Forest Vegetation of Eastern Washington and Northern Idaho

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SUMMARY

The forest vegetation of the northern Rocky Mountains is potentially a rather simple mosaic determined by macroclimate, microclimate, soil fertility and soil drainage. In actuality, however, the vegetation consists mainly of a wide variety of intergrading, disturbance-induced communities that are difficult to treat except as developmental series related to specific climaxes. These relatively stable units, the associations, are defined primarily on the basis of the relative reproductive success of trees, as this indicates which species will become self-perpetuating dominants of the overstory. Subdivisions are then based on the types of herbaceous and shrubby undergrowth.

Most of the land has been disturbed by lightning-induced fires or by man's activities in the past century. Therefore, the majority of forest communities represent varying stages of secondary succession progressing toward one of the climax types, and attention is inevitably directed toward the potentialities of the land. Habitat types are considered the basic ecologic subdivisions of landscapes. Each has a distinctive potential as to sere and climax, and is recognized by a distinctive combination of overstory plus understory at maturity. Twenty-two of these units are recognized in the coniferous forest vegetation of eastern Washington and northern Idaho. For each, the oldest virgin stands have been sought and analyzed. The available data on population structure of trees, dominance and frequency among shrubs and herbs, responses to disturbance, animal life, topography, soil, and total known geographic distribution are given.

A key is presented for the identification of habitat types. Consistent differences in the rate of height growth of trees, shapes of their growth curves, and differences in their disease susceptibility, along with predictable differences in their soil moisture regimes, all bear evidence that these landscape units have fundamental ecologic significance.

Concepts discussed in relation to the data obtained include the principle of competitive exclusion, continuity of variation, species diversity, and the synecologic significance of basal area.

INTRODUCTION

Objectives

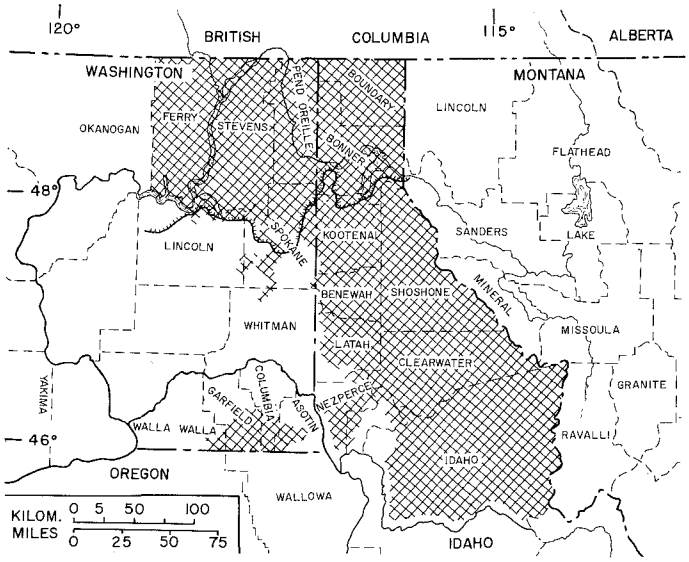
The objectives of this study were:

1. to record the structure and composition of remnants of virgin forest vegetation that are rapidly disappearing
2. to provide a classification of this vegetation on an ecosystem basis
3. to draw together the available information on climate, soils and animal life that can be correlated with the vegetation pattern
4. to include enough area to provide an accurate evaluation of geographic gradients in vegetation and problems of local differentiation.

The *core area* for the study is the forest lands of Washington east of the San Poil and Kettle Rivers, plus Idaho north of the Salmon-Clearwater River divide (fig. 1). But wherever an association found in this area was known to exist beyond its limits, an effort was made to include a few remote stands (as in Montana, Alberta, British Columbia, central Washington and Oregon) to obtain data showing geographic variation.

This core area provides a field laboratory for synecologic study that is scarcely equalled elsewhere in the U.S.A. Although the tree flora is not as rich as in the Appalachian region, it is richer than in most other parts of extra-tropical North America where much virgin forest may still be found. Other advantages result from the fairly deep soils virtually throughout a sizeable tract of mountains, and above all the very limited grazing pressure in all but the lower margin of the zonal sequence.

Remnants of primeval forest representing most of the associations are still to be found. However, as more and more of the land is brought under management, these stands are the first to suffer, for in terms of timber production they are "overmature" and "decadent." Simple economics dictate their replacement by young and vigorously growing trees. Thus the possibility of making such a study as this is rapidly



1. Map showing area of primary study (shaded), total extent of continental ice in the Pleistocene Epoch (ornamented line), and names of counties mentioned in the text.

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dwindling and another useful purpose, the historical, is served by recording the character of the primeval forest.

Intensified management of forest land involves planning to accommodate diverse needs (timber, water, recreation, livestock grazing, game, etc.). The potential of each unit of land must come under scrutiny, for efficient management requires that each unit be used for the purpose it serves best. Natural vegetation here and elsewhere has proven of high value for indicating land potentialities, so practical uses will certainly result from the findings in this report.

Synecologic theory is still actively developing, and, unfortunately, pristine vegetation is critical for testing the validity of conflicting theories as well as the propriety of methods (28). The detailed analyses included in our report will not only document our conclusions, but can be combined and treated in various ways for testing other synecologic concepts. The analyses will also permit critical comparisons with similar data that are being assembled for surrounding areas.

Acknowledgments

Ecologic study of this forest mosaic was begun by one of us (R. D.) in 1936. Between 1946 and 1951, financial support by Washington State University through State Initiative 171 funds led to the publication of a general survey of the forests. From 1959-1968, the National Science Foundation supported a more intensive level of investigation, through grants G-8900 and GB-2419, which culminated in the present work.

Helpful suggestions have been contributed from time to time by many of the U.S. Forest Service personnel. The Clearwater Timber Protective Association and corresponding organizations in Montana and Alberta favored us with special permits to enter areas that were closed because of high fire hazard. Several professional pedologists contributed soil profile descriptions that are acknowledged at appropriate places. The U.S. Weather Bureau, through the courtesy of Marvin D. Magnuson, supplied the data for calculated evaporation and evapotranspiration. Roald Fryxell identified pebbles found in parent materials in the subalpine forests. The manuscript has benefited by criticisms from Betty W. Higinbotham, Noe Higinbotham, and Warren Starr.

Methods

An earlier study of these forests (23) was based on reconnaissance methods—mainly on constancy of vascular plants in plots 5 x 25 m in six widely scattered stands of each of the forest associations recognized at that time. The present study is both more intensive and more extensive. We have made a complete census by size classes of all the trees at each study site, determined coverage and frequency of all species of shrubs and herbs, and recorded altitude, aspect, percent slope, pH and other soil data at each site. This study is more extensive in that for the most part more than six stands of each association were analyzed, and some stands outside the core area were studied.

