4.0000	3.9500	.70711 -1	
20.APHCAL	2	3.3000	3.4000	3.3500	.70711 -1	
21.B1PHWAT	4	4.2000	5.0000	4.6500	.41231	
22.B1PHCAL	4	3.7000	4.6000	4.1750	.49244	
23.COARSE%	4	30.000	80.000	53.750	27.500	
24.TEXTURE	4	4.0000	6.0000	5.5000	1.0000	
25.B1%N	4	.10000	.24000	.17750	.57951 -1	
26.B1%C	4	3.0000	4.8200	4.0600	.83315	
27.B1CNRAT	4	12.500	36.500	24.950	9.8605	
28.B2PHWAT	4	4.5000	5.0000	4.8750	.25000	
29.B2PHCAL	4	4.3000	4.7000	4.5000	.18257	
30.ORG%C	4	39.820	50.300	44.800	5.2745	
31.ORG%N	4	.88000	1.6300	1.2175	.37509	
32.ORGCNRAT	4	25.000	54.900	39.525	12.689	

Appendix 2 : Montane <u>Abies</u>–<u>Streptopus</u> forests (A4)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	4	580.00	710.00	672.50	61.847
2.ASPECT	4	12.000	67.000	43.250	24.281
3.SLOPE	4	40.000	45.000	42.250	2.6300
4.POSIT	4	2.0000	3.0000	2.5000	.57735
5.DRAINAGE	4	3.0000	5.0000	4.5000	1.0000
6.EROOTDEP	4	16.000	103.00	41.750	41.040
7.ROOTDEP	4	33.000	103.00	67.250	33.130
8.SOILDEP	4	69.000	127.00	93.000	27.653
9.MATERIAL	4	1.0000	1.0000	1.0000	
10.RATIO1	4	.30000	1.0000	.58000	.32445
11.RATIO2	4	.22000	.81000	.40000	.27653
12.RATIO3	4	.26000	1.0000	.74750	.34903
13.FIRE	4	0.	0.	0.	
14.WIND	4	0.	1.0000	.50000	.57735
15.WORMS	4	0.	2.0000	.50000	1.0000
16.ORGPHWAT	4	3.0000	3.6000	3.2500	.26458
17.ORGPHCAL	4	2.4000	3.0000	2.7250	.27538
18.ORGTHICK	4	16.000	27.000	21.000	4.6904
19.APHWAT	2	3.6000	3.7000	3.6500	.70711 -1
20.APHCAL	2	3.0000	3.0000	3.0000	
21.B1PHWAT	4	4.0000	4.8000	4.3500	..36968
22.B1PHCAL	4	3.6000	4.5000	3.9250	.42720
23.COARSE%	4	5.0000	50.000	26.250	22.127
24.TEXTURE	4	3.0000	6.0000	4.5000	1.7321
25.B1%N	4	.80000 -1	.29000	.16750	.88459 -1
26.B1%C	4	2.8000	12.670	5.3350	4.8905
27.B1CNRAT	4	17.700	43.700	29.200	12.417
28.B2PHWAT	4	4.4000	5.4000	4.7750	.47871
29.B2PHCAL	4	3.8000	5.1000	4.3000	.55976
30.ORG%C	4	49.240	50.600	49.995	.59248
31.ORG%N	4	.82000	1.6800	1.1800	.41817
32.ORGCNRAT	4	30.100	60.000	46.350	15.205

Appendix 2 : Lowland _Abies_ forests (A5)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	12	55.000	415.00	194.67	116.39
2.ASPECT	12	0.	157.00	53.417	53.241
3.SLOPE	12	3.0000	50.000	19.833	15.379
4.POSIT	12	4.0000	5.0000	4.2500	.45227
5.DRAINAGE	12	2.0000	5.0000	3.6667	.88763
6.EROOTDEP	12	10.000	56.000	32.000	16.586
7.ROOTDEP	12	26.000	100.00	60.417	21.082
8.SOILDEP	12	51.000	141.00	94.917	22.952
9.MATERIAL	12	1.0000	3.0000	2.3333	.77850
10.RATIO1	12	.24000	1.0000	.54750	.27367
11.RATIO2	12	.90000 -1	1.0000	.36417	.25239
12.RATIO3	12	.26000	1.0000	.58250	.31606
13.FIRE	12	0.	1.0000	.16667	.38925
14.WIND	12	0.	1.0000	.41667	.51493
15.WORMS	12	0.	2.0000	1.0833	.99620
16.ORGPHWAT	12	3.4000	4.9000	3.7917	.50355
17.ORGPHCAL	12	2.8000	4.5000	3.2083	.52477
18.ORGTHICK	12	8.0000	25.000	14.750	4.8077
19.APHWAT	8	3.5000	5.1000	3.9750	.49497
20.APHCAL	8	3.0000	4.3000	3.3500	.41057
21.B1PHWAT	12	3.8000	5.1000	4.5833	.36139
22.B1PHCAL	12	3.6000	4.7000	4.1333	.30251
23.COARSE%	12	10.000	95.000	42.500	27.593
24.TEXTURE	12	3.0000	6.0000	4.5833	1.5050
25.B1%N	12	.90000 -1	.28000	.20333	.65273 -1
26.B1%C	12	2.4000	8.5800	5.4100	1.9536
27.B1CNRAT	12	18.700	37.200	26.733	5.7299
28.B2PHWAT	11	4.7000	5.5000	5.0455	.23817
29.B2PHCAL	11	4.1000	5.2000	4.5455	.30778
30.ORG%C	12	36.300	53.300	46.277	6.3396
31.ORG%N	12	.75000	1.6300	1.1725	.29815
32.ORGCNRAT	12	23.500	53.000	41.283	8.4671

Appendix 2 : Tsuga-Gaultheria-Blechnum forests (A6)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	2	125.00	200.00	162.50	53.033
2.ASPECT	2	12.000	103.00	57.500	64.347
3.SLOPE	2	27.000	30.000	28.500	2.1213
4.POSIT	2	3.0000	4.0000	3.5000	.70711
5.DRAINAGE	2	4.0000	4.0000	4.0000	
6.EROOTDEP	2	31.000	47.000	39.000	11.314
7.ROOTDEP	2	69.000	72.000	70.500	2.1213
8.SOILDEP	2	89.000	117.00	103.00	19.799
9.MATERIAL	2	2.0000	2.0000	2.0000	
10.RATIO1	2	.45000	.65000	.55000	.14142
11.RATIO2	2	.35000	.40000	.37500	.35355 -1
12.RATIO3	2	.25000	.35000	.30000	.70711 -1
13.FIRE	2	O.	O.	O.	
14.WIND	2	O.	1.0000	.50000	.70711
15.WORMS	2	O.	2.0000	1.0000	1.4142
16.ORGPHWAT	2	3.5000	3.6000	3.5500	.70711 -1
17.ORGPHCAL	2	2.9000	3.0000	2.9500	.70711 -1
18.ORGTHICK	2	11.000	12.000	11.500	.70711
19.APHWAT	1	3.7000	3.7000	3.7000	
20.APHCAL	1	3.2000	3.2000	3.2000	
21.B1PHWAT	2	4.3000	5.1000	4.7000	.56569
22.B1PHCAL	2	4.1000	4.7000	4.4000	.42426
23.COARSE%	2	30.000	40.000	35.000	7.0711
24.TEXTURE	2	3.0000	3.0000	3.0000	
25.B1%N	2	.16000	.19000	.17500	.21213 -1
26.B1%C	2	3.8500	6.1900	5.0200	1.6546
27.B1CNRAT	2	23.800	32.700	28.250	6.2933
28.B2PHWAT	2	4.6000	4.8000	4.7000	.14142
29.B2PHCAL	2	4.2000	4.5000	4.3500	.21213
30.ORG%C	2	38.740	44.290	41.515	3.9244
31.ORG%N	2	1.0500	1.3400	1.1950	.20506
32.ORGCNRAT	2	33.000	36.900	34.950	2.7577

Appendix 2 : <u>Tsuga-Blechnum-Polystichum</u> forests (A7)

DESCRIPTIVE MEASURES

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
1.ELEV	5	25.000	350.00	183.00	123.98
2.ASPECT	5	15.000	72.000	44.800	26.376
3.SLOPE	5	20.000	75.000	40.600	20.477
4.POSIT	5	3.0000	4.0000	3.6000	.54772
5.DRAINAGE	5	2.0000	4.0000	3.2000	.83666
6.EROOTDEP	5	5.0000	45.000	22.800	17.922
7.ROOTDEP	5	25.000	100.00	51.000	32.581
8.SOILDEP	5	82.000	113.00	100.40	12.857
9.MATERIAL	5	1.0000	2.0000	1.6000	.54772
10.RATIO1	5	.17000	.65000	.42200	.17880
11.RATIO2	5	.50000 -1	.40000	.22200	.16208
12.RATIO3	5	.41000	1.0000	.76600	.32044
13.FIRE	5	O.	1.0000	.40000	.54772
14.WIND	5	O.	1.0000	.20000	.44721
15.WORMS	5	1.0000	3.0000	2.4000	.89443
16.ORGPHWAT	5	3.6000	4.0000	3.7600	.15166
17.ORGPHCAL	5	2.9000	3.6000	3.1800	.25884
18.ORGTHICK	5	5.0000	19.000	13.000	5.2440
19.APHWAT	O				
20.APHCAL	O				
21.B1PHWAT	5	4.5000	5.2000	4.8600	.35071
22.B1PHCAL	5	3.8000	5.0000	4.3400	.49800
23.COARSE%	5	30.000	75.000	59.000	18.841
24.TEXTURE	5	3.0000	6.0000	4.6000	1.3416
25.B1%N	5	.17000	.36000	.26000	.82158 -1
26.B1%C	5	2.8000	10.230	7.1420	2.9069
27.B1CNRAT	5	16.000	51.100	27.960	13.504
28.B2PHWAT	5	4.8000	5.3000	5.1800	.21679
29.B2PHCAL	5	4.3000	5.3000	4.7400	.37815
30.ORG%C	5	38.900	49.480	43.300	4.1590
31.ORG%N	5	.86000	1.5200	1.0680	.26621
32.ORGCNRAT	5	25.600	57.500	42.680	11.531

Appendix 3 : Community types complete understory vegetation tables.

cons.   = constancy (%)

m. cov.   = mean coverage (%)

max. cov. = maximum coverage (%)

m. fre.   = mean frequency (%)

m.i.v.   = mean importance value (%)
              (i.v. = [relative cov.+ relative fre.]/2)

t. spp   = total number of species

m. spp   = mean number of species

(Refer to Appendix 1 for abbreviations of species names)

