Changes in Plant Diversity in Douglas-fir Stands Following the Conversion of Old Growth to Second Growth

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Introduction

The goals of this investigation were:

1. to characterize the vegetation of old-growth Douglas-fir stands in the study area;
2. to assess the rate and degree of restoration of plant diversity (especially cryptogams and shrubs) at different stages of second growth;
3. to classify the vegetation on the study sites according to the biogeoclimatic system;
4. to investigate the diversity of cryptogams on a variety of substrates; and
5. to investigate the variability of the plots, to determine if they serve as good replicates of the type and age of stand they were chosen to represent.

Methods and Results

Information on cover and abundance of all vascular and non-vascular plants was gathered in each one-quarter of the plots using both visual surveys and sampling along transect lines. Information was also gathered on the type of substrate (rock, wood, decayed wood, humus or mineral soil) that cryptogams were growing on. Detrended correspondence analysis (DCA) (Hill and Gauch 1980) was used to assess the dissimilarity of the vegetation composition and cover values between the 12 plots using the CANOCO (Ter Braak 1988) and PC-ORD computer programs (McCune 1991).

The South, North and Koksilah plots were located in the CWHxm1, CWHxm2 and CWHmm2 variants, respectively, of the Coastal Western Hemlock zone of the Biogeoclimatic Ecosystem Classification system (see Harcombe and Oswald 1990a, b).

A total of 251 species were identified. The old-growth plots contained slightly fewer species (143) than did younger aged plots (161–169). North plots contained fewer species (143) than did the South (191) and Koksilah (193) plots. The number of species of trees, shrubs, herbs, and cryptogams varied depending on the age of the stand (Figure 1). Herb species richness increased with logging, but cryptogams richness decreased.

The vegetation on regeneration plots was composed of many invasive herbaceous species, in addition to residual forest species which appeared to have survived logging disturbances. Only forest cryptogams and some saprophytic vascular plants appeared to have been eliminated on regeneration sites. Herb cover was lower and cryptogam and shrub cover was higher on forest plots (Figure 2). In forest plots, cryptogam species richness was greatest on wood or rock (Figure 3), but cover was greatest on humus substrates. Large pleurocarpous mosses provided most of the cover.

The number of species restricted to a specific age class decreased with increasing age of the plot. Regeneration sites had a large number of species that were absent on forest plots; the old-growth forests lacked a few species that were present in younger plots (Table 1).

The vegetation structure on some plots was more diverse than that on other plots, but there appeared to be little relationship between the vegetation structure and either the species diversity or the location of the plot. Similarly, there were few discernible patterns in the structure of the vegetation with respect to the age of the plot. Immature stands appear to have a large number of small gaps in the tree and shrub layers, whereas mature and old-growth plots have a fewer number of small gaps and a greater number of large gaps.

Differences in the vegetation composition between plots are shown in the Detrended Correspondence Analysis (DCA) results. Initial results indicated that regeneration plots are substantially different from forested plots; so much so that all the forested plots are compacted to one side of the ordination. The data were re-analyzed after the regeneration plots were removed (Figure 4). The forested plots are widely scattered in the ordination and there appears to be no relationship between the distribution of the plots and age class, but there is some pattern with respect to the location of the plots.

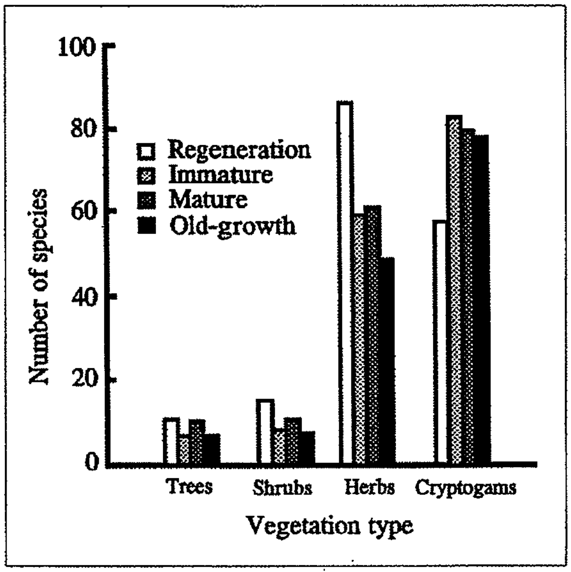

FIGURE 1. Number of species of trees, shrubs, herbs, and cryptogams found in each age class.