The fact is well established that the vegetation of disturbed areas is highly variable from place to place even on a relatively uniform type of habitat. Species characteristic of such areas have wide ecologic amplitudes so long as they do not have to meet intensive competition. Thus, to establish the closest relationships between vegetation and environment it is desirable to stress relatively stable vegetation in which competitive elimination has provided the clearest distinctions among the habitats in the environmental mosaic. Accordingly, stands were selected to obtain the most nearly self-reproducing populations that could be found, and to have each type of climax[2] community represented by stands spread over a wide area. To be accepted, a stand also had to have an area 15 x 25 m in which environment, overstory, and understory all seemed as homogeneous[3] as possible, with complete freedom from ecotonal effects. Floristic composition was taken into account not only as a basis for avoiding nonhomogeneous areas, but also as a basis for deliberately including as wide a variation in climax structure as could be found. The only climax type of coniferous forest not studied was the *Pinus albicaulis-Abies lasiocarpa* savanna (or groveland) characteristic of upper timberline. Because mountains in the main study area are too low, this climax is barely represented on the summits of a few prominences.

Even where a stand was a kilometer or more across, consideration was restricted to a 15 x 25 m rectangle, with its axis paralleling contours to maximize soil homogeneity. Only one such sample was taken in each stand in order to encompass more area and more variation. It is felt that as a result of restricted sample size, each study unit represented a single soil type. Profile descriptions, unless otherwise indicated, refer to a pit dug at the center of the 15 x 25 m sample. Pedologists have thus far so slighted mountain topography that many soil profiles cannot be correlated with comprehensive classification. We were unable to enlist a pedologist to collaborate regularly, but some gratuitous assistance was occasionally offered. Thus, representative profile descriptions can be given for most of the ecosystem types studied.

The 15 x 25 m area is large enough to provide a sufficient sample of tree populations that when all individuals are tallied by size-classes, the successional status is rather clear from population structure. In a few instances, seral stands were analyzed to obtain evidence supporting interpretations of climax and near-climax vegetation.

In practice, laying out the 15 x 25 m rectangle was the first operation in a stand. This area was chosen carefully to avoid ecotonal effects, trails, etc. Next, the area was divided into 3 strips 5 x 25 m, each of which will be referred to as

[2] We use the term *climax* for any apparently self-perpetuating phytocoenosis, or for nonreproducing populations where there is no evidence of a possible successor. By *pristine* we mean the absence of evidence that an area has been altered by man even before the advent of the white man. Certainly such vegetation would contain no cut stumps (which, in view of the recency of the white man's appearance here would still be conspicuous) and no evidence of livestock alteration other than what might be inferred from the presence of a few exotics that are singularly favored by livestock spreading their disseminules. Pristine vegetation may or may not have achieved climax status.

[3] Absolute *homogeneity* is of course impossible in complex communities where chance or clonal spread determines the locations of individuals. By homogeneous we mean that variation in composition or structure from place to place seems unrelated to intrinsic variation in soil characters, in relief or in recency of fire. Since means based on parts of two populations having different parameters in consequence of environment or history constitutes a misrepresentation of fact, it behooves an investigator to strive for the most rigorous stratification of vegetation that the material and his observational acuity permit. Heterogeneity is often clearly evident in undergrowth or in minor tree species, without being reflected by the species dominating the overstory.

a "macroplot." Along the inner sides of the central macroplot, small 20 x 50 cm "microplots" were placed at 1 m intervals (fig. 2). In these, canopy coverage was then determined for each species of shrub, herb and bryophyte.[4] Thus the exact position of the lines delimiting the central macroplot and consequently the positions of the microplots along its sides were established objectively. The use of elongated microplots, their arrangement in long rows, and their systematic placement each contributes an increment of efficiency to the sampling system.

Trees were tallied by decimeter diameter classes as measured at breast height. The midpoint of the class interval was used in calculating basal area, ignoring individuals under 1 m tall. All trees over 1 m high were tallied for the entire 15 x 25 m area. Those less than 1 m tall were counted on two strips located along the inner sides of the central macroplot (fig. 2); counts were adjusted to the 375 m^2 basis in the tables. Although the numbers of seedlings sometimes exceeded 9,999/375 m^2, no figure higher than this appears in the tables. The data, obtained from plots marked by tapes lying on or near the ground, have not been adjusted for slope, but the slope records included permit such a calculation if it should be thought desirable.

A deliberate attempt was made to lay out each study site to include the largest trees in a stand, assuming these to indicate the oldest and most mature part of the forest. Therefore, in most cases the basal area data are undoubtedly higher than the average would have been if a considerably larger area had been used. However, any bias is a consistent one, and the trends shown by the data are clear. Where other data are available for comparison, our values agree very closely (3).

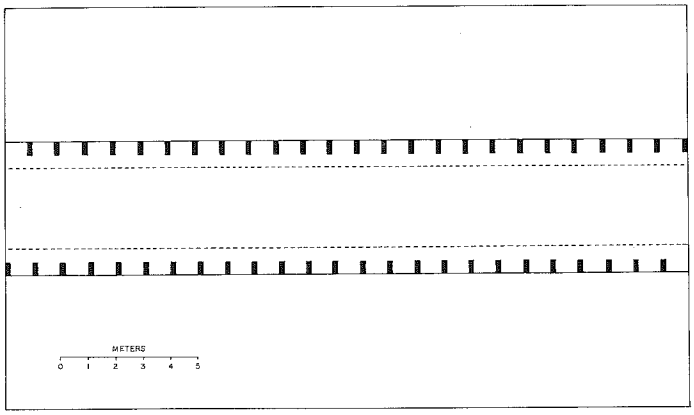
In the microplots, canopy coverage was recorded independently for each species as one of six coverage classes (0-5, 5-25, 25-50, 50-75, 75-95 and 95-100%). The midpoints of these classes were later used in calculating average percent coverage of the taxa encountered in the 50 microplots. For further details of the method of analysis see Daubenmire (25a).

In addition to the quantitatively analyzed flora that occurred in the microplots (5 m^2 total), a supplemental list was made of any other species that occurred within the boundaries of the central macroplot (125 m^2). A third list consisted of any additional species noted in the stand anywhere outside the central macroplot. Thus a total floristic list was made, divided so that the contents of different sized areas are available for different types of study.

Tabular data that compare most or all of the spectrum of associations are gathered together in the appendix. Along with the vegetation analyses in appendices A and B, aspect, altitude, and location with respect to the official land survey system are given. The stands thereby can be relocated for checking or for further study until they are logged, grazed or burned. Only six stands in Glacier National Park and two others are where they are to be protected from logging or grazing.

Tall shrubs, medium shrubs, and low shrubs as segregated in the tables correspond with Raunkiaer's life form classes:

[4] The bryophyte studies were made by Betty W. and Noe Higinbotham, and will be reported separately.