Appendix 3 : Dry Pinus-Pseudotsuga forests (D1)

plots: 9 110 144

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
amal	66	0.007	0.01	0.67	0.033
arco	100	7.047	10.63	15.33	3.013
bene	100	4.733	8.52	20.00	2.540
gash	100	12.850	17.90	33.33	5.760
hodi	33	0.003	0.01	0.33	0.017
pamy	33	0.750	2.25	5.00	0.457
rogy	100	0.307	0.90	4.00	0.273
ruur	100	1.210	1.35	21.67	1.443
sali	33	0.003	0.01	0.33	0.017
vame	33	0.003	0.01	0.33	0.017
vaot	66	17.800	37.00	30.00	7.573
vapa	100	0.010	0.01	1.00	0.050
herbs					
achi	66	0.013	0.03	2.00	0.100
actr	33	0.003	0.01	0.33	0.017
agal	33	0.003	0.01	0.33	0.017
agsc	33	0.060	0.18	3.33	0.183
anne	33	0.050	0.15	1.67	0.090
apan	66	0.527	0.90	15.00	0.887
aren	33	0.003	0.01	0.33	0.017
aruv	33	10.627	31.88	23.33	4.360
chum	33	0.050	0.15	1.67	0.090
crcr	66	0.020	0.05	3.67	0.170
dasp	100	4.073	11.93	38.67	3.030
erla	33	0.003	0.01	0.33	0.017
feoc	66	0.260	0.75	3.33	0.247
feov	66	1.000	2.97	11.67	0.933
frag	66	0.383	0.93	11.67	0.667
goob	100	0.160	0.18	6.67	0.380
hial	100	0.333	0.77	16.67	0.873
hypa	66	0.007	0.01	0.67	0.033
liao	33	0.017	0.05	3.33	0.170
libo	33	1.000	3.00	6.67	0.607
lica	33	0.017	0.05	3.33	0.170
lico	66	0.220	0.63	10.00	0.517
luzc	33	0.050	0.15	1.67	0.100
poly	66	0.013	0.03	2.00	0.103
pomu	66	0.007	0.01	0.67	0.033
prun	33	0.003	0.01	0.33	0.017
saxf	66	0.060	0.15	3.33	0.177
sewa	100	4.727	7.40	38.33	3.433
trla	66	0.210	0.45	8.33	0.457
trma	33	0.500	1.50	10.00	0.597
vise	33	0.003	0.01	0.33	0.017
zyve	33	0.010	0.03	1.67	0.077
bryophytes and lichens					
clar	100	5.527	15.48	30.00	3.113
clas	66	1.253	3.75	3.67	0.600
cldb	100	0.710	1.08	50.00	2.610
cldf	100	2.793	7.25	33.33	2.583
cldg	66	1.170	2.38	36.67	2.130
cldp	33	0.100	0.30	20.00	1.053

```
cldu    33    0.003    0.01    0.33    0.017
cleb    33    0.127    0.38    8.33    0.450
dicf    33    0.227    0.68   11.67    0.647
dics    66   10.260   20.63   60.00    6.267
hylo   100    2.117    3.55   15.00    1.393
isop    33    0.060    0.18    3.33    0.190
isst    33    1.760    5.28   20.00    1.620
pelo   100    1.143    1.75   40.00    2.300
pelt    33    0.067    0.20    5.00    0.277
plun    33    0.050    0.15    1.67    0.103
plzs    33    3.100    9.30   10.00    1.413
ponc   100    0.900    1.65   10.00    0.783
ponj   100    3.810    5.13   78.33    5.003
ponp    33    0.450    1.35   23.33    1.297
rhac   100    3.217    6.55   25.00    2.250
rhah    33    0.710    2.13   11.67    0.837
rhal    33    7.900   23.70   23.33    3.797
rhlo    66    0.110    0.18    5.00    0.280
rhtr    66    0.677    1.88    3.33    0.393
rhyt    33    0.050    0.15    1.67    0.100
scaa    66    0.390    0.95   20.00    1.140
steo    33    0.033    0.10    6.67    0.350
stet    66    0.727    2.00   23.33    1.317
stor   100    4.153    5.93   23.33    2.567
tame    33    0.777    2.33    6.67    0.537

bare rock
  rock  100   27.937   38.50   71.67    0.000

totals:
          m.cov max.cov  t.spp  m.spp

  shrubs   44.73   50.6    12     8.7
  herbs    24.40   55.0    32    17.3
  bryo.    54.37   59.0    31    18.7
  all spp. 123.43  147.7   75    44.7
```

Note :   Pelo = <u>Peltigera leucophlebia</u> (9, 100)
                and <u>P</u>. <u>aphtosa</u> (144)

       Pelt = <u>P</u>. <u>membranacea</u>

Appendix 3 : Coastal dry _Pinus_ forests (D2)

plots: 53 157 158 169

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
amal	25	0.188	0.75	1.25	0.125
gash	100	44.895	61.50	86.25	16.863
mefe	50	0.992	2.92	8.75	0.673
pamy	25	0.038	0.15	1.25	0.077
pyus	25	0.003	0.01	0.25	0.013
sali	25	0.003	0.01	0.25	0.015
vaal	50	2.167	8.52	8.75	0.893
vame	25	0.412	1.65	3.75	0.330
vaol	25	0.188	0.75	1.25	0.100
vaot	75	24.558	44.78	55.00	9.238
vapa	100	5.920	13.40	27.50	3.052
herbs					
agal	25	0.003	0.01	0.25	0.013
agsc	75	0.043	0.15	1.75	0.102
blsp	25	0.003	0.01	0.25	0.013
boho	75	0.060	0.20	5.25	0.277
corn	50	1.785	7.13	15.25	1.195
crcr	25	0.003	0.01	0.25	0.015
dasp	75	0.423	0.93	5.25	0.382
goob	75	0.013	0.03	1.75	0.090
hial	25	0.003	0.01	0.25	0.013
hypo	25	0.003	0.01	0.25	0.013
liao	25	0.038	0.15	1.25	0.077
libo	100	3.635	5.00	55.00	3.630
lycl	25	0.188	0.75	1.25	0.100
madi	50	0.488	1.60	17.50	0.930
paoc	25	0.003	0.01	0.25	0.013
pens	25	0.003	0.01	0.25	0.013
phyl	25	1.595	6.38	5.00	0.685
poly	25	0.003	0.01	0.25	0.015
saxf	75	0.245	0.75	6.25	0.380
sewa	50	0.420	0.93	5.00	0.395
bryophytes and lichens					
andr	50	0.195	0.75	13.75	0.727
camy	50	0.100	0.20	7.50	0.387
clar	100	9.265	15.95	65.00	5.848
clas	100	3.360	6.15	37.50	2.742
cldb	100	0.275	0.40	36.25	1.863
cldf	50	0.150	0.45	5.00	0.275
cldg	100	0.605	1.38	21.25	1.207
cldu	100	1.083	2.63	25.00	1.520
dicf	25	0.450	1.80	5.00	0.408
dics	100	7.325	17.20	72.50	5.380
dipa	25	0.262	1.05	3.75	0.243
ditr	25	0.008	0.03	1.25	0.057
heba	75	0.445	1.35	15.00	0.818
hylo	100	6.813	16.40	57.50	4.495
isst	25	0.387	1.55	10.00	0.650
myta	25	0.038	0.15	1.25	0.067
nasc	25	0.038	0.15	1.25	0.067
pelo	25	0.055	0.22	5.00	0.280
pelt	25	0.013	0.05	2.50	0.135

```
plun    100     0.190    0.30    18.75    0.955
plzs     75     1.020    3.05    38.75    2.115
ponc     75     0.545    1.98    11.25    0.730
ponj     50     0.195    0.75    13.75    0.777
ponp     50     0.010    0.03     1.50    0.075
rhah     50     5.682   17.85    27.50    2.997
rhal     75     6.588   12.20    41.25    3.940
rhgl     50     0.025    0.05     5.00    0.248
rhlo    100    10.850   18.90    50.00    5.307
scab     75     2.470    5.90    38.75    2.708
sphg     50     1.238    4.65     7.50    0.625
steo    100     0.073    0.18     7.50    0.388
stor     75     2.388    8.30    26.25    1.828

bare rock
rock    100    26.420   37.13    47.50    0.000


totals:
               m.cov max.cov  t.spp   m.spp

    shrubs     79.35   123.0    11      5.3
    herbs       8.93    18.7    20      9.0
    bryo.      62.13    87.5    32     20.5
    all spp.  150.43   216.7    63     34.8
```

Appendix 3 : Floodplain forests (Fl)

plots: 58 92 118 121 122 160 170 171

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
acgl	12	0.001	0.01	0.13	0.011
cost	12	0.723	5.78	2.50	0.296
gash	37	0.739	5.75	2.63	0.326
mefe	12	0.001	0.01	0.13	0.006
opho	12	0.391	3.13	0.63	0.124
phys	12	0.001	0.01	0.13	0.006
pyus	12	0.001	0.01	0.13	0.006
ribb	62	5.348	31.25	9.75	1.521
rogy	25	0.424	3.38	2.00	0.298
rupa	37	5.880	45.38	13.25	2.070
rusp	100	23.180	81.38	39.38	6.591
ruur	12	0.001	0.01	0.13	0.006
samr	25	2.032	14.38	2.50	0.476
vaal	75	1.481	6.88	5.25	0.809
vaol	37	0.861	5.00	2.00	0.289
vapa	100	5.155	14.15	22.00	2.686
herbs					
actr	50	4.845	22.52	32.50	3.229
adbi	50	0.195	0.93	5.00	0.320
adpe	50	0.444	2.78	2.75	0.230
aruy	62	0.193	1.50	1.75	0.194
atfi	100	12.750	26.05	34.38	4.739
blsp	62	6.534	26.88	25.63	3.259
boye	25	0.008	0.05	1.38	0.113
brov	50	0.357	1.80	4.50	0.318
card	12	0.112	0.90	1.25	0.079
carh	25	0.095	0.75	0.75	0.045
caro	12	0.001	0.01	0.13	0.006
circ	12	0.063	0.50	3.13	0.122
coas	12	0.001	0.01	0.13	0.006
diho	37	1.015	5.55	11.88	0.824
drau	50	0.535	3.22	5.75	0.360
fesa	25	0.020	0.15	0.75	0.039
fesu	12	0.001	0.01	0.13	0.011
gali	87	0.704	2.90	20.25	1.066
goob	12	0.004	0.03	0.63	0.054
gydr	25	3.894	29.50	16.88	1.746
lamu	37	0.006	0.03	0.88	0.049
luzp	75	0.129	0.77	4.00	0.213
lysi	12	0.001	0.01	0.13	0.006
madi	100	2.811	12.57	33.88	2.146
mecu	62	0.761	3.22	8.38	0.555
miov	25	0.356	2.50	7.50	0.360
mono	12	0.001	0.01	0.13	0.006
mopa	12	0.001	0.01	0.13	0.006
mosi	25	0.081	0.45	6.88	0.281
oxor	25	11.623	65.40	24.38	4.649
pler	12	0.001	0.01	0.13	0.006
poam	37	0.872	5.78	9.38	0.533
poly	12	0.112	0.90	1.25	0.079
pomu	100	45.226	85.88	70.63	15.925
smra	12	0.001	0.01	0.13	0.005
smst	12	0.001	0.01	0.13	0.006

```
      stac    37   0.709    5.63     4.50    0.393
      stra    75   0.294    1.88     2.75    0.209
      strr    37   0.563    1.95     6.25    0.465
      tila    62   0.550    3.17    11.88    0.630
      titr   100   8.799   27.65    55.63    5.039
      tome    25   1.369   10.80     5.63    0.456
      trau   100   9.890   36.13    42.50    5.069
      trla    25   0.005    0.03     0.75    0.038
      trmc    25   0.005    0.03     0.75    0.043
      trov    75   1.501    5.47    20.88    1.440
      vevi    37   0.300    0.90     2.50    0.240
      vigl    50   1.070    7.45    10.75    0.625
      vise    12   0.004    0.03     0.63    0.054

bryophytes and lichens
      bazz    12   0.329    2.63     1.25    0.209
      ceph    12   0.038    0.30     1.25    0.065
      coco    37   0.647    4.97    10.00    0.496
      dicf    12   0.040    0.32     1.88    0.171
      dics    12   0.019    0.15     0.63    0.026
      dipa    12   0.023    0.18     1.25    0.112
      hete    25   0.131    0.90     1.88    0.153
      holu    62   0.445    2.55    15.63    0.980
      hylo    87   1.985    8.88    13.75    1.274
      hypu    37   0.135    0.75     2.50    0.191
      isop    50   0.629    3.05    10.00    0.730
      isst    75   1.414    4.53     8.13    0.845
      ledo    12   0.075    0.60     2.50    0.160
      leme    75   5.810   33.22    28.13    2.656
      peli    50   0.266    1.58    10.00    0.581
      plag    62   0.316    1.08    16.88    0.914
      plin    75   2.169    9.27    30.00    1.910
      plun    62   2.006    8.75    31.88    2.191
      pogc    12   0.112    0.90     1.25    0.095
      pogm    12   0.188    1.50     1.25    0.165
      rhgl   100   2.114    4.80    36.25    2.365
      rhlo   100   4.720   15.88    35.00    2.996
      ricl    12   0.038    0.30     1.25    0.051
      scab    87   0.498    0.93     8.13    0.553
      stor    62   8.920   28.58    41.88    3.935
      stpr    50   6.046   23.20    36.88    4.169

bare rock
      rock    12   1.016    8.13     1.25    0.000


   totals:
                 m.cov max.cov  t.spp  m.spp

      shrubs     46.20   131.9    16     5.9
      herbs     118.80   168.6    49    20.1
      bryo.      39.11    86.2    26    12.1
      all spp.  204.10   278.1    91    38.1
```