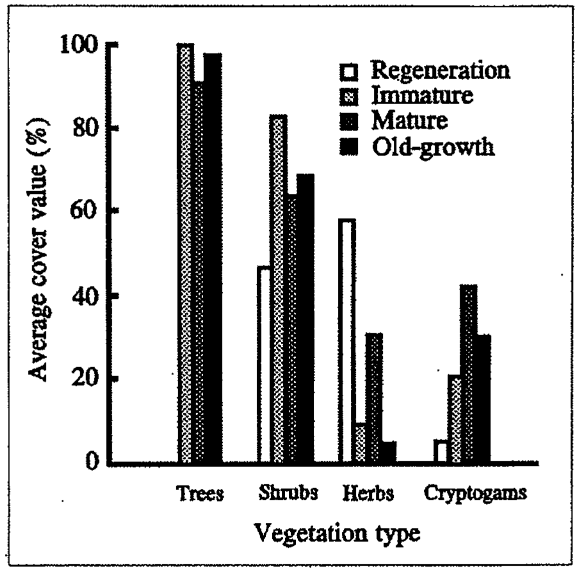

FIGURE 2. Average cover values of trees, shrubs, herbs, and cryptogams in each age class. Cover values for trees and shrubs are based on the sum of the cover values from their repective vegetation layers (e.g., dominant, main canopy, and A3 layers).

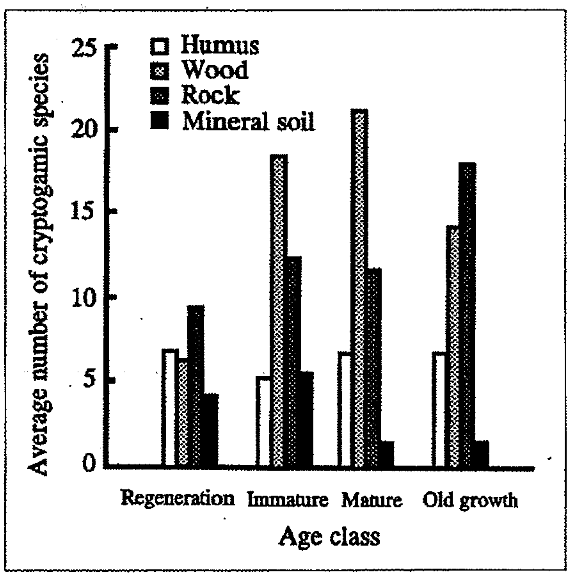

FIGURE 3. Average number of cryptogamic species on various substrates in each age class.

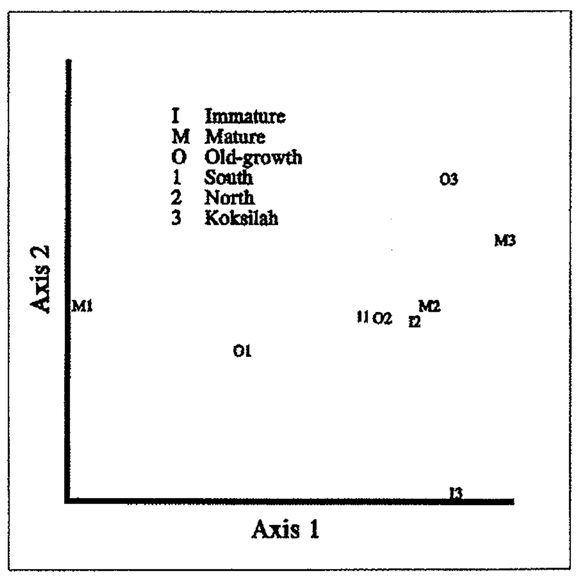

FIGURE 4. Ordination of all plots except regeneration plots. Each plot is represented by an alphanumeric code in which the letter and number represent the age class and location, respectively, of the plot.

TABLE 1. Species restricted to specific age classes. Those species followed by an asterisk are introduced species. Species are listed in alphabetical order, beginning with vascular plants followed by cryptogams.

Regeneration Sites
Agrostis exarata
*Anthoxanthum odoratum**
Aquilegia formosa
Arbutus menziesii
Carex lenticularis
Carex pachystachya
*Cirsium arvense**
*Cirsium vulgare**
*Crepis capillaris**
*Cytisus scoparius**
*Digitalis purpurea**
Epilobium minutum
Epilobium paniculatum
Gnaphalium microcephalum
Gnaphalium purpureum
*Holcus lanatus**
Juncus effusus
Lathyrus nevadensis
Lilium columbianum
Mimulus moschatus
Prunella vulgaris
Prunus emarginata
*Ranunculus repens**
*Rubus lancinatus**
Rubus leucodermis
*Rumex acetosella**
Salix sitchensis
*Sonchus asper**
Stellaria calycantha
*Veronica officinalis**
Vicia americana
Barbula species
Cephaloziella turneri
Cladonia species

Immature Sites
Allium cernuum
Athyrium filix-femina
Carex species
Equisetum arvense
Festuca subulata
Lycopodium selago
Orobanche species
Pterospora andromedea
Trisetum cernuum

Immature Sites (cont.)
Anthoceros punctatus
Brachythecium frigidum
Cladonia cenotea
Cladonia gracilis
Cladonia pyxidata
Dichodontium pellucidum
Didymodon vinealis
Diplophyllum albicans
Lophozia ventricosa
Marsupella emarginata
Philonotis fontana
Scapania umbrosa
Scleropodium obtusifolium
Tortula ruralis