2. System of nested plots used in sampling bryophytes and vascular plants, consisting of 3 contiguous macroplots, with 50 microplots and 2 strips for tree-seedling counts within the central macroplot.

microphanerophytes, nanophanerophytes, and chamaephytes.

Acer, Amelanchier, Sorbus, and *Taxus* all range in size from shrubs to small trees in different stands, but they have been treated as undergrowth in the microplot analyses, with *Taxus* included in the tree census as well.

At high altitudes, plots were analyzed before early-maturing herbs had withered appreciably, but after late-maturing species had attained approximately maximal coverage. At low altitudes where the summer is longer, more than one tally of each plot was frequently necessary to account for staggered phenologies and so tally most species during their highest coverage.

Soil cores 10 cm deep, starting at the bottom of the strictly organic layer (A_0 horizon), were collected at regular intervals along the sides of the central macroplot and dried as quickly as possible in the field. Later, portions of each of these samples were moistened with deionized water to paste consistency, then allowed to stand 24 hours before determining pH with a glass electrode. Owing to the well-known variation in pH from place to place within a stand, replication is necessary to get a reproducible measure of soil reaction. Curtis (18) considered three samples adequate to represent a forest stand of 10-15 acres, but Frankland, et al. (34) found 64 samples necessary for a reasonable approximation of the parameter in a much smaller area (800 m^2). We have used 25 replicates, systematically located, to represent the 375 m^2 study site. We early discovered that the average for 25 samples so collected was always within 0.1 pH of the average for 50 samples. Since the frequency distribution of pH values for one stand was always clearly normal, it was feasible to average the 25 values in summarizing the data. Terminology in the profile descriptions follows Soil Survey Staff (81, 82).

Parts of the 25 samples not needed for the pH tests were composited, and chemical analyses made in the Soil Testing Laboratory at Washington State University for organic matter, P, K, Ca, Mg, and cation-holding capacity. Only material passing through a 2 mm screen was submitted for testing, and practically all roots were removed in screening the samples. Not all sites were included in this nutrient survey.

All field work involved after arrival at a stand required

1.1-2.7 hours time on the part of two individuals. By our technique, far more time was required to find old undisturbed stands than to make the field records and collections.

Taxonomic considerations

Despite our efforts to identify every individual of the vascular flora as precisely as possible, many specimens could not be determined to subspecies and some not even to species. Even climax herbs and shrubs growing in the shade of a heavy forest canopy may remain sterile if not depauperate as well, and bear little resemblance to the specimens in vigorous flowering condition that one must use in the herbarium for comparison. Nearly all species in this report are represented by vouchers filed in the Herbarium at Washington State University. Nomenclature for dicotyledonous plants follows Hitchcock, et al. (100) and for other vasculares follows Davis (31), with the following exceptions:

We prefer to group *Agropyron inerme* with *A. spicatum,* considering the former as no more than a biotype in the latter. For the cytologic basis of our contention see Stebbins and Pun (84), and for the ecologic evidence and progeny tests see Daubenmire (26).

Wherever we have found *Tiarella unifolia* abundant in the Rockies, we could nearly always find trifoliate individuals by diligent search. These are otherwise very similar to the unifoliate individuals and flower at the same time, but bear less resemblance to what we consider to be *T. trifoliata* as it occurs in southeastern British Columbia. Therefore, we are inclined to consider all trifoliate individuals we have seen south of the international border as *T. unifoliata* f. *trisecta.* C. L. Hitchcock, however, has annotated all but one of our vouchers from south of the border as *T. trifoliata.* We have here lumped the form with the species *T. unifoliata* and recognized *T. trifoliata* only in our plots in British Columbia northwest of Glacier National Park.

Taxonomists have traditionally recognized two species of *Fragaria* in our area, but have disagreed on their distinguishing characters. Owing to this confusion, and the fact that these heliophytes are almost invariably sterile when they occur in old stands of timber, we have not attempted to make a distinction. *Rosa woodsii* var. *ultramontana* and *R. nutkana* var. *spaldingii* also are usually sterile under shaded conditions and have had to be lumped. However, their ecotypes in our area are ecologically almost identical, and as a group are easily distinguished by vegetative characters from the sciophytic *R. gymnocarpa.*

Polygonum majus has been split from *P. douglasii* only on the basis of size of the achene. Since there is no discontinuity in this character, we have used only the latter name for the series as represented in our study sites.

Synecologic perspective and terminology

The first stage in vegetation classification was to study the population structure of the trees and to group stands according to the species that show strongest evidence of self-perpetuation on each site. This led to the definition of relatively few basic types of coniferous forest which form an ecologic sequence that is predictable over a wide geographic area. In this first step in stratification of data, the composition of the currently dominant trees in the overstory is of minor importance; the species that are demonstrating reproductive success in the face of intense competition are the critical ones. On this basis eight subdivisions of our forest clearly related to the pattern of macroclimates can be objectively delimited (25): *Pinus ponderosa, Pseudotsuga menziesii, Abies grandis, Thuja plicata, Tsuga heterophylla, T. mertensiana, Abies lasiocarpa,* and *Pinus albicaulis* plus *Abies lasiocarpa.*

For the second level of stratification, most of the above eight major kinds of forest were subdivided on the basis of differences in the shrubs and herbs dominating their undergrowth. These secondary divisions reflect mainly soil or microclimatic variations from place to place in the same macroclimatic belt. The view was taken that among undergrowth plants the ecologic character of a habitat is reflected not only in the species list, but especially in the particular species that have been able to achieve dominance in the face of strong competition.

The above combination of procedures segregates 22 types of coniferous forest in the core area. Each type is characterized by a particular combination of climax tree and understory dominants, and these types are called *associations.* Daubenmire (23) concluded earlier that a fundamental classification of forest ecosystems must be based on a consideration of dominance simultaneously in the different layers. This conclusion has been strengthened by the data added in the present study. That each association indicates the extent of a specific ecosystem type is shown by the close correlation that can sometimes be drawn between such units and specific climate, edaphic or microclimatic conditions. Furthermore, the growth rates of trees, the shape of their ontogenetic growth curves and disease susceptibility show significant differences among the ecosystem types (27, 75).

In presenting our account it has been convenient to group associations into "series," making it possible to discuss the features held in common by a group of associations. The term series is not here proposed as a taxonomic category.

As with other biologic classifications, we do not imply that intergrades do not exist. Not only is variation within types recognized, but a deliberate attempt has been made to document as much of this variation as possible. The ecotones of the eight primary divisions based on overstory are relatively sharp, but those of the subdivisions based on undergrowth sometimes intergrade to a considerable extent.

Most of the land area that has the potentiality of supporting a single type of climax association has been variously grazed, logged, burned or cleared for agriculture. Therefore, it seems rational to look upon it as comprising a *habitat type.* Habitat types are then fundamental ecologic units in a landscape. Such an interpretive approach emphasizes the common potentiality of many diverse and imperceptibly intergrading types of vegetation that exist. Hence, a relatively simple classification can take into account most of the elements of a very complex region. We refer to the term "habitat type" so often that we have used the abbreviation "h.t." ("h.ts." plural) to conserve space.