Appendix 3 : Floodplain forests (<u>Lysichitum</u> variant) (F2)

plots: 46 51

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	100	33.335	50.65	65.00	9.535
mefe	100	5.015	6.63	20.00	1.860
rusp	100	20.895	21.77	70.00	7.235
vaal	100	7.315	7.75	17.50	2.225
vaol	100	4.030	4.78	15.00	1.440
vaot	100	2.095	4.18	10.50	0.885
vapa	100	13.110	14.15	40.00	4.340
herbs					
adbi	50	1.175	2.35	12.50	0.785
atfi	100	1.500	2.25	10.00	0.710
blsp	100	28.825	35.90	72.50	8.895
boye	100	0.010	0.01	1.00	0.045
caro	100	2.880	5.75	8.00	0.935
fesa	50	0.075	0.15	2.50	0.125
gali	50	0.100	0.20	7.50	0.345
luzp	50	0.015	0.03	2.50	0.110
lysi	100	26.125	46.03	60.00	7.860
madi	100	1.310	1.67	40.00	1.915
pomu	100	23.325	25.90	37.50	6.380
stra	100	0.525	0.90	7.50	0.410
tila	100	2.510	3.35	60.00	2.980
titr	100	5.260	5.57	65.00	3.760
trmc	100	0.230	0.45	8.00	0.390
vevi	50	0.005	0.01	0.50	0.025
vigl	100	0.240	0.47	10.50	0.505
bryophytes and lichens					
blet	50	0.050	0.10	10.00	0.395
calm	50	0.700	1.40	17.50	0.825
ceph	50	0.050	0.10	10.00	0.395
holu	100	0.590	0.73	42.50	1.870
hylo	100	1.765	1.88	20.00	1.150
isop	50	0.075	0.15	2.50	0.125
isst	50	0.825	1.65	7.50	0.495
leme	100	9.760	19.20	30.00	3.270
peli	100	2.915	4.78	32.50	1.900
plag	100	3.295	5.32	62.50	3.185
plin	100	0.455	0.88	27.50	1.275
plun	100	3.660	4.22	65.00	3.390
pogm	50	0.005	0.01	0.50	0.020
rhgl	100	14.775	18.20	82.50	6.420
rhlo	100	2.690	4.15	35.00	1.975
ricl	50	1.200	2.40	10.00	0.635
scab	100	1.805	2.53	27.50	1.520
sphh	100	0.100	0.15	10.00	0.430
stor	50	0.005	0.01	0.50	0.020
stpr	100	17.135	18.75	85.00	7.025

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	85.80	103.7	7	7.0
herbs	94.15	113.9	17	14.5
bryo.	61.85	61.9	20	16.0
all spp.	241.75	243.6	44	37.5

Appendix 3 : Dry <u>Pseudotsuga</u> forests (P1)

plots: 10 18 111 161

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
amal	50	0.010	0.03	1.50	0.085
arco	25	0.003	0.01	0.25	0.010
bene	100	11.655	16.05	50.00	5.475
gash	100	60.413	92.50	97.50	19.843
hodi	50	2.725	9.02	7.50	1.030
loci	25	0.525	2.10	7.50	0.450
pamy	25	0.003	0.01	0.25	0.015
rogy	75	1.173	4.65	10.25	0.795
ruur	75	1.613	3.75	18.75	1.310
sali	25	0.003	0.01	0.25	0.010
syal	50	0.150	0.45	5.00	0.275
vaal	25	2.325	9.30	13.75	1.378
vaot	50	10.660	42.63	14.00	3.165
vapa	100	7.120	16.27	26.25	3.120
herbs					
actr	100	2.255	3.72	25.00	1.860
alvi	50	0.005	0.01	0.50	0.025
apan	50	0.083	0.30	3.75	0.185
aren	50	0.090	0.18	5.00	0.248
aruv	25	0.188	0.75	1.25	0.120
boho	100	0.438	0.95	25.00	1.340
camp	75	0.047	0.15	2.75	0.145
chme	50	0.050	0.15	3.75	0.225
chum	100	6.098	9.38	62.50	4.715
coaa	25	0.045	0.18	2.50	0.138
dasp	50	0.970	3.70	10.00	0.732
feoc	100	2.808	4.80	42.50	2.672
fesu	50	0.553	2.03	5.00	0.400
frag	50	0.040	0.15	1.50	0.075
goob	125	0.175	0.28	21.50	1.173
hael	25	0.038	0.15	1.25	0.060
hial	75	1.060	4.22	21.75	1.173
hypa	50	0.010	0.03	1.50	0.075
hypo	25	0.003	0.01	0.25	0.013
liao	25	0.003	0.01	0.25	0.015
libo	100	8.553	10.02	71.25	5.792
lico	75	0.332	1.08	22.50	1.355
lupi	25	0.003	0.01	0.25	0.013
luzc	25	0.457	1.83	6.25	0.382
maad	50	0.608	2.40	6.25	0.450
poly	100	0.057	0.18	4.25	0.203
pomu	100	0.550	2.17	4.50	0.353
ptaq	100	6.103	13.77	26.50	2.895
pyas	25	0.008	0.03	1.25	0.065
pypi	25	0.038	0.15	1.25	0.075
sewa	25	0.038	0.15	1.25	0.060
trla	100	2.550	4.90	45.00	2.823
vise	75	0.338	0.75	17.50	1.005
bryophytes and lichens					
clar	50	0.010	0.03	1.50	0.065
cldb	25	0.038	0.15	1.25	0.073
cldf	50	0.208	0.68	10.00	0.568

```
cldg     25    0.055     0.22     5.00     0.210
clec     25    0.225     0.90    13.75     0.600
dicf    100    2.233     2.85    25.00     1.810
dics     50    1.688     5.25    12.50     1.008
hylo    100   21.203    46.78    45.00     7.565
hypu     50    0.075     0.15     2.50     0.148
isst     75    2.958     8.15    18.75     1.642
pelo     75    0.490     1.75    17.50     0.870
pelt     75    0.682     1.80     8.75     0.583
plun     25    0.038     0.15     1.25     0.075
plzs     25    0.038     0.15     1.25     0.075
ponc     25    0.008     0.03     1.25     0.065
ponj    100    1.683     5.93    30.00     1.810
ponp     25    0.275     1.10     6.25     0.325
rhac     75    2.128     5.88    13.75     1.168
rhlo    100    0.533     1.20     8.75     0.600
rhtr     75    0.438     0.93     8.75     0.548
scle     25    0.508     2.03     2.50     0.243
stor    100   27.688    50.10    73.75    10.563
tame    100    0.890     2.50    11.50     0.847

bare rock
rock     50    1.813     5.75     6.25     0.000


totals:
              m.cov  max.cov  t.spp   m.spp

    shrubs    98.35   132.7     14      7.8
    herbs     34.55    43.5     33     20.3
    bryo.     64.07    84.9     23     13.8
    all spp. 197.00   213.1     70     41.8
```

Note :   Pelt = _Peltigera_ _membranacea_

Appendix 3 : <u>Pseudotsuga-Thuja-Acer</u> forests (P2)

plots: 13 14 16 131

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
acgl	25	0.003	0.01	0.25	0.013
amal	25	0.003	0.01	0.25	0.013
bene	100	12.722	24.83	49.00	8.028
gash	75	13.282	26.58	40.00	5.948
hodi	25	0.003	0.01	0.25	0.013
ribl	25	0.038	0.15	1.25	0.070
rogy	100	1.757	4.07	12.75	1.128
ruur	100	8.212	31.90	33.75	3.830
samr	25	0.003	0.01	0.25	0.013
syal	50	0.232	0.90	3.75	0.253
vaot	25	0.003	0.01	0.25	0.025
vapa	100	2.290	6.45	17.75	1.765
herbs					
actr	100	10.590	22.52	63.75	6.440
adbi	50	0.265	1.05	4.00	0.275
adpe	25	0.600	2.40	5.00	0.395
anly	25	0.080	0.32	3.75	0.210
brov	50	0.075	0.15	2.50	0.145
caly	50	0.020	0.05	3.75	0.190
camp	50	0.237	0.90	10.00	0.555
chme	75	0.138	0.30	15.00	0.880
chum	50	0.208	0.80	5.00	0.300
coma	25	0.003	0.01	0.25	0.013
drau	25	0.003	0.01	0.25	0.013
feoc	50	1.895	7.28	15.00	1.370
fesu	100	3.028	5.95	43.75	3.068
gali	50	0.482	1.90	16.25	0.920
goob	100	0.185	0.38	17.50	1.070
heco	25	0.038	0.15	1.25	0.130
hial	25	0.038	0.15	1.25	0.073
hypo	25	0.008	0.03	1.25	0.063
lamu	25	0.003	0.01	0.25	0.013
lane	25	0.003	0.01	0.25	0.013
libo	100	10.100	20.45	57.50	5.825
lico	75	0.045	0.10	8.75	0.442
mono	25	0.038	0.15	1.25	0.073
mopa	50	0.040	0.15	1.50	0.083
mosi	25	0.813	3.25	8.75	0.635
poly	100	0.710	2.60	13.75	0.908
pomu	100	18.248	41.38	41.25	7.873
ptaq	75	0.078	0.15	2.75	0.170
ptea	25	0.003	0.01	0.25	0.025
pypi	25	0.080	0.32	3.75	0.205
smra	25	0.003	0.01	0.25	0.013
tila	25	0.003	0.01	0.25	0.013
titr	50	0.577	2.30	11.50	0.710
trla	100	4.175	9.07	48.75	3.742
trov	25	0.003	0.01	0.25	0.013
vise	75	1.070	2.95	25.00	1.648
bryophytes and lichens					
dicf	100	1.163	2.22	20.00	1.348
dics	25	0.038	0.15	1.25	0.070

```
hylo    100    22.005    53.20    60.00     9.455
hypu     50     0.450     1.50     5.00     0.375
isst     75     3.013     7.53    16.25     1.930
leme     75     2.683     7.30    25.00     2.435
meta     25     0.225     0.90     2.50     0.190
mniu     25     0.038     0.15     1.25     0.073
plin     25     0.287     1.15    13.75     0.750
plun     50     0.020     0.05     3.75     0.245
pogm     50     1.295     5.03     3.75     0.568
rhgl     25     0.050     0.20     3.75     0.197
rhlo     75     2.405     4.82    17.50     1.598
rhtr     75     6.220    16.88    32.50     3.547
scab     50     0.118     0.32     5.00     0.278
stor    100    24.340    48.78    75.00    13.655
timm     25     0.038     0.15     1.25     0.070

bare rock
  rock   50     9.070    32.00    17.50     0.000


totals:
              m.cov max.cov  t.spp  m.spp

  shrubs     38.55    55.5    12     6.8
  herbs      53.88    77.7    36    18.5
  bryo.      64.40    77.1    17     9.5
  all spp.  156.80   183.5    65    34.8
```