Regeneration & Immature Sites
*Aira caryophyllea**
Arctostaphylos columbiana
Cerastium vulgatum
*Chrysanthemum leucanthemum**
Danthonia spicata
Deschampsia elongata
Epilobium watsonii
Lonicera ciliosa
Madia exigua
Pinus contorta
Ribes lobbii
Trisetum canescens
Viola adunca
Funaria hygrometrica

Mature Sites
Blechnum spicant
*Epipactis helleborine**
*Ilex aquifolium**
Paxistima myrisinites
Symphoricarpos albus
Trillium ovatum
Cladonia verruculosa
Homalothecium fulgescens
Peltigera pacifica
Porotrichum bigelovii

Old-Growth Sites
Collinsia parviflora
Listera caurina
Barbilophozia barbarta
Encalypta affinis
Heterocladium macounii
Metaneckera menziesii
Porella cordeana

Mature & Old-Growth Sites
Allotropa virgata
Calypso bulbosa
Hemitomes congestum
Hypopitys monotropa
Madia sativa
Monotropa uniflora
Taxus brevifolia
Frullania tamarisci
Isothecium cristatum
Lophizia incisa
Neckera douglasii
Plagiochila asplenoides
Plagiomnium venustum
Psoroma hypnorum
Timmia austriaca

The vegetation on a given plot tends to be more similar to that found in other plots occurring in the same location (but of a different age class) than with plots belonging to the same age class but occurring in different locations.

Discussion

In a previous study of the changes in western hemlock and Douglas-fir forests in the Nanaimo River valley, Mueller-Dombois (1965) reported similar results to those found in this study. Regeneration sites had the largest number of species because of the resilience of the understory vegetation, which resprouted after logging, and the occurrence of a large number of invasive herbs (of which many species were the same as those found in this study). Cryptogams and saprophytic species were also largely eliminated from sites that had been logged. Likewise, in Washington and Oregon, Schoonaker and McKee (1988) reported that species diversity was greatest on logged Douglas-fir sites as a result of an influx of weedy species and the occurrence of residual forest species. Once canopy closure was achieved on immature sites, diversity reached its lowest values. Alternatively, in the old-growth forests where the canopy was more structurally heterogeneous, intermediate levels of diversity were recorded although the number of plant species remained low, similar to that found in 30- to 40-year-old immature stands.

Distinct differences where observed in the total number of species found in the study areas. The lower total number of species and lower number of restricted species in the North plots may reflect the lack of microsite variability observed at these sites. In comparison, the perennially moist areas in the South plots and the rock outcrops in the Koksilah and South plots supported additional species not seen elsewhere.

The lack of specificity of cryptogams to a given age class (except for regeneration plots) contrasts with the results found by Lesica *et al.* (1991) who compared the cryptogams in stands of grand fir in Montana. In their study, 64 species were found on the forest floor, 29 were found in only one age class and 23 of these were found only in old-growth forests. The authors concluded that as old-growth forests are converted to younger aged forests many of these species will become less common. This contrasts with our results. Out of a total of 109 species of cryptogams, only 5 of the 28 species restricted to a specific age class were found in old-growth stands and these species appeared to be chance occurrences of uncommon species.

Cover values of cryptogams increased dramatically with age class, peaking in mature forests and then declining in old-growth forests. Similar results have also been noted by Alaback (1982) who studied the dynamics of understory species in Sitka spruce–western hemlock forests in southeast Alaska. He reported that moss biomass peaks in 140- to 160-year-old forest stands and declines with a corresponding increase in herbs and shrub cover. Similarly, in a comparison of bryophyte cover on old landslides (80+ years) and adjacent old growth forests on the Queen Charlotte Islands, Smith *et al.* (1986) found bryophyte cover was greater on landslides. Visual observations suggested that the amount of litter produced in old-growth forests was higher than that on landslides, so that the bryophyte cover was reduced because of increased mortality from smothering by litter.

Successional trends at the three locations are likely to be similar in that regeneration sites will have the greatest number of species because of (1) the invasion of these sites by a large number of weedy herbaceous species and (2) the re-emergence of almost all forest vascular species soon after logging. Once canopy closure occurs, many of the herbs will be eliminated and the shrub layer (dominated by salal) and cryptogam layer will increase in cover. As the stand matures, several saprophytic herbs will appear for the first time. Eventually, cryptogam cover will decline and the structure of the canopy will become more heterogeneous as individual Douglas-fir trees die and are replaced by western hemlock or western redcedar regeneration in the understory.

Current methods used to describe vegetation diversity are inadequate. Measurements of diversity or species richness use only quantitative values (number of species and cover values) as a measure of diversity, and fail to account for qualitative differences. Hence, a plot with a low number of species but supporting several rare or endangered species will have a lower index value than a plot with numerous widely-distributed weedy or introduced species. This problem is of particular concern when the preservation or conservation of rare or endangered species and ecosystems is being considered.

An important next step in the study of these systems will be to investigate the habitat requirements of rarer plant species and indicate how they are affected by conversion of old-growth to second-growth forests.

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