For each h.t., the association it supports in undisturbed condition is defined and described. All available information on potential seral and disclimax communities, animal life, climate, topography and soil is brought together and the

total known distribution of the unit is indicated. For lack of comparable data for adjacent areas, the characters listed for recognizing each h.t. are intended for use mainly in the core area. When surrounding regions become better known, the list of characters may need to be augmented to exclude similar vegetation units in those regions that seem to deserve a distinctive status, or perhaps broadened to include minor variants. It is hoped that these data will prove complete enough for such possible re-evaluations.

Except for *Larix occidentalis, Pinus ponderosa,* and sometimes *Thuja plicata,* all the trees in our region are readily killed when a surface fire sweeps through a stand. However, a large percentage of the herbs and shrubs found in climax forests are killed back only to the soil surface and regenerate new shoots in the next growing season. Thus, unless a second devastating fire occurs soon, most undergrowth species remain rather permanent occupants of a site. The lower vegetation strata they comprise invariably approximate stability long before this state is attained in the tree layer. Obligate heliotypes usually invade in abundance after a fire, then dwindle slowly as the new forest develops. The persistence of climax herbs and shrubs (one must often part the tall heliophytes to find them!) thus provides valuable clues for the identification of habitat types in early stages of secondary succession.

The life span of individual trees is long in comparison with the frequency of devastation by lightning-induced fire. Therefore, stands showing in their population structure that relative stability has been attained are exceedingly rare. The bulk of the pristine stands we have found are technically in only near-climax condition, insofar as the trees are concerned. But since size-class analyses are given in full for the trees of each stand, all the basic data are available for alternative interpretations. Inclusion of stands in which the trees are patently not in complete equilibrium is in fact desirable since such stands reveal the taxonomy of the preclimax overstory. They also show that fire influences on the composition of the undergrowth are erased long before competitive forces operating on the long-lived trees can eliminate the last seral tree from the main canopy and thereby establish a stable population structure.

For want of a better system of classifying climaxes ecologically, we have followed Tansley (101). In his system, a *climatic climax* is the apparently self-regenerating vegetation found on deep loamy soils of gentle slopes that have long been free of disturbance by fire, grazing, mowing, etc. An *edaphic climax* is any that differs from the climatic climax only in consequence of abnormal soil conditions, such as coarse texture, stoniness, or poor drainage. A *topographic climax* is a stable community that is restricted to a highly specialized type of topography within a particular landscape. In the northern Rockies this category is well represented on slopes that face steeply to the south or to the north and are therefore sufficiently warmer and drier, or cooler and wetter, than gently undulating topography to support distinctive climaxes. Other topographic climaxes occupy frost pockets above constrictions in valleys, or windswept peaks and ridges. The term *topo-edaphic climax* is appropriate where special soil conditions and special microclimates both contribute to the development of a special type of vegetation. A *zootic climax* is one in which the special character of the vegetation is maintained by a special type and intensity of animal disturbance.

All of the above climax types may occur in close proximity, and all appear to be equally capable of self-perpetuation.

The physical setting

The forests of our core area cover an arc of mountainous topography that curves around the eastern extremity of an arid steppe-covered plateau (fig. 1). For the most part, the elevation of the edge of the steppe falls between 600 and 900 m above sea level, with the mountain slopes on the north and east rising to approximately 1800 and 2100 m. The southwestern extremity of the mountainous arc consists of the tip of the Blue Mountains as they barely extend into Washington. The mountains whose crest rather well defines the eastern border of the core area are sometimes referred to, in the aggregate, as the Bitterroot Mountains. Some prefer to divide the same area, from south to north, into the Bitterroot (sensu ancha), Clearwater, Coeur d'Alene and Cabinet Mountains. North of the glacial border the mountains are divided, from east to west into the Cabinet, Selkirk and Okanogan Mountains.

The bulk of the precipitation dropped by the Westerlies is on the approaches to the mountain crest along the eastern boundary of our area. The highest long-term mean annual precipitation record is for Roland, Idaho, where the elevation is 1265 m and the precipitation 1260 mm/yr. Although the Okanogan Mountains rise fully as high as the Selkirks and Cabinet Mountains, which lie successively to the east of them, they are less massive and considerably drier. Xerophytic forests rise to near their summits, whereas on approaching the Selkirk and Cabinet Mountains one finds that mesophytic forests descend to the valley floors.

For the most part, the mountains of the entire core area consist of a monotonous series of sharp accordant ridges with valleys that are V-shaped except locally where they were somewhat reamed out during glaciation. In the Cabinet, Selkirk and Okanogan Mountains, all but the highest peaks were twice briefly covered by ice during Pleistocene time.

The mean elevation of alpine timberline at this latitude in the Rockies is about 1900 m. Only a few of our peaks rise above this elevation, and there is no alpine zone in the core area. However, the summits of the highest peaks and ridges support a discontinuous cover of stunted trees (*Abies lasiocarpa* and *Pinus albicaulis*) similar in physiognomy and taxonomy to the alpine timberlines of other parts of the Rockies in Montana where the mountains are higher.

A meaningful elevation for lower timberline cannot be stated since in major valleys forest continues downward where well protected from isolation to about 250 m. On the elevated rim of the Columbia Basin, unbroken steppe may rise on insolated slopes to 1000 m where the median annual precipitation is approximately 500 mm.

A variety of igneous, sedimentary and metamorphic rocks form the mountain masses, but these have no extreme physical or chemical properties that play a conspicuous role in determining the character of the vegetation. From time to time in the geologic past, increments of eolian materials, especially loess and volcanic ash, have been deposited on the mountain

slopes. Most of these are in the foothills and to the south of the glacial border. Since the ash lies mainly on the leeward slopes in the foothills, it is tempting to speculate that windward slopes were then too thinly vegetated to prevent transfer of the ash showers to lee slopes. Such a hypothesis is in full accord with the dating of the major ash fall, 4600 B.C., during the xerothermic period. These eolian deposits form excellent soils. In comparison with many other parts of the Rockies, shallowness and stoniness of soils play a relatively minor part in forest distribution in our core area. From our standpoint, the chief consequences of glaciers covering the northern half of the core area in Pleistocene time was a partial replacement of preglacial loess with a more stony and less fertile material on the uplands, and the scouring out of broad drainageways leading from the edge of the melting ice. These drainageways were left floored with coarse alluvium and now support distinctive forest types.