Appendix 3 : <u>Pseudotsuga-Linnaea</u> forests (P3)

plots: 7 11 12 109 138

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
amal	40	0.032	0.15	1.20	0.074
bene	100	10.392	22.42	38.20	4.208
gash	100	43.694	93.13	65.00	15.446
hodi	40	1.906	9.52	3.20	0.504
loci	20	0.030	0.15	1.00	0.054
rogy	80	2.832	9.98	16.00	1.356
ruur	60	1.518	6.00	21.20	1.368
syal	40	0.566	2.65	5.00	0.370
vaal	20	0.150	0.75	1.00	0.100
vame	20	0.002	0.01	0.20	0.010
vaot	20	0.706	3.53	4.00	0.558
vapa	100	10.334	19.90	43.00	5.586
herbs					
actr	100	12.360	28.65	54.00	5.428
adbi	20	0.002	0.01	0.20	0.010
adpe	20	0.002	0.01	0.20	0.010
alvi	40	0.004	0.01	0.40	0.022
anly	20	0.030	0.15	1.00	0.054
aren	20	0.030	0.15	1.00	0.054
boho	60	0.022	0.05	4.20	0.280
brov	20	0.426	2.13	7.00	0.404
caly	40	0.042	0.18	3.00	0.154
camp	40	0.252	1.08	6.00	0.348
chme	80	0.200	0.47	15.00	0.804
chum	100	2.480	4.22	31.20	2.498
coma	60	0.044	0.18	3.20	0.168
come	60	0.042	0.15	3.20	0.182
feoc	40	1.176	5.13	17.00	1.130
fesu	100	1.698	6.38	17.20	1.380
goob	100	0.246	0.80	19.20	0.976
heco	20	0.002	0.01	0.20	0.010
hial	20	0.304	1.52	7.00	0.412
lamu	20	0.002	0.01	0.20	0.010
lane	60	1.488	5.40	7.20	0.632
liao	20	0.002	0.01	0.20	0.010
libo	100	19.622	38.40	79.00	9.046
lico	80	0.150	0.30	15.00	0.882
pedi	20	1.556	7.78	11.00	0.996
poly	40	0.046	0.22	4.20	0.210
pomu	100	3.764	12.40	11.20	1.590
ptaq	60	0.190	0.93	3.40	0.218
pypi	40	0.070	0.32	4.00	0.198
sewa	20	0.030	0.15	1.00	0.054
strr	20	0.002	0.01	0.20	0.012
tila	20	0.030	0.15	1.00	0.064
titr	20	0.006	0.03	1.00	0.048
trla	80	1.584	3.97	31.00	1.966
vise	80	1.612	3.60	38.00	2.262
bryophytes and lichens					
dicf	100	0.726	1.13	18.00	1.286
dics	20	0.094	0.47	4.00	0.352
hylo	100	52.232	79.50	87.00	17.726

```
hypu    40    0.420    1.50     6.00    0.546
isop    20    0.240    1.20     4.00    0.292
isst    20    0.526    2.63     2.00    0.260
leme    60    0.300    1.20     6.00    0.376
mniu    40    0.036    0.15     2.00    0.110
pelt    20    0.180    0.90     6.00    0.326
plun    60    1.266    5.65    23.00    1.886
pogm   100    2.654   11.90    10.00    1.106
ponj    20    0.064    0.32     3.00    0.156
ponp    20    0.030    0.15     1.00    0.054
rhgl    20    0.036    0.18     2.00    0.172
rhlo   100    4.372   10.05    43.00    3.548
rhtr    80    1.466    3.83    28.00    1.838
rhyt    40    0.714    3.42    10.00    0.714
scab   100    0.616    2.00    11.00    0.778
stor   100    5.864   10.90    53.00    4.702
tame    40    1.490    7.30    18.00    1.286

bare rock
  rock    20    0.750    3.75     2.00    0.000


totals:
               m.cov max.cov  t.spp  m.spp

   shrubs      72.16   117.3    12    6.4
   herbs       49.50    79.6    35   17.4
   bryo.       73.34   104.8    20   11.0
   all spp.   195.00   268.9    67   34.8
```

Appendix 3 : <u>Pseudotsuga-Berberis</u> forests (P4)

plots: 8 15 19 39 41 61 123 132 145 165 166

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
acgl	18	0.523	5.00	0.91	0.205
amal	18	0.004	0.03	0.54	0.028
bene	100	11.493	26.40	41.00	7.648
gash	90	10.355	28.65	25.91	5.564
hodi	9	0.001	0.01	0.09	0.007
mefe	9	0.082	0.90	0.91	0.071
opho	9	0.001	0.01	0.09	0.005
rogy	54	0.457	4.20	5.27	0.365
rusp	9	0.001	0.01	0.09	0.007
ruur	72	0.551	4.15	9.64	0.773
syal	18	0.021	0.20	1.82	0.083
vaal	36	3.253	14.07	14.54	1.895
vaol	9	0.548	6.03	1.82	0.268
vaot	18	0.455	5.00	0.54	0.249
vapa	100	11.869	37.50	47.73	7.167
herbs					
actr	100	4.115	17.13	46.36	4.500
adbi	18	0.007	0.05	1.36	0.079
adpe	9	0.171	1.88	0.46	0.056
alvi	27	0.003	0.01	0.27	0.027
aren	9	0.014	0.15	0.46	0.026
blsp	9	0.001	0.01	0.09	0.006
boho	9	0.003	0.03	0.46	0.019
boye	9	0.001	0.01	0.09	0.005
caly	27	0.006	0.03	1.00	0.067
camp	9	0.001	0.01	0.09	0.008
chme	63	0.093	0.45	11.46	0.914
chum	54	0.025	0.18	2.18	0.158
come	27	0.018	0.18	1.09	0.096
corn	9	0.136	1.50	0.91	0.104
diho	18	0.281	3.08	3.27	0.251
feoc	9	0.027	0.30	0.91	0.094
fesu	36	0.339	1.50	7.73	0.723
goob	81	0.165	0.43	16.46	1.073
heco	27	0.005	0.03	0.64	0.068
hypo	45	0.123	1.27	4.27	0.473
lamu	18	0.004	0.03	0.54	0.032
libo	81	8.530	24.10	43.18	5.202
lica	27	0.013	0.10	2.36	0.155
lico	54	0.096	0.38	10.00	0.692
madi	9	0.001	0.01	0.09	0.007
mono	36	0.005	0.03	0.73	0.056
mopa	9	0.014	0.15	0.46	0.026
poly	36	0.034	0.20	2.00	0.099
pomu	100	7.750	28.50	28.82	4.792
ptaq	63	0.488	2.92	4.36	0.586
ptea	9	0.001	0.01	0.09	0.006
pyap	9	0.003	0.03	0.46	0.052
pyas	9	0.003	0.03	0.46	0.029
pypi	27	0.010	0.05	1.82	0.164
smra	18	0.148	1.58	3.18	0.207
smst	9	0.014	0.15	0.46	0.041
tila	54	0.065	0.30	3.64	0.256

```
titr    63    1.110    7.45   13.64    1.026
trla    81    0.292    2.13   10.54    0.763
trov    54    0.074    0.32    5.64    0.325
vise    54    1.561   16.85   11.00    0.945

bryophytes and lichens
blet     9    0.003    0.03    0.46    0.029
calm     9    0.016    0.18    0.91    0.062
ceph     9    0.082    0.90    0.91    0.085
cloa     9    0.070    0.77    0.91    0.166
dicf    90    0.453    1.88   23.64    1.914
hete    27    0.753    4.53   10.91    0.780
hylo   100   22.647   58.03   56.82   13.516
hypu    81    1.515    5.50   20.46    2.594
isop    27    0.319    2.13   10.00    1.048
isst    81    2.484    7.78   29.54    2.980
ledo     9    0.068    0.75    0.46    0.045
leme    18    0.069    0.75    0.54    0.070
mniu    36    0.070    0.30    5.00    0.406
pelt    36    0.103    0.75    2.73    0.206
plag     9    0.003    0.03    0.46    0.025
plin     9    0.003    0.03    0.46    0.023
plun    45    0.142    0.63    7.73    0.564
pogm     9    0.014    0.15    0.46    0.022
ptic     9    0.014    0.15    0.46    0.043
rhgl    54    0.362    2.30    8.18    0.683
rhlo    90    6.130   16.63   40.91    4.910
rhtr    18    0.092    0.98    2.73    0.296
rhyt    63    2.123   14.25   20.46    2.128
scab    81    1.076    2.72   26.36    2.286
stor   100   20.375   77.28   77.73   14.259
tame    45    0.467    3.30    3.73    0.405

bare rock
rock    54    1.985    7.13    9.54    0.000


totals:
          m.cov max.cov  t.spp  m.spp

shrubs    39.62    73.8    15    5.7
herbs     25.71    84.0    41   14.3
bryo.     59.44    95.4    26   10.8
all spp. 124.80   226.6    82   30.8
```

Note : Pelt = *Peltigera membranacea* (19, 39)
             and *P. polydactyla* (123, 166)

Appendix 3 : <u>Tsuga</u>-<u>Pseudotsuga</u>-<u>Polystichum</u> forests (P5)

plots: 1 17 27 59 98 101 104 117 124 125 133 135 140 141 142 163 167

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
acgl	5	0.184	3.13	0.29	0.069
amal	5	0.001	0.01	0.06	0.004
bene	58	2.843	13.52	10.47	2.136
gash	35	0.144	0.90	1.59	0.194
mefe	5	0.009	0.15	0.29	0.018
opho	5	0.001	0.01	0.06	0.006
ribb	5	0.001	0.01	0.06	0.004
ribl	11	0.097	0.90	0.88	0.101
rogy	11	0.133	2.25	0.94	0.086
rupa	17	0.010	0.15	0.41	0.025
rusp	41	0.019	0.20	3.41	0.319
ruur	35	0.356	1.80	5.35	0.440
samr	5	0.001	0.01	0.06	0.004
vaal	64	1.054	7.78	6.06	0.775
vaol	23	0.414	5.13	1.00	0.189
vaot	11	0.221	1.88	0.59	0.209
vapa	100	6.550	21.05	38.29	6.154
herbs					
actr	100	2.631	14.75	26.53	3.015
adbi	17	0.046	0.75	0.65	0.058
adpe	35	0.806	9.93	3.65	0.491
aruy	5	0.001	0.01	0.06	0.003
astr	5	0.009	0.15	0.29	0.018
atfi	29	0.778	9.02	2.77	0.409
blsp	52	3.499	19.65	12.65	2.599
bovi	5	0.001	0.01	0.06	0.003
brov	5	0.001	0.01	0.06	0.004
chme	17	0.004	0.03	0.65	0.045
chum	5	0.009	0.15	0.29	0.019
clun	5	0.002	0.03	0.29	0.015
come	11	0.001	0.01	0.12	0.011
corn	5	0.062	1.05	0.88	0.076
dice	5	0.001	0.01	0.06	0.008
diho	35	0.651	9.15	6.53	0.661
dism	5	0.001	0.01	0.06	0.005
drau	29	0.209	2.78	1.35	0.152
fesu	35	0.076	0.75	2.18	0.281
gali	29	0.041	0.30	2.18	0.180
gaov	5	0.001	0.01	0.06	0.004
goob	35	0.017	0.20	1.65	0.130
hemi	5	0.001	0.01	0.06	0.003
hypo	11	0.006	0.08	1.18	0.158
lamu	47	0.768	7.75	9.24	1.158
libo	29	1.716	18.70	11.47	1.299
lica	5	0.001	0.01	0.06	0.005
lico	17	0.008	0.10	1.53	0.096
luzp	5	0.002	0.03	0.29	0.018
madi	17	0.028	0.45	1.00	0.062
mecu	5	0.001	0.01	0.06	0.004
mono	23	0.006	0.05	1.00	0.117
mopa	17	0.003	0.03	0.41	0.025
mosi	11	0.009	0.15	0.35	0.039
poly	35	0.155	2.30	3.41	0.262

```
pomu    100    28.688    59.03    65.59    20.375
ptaq     23     0.411     3.70     2.41     0.446
pyap      5     0.001     0.01     0.06     0.009
pyse      5     0.001     0.01     0.06     0.004
runi      5     0.316     5.38     1.18     0.180
sewa      5     0.001     0.01     0.06     0.004
smra     11     0.092     1.55     1.23     0.093
smst     11     0.055     0.90     0.88     0.061
stac      5     0.111     1.88     0.29     0.115
sten      5     0.001     0.01     0.06     0.004
stra      5     0.128     2.17     0.88     0.081
strr      5     0.001     0.01     0.06     0.003
tila     41     0.384     6.13     5.77     0.501
titr     88     1.789    17.60    21.94     2.056
trau      5     0.001     0.01     0.06     0.004
trla     17     0.054     0.75     0.65     0.092
trov     76     0.365     1.70    11.76     0.986
vigl      5     0.001     0.01     0.06     0.003
vise     17     0.126     1.98     2.12     0.171

bryophytes and lichens
bazz      5     0.044     0.75     0.29     0.031
blet      5     0.006     0.10     1.18     0.091
ceph     17     0.143     1.23     2.65     0.278
cloa     11     0.156     2.03     2.06     0.286
dicf     58     0.193     1.05    13.82     1.250
hete     52     1.214     4.97    17.35     1.748
holu     23     0.033     0.45     2.06     0.161
hylo     76     2.524    16.75    14.88     2.248
hypu     94     2.611     5.97    31.47     4.439
isop     76     0.468     1.13    12.65     1.381
isst     94     5.178    13.50    47.94     7.014
ledo     17     0.125     0.93     3.23     0.258
leme     11     0.019     0.18     0.88     0.052
mniu     29     0.242     1.90     6.47     0.522
pelt     23     0.065     0.75     1.47     0.154
plag     17     0.037     0.55     2.94     0.173
plin     17     0.168     2.65     1.77     0.144
plun     70     2.125    12.45    23.23     3.249
pogm     29     0.038     0.30     1.53     0.132
rhah      5     0.012     0.20     0.88     0.083
rhgl     64     0.541     2.00    17.35     1.714
rhlo     76     3.804    31.77    22.94     3.218
rhtr      5     0.002     0.03     0.29     0.016
rhyt     17     0.145     1.50     2.06     0.162
scab     94     2.409     8.70    42.65     4.738
stor     94    12.915    50.15    62.35    12.459
tame      5     0.001     0.01     0.06     0.005

bare rock
rock     88     9.604    41.50    29.41     0.000


totals:
              m.cov max.cov  t.spp  m.spp

    shrubs    12.02    34.7    17     4.5
    herbs     44.07   113.9    54    11.7
    bryo.     35.21    80.2    27    11.0
    all spp.  91.31   177.5    98    27.2
```