Air masses following the path of the Westerlies drag the summer-dry climate of the Pacific Coast inland across the study area. The effect is strongest at approximately the Canada-U.S. border. The result is a distinct climatic gradient from north to south in the core area that is reflected in both flora and vegetation types. Since the oceanic influence diminishes with each crossing of a major mountain range, the components of the vegetation mosaic also change in an east-west direction across the northern Rockies. With gradients of climate thus extending in all directions, not all the components of our core area should be expected to occur even in the immediately surrounding areas. With increasing distance, more and more of our vegetation types drop out of the landscape mosaic and new ones appear.

The microclimates of north and south slopes that are everywhere well differentiated in the forested Rockies are especially contrasted in our area. A large share of the precipitation is blown across ridgetops by the prevailing southwest winds before it falls. Furthermore, the thinness of the mantle of volcanic ash and loess on southerly slopes results in a lower moisture-holding capacity of the soil there, and this is especially crucial in a climate that is virtually without rain in the warm summer.

Another noteworthy feature of this mountain region is the frequency of frost pockets above constrictions in valleys. The nightly accumulation of cold air in these places creates microclimates that permit trees characteristic of the high mountain summits to descend to remarkably low altitudes.

Fire history

The northern Rockies is a region of unusually high fire hazard during summer. Lightning storms are frequent and many are accompanied by too little rain to extinguish the many forest fires they start. In the past, individual fires (especially during unusually dry seasons such as occurred in 1910, 1916, 1931 and 1967) have run over extensive area, but techniques for fire suppression have developed to such efficiency that even in the aggregate, relatively little area is burned by unplanned fires each summer. As might be expected from the above, charcoal fragments are universally present in our forest soils. Secondary succession is a conspicuous feature in landscapes in which only scattered patches of forest have escaped burning long enough to have approximated climax status. Wild fire was formerly the outstanding creator of secondary bare areas. Now, the annual logging of scattered patches, followed by the burning of all residual material, is playing this role. This type of silviculture would be ecologically sound but for the serious erosion problem created by the intricate network of roads it necessitates.

Following the destruction of forest by fire or by timber harvest, if there is no artificial planting and subsequent management, forest vegetation at all altitudes tends to pass through the same sequence of three developmental stages. The floristic details of these vary considerably.

1. *Invasion stage.* All trees within dissemination distance may seed into the bare area so that within a decade or so, trees are well represented. Not even our most demanding tree species require special amelioration of soil or atmosphere for invasion, as their appearance on raw exposures of subsoil testifies abundantly. The primary factor determining the species of tree seedlings that can get established on any particular burn is the occurrence of seed trees with appropriate ecologic amplitude within disseminating distance.

Although most trees are killed outright when a forest burns, many of the sciophytic shrubs and herbs beneath will regenerate directly from underground organs the next spring. In addition, a heliophytic flora of shrubs and herbs invades. These form a mixture with the regenerating undergrowth species and young tree seedlings.

2. *Stagnation stage.* Tree seedlings usually continue invasion for a decade or two. The length of the invasion period is inversely proportional to the nearness of a seed source. Invasion time also depends on how well weather favors the size of the seed crop for each tree species. Eventually, increasing population density, in combination with increasing sizes of the individual canopies, leads to a closed stand. Further accretion from without ceases. Shade from the crowded tree canopies now becomes so dense that all but the most sciophytic undergrowth plants (these chiefly the highly mycotrophic members of the *Ericaceae* and *Orchidaceae*) are eliminated. Sometimes even these die out, leaving only a carpet of brown needles on the forest floor

Among tree invaders, the most heliophytic species grow fastest in height, overtopping the others so that a two-storied canopy forms. The lower story consists largely if not entirely of slow-growing climax species. Diameter growth of the trees slows progressively during the development of such a very dense canopy. In areas where *Pinus ponderosa* is the only tree species, the stagnation stage lacks an understory of other trees, and where shrubs dominate beneath this pine, its seedlings invade so slowly that stagnation may never occur.

3. *Resumption of regeneration.* As the seral trees of the taller stratum die one by one, they are replaced by suppressed individuals of the more shade-tolerant species beneath. Throughout this replacement, the canopy tends to remain so thick that the forest floor continues to be bare or nearly so, with still no tree seedlings becoming established. Eventually, however, progressive reduction of tree density allows shafts of light to penetrate and conditions once more become suitable for the success of seedlings of autotrophes. The most shade-tolerant trees begin to produce a few seedlings, and sciophytic herbs and shrubs appear. This regeneration is often confined to well-defined spots only a few meters in diameter

where light intensity has risen a little above the compensation point. By the time the last relics of the seral overstory die (approximately 300-400 years after a fire), the climax tree species has usually produced a complete series of age classes. The herb and shrub flora has long ago reached equilibrium, and the patchy distribution of tree seedlings and small plants has weakened if not disappeared.

Relatively few of our study sites represent climax stands that appear to have reached a completely homeostatic equilibrium, but a few in most associations fit this category. Many fall just short of this equilibrium merely by having a few ancient individuals of seral species still standing. The latter group differ from the former mainly by a technicality. The fewness of stands completely free of seral relics reflects no more than the increasing probability of another holocaust as time passes. The probability rises to the point of certainty in about 400-500 years (except for swampy habitat types). Since seral trees frequently live to about this age, they seldom disappear before another fire starts the cycle anew.

While the above comments describe general tendencies in nearly all h.ts., several of the latter showed deviations that will be detailed later.

The foregoing discussion concerned crown fires in which the entire tree flora is removed, but cooler fires often remain surface fires and kill only very small trees. Old trees in many of our stands show by charred bark or fire scars that they have survived one or more surface fires that may have eliminated some of the more sensitive of the older trees along with the small size classes of all. Starker (83) has published a subjective rating of the relative tolerance of coniferous trees in the core area to surface fires:

1. *Larix occidentalis* (most resistant)
2. *Pinus ponderosa* = *Pseudotsuga menziesii*
3. *Abies grandis* = *Pinus contorta* = *P. monticola* = *Thuja plicata*
4. *Picea engelmanni* = *Tsuga mertensiana* = *T. heterophylla*
5. *Abies lasiocarpa* (most sensitive)

The abundance of seedlings and small saplings shown in our tabular data will attest that we avoided stands that had recently been altered by fire.

The shrubs and herbs of climax forests have a remarkable ability to regenerate after light burning. Thus, evidence of damage in the undergrowth is erased even before the trees have had time to re-establish their normal size-class distribution.

THE HABITAT TYPES

The *Pinus ponderosa* series

Nearly everywhere in eastern Washington and northern Idaho as one leaves the steppe at the foot of the mountains and enters the forest, the first coniferous tree encountered is *Pinus ponderosa.* The ability of this species to endure dry climates well exceeds that of our next most drouth-tolerant conifer, *Pseudotsuga menziesii.* Therefore, typically a belt of climax pine forest separates steppe from *Pseudotsuga* forest. *Pinus ponderosa* does indeed extend farther up the moisture-temperature gradient than this marginal belt in which no other tree challenges its supremacy. But there it either perpetuates itself on slopes that are excessively dry for those altitudes and so spare it from competition or it is a temporary invader of logged or burned sites. After one generation, devastating competition from other trees completely eliminates it. In the present section, attention will be restricted to areas in which the pine is the climax dominant, i.e., the *Pinus ponderosa* Series.

In Montana, southern Idaho, central Oregon, and southward in the Rocky Mountains, the transition from steppe on the basal plains to forest in the foothills is usually marked by associations having a savanna physiognomy. These associations are often dominated by trees considerably lower in stature than *Pinus ponderosa* such as *P. cembroides* and *Juniperus* spp. (20). But in eastern Washington and northern Idaho, the transition from steppe to *Pinus ponderosa* forest is relatively abrupt. Only occasionally is the margin of the pine belt open enough to give the appearance of savanna.

Soils are more varied in the *Pinus ponderosa* series than anywhere else in the mountains. They include glacial till, glacio-fluvial sand and gravel, dune, basaltic rubble, colluvium and deep loess or volcanic ash. Larson's statement (53) that soils supporting the "*Pinus ponderosa* type in the northern Rockies invariably contain much rock near the surface" is not correct. A considerable share of the variation in herbaceous and shrubby layers beneath the trees reflects these soil variations from place to place within the macroclimatic belt favoring pure pine forest.

Along the western flank of the Bitterroots to the south of the glacial border, the soils of the interfluves are developed mainly on deep loess and ash. Here two pine h.ts. prevail—a more xerophytic *P. ponderosa-Symphoricarpos* h.t. at lower altitudes or on southerly slopes, and a less xerophytic *P. ponderosa-Physocarpus* h.t. that is restricted to northerly slopes. This pattern is interrupted on the thin stony soils of valley sides that slope steeply southward. There, the shrubby undergrowth is lacking and a *P. ponderosa-Agropyron* h.t. is differentiated.

On soils to the north of the glacial border, all three of the above h.ts. reappear but there they are less prevalent. In that area, glacio-fluvial sorting and wind action have left sandy soils over so much of the land within the appropriate climate that special h.ts. of pine with *Festuca idahoensis* or *Stipa comata* are abundant.

A division of pine h.ts. into two groups, (1) a shrubby group on deep heavy-textured and more fertile soils, and (2) a grassy group (including the *Pinus-Purshia* h.t., in which the shrub *Purshia* is superimposed over the same xerophytic grasses) on stony or coarse-textured or shallow soils, coincides with remarkable differences in the growth rate, disease resistance and reproductive behavior of the pine. In the group lacking the xerophytic grasses (i.e., *Pinus-Symphoricarpos* and *Pinus-Physocarpus*) the pine grows rapidly. On a normal site it has never been seen parasitized by *Arceuthobium campylopodum* (27), whereas in association with the xerophytic grasses the pine grows slowly, and *Arceuthobium* infection is widespread. In the *Pinus-Symphoricarpos* and *Pinus-Physocarpus* group, tree reproduction is sparse and continuing so that young trees are independently scattered over the forest. In the dry group, reproduction is episodic;

the forest consists of a mosaic of dense patches of trees, each tending to be distinctive in height and age. Excessive density of these patches when they are young eliminates herbs and shrubs beneath. Later, the undergrowth species slowly reappear as the tree population gets progressively thinner and the canopy more elevated (63). In old age the patches become so open that the trees have negligible influence on the steppelike ground cover. Indeed, small openings develop that are essentially identical with steppe associations to the west and south of the forest border.

The fine texture of this dynamic mosaic of arborescent and herbaceous patches usually made it impractical to follow the system of vegetation analysis adopted for the study as a whole. Here it usually seemed more meaningful to sample the herbaceous vegetation where it was well developed in small treeless openings, then sample the tree population in a contiguous area where there was hardly more than a deep mat of dry needles beneath the canopy. Both areas were considered parts of the same h.t. in different phases of a cycle. In comparing data for undergrowth and overstory it must be kept in mind that the data for these associations usually represent contiguous rather than concentric areas.

Pinus - Symphoricarpos and *Pinus - Physocarpus* h.ts., in which the growth of the pine reflects more favorable levels of environmental resources, are further distinguished by having fewer annuals than the pine-with-grass h.ts.

There is undoubtedly much truth to the common opinion that before the white man came, frequent fires caused by lightning or aborigines kept the pine stands in the grassy group open to the point of being savannalike. Where moderate fire protection has been operative in the last few decades, dense patches of young trees have become established from time to time. This suggests that perhaps in the absence of burning, the patchy pattern of population structure might disappear. However, one cannot accept an inference that episodic reproduction is but a simple consequence of intermittent burning, for *Pinus-Symphoricarpos* and *Pinus-Physocarpus* stands are also subject to intermittent ground fires, yet patchy structure is lacking there.

It has been strongly advocated that controlled burning is necessary for the economic management of *Pinus ponderosa* in this region (92, 94, 95). However, whether fire is equally necessary or indeed useful in all h.ts. that support the pine has not been determined. Furthermore, the optimal time for burning in relation to phenology may well differ according to h.t.

Common opinion is undoubtedly in error regarding the alleged role of fire in determining whether the undergrowth beneath the pine is dominated by shrubs or by grasses. There is unmistakable evidence that all undergrowth layers except the one consisting of the fire-sensitive *Purshia tridentata* regenerate immediately from underground organs after each fire. Rather than fire history, these subordinate layers reflect intrinsic differences in moisture, fertility and microclimate. Perhaps much of this confusion is a consequence of uncritically lumping shrubs plus young pines as "brush" in popular speech and writing. The ecologies of these two elements of forest undergrowth are vastly different. Dense stands of young pines can be completely eliminated by one or a few surface fires, whereas dense stands of the shrubs (except *Purshia*) cannot be so eliminated.

Our objective of studying vegetation that has been unaltered by logging and grazing has been most difficult to achieve in the *Pinus ponderosa* forests. In the grass-dominated and *Pinus-Purshia* associations, the fragile crust of mosses and lichens is very easily broken by animals merely walking over the stands. This allows small native annuals to increase and alien annuals to gain a foothold. The change perists for many years after the animals are removed. In the *Pinus-Symphoricarpos* and *Pinus-Physocarpus* forests, *Poa pratensis* and *P. compressa* are the important indicators of heavy grazing. These gain representation in proportion to the severity of use but then show negligible tendency to give way to native perennials when grazing ceases. Thus the proportion of *Poa pratensis* and *Poa compressa* in the undergrowth seems to reflect the most severe grazing pressure to which a stand has been subjected in the past.

Owing to the abundance of early spring annuals in the pine-with-grass communities, sample plots must be tallied in late April then again in mid-June to evaluate the total vascular flora. In the *Pinus-Symphoricarpos* and *Pinus-Physocarpus* forests, a single tally between about May 15 and June 10 is sufficient. However, later visits are sometimes necessary to identify with certainty some of the late-maturing species.