Note : Pelt = <u>Peltigera</u> <u>polydactyla</u> (98, 124, 142)
and <u>P.</u> <u>membranacea</u> (133)

Appendix 3 : Montane <u>Tsuga</u> forests (P6)

plots: 21 33 64 66 95 96 103 119 120 128 130 139

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
amal	16	0.002	0.01	0.17	0.011
bene	58	5.957	44.28	15.50	3.129
gash	66	4.535	20.67	15.50	3.723
rham	8	0.001	0.01	0.08	0.005
rogy	16	0.067	0.80	1.33	0.128
rusp	16	0.013	0.10	2.50	0.215
ruur	16	0.265	3.17	4.25	0.353
syal	8	0.013	0.15	0.42	0.034
vaal	50	4.922	25.00	16.67	2.829
vame	8	0.013	0.15	0.42	0.034
vaol	8	0.157	1.88	0.42	0.068
vapa	100	19.954	64.38	64.58	12.590
herbs					
actr	75	4.138	13.48	27.08	3.402
adpe	8	0.001	0.01	0.08	0.005
alvi	16	0.002	0.01	0.17	0.011
anly	8	0.001	0.01	0.08	0.006
apan	8	0.001	0.01	0.08	0.006
atfi	8	0.001	0.01	0.08	0.005
blsp	58	2.247	21.17	7.58	1.323
camp	16	0.013	0.15	0.50	0.035
chme	50	0.163	1.33	9.42	0.646
chum	41	0.083	0.45	3.92	0.308
coma	8	0.003	0.03	0.42	0.024
come	50	0.022	0.15	1.92	0.144
corn	8	0.001	0.01	0.08	0.006
diho	8	0.001	0.01	0.08	0.007
feoc	8	0.001	0.01	0.08	0.005
fesu	16	0.002	0.01	0.17	0.011
goob	33	0.091	0.60	7.50	0.507
heco	16	0.003	0.03	0.50	0.033
hial	16	0.003	0.03	0.50	0.030
hypo	33	0.007	0.03	1.00	0.082
lamu	25	0.003	0.01	0.25	0.019
libo	33	0.994	5.43	6.67	0.941
lica	25	0.010	0.08	1.75	0.111
lico	50	0.049	0.20	5.42	0.427
lycl	16	0.438	4.50	1.67	0.283
madi	8	0.001	0.01	0.08	0.005
mone	16	0.110	1.27	3.75	0.375
mono	8	0.001	0.01	0.08	0.005
poly	25	0.003	0.01	0.25	0.020
pomu	75	3.248	10.75	10.92	1.847
ptaq	8	0.001	0.01	0.08	0.006
ptea	8	0.013	0.15	0.42	0.035
pypi	16	0.002	0.01	0.17	0.013
pyse	8	0.001	0.01	0.08	0.008
smra	8	0.003	0.03	0.42	0.027
stra	16	0.002	0.01	0.17	0.010
strr	8	0.001	0.01	0.08	0.005
tila	41	0.362	2.47	4.75	0.398
titr	33	0.940	6.15	8.33	0.813
trla	33	0.017	0.15	1.00	0.075

```
      trov    58    0.129    0.82    9.17    0.671
      vise    25    0.132    1.52    5.92    0.398

bryophytes and lichens
      ceph    16    0.253    1.95    3.75    0.308
      clea     8    0.003    0.03    0.42    0.031
      cloa    16    0.346    3.10    5.42    0.528
      dicf    58    1.022    4.82   28.75    2.667
      dipa     8    0.175    2.10    2.50    0.251
      heba     8    0.125    1.50    0.83    0.112
      hete    33    0.079    0.30    3.33    0.268
      holu    16    0.097    1.13    2.92    0.198
      hylo    91   14.379   41.88   51.67   10.083
      hypu   100    2.938    5.95   45.83    5.084
      isop    58    0.531    3.97   11.67    1.145
      isst    83    4.198   17.73   33.75    5.178
      ledo     8    0.027    0.32    1.25    0.128
      leme     8    0.003    0.03    0.42    0.026
      loba     8    0.003    0.03    0.42    0.031
      metz     8    0.025    0.30    0.83    0.058
      mniu    25    0.145    0.77    8.33    0.631
      pelo     8    0.001    0.01    0.08    0.007
      pelt    66    0.377    1.50   13.75    1.170
      plag    16    0.005    0.03    0.83    0.050
      plun    50    2.384   17.08   24.17    2.469
      pogm    50    0.198    1.88    2.17    0.293
      rhah    16    0.108    1.27    3.33    0.283
      rhgl    41    0.328    1.70    8.75    0.663
      rhlo    83    3.790   10.35   30.00    4.145
      rhyt    66    8.608   30.88   40.00    7.028
      scab   100    4.400   13.27   62.92    6.454
      stor    91    9.594   36.17   42.92    6.503
      tame    50    1.319    7.03    8.92    1.188

bare rock
      rock    75    8.068   37.15   27.92    0.000
```

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	35.90	101.1	12	3.8
herbs	13.23	47.8	42	10.4
bryo.	55.44	95.2	29	12.0
all spp.	104.57	180.1	83	26.2

Note : Pelo = Peltigera aphtosa (33)

Pelt = P. polydactyla (33, 64, 66, 103, 130, 139)
and P. membranacea (96, 128)

Loba = Lobaria oregana (21)

Appendix 3 : Montane Tsuga-Gaultheria forests (P7)

plots: 32 38 40 62 65 67 115

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
bene	57	3.966	22.55	13.57	2.031
gash	100	74.924	95.63	98.57	30.344
mefe	14	0.021	0.15	0.71	0.040
rogy	14	1.181	8.27	2.86	0.427
ruur	28	0.954	4.88	6.43	0.946
vaal	14	8.429	59.00	14.29	2.357
vaol	14	1.929	13.50	8.57	0.810
vaot	14	3.607	25.25	6.43	1.410
vapa	100	6.781	15.88	38.57	4.953
herbs					
actr	42	0.013	0.05	2.29	0.221
alvi	14	0.001	0.01	0.14	0.009
blsp	28	0.003	0.01	0.29	0.016
boho	42	0.034	0.20	3.00	0.219
chum	42	0.544	2.28	8.00	0.559
coma	14	0.001	0.01	0.14	0.007
come	28	0.006	0.03	0.86	0.091
corn	14	0.197	1.38	7.14	0.401
feoc	14	0.257	1.80	2.86	0.220
fesu	28	0.740	5.03	5.00	0.464
gaov	14	0.393	2.75	5.71	0.367
goob	42	0.010	0.03	1.57	0.090
hial	14	0.007	0.05	1.43	0.083
hypo	14	0.001	0.01	0.14	0.009
lamu	14	0.021	0.15	0.71	0.046
libo	28	3.080	17.98	25.00	2.394
lica	28	0.006	0.03	0.86	0.049
lico	85	0.316	0.80	34.29	2.703
poly	14	0.004	0.03	0.71	0.057
pomu	57	0.489	2.65	3.14	0.313
ptaq	14	0.107	0.75	0.71	0.130
ptea	14	0.001	0.01	0.14	0.009
pypi	28	0.026	0.15	1.43	0.106
rupe	14	0.447	3.13	0.71	0.123
trla	28	0.270	1.88	0.86	0.111
bryophytes and lichens					
bazz	14	0.021	0.15	0.71	0.059
clar	14	0.021	0.15	0.71	0.040
cldb	14	0.001	0.01	0.14	0.007
clds	14	0.004	0.03	0.71	0.041
dicf	100	1.944	3.70	50.00	4.539
hylo	100	34.777	69.03	74.43	13.331
hypu	85	1.333	2.85	25.00	2.663
isst	42	0.179	0.77	4.29	0.347
ledo	14	0.021	0.15	0.71	0.059
pelo	28	0.026	0.15	1.43	0.083
pelt	28	0.153	0.77	2.86	0.274
plun	57	0.379	1.67	6.43	0.626
plzs	14	0.983	6.88	2.14	0.299
pogm	28	0.171	0.75	2.86	0.219
rhgl	14	0.021	0.15	0.71	0.059
rhlo	85	14.584	30.55	55.71	7.477

```
rhtr    28    0.890     6.20     5.00     0.499
rhyt    71    5.139    12.35    52.14     5.051
scab    85    1.711     4.60    35.71     3.197
stor    71    9.621    32.95    51.43     6.989
tame    71    0.933     3.75    15.00     1.101

bare rock
rock    28    1.850     7.20     7.86     0.000


totals:
            m.cov max.cov  t.spp  m.spp

    shrubs  101.81  119.8      9    3.6
    herbs     6.99   18.9     25    6.9
    bryo.    72.93  126.4     21    9.9
    all spp. 181.67 258.8     55   20.3
```

Note :   Pelt = Peltigera membranacea (65)
                and P. polydactyla (62)

Appendix 3 : Coastal dry _Thuja_ forests (T1)

plots: 94 149 159

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	100	64.543	70.25	100.00	20.507
mefe	100	2.537	4.82	15.33	1.507
rusp	33	0.010	0.03	1.67	0.093
vaal	66	0.253	0.75	2.00	0.173
vaot	100	50.200	78.75	76.67	15.730
vapa	100	7.160	11.35	55.00	4.843
herbs					
blsp	100	32.527	63.42	52.00	10.500
boho	66	0.007	0.01	0.67	0.043
corn	33	0.010	0.03	1.67	0.093
libo	66	0.927	2.63	5.00	0.473
lico	33	0.003	0.01	0.33	0.023
lyse	33	0.010	0.03	1.67	0.093
madi	33	0.483	1.45	15.00	0.923
bryophytes and lichens					
blet	33	0.033	0.10	6.67	0.377
calm	33	0.150	0.45	5.00	0.307
ceph	33	0.760	2.28	13.33	0.927
dicf	100	0.350	0.38	20.00	1.237
dipa	33	1.073	3.22	20.00	1.563
dipp	33	1.250	3.75	20.00	1.417
hete	66	0.200	0.45	6.67	0.427
holu	100	0.077	0.15	6.67	0.403
hylo	100	13.793	22.23	88.33	8.193
hypu	66	0.300	0.75	3.33	0.270
isop	33	0.010	0.03	1.67	0.113
isst	100	5.443	7.78	31.67	3.040
kurz	33	0.033	0.10	6.67	0.377
plag	33	0.010	0.03	1.67	0.093
plun	100	2.523	3.42	71.67	4.863
rhgl	100	0.353	0.70	20.00	1.223
rhlo	100	19.797	30.17	81.67	9.187
scab	33	1.657	4.97	23.33	1.630
sphg	66	1.717	4.40	5.00	0.663
stor	100	12.870	20.40	93.33	8.333
bare rock					
rock	33	0.877	2.63	3.33	0.000

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	124.70	160.8	6	5.0
herbs	33.97	63.6	7	3.7
bryo.	62.40	85.6	20	13.0
all spp.	221.07	230.7	33	21.7