Another small but significant difference is correlated with the two groups of pine ecosystems. In the two characterized by *Symphoricarpos* or *Physocarpus, Agropyron spicatum,* when present, is represented by the rhizomatous ecotype; in the other h.ts., only the caespitose form occurs.

Spokane, Potlatch and Kooskia have weather stations representative of the *Pinus ponderosa* series in the core area. Some normal climatic parameters are shown in Appendix F. At Spokane, the climatic climax is the *Pinus-Festuca* association; at Potlatch it is the *Pinus-Symphoricarpos* association; at Kooskia the climatic climax has not been determined.

Behre (3) indicates a range in basal area of 15.3 to 53.26 m^2/ha for *Pinus ponderosa* stands 60-180 years old in northern Idaho and adjacent areas. These values encompass the range from the poorest to the best quality sites. His data are in very close agreement with the range shown in Appendix A for the poor grassy and the good shrubby h.ts.

Pinus ponderosa-Symphoricarpos albus h.t.

Climax vegetation in the *Pinus-Symphoricarpos* h.t. is distinguished by the occurrence of *Pinus ponderosa* as the only coniferous tree. This pine is in combination with an undergrowth dominated by an essentially continuous cover of low deciduous shrubs, usually 0.5-1.0 m tall (fig. 3), among which *Symphoricarpos albus, Rosa woodsii, R. nutkana* and *Spiraea betulifolia* are the chief species. (The ecologies of these shrubs are so similar in the region of study that it is convenient to refer to them collectively as the *Symphoricarpos albus* union.)

Population structures for trees in eight stands are included in appendix A.

A floristically rich assortment of forbs and grasses, mostly perennials, accompanies the dominant shrubs (appendix B-1). With few exceptions, the herbs, like the shrubs, are shared with the contiguous steppe. The *Pinus-Symphoricarpos* Association is essentially like the shrub phase of the *Festuca*

3. Stand 87 representing the *Pinus ponderosa-Symphoricarpos albus* association. The shrub layer is tall enough to hide about 2.5 dm of the stake.

idahoensis-Symphoricarpos albus Association (29) with a tree layer superimposed. Just as shrub patches in the steppe are sometimes dominated by *Prunus virginiana* growing 2 m tall or more, so the undergrowth beneath *Pinus ponderosa* is sometimes dominated by tall populations of this *Prunus*. Judging from the accompanying flora, these stands are probably similar enough in their total ecology to be lumped with the more abundant *Pinus-Symphoricarpos* stands, but none of them has been sampled.

Cooke (15) has provided lists and ecologic information on fungi, lichens, and bryophytes in three stands of *Pinus-Symphoricarpos* forest in the core area. For data on small mammals, see appendix C.

Pinus-Symphoricarpos forest penetrates far into the steppe —virtually across the *Festuca-Symphoricarpos* zone in the south, and well into the *Festuca idahoensis-Artemisia tripartita* zone in the north. *Pinus-Symphoricarpos* forest occurs there either as topographic climaxes on shaded slopes mantled with deep soil, or as edaphic climaxes in trains of frost-riven basaltic rubble exposed by glacial floods or on glacio-fluvial gravel. In the foothills, the association becomes a climatic climax occupying gentle slopes, with *Pinus-Physocarpus* forest on protected slopes and *Festuca-Symphoricarpos* steppe on slopes facing steeply to the south. Farther back into the mountains, *Pinus-Symphoricarpos* stands once more play the role of topographic climax there, being restricted to the warm microclimates of slopes facing steeply southward.

To judge from these topographic relations, the *Pinus-Symphoricarpos* h.t. is moister than the *Festuca-Symphoricarpos* h.t. on the one hand, but drier than the *Pinus-Physocarpus* h.t. on the other. Single-season studies of soil-moisture regimes confirm this interpretation. Daubenmire (29) found that the soil dried to the wilting point in the top decimeter in late June, and by late August the dry zone had extended below the fifth dm. Soil drouth was slightly less severe than in a *Festuca-Symphoricarpos* stand studied comparatively the same summer. In another season, McMinn (61) found that soil moisture depletion to the wilting point started in the upper part of the profile in late July and progressed to the ninth dm by the end of August. This desiccation was earlier than in either the *Pinus-Physocarpus* or *Crataegus-Symphoricarpos* h.ts. These results were consistent among the three stands studied in each h.t. McMinn also found the soil at 2 dm was warmer in the *Pinus-Symphoricarpos* h.t. than in the other two communities through June, July and August.

Where the *Pinus-Symphoricarpos* h.t. occurs in major valleys in the steppe, it follows but part way up the side ravines, with the *Crataegus-Symphoricarpos* h.t. continuing up to the

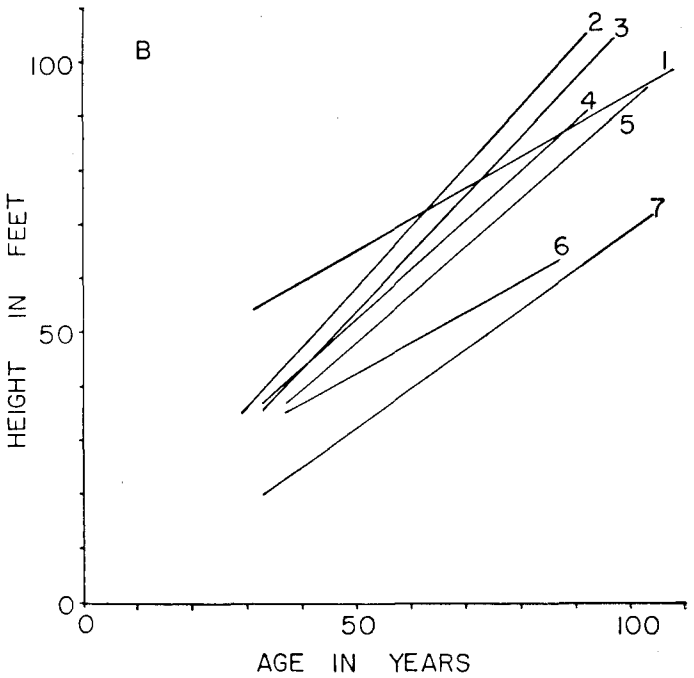
head of these ravines. According to McMinn's data, deficient soil moisture is not the critical factor limiting the pine at this ecotone.

Although south of the glacial border the drier ecotone of the *Pinus-Symphoricarpos* h.t. defines the lower timberline, the tree grows well throughout the moisture range encompassed, the expected height at 50 years being 15.8 m (fig. 4).

On the poorer soils of the glaciated region to the north, the h.t. is not very abundantly represented. There it alternates with the *Pinus-Festuca* (fig. 5) or *Pinus-Agropyron* h.ts.