Appendix 3 : Coastal <u>Tsuga-Blechnum-Polystichum</u> forests (T2)

plots: 69 74 88 93 105 155

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	83	9.522	44.30	21.67	5.505
mefe	33	0.210	1.25	5.17	0.482
rusp	83	0.328	1.65	12.67	1.047
vaal	83	5.003	17.13	14.33	3.355
vaol	66	0.403	⁻1.50	3.67	0.455
vaot	16	0.025	0.15	0.83	0.062
vapa	100	13.395	25.27	61.67	10.970
herbs					
atfi	33	0.003	0.01	0.33	0.025
blsp	100	46.347	74.50	83.33	26.553
drau	50	0.032	0.15	1.83	0.140
lica	33	0.010	0.03	1.67	0.122
lico	16	0.005	0.03	0.83	0.060
luzp	16	0.002	0.01	0.17	0.012
mone	16	0.002	0.01	0.17	0.013
poly	16	0.002	0.01	0.17	0.017
pomu	100	12.163	35.88	29.17	6.878
stra	33	0.003	0.01	0.33	0.025
tila	66	0.392	2.13	8.50	0.827
titr	66	0.363	0.75	10.83	0.935
trov	50	0.060	0.20	3.50	0.355
vise	16	0.283	1.70	4.17	0.457
bryophytes and lichens					
blet	16	0.013	0.08	2.50	0.250
calm	50	0.265	1.23	7.50	0.733
ceph	66	2.213	6.85	26.67	2.873
dicf	16	0.025	0.15	0.83	0.082
hete	33	0.205	1.05	4.17	0.367
holu	66	0.272	0.93	13.33	1.115
hylo	16	0.053	0.32	2.50	0.203
hypu	83	0.785	3.30	10.83	1.252
isop	100	1.363	1.88	20.00	2.262
isst	83	3.478	12.82	29.17	4.308
ledo	16	0.800	4.80	10.00	1.197
myta	16	0.125	0.75	4.17	0.310
peli	33	0.103	0.47	4.17	0.335
plag	33	0.147	0.85	5.00	0.377
plun	83	5.607	13.23	65.00	7.580
pogc	33	0.055	0.30	2.50	0.197
pogm	16	0.005	0.03	0.83	0.082
rhgl	100	2.208	5.57	37.50	3.862
rhlo	83	0.932	2.03	10.83	1.225
ricl	16	0.125	0.75	0.83	0.148
scab	100	4.908	8.05	71.67	7.790
stor	100	3.535	8.55	36.83	4.330
bare rock					
rock	66	1.255	5.13	5.00	0.000

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	28.88	76.1	7	4.7
herbs	59.67	96.0	14	6.2
bryo.	27.22	41.4	22	11.7
all spp.	115.75	139.6	43	22.5

Appendix 3 : Coastal montane _Thuja_ forests (T3)

plots: 60 70 147 152 153 154 172

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	100	45.101	74.38	80.00	15.684
mefe	85	4.109	13.77	19.43	1.930
rusp	57	0.011	0.03	1.71	0.083
sosi	14	0.001	0.01	0.14	0.006
vaal	100	14.906	35.38	39.29	5.390
vaol	71	2.479	14.40	7.43	0.993
vapa	100	13.599	20.63	64.29	7.214
herbs					
blsp	100	47.724	67.90	83.57	17.346
boye	28	0.003	0.01	0.29	0.016
coas	57	2.987	8.35	24.43	2.091
come	14	0.001	0.01	0.14	0.009
corn	71	2.086	7.50	23.57	1.699
fesu	14	0.004	0.03	0.71	0.044
goob	28	0.164	1.00	5.00	0.259
libo	42	1.307	7.63	7.86	0.813
lica	71	0.034	0.10	6.43	0.379
lico	85	0.063	0.22	12.29	0.686
lycl	14	0.107	0.75	0.71	0.057
lysi	42	1.197	6.32	6.57	0.759
madi	71	1.804	5.60	29.43	1.873
mone	14	0.001	0.01	0.14	0.009
pomu	42	0.717	5.00	1.71	0.337
pral	14	0.107	0.75	0.71	0.071
rupe	57	2.747	11.95	21.57	1.634
stra	85	0.347	1.50	3.29	0.253
tila	85	1.143	7.30	15.29	1.333
titr	85	0.764	3.80	13.14	0.997
trov	42	0.024	0.15	1.00	0.053
vevi	28	0.066	0.45	2.29	0.113
vigl	14	0.001	0.01	0.14	0.009
vise	14	2.411	16.88	9.29	1.531
bryophytes and lichens					
bazz	28	0.376	1.88	1.43	0.153
ceph	71	2.351	6.38	33.57	2.193
dicf	42	0.133	0.75	2.14	0.147
dipa	14	0.129	0.90	1.43	0.119
holu	100	0.543	0.85	33.57	1.797
hylo	85	3.686	14.52	34.29	2.469
hypu	85	0.326	1.05	5.71	0.404
hypv	14	0.021	0.15	0.71	0.040
isop	57	0.171	0.75	5.71	0.379
isst	100	2.646	9.13	21.43	2.004
jule	14	0.190	1.33	9.29	0.414
metz	14	0.004	0.03	0.71	0.044
myta	14	0.150	1.05	2.14	0.139
nasc	14	0.026	0.18	1.43	0.063
peli	57	0.181	0.93	4.43	0.259
plag	42	0.057	0.20	4.29	0.247
plun	100	4.159	7.20	83.57	5.509
pogc	14	0.043	0.30	1.43	0.067
rhaa	14	0.004	0.03	0.71	0.043

```
rhgl     100     3.970    10.25    47.86     3.306
rhlo     100    10.630    23.20    58.57     5.640
ricl      28     0.257     1.50     9.29     0.459
scab     100     5.794    17.83    65.00     4.947
sphg      28     0.027     0.18     1.57     0.073
stor     100     6.170    14.77    52.86     4.466

bare rock
rock      28     1.404     5.40     7.86     0.000
```

```
totals:
             m.cov max.cov  t.spp   m.spp

   shrubs    80.20   116.8     7     5.3
   herbs     65.81   101.7    24    11.3
   bryo.     42.04    77.4    25    13.4
   all spp. 188.04   247.0    56    30.0
```

Appendix 3 : Coastal <u>Thuja</u> forests (T4)

plots: 5 22 24 42 43 49 50 52 54. 55 57 72 73 76 84 86 100 146 150

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	100	56.675	84.63	83.42	18.895
mefe	94	1.776	7.18	13.58	1.279
pyus	5	0.231	4.38	0.26	0.059
rham	10	0.166	3.15	0.58	0.061
rogy	5	0.001	0.01	0.05	0.003
rusp	78	1.663	7.95	12.79	1.101
vaal	100	11.143	22.27	25.00	4.400
vaol	57	0.886	3.90	3.05	0.375
vaot	57	1.111	17.75	3.47	0.428
vapa	100	13.446	24.90	53.68	6.842
herbs					
actr	5	0.016	0.30	0.53	0.036
atfi	10	0.099	1.88	0.32	0.048
blsp	100	60.881	89.38	90.79	22.002
boho	5	0.008	0.15	0.26	0.015
caro	10	0.431	4.65	2.10	0.182
coas	5	0.016	0.30	0.53	0.027
corn	36	0.183	1.80	3.05	0.199
eqte	5	0.001	0.01	0.05	0.003
gali	5	0.001	0.01	0.05	0.003
goob	15	0.004	0.03	0.58	0.034
libo	10	0.001	0.01	0.10	0.005
lica	5	0.001	0.01	0.05	0.004
lico	47	0.021	0.13	3.79	0.206
lycl	5	0.039	0.75	0.26	0.025
lysi	10	2.335	29.92	7.10	0.798
madi	57	0.237	3.67	4.42	0.374
miov	5	0.001	0.01	0.05	0.003
poly	10	0.009	0.15	0.53	0.034
pomu	26	0.449	4.63	1.42	0.221
stra	10	0.002	0.03	0.32	0.014
tila	21	0.188	2.03	5.05	0.299
titr	26	0.260	3.17	5.58	0.374
trov	36	0.008	0.05	1.26	0.095
vevi	5	0.001	0.01	0.05	0.003
bryophytes and lichens					
anti	5	0.008	0.15	0.26	0.018
bazz	47	0.332	1.80	5.84	0.489
blet	21	0.056	0.65	7.10	0.396
calf	5	0.025	0.47	1.05	0.058
calm	26	0.263	2.30	11.84	0.723
ceph	57	2.494	8.88	26.84	2.411
coco	5	0.001	0.01	0.05	0.003
dicf	36	0.081	0.50	4.47	0.312
dicm	5	0.047	0.90	0.53	0.034
dipa	26	0.538	4.47	7.37	0.512
dipp	10	0.166	2.85	2.37	0.142
heba	15	0.055	0.75	0.79	0.056
holu	84	0.338	2.13	20.53	1.274
hylo	100	7.367	30.20	47.37	4.307
hypu	26	0.114	0.93	2.10	0.204
isop	10	0.039	0.60	1.32	0.102

isst	89	1.412	4.28	15.26	1.403
jule	5	0.026	0.50	1.32	0.070
kurz	10	0.205	3.30	2.63	0.285
ledo	5	0.168	3.20	3.95	0.237
leme	10	0.048	0.77	0.79	0.047
myta	5	0.002	0.03	0.25	0.014
nasc	5	0.001	0.01	0.05	0.003
peli	15	0.445	8.05	3.16	0.235
plag	63	0.415	3.65	11.84	0.812
plun	100	4.122	9.63	78.68	6.202
pogm	5	0.001	0.01	0.05	0.004
pore	5	0.002	0.03	0.26	0.013
rhgl	94	5.348	32.00	51.58	4.340
rhlo	94	5.935	25.90	42.37	3.887
ricl	42	0.834	8.57	10.05	0.677
scab	78	3.184	11.00	41.05	3.797
sphf	5	0.288	5.47	1.58	0.126
sphg	10	0.040	0.75	0.32	0.027
sphh	5	0.016	0.30	0.53	0.027
stor	100	12.654	26.58	80.79	8.307

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	87.09	124.6	10	6.1
herbs	65.19	91.4	24	4.8
bryo.	47.07	92.9	36	12.4
all spp.	199.33	269.3	70	23.3

Appendix 3 : Coastal wet <u>Thuja</u> forests (T5)

plots: 47 48 77 148

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	100	75.290	80.63	98.75	17.402
mefe	100	5.165	7.28	23.75	1.960
pyus	100	7.660	13.13	14.00	1.938
rham	25	0.783	3.13	1.25	0.182
rusp	75	1.615	5.43	22.50	1.295
vaal	100	5.663	8.52	17.50	1.745
vaol	25	0.225	0.90	2.50	0.165
vaot	100	33.693	50.67	65.00	8.590
vapa	100	13.230	19.33	70.00	5.410
herbs					
blsp	100	64.910	78.75	96.25	15.515
boho	50	0.015	0.05	2.75	0.118
caia	50	0.970	3.13	2.50	0.270
caro	75	5.255	14.38	11.50	1.432
carr	25	0.658	2.63	2.50	0.217
corn	100	9.080	10.95	51.25	3.840
eqte	25	0.038	0.15	1.25	0.067
libo	100	5.430	12.18	46.25	2.900
lico	25	0.008	0.03	1.25	0.052
lysi	25	0.188	0.75	1.25	0.095
madi	100	1.948	3.13	47.50	2.367
stra	25	0.038	0.15	1.25	0.067
vevi	50	0.005	0.01	0.50	0.023
bryophytes and lichens					
bazz	25	0.013	0.05	2.50	0.125
blet	50	0.920	3.63	18.75	0.962
ceph	75	2.045	5.63	28.75	1.608
dicf	25	0.055	0.22	5.00	0.220
dics	75	0.158	0.30	6.25	0.308
dipa	75	0.933	2.05	31.25	1.480
dipp	50	0.645	2.13	12.50	0.702
heba	75	0.863	3.00	8.75	0.515
holu	100	0.425	0.90	17.50	0.848
hylo	100	7.750	11.35	81.25	4.883
hypu	25	0.038	0.15	2.50	0.115
myta	50	0.195	0.63	7.50	0.347
plag	75	0.445	1.55	15.00	0.723
plun	100	3.635	6.57	87.50	4.475
rhgl	100	1.410	4.57	32.50	1.645
rhlo	100	11.880	14.43	80.00	5.530
ricm	25	0.563	2.25	3.75	0.287
scab	25	2.138	8.55	21.25	1.247
sphg	75	3.272	12.88	11.50	1.035
sphh	25	0.003	0.01	0.25	0.013
stor	75	17.143	36.25	62.50	5.540
stpr	25	3.095	12.38	23.75	1.735

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	143.30	152.5	9	7.3
herbs	88.55	102.9	13	7.5
bryo.	57.63	81.5	22	13.5
all spp.	289.42	300.3	44	28.3

Appendix 3 : Montane <u>Tsuga-Abies-Gaultheria</u> forests (A1)

plots: 3 78 164

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
bene	33	0.500	1.50	3.33	0.370
gash	100	33.983	41.78	68.33	17.427
mefe	66	0.007	0.01	0.67	0.060
sosi	66	0.007	0.01	0.67	0.053
vaal	100	41.077	71.63	81.67	19.493
vaol	66	1.180	3.53	7.00	1.000
vapa	100	27.503	49.63	83.33	16.823
herbs					
actr	33	0.003	0.01	0.33	0.030
blsp	33	0.877	2.63	3.33	0.720
chum	33	0.907	2.72	11.67	1.080
coma	33	0.010	0.03	1.67	0.123
corn	33	0.860	2.58	10.00	1.157
gaov	33	0.310	0.93	5.00	0.440
hypo	33	0.003	0.01	0.33	0.030
libo	33	0.227	0.68	11.67	0.900
lico	66	0.037	0.08	6.67	0.517
madi	33	0.010	0.03	1.67	0.150
pomu	33	0.003	0.01	0.33	0.030
pyse	33	0.003	0.01	0.33	0.023
strr	33	0.003	0.01	0.33	0.030
trov	33	0.003	0.01	0.33	0.030
bryophytes and lichens					
dicf	100	1.360	3.50	43.33	3.843
hylo	100	3.343	6.63	23.33	2.820
hypu	66	2.007	4.07	35.00	3.963
isst	66	2.500	7.03	23.33	3.243
ledo	33	0.517	1.55	13.33	1.330
plun	33	0.527	1.58	8.33	0.993
rhlo	100	17.427	36.80	58.33	9.737
rhyt	66	3.203	9.43	31.67	3.173
scab	100	3.090	5.32	56.67	6.003
stor	66	5.427	16.20	20.00	4.390

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	104.27	128.8	7	5.3
herbs	3.23	4.4	14	5.0
bryo.	39.37	57.5	10	7.3
all spp.	146.90	190.8	31	17.7

Appendix 3 : Montane <u>Abies</u>-<u>Tsuga</u> forests (A2)

plots: 79 81

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	50	1.940	3.88	5.00	0.835
mefe	50	0.005	0.01	0.50	0.030
rusp	50	0.075	0.15	2.50	0.170
vaal	100	43.315	56.53	77.50	28.630
vaol	50	0.940	1.88	2.50	0.410
vapa	100	14.475	21.60	62.50	11.670
herbs					
actr	50	4.160	8.32	22.50	2.490
adbi	50	0.025	0.05	5.00	0.300
atfi	50	0.450	0.90	5.00	0.420
blsp	100	16.030	32.05	40.50	6.910
corn	50	0.005	0.01	0.50	0.030
gali	50	0.015	0.03	2.50	0.150
goob	50	0.005	0.01	0.50	0.030
lica	100	0.195	0.38	25.50	1.585
lico	50	0.125	0.25	12.50	0.770
luzp	50	0.005	0.01	0.50	0.030
madi	50	0.015	0.03	2.50	0.150
poam	50	0.075	0.15	2.50	0.170
pomu	50	4.500	9.00	10.00	1.850
rupe	50	0.600	1.20	10.00	0.755
stra	50	0.005	0.01	0.50	0.030
strr	50	0.375	0.75	2.50	0.250
tila	50	0.150	0.30	5.00	0.335
titr	50	2.775	5.55	15.00	1.660
trov	50	1.200	2.40	17.50	1.365
vise	50	0.015	0.03	2.50	0.150
bryophytes and lichens					
dicf	100	1.035	1.75	47.50	6.140
holu	50	0.450	0.90	5.00	0.420
hylo	50	0.075	0.15	2.50	0.170
hypu	100	3.490	5.63	52.50	8.380
isop	50	0.525	1.05	7.50	0.590
isst	100	0.855	1.70	13.00	1.040
ledo	50	0.525	1.05	7.50	0.590
plun	100	3.810	7.47	27.50	2.885
pogc	50	0.075	0.15	2.50	0.170
rhgl	50	0.690	1.38	15.00	1.075
rhlo	100	5.550	11.02	27.50	3.665
rhyt	100	3.345	6.68	15.50	4.945
scab	100	4.030	5.93	70.00	8.425
stor	50	0.150	0.30	5.00	0.335

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	60.75	84.0	6	4.0
herbs	30.70	61.4	20	11.0
bryo.	24.60	32.8	14	10.5
all spp.	116.05	178.2	40	25.5

Appendix 3 : Montane <u>Tsuga-Abies</u> forests (A3)

plots: 36 44 75 106

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	50	0.005	0.01	0.50	0.048
mefe	25	0.003	0.01	0.25	0.033
rusp	100	1.645	6.25	12.50	2.668
vaal	100	2.123	5.55	12.75	2.405
vapa	100	21.640	55.42	63.75	20.133
herbs					
actr	25	0.475	1.90	10.00	1.283
blsp	75	11.115	20.88	33.75	11.478
chum	25	0.003	0.01	0.25	0.025
diho	25	0.380	1.52	3.75	0.650
drau	25	0.003	0.01	0.25	0.025
goob	25	0.003	0.01	0.25	0.025
hypo	50	0.010	0.03	1.50	0.130
lamu	25	0.188	0.75	1.25	0.268
lica	50	0.015	0.05	2.75	0.255
madi	25	0.003	0.01	0.25	0.025
poly	25	0.008	0.03	1.25	0.115
pomu	100	1.863	4.63	9.00	2.583
stra	75	0.008	0.01	0.75	0.083
tila	50	0.005	0.01	0.50	0.058
titr	25	0.008	0.03	1.25	0.115
trov	75	0.080	0.30	3.00	0.343
bryophytes and lichens					
anti	25	0.237	0.95	10.00	1.085
blet	25	0.050	0.20	3.75	0.332
ceph	50	2.445	8.40	18.75	3.005
dicf	50	0.180	0.47	23.75	2.100
dipa	50	1.592	3.97	26.25	4.238
hete	25	1.875	7.50	2.50	1.780
holu	75	0.048	0.15	2.75	0.325
hylo	25	1.133	4.53	13.75	1.885
hypu	75	2.375	7.85	31.25	4.813
isop	100	1.953	4.28	28.75	4.355
isst	75	2.390	4.13	31.25	4.302
ledo	75	0.487	1.05	6.25	0.955
loba	25	0.038	0.15	1.25	0.143
mniu	25	0.038	0.15	1.25	0.143
pelt	25	0.008	0.03	1.25	0.115
plun	100	5.130	6.78	66.25	9.823
pogc	25	0.013	0.05	2.50	0.313
pogm	25	0.038	0.15	1.25	0.135
rhaa	25	0.038	0.15	1.25	0.143
rhgl	75	4.260	13.13	32.50	5.755
rhlo	50	2.640	10.55	10.25	2.418
scab	75	5.895	9.77	53.75	8.255
stor	25	0.003	0.01	0.25	0.025
bare rock					
rock	50	0.732	1.88	5.00	0.000

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	25.40	61.1	5	3.8
herbs	14.15	21.3	16	7.0
bryo.	32.83	56.3	23	11.3
all spp.	72.43	89.4	44	22.0

Appendix 3 : Montane _Abies-Streptopus_ forests (A4)

plots: 25 26 80 82

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
opho	75	0.848	1.88	4.00	0.557
rusp	25	0.003	0.01	0.25	0.020
vaal	100	31.370	67.88	66.25	15.608
vaol	25	0.188	0.75	1.25	0.110
vapa	100	4.057	6.38	41.25	4.765
herbs					
actr	100	4.273	8.27	14.00	2.180
adpe	50	0.545	2.03	3.75	0.350
atfi	75	2.598	7.25	7.75	1.177
blsp	100	6.680	14.00	26.50	3.538
chme	25	0.020	0.08	3.75	0.397
clun	50	0.960	3.83	7.75	1.720
come	25	0.003	0.01	0.25	0.013
corn	50	0.010	0.03	1.50	0.115
drau	50	1.350	3.00	10.00	1.030
gydr	75	1.355	2.78	6.50	0.808
hypo	25	0.003	0.01	0.25	0.028
lica	75	0.047	0.15	2.75	0.178
lyse	25	0.003	0.01	0.25	0.013
madi	50	1.545	3.38	8.75	1.005
mone	25	0.008	0.03	1.25	0.103
pomu	75	1.980	5.28	6.50	1.080
rupe	75	31.078	59.38	63.75	13.493
strr	100	5.495	12.88	31.25	3.635
strs	100	8.542	18.77	51.25	5.895
tila	75	0.018	0.03	2.75	0.170
titr	75	3.038	10.32	18.75	1.880
tiun	25	0.080	0.32	3.75	0.213
trau	50	0.695	1.88	3.75	0.452
trov	100	0.052	0.18	3.25	0.205
vevi	25	0.003	0.01	0.25	0.020
bryophytes and lichens					
bazz	25	0.038	0.15	1.25	0.073
ceph	25	0.605	2.42	11.25	0.980
dicf	100	0.308	0.52	30.00	2.578
eurp	50	0.263	0.75	3.75	0.305
holu	50	0.245	0.95	6.25	0.400
hylo	25	0.188	0.75	1.25	0.153
hypu	100	3.418	6.25	48.75	5.938
isop	25	0.270	1.08	5.00	0.773
isst	100	0.788	2.03	10.00	1.018
mniv	25	0.008	0.03	1.25	0.065
peli	25	0.045	0.18	2.50	0.140
pelt	25	0.075	0.30	2.50	0.147
plag	50	0.175	0.45	10.00	0.628
plun	100	7.863	11.95	53.75	6.090
rhgl	75	1.075	1.95	20.00	1.615
rhlo	75	11.290	41.83	30.00	6.193
rhyt	100	1.057	4.20	14.50	2.478
scab	100	2.458	3.10	56.25	5.560
stor	25	0.003	0.01	0.25	0.020
bare rock					
rock	25	2.987	11.95	11.25	0.000

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	36.45	76.1	5	3.3
herbs	70.35	142.3	25	15.0
bryo.	30.15	60.2	19	11.0
all spp.	136.98	206.3	49	29.3

Note : Pelt = _Peltigera membranacea_ (25)

Appendix 3 : Lowland <u>Abies</u> forests (A5)

plots: 4 6 23 29 45 90 102 108 126 134 156 162

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	41	1.302	10.38	6.42	0.930
mefe	41	0.160	1.88	0.75	0.094
opho	16	0.002	0.01	0.17	0.012
ribb	8	0.001	0.01	0.08	0.004
rusp	91	1.373	4.38	14.58	1.339
samr	8	0.001	0.01	0.08	0.004
vaal	100	24.761	76.50	57.08	13.152
vaol	66	2.798	13.27	9.17	1.428
vapa	100	10.107	22.10	56.67	8.363
herbs					
actr	50	2.682	30.33	9.33	1.250
adbi	25	0.003	0.01	0.25	0.016
adpe	16	0.399	4.78	1.75	0.178
atfi	50	0.433	5.00	1.58	0.198
blsp	100	17.433	37.78	52.08	10.093
boye	16	0.063	0.75	0.50	0.045
chme	8	0.001	0.01	0.08	0.007
clun	16	0.002	0.01	0.17	0.009
coas	16	0.477	3.17	6.25	0.501
coma	8	0.003	0.03	0.42	0.030
corn	16	0.003	0.03	0.50	0.035
diho	8	0.001	0.01	0.08	0.005
drau	66	1.562	12.65	12.17	1.114
gali	25	0.031	0.35	1.83	0.093
gocb	8	0.004	0.05	0.83	0.060
gydr	25	0.027	0.30	1.00	0.069
heco	8	0.001	0.01	0.08	0.008
hypo	25	0.003	0.01	0.25	0.019
lamu	8	0.013	0.15	0.42	0.022
lica	16	0.007	0.05	1.25	0.086
luzp	8	0.001	0.01	0.08	0.004
madi	41	0.116	0.85	4.67	0.306
miov	8	0.001	0.01	0.08	0.005
mone	8	0.015	0.18	0.83	0.057
mosi	8	0.064	0.77	0.83	0.054
poam	8	0.001	0.01	0.08	0.005
pomu	83	3.157	12.30	13.17	1.919
pral	8	0.013	0.15	0.42	0.029
pyse	8	0.001	0.01	0.08	0.005
rupe	50	2.772	10.93	18.75	2.163
smst	8	0.013	0.15	0.42	0.029
stra	41	0.140	0.90	1.50	0.123
strr	25	0.191	1.23	3.42	0.253
strs	8	0.289	3.47	3.33	0.418
tila	50	0.136	0.98	6.08	0.365
titr	91	4.497	24.77	20.08	2.249
trau	33	0.138	0.90	3.00	0.202
trov	58	0.138	1.08	4.75	0.304
vevi	8	0.063	0.75	0.42	0.045
vigl	8	0.003	0.03	0.42	0.026
vise	8	0.013	0.15	0.42	0.026

```
bryophytes and lichens
   bazz   16   0.307    2.63    2.08    0.239
   blet   25   0.096    0.75    8.75    0.682
   calm   16   0.336    3.85    5.42    0.503
   ceph   83   2.693    7.13   32.08    3.453
   coco    8   0.001    0.01    0.08    0.005
   dicf   33   0.099    0.47    7.50    0.542
   dipa   16   0.672    7.13    7.92    0.933
   hete    8   0.003    0.03    0.42    0.035
   holu   75   0.707    3.45   15.83    1.214
   hylo   83   2.868    9.27   22.17    2.663
   hypp    8   0.015    0.18    0.83    0.042
   hypu   25   0.382    2.25    5.42    0.548
   isop   66   0.582    1.95    8.75    0.779
   isst   83   1.842    6.38   22.92    2.707
   ledo    8   0.025    0.30    0.83    0.074
   leme   25   0.014    0.15    0.58    0.035
   peli   25   0.353    3.90    2.50    0.246
   pelt   16   0.038    0.30    1.25    0.080
   plag   58   0.117    0.93    6.67    0.483
   plin    8   0.013    0.15    0.42    0.022
   plun  100   7.685   19.30   76.67    8.423
   pogc   33   0.090    0.77    1.75    0.137
   pogm    8   0.158    1.90    0.83    0.076
   ptic    8   0.063    0.75    0.42    0.067
   rhgl  100   6.700   15.10   60.00    6.698
   rhlo  100  16.952   44.20   64.58   10.271
   ricl   25   0.763    8.10    5.83    0.664
   scab   91   1.651    5.70   36.33    2.916
   sphg   33   1.662   19.88    5.92    0.780
   stor   75   7.140   20.65   40.42    6.358

bare rock
   rock   33   0.475    3.90    4.17    0.000


totals:
             m.cov max.cov  t.spp  m.spp

   shrubs    40.51   84.1     9     4.8
   herbs     34.90  103.7    41    10.9
   bryo.     54.01   76.5    30    12.7
   all spp. 129.40  214.1    80    28.3
```

Note : Pelt = <u>Peltigera</u> <u>membranacea</u> (29)
        and <u>P</u>. <u>polydactyla</u> (45)

Appendix 3 : Tsuga-Gaultheria-Blechnum forests (A6)

plots: 71 97

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	100	43.525	55.25	77.50	19.610
mefe	50	2.190	4.38	2.50	0.810
vaal	100	6.500	7.25	20.00	3.730
vapa	100	28.260	35.42	82.50	15.355
herbs					
actr	50	0.375	0.75	2.50	0.350
atfi	50	0.005	0.01	0.50	0.045
blsp	100	15.285	28.17	45.00	9.040
dism	50	0.005	0.01	0.50	0.045
lico	50	0.015	0.03	2.50	0.225
pomu	100	0.080	0.15	3.00	0.280
tila	50	0.075	0.15	2.50	0.245
titr	50	0.005	0.01	0.50	0.045
trau	50	0.375	0.75	2.50	0.350
trov	50	0.150	0.30	5.00	0.490
bryophytes and lichens					
bazz	50	0.375	0.75	2.50	0.350
holu	50	0.015.	0.03	2.50	0.180
hylo	50	6.840	13.68	30.00	5.020
hypu	100	0.165	0.18	7.50	0.670
isop	50	0.375	0.75	2.50	0.285
isst	100	1.930	2.78	17.50	2.015
ledo	50	3.000	6.00	30.00	3.010
plag	100	0.150	0.15	5.00	0.445
plun	100	10.725	11.85	82.50	9.815
ponf	50	0.075	0.15	2.50	0.245
rhgl	100	5.965	11.63	52.50	5.565
rhlo	100	1.200	1.50	10.00	1.185
scab	100	6.680	10.48	65.00	6.990
stor	100	23.825	26.27	77.50	13.595

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	80.50	100.8	4	3.5
herbs	16.35	30.3	10	6.0
bryo.	61.30	69.3	14	11.0
all spp.	158.15	172.5	28	20.5

Appendix 3 : <u>Tsuga-Blechnum-Polystichum</u> forests (A7)

plots: 56 87 91 99 107

	cons.	m.cov	max.cov	m.fre.	m.i.v
shrubs					
gash	40	0.490	2.25	6.00	0.834
rusp	80	0.066	0.22	13.00	1.110
samr	20	0.002	0.01	0.20	0.016
vaal	100	5.302	18.30	18.20	4.684
vapa	100	8.828	18.35	39.00	7.988
herbs					
actr	40	0.192	0.95	4.20	0.452
adpe	20	0.002	0.01	0.20	0.024
atfi	60	0.408	1.88	2.20	0.354
blsp	100	25.002	47.08	63.00	17.902
dism	20	0.030	0.15	1.00	0.100
drau	60	0.154	0.75	1.40	0.182
lico	20	0.002	0.01	0.20	0.024
luzp	20	0.006	0.03	1.00	0.096
madi	20	0.016	0.08	3.00	0.250
mone	20	0.006	0.03	1.00	0.112
pomu	100	28.820	50.38	52.00	19.048
ptaq	20	0.510	2.55	5.00	0.748
stra	60	0.182	0.75	2.20	0.270
strr	20	0.002	0.01	0.20	0.018
tila	60	0.048	0.20	4.20	0.358
titr	80	0.162	0.35	7.20	0.712
trov	60	0.416	1.92	10.20	1.080
bryophytes and lichens					
bazz	20	0.030	0.15	1.00	0.090
calm	40	0.258	0.77	12.00	1.076
ceph	80	1.326	2.88	25.00	2.864
cloa	20	0.030	0.15	1.00	0.090
dicf	20	0.076	0.38	5.00	0.510
hete	80	0.500	1.80	12.00	1.364
holu	80	0.226	0.75	11.00	1.070
hylo	20	0.040	0.20	3.00	0.268
hypu	80	1.300	4.20	17.00	2.322
isop	40	0.616	2.03	5.00	0.858
isst	100	3.666	8.05	38.00	5.328
leme	20	0.030	0.15	1.00	0.090
plag	20	0.006	0.03	1.00	0.092
plun	80	4.106	13.25	49.00	6.632
pogm	40	0.072	0.18	4.00	0.404
poro	20	0.180	0.90	2.00	0.236
rhgl	80	1.734	3.05	35.00	3.804
rhlo	80	1.760	6.20	13.00	1.934
ricl	20	0.076	0.38	5.00	0.410
scab	100	3.796	6.25	53.00	6.796
stor	100	2.262	5.50	27.00	3.648
bare rock					
rock	60	4.776	17.50	13.00	0.000

totals:

	m.cov	max.cov	t.spp	m.spp
shrubs	14.68	20.6	5	3.4
herbs	55.96	102.4	17	7.8
bryo.	22.08	28.6	21	11.4
all spp.	92.70	127.1	43	22.6

Appendix 4 : Discriminant analysis results.

Table 1 : Forward stepwise discriminant analysis of vegetation groups
based on environmental data.

Step forward separation:

Variables	F-statistic	Signif.
1 - Drainage	32.80	.000
2 - Elevation	18.58	.000
3 - Topographic position	14.03	.000
4 - LFH thick./effect. root. depth	10.14	.000
5 - Wind	9.54	.000
6 - Slope (%)	6.28	.000
7 - B_1 % coarse fragments	5.84	.000
8 - LFH pH ($CaCl_2$)	6.15	.000
9 - LFH C/N	5.88	.000
10 - B_1 C/N	4.29	.001
11 - Aspect	4.30	.001
12 - Root restricting depth	3.40	.002
13 - Worms	4.08	.002
14 - Fire	3.46	.006

Table 2 : Classification of vegetation plots into groups using
discriminant functions (plots = 167; non-classified
plots = 10; total classified plots = 157).

Group	n	Classification success (%)
Subalpine	10	90.0 %
Floodplain	10	100.0 %
Pinus	5	100.0 %
Pseudotsuga	55	90.9 %
Thuja	37	86.5 %
Abies	40	60.0 %
Total	157	82.8 %

Appendix 4 (continued)

Table 3 : Forward stepwise discriminant analysis of the community types
of the Pseudotsuga group based on environmental data.

Step forward separation :

Variables	F-statistic	Signif.
1 - Topographic position	8.08	.000
2 - Elevation	6.01	.000
3 - B_1 % C	5.12	.000
4 - LFH pH ($CaCl_2$)	3.91	.003

Table 4 : Classification of Pseudotsuga group plots into types using
discriminant functions (plots = 60; non-classified plots = 4;
total classified plots = 56).

Type	n	Classification success (%)
P1	4	75.0 %
P2	4	100.0 %
P3	5	40.0 %
P4	11	54.5 %
P5	14	71.4 %
P6	11	63.6 %
P7	7	42.8 %
Total	56	62.5 %

Table 5 : Forward stepwise discriminant analysis of the community
types of the Thuja group based on environmental data.

Step forward separation :

Variables	F-statistic	Signif.
1 - Elevation	19.17	.000
2 - B_1 % N	5.81	.003

Appendix 4 (continued)

Table 6 : Classification of <u>Thuja</u> group plots into types using
discriminant functions (plots = 39; non-classified
plots = 3; classified plots = 36).

Type	n	Classification success (%)
T2	6	33.3 %
T3	7	85.7 %
T4	19	68.4 %
T5	4	100.0 %
Total	36	69.4 %

Table 7 : Forward stepwise discriminant analysis of the community
types of the <u>Abies</u> group based on environmental data.

Step forward separation :

Variables	F-statistic	Signif.
1 – Elevation	10.87	.000
2 – Slope (%)	3.86	.008
3 – LFH thickness	3.38	.015
4 – Texture	2.68	.042

Table 8 : Classification of <u>Abies</u> group plots into types using
discriminant functions (plots = 32).

Type	n	Classification success (%)
A1	3	33.3 %
A2	2	100.0 %
A3	4	50.0 %
A4	4	100.0 %
A5	12	66.6 %
A6	2	100.0 %
A7	5	40.0 %
Total	32	65.6 %

Appendix 4 (continued)

Table 9 : Forward stepwise discriminant analysis of community types
based on environmental data.

Step forward separation :

Variables	F-statistic	Signif.
1 - Elevation	16.38	.000
2 - Drainage	12.27	.000
3 - Topographic position	7.35	.000
4 - LFH pH ($CaCl_2$)	5.49	.000
5 - LFH C/N	4.43	.000
6 - Slope (%)	4.28	.000
7 - Fire	4.06	.000
8 - B_1 C/N	3.35	.000
9 - B_1 % N	2.57	.001
10 - B_1 % coarse fragments	2.12	.006
11 - LFH thick./effect. root. depth	1.91	.015
12 - Wind	1.91	.015
13 - Aspect	2.03	.008

Appendix 4 (continued)

Table 10 : Classification of plots into types using discriminant
functions (plots = 159; non-classified plots = 10;
total classified plots = 149).

Type	n	Classification success (%)
Sub-alpine	10	90.0 %
F1	8	100.0 %
F2	2	100.0 %
D1	2	100.0 %
D2	3	100.0 %
P1	4	50.0 %
P2	4	75.0 %
P3	5	80.0 %
P4	11	54.5 %
P5	14	78.6 %
P6	11	54.5 %
P7	7	28.6 %
T2	6	50.0 %
T3	7	85.7 %
T4	19	73.7 %
T5	4	75.0 %
A1	3	66.6 %
A2	2	100.0 %
A3	4	100.0 %
A4	4	100.0 %
A5	12	50.0 %
A6	2	100.0 %
A7	5	80.0 %
Total	149	72.5 %