On relatively dry sites, when the pine is logged off and reinvasion is not prompt, the *Symphoricarpos* union often deteriorates, and the herbaceous component of the undergrowth assumes dominance. In consequence, the h.t. comes to support a vegetation indistinguishable from the *Festuca-Symphoricarpos* Association of the adjacent steppe to the west. The cemetery in Spokane County, Washington that is northeast of Valley Ford and south of California Creek seems to provide a good illustration of this. The long-cleared square is well differentiated from fragments of *Pinus-Symphoricarpos* forest on all sides, and appears identical with the *Festuca-Symphoricarpos* Association.

On relatively moist sites in the *Pinus-Symphoricarpos* h.t., between the time trees are removed and a new forest develops, the tall deciduous shrub *Crataegus douglasii* frequently gets established in numbers. As this plant is highly intolerant of shade, it dwindles as a new generation of pine overtops it, but it can persist for many years in a conspicuously unhealthy condition. Three of the *Pinus-Symphoricarpos* stands sampled (appendix B-1) contained relic *Crataegus* bushes that had invaded in low density after the last fire devastation.



4. Regression analyses of growth rates of *Pinus ponderosa* in seven habitat types in eastern Washington and northern Idaho (27).

1, *Abies grandis-Pachistima;* 2, *Pseudotsuga-Physocarpus;* 3, *Pinus-Physocarpus;* 4, *Pinus-Symphoricarpos;* 5, *Pseudotsuga-Calamagrostis;* 6, *Pinus-Purshia;* 7, *Pinus-Festuca* + *Pinus-Agropyron* + *Pinus-Stipa.*

On the river terrace at Lewis and Clark State Park, in the steppe a few miles west of Dayton, Washington, there is a fine stand of old even-aged pine with a dense *Crataegus* understory that has prevented the pine from reproducing. Either the ages of these trees coincide with some temporary reduction in the density of the shrubbery, or the *Crataegus* and associated shrubs are recent invaders. This reversal of the usual outcome of competition between these species at this place is noteworthy.

All old stands of pine show by charcoal on their bark that they have survived surface fires. Whereas fire will kill small pines, practically all the shrubs and herbs regenerate so quickly from subterranean organs that there is virtually no chance for seral opportunists other than a scattering of *Crataegus* to invade. Within about 2 years, evidence of the fire is not easily seen in the undergrowth.

Essentially all of the undergrowth shrubs and herbs are palatable to livestock. But as the introduced *Poa pratensis* and *P. compressa* are very aggressive and more tolerant of grazing than the native shrubs and herbs, use by livestock converts the undergrowth to a nearly pure stand of *Poa.* The coverage of *Poa pratensis* plus *P. compressa* in a stand is probably a good indicator of the maximum intensity of past grazing pressure to which near-virgin stands have been subjected. Once the *Poas* gain a foothold, cessation of grazing pressure seems only to halt further increase rather than allow the natives to regain exclusive control. Where topography is suitable for cultivation, most of the *Pinus-Symphoricarpos* h.t. has been preempted for agriculture. Elsewhere, most stands have been altered by grazing. The potential for timber production is regularly overlooked.

Comparative data on soil chemistry in appendix D indicate a high level of fertility in the *Pinus-Symphoricarpos* h.t., in comparison with others.

Owing to the high degree of cover of the undergrowth shrubs, and the intricacy of their branching, the long fascicles of pine needles tend to lodge in the canopies of the shrubs. From there they are released so slowly through time that the litter layer tends to have a very diffuse upper boundary, and the footing as one walks across a stand is definitely soft and spongy. Detailed descriptions of soil profiles in three stands (69, 70 and 87) of *Pinus-Symphoricarpos* forest are available. All are Larkin silt loams in the Gray-Brown Podzolic Group and Typic Argixerolls.[5] The profile in stand 69 is:

02 2-1″ Needle and twig litter

01 1-0″ Duff

0-7″ Dark grayish brown (10YR 4/2m) silt loam; slightly compact, moderate medium and coarse platy; slightly sticky, nonplastic, friable, slightly hard; gray siliceous coatings on ped faces; abundant roots; abrupt smooth boundary

A3 & A2 7-14″ Brown (10YR 5/2m) or dark brown (10YR 3/3m) silt loam; mixed moderate, medium, subangular blocky and medium and fine granular; slightly sticky, nonplastic, slightly firm, slightly hard; numerous roots; clear wavy boundary

[5] For explanations of terms used in soil description, see citations 8 and 82.

5. Edge of an island-like patch of *Symphoricarpos albus* union in a slight depression in the same till plain supporting mostly *Pinus-Festuca* forest. Spokane, Washington.

B1 14-20″ Dark grayish brown (10YR 4/2m) silt loam; moderate, medium and fine subangular blocky; sticky, slightly plastic, firm, hard; frequent roots; clear wavy boundary

B21 20-29″ Dark brown (7.5YR 4/2m) silty clay loam; moderate, medium and fine angular blocky; sticky, plastic, firm, hard; conspicuous siliceous coatings on ped faces; occasional roots; clear wavy boundary

B22 29″+ Dark brown (7.5YR 3/2m) silty clay loam; moderate, medium and fine subangular blocky; sticky, plastic, firm, hard; occasional roots (by W. A. Starr)

The soil profile at stand 87 is:

01 3-0″ Needle and twig litter

A11 0-9″ Very dark brown (10YR 2/2m) silt loam; strong medium and coarse granular, and moderate, fine subangular blocky; slightly sticky, nonplastic, friable, slightly hard; abundant roots; clear wavy boundary

A12 9-14″ Very dark grayish brown (10YR 3/2m) silt loam; moderate, medium and coarse granular, and weak, medium and fine subangular blocky; numerous roots; clear, wavy boundary

A13 14-27″ Brown (10YR 4/3m) silt loam; mixed, weak, medium granular, and fine subangular blocky; slightly sticky, nonplastic, friable, slightly hard; numerous roots; clear wavy boundary

A2 27-34″ Pale brown (10YR 6/3m) silt loam; massive; slightly sticky, nonplastic, friable, hard; numerous roots; clear, wavy boundary

A2 & B2 34-37″ Mixed light brownish gray (10YR 6/2m) and dark brown (7.5YR 4/2m) silt loam; moderate, medium and fine subangular blocky; slightly sticky, slightly plastic, slightly firm, hard; occasional roots; clear wavy boundary

B2 & A2 37″+ Mixed very pale brown (10YR 8/3m) and dark brown (7.5YR 4/2m) silty clay loam; strong, medium and fine angular blocky; slightly sticky, plastic, firm, hard; strong, thick, gray, siliceous coatings on ped faces; occasional roots; boundary not determined. (by W. A. Starr)

Another detailed soil profile description for a *Pinus-Symphoricarpos* stand in Benewah (?) County, Idaho, has been published by Hauxwell (42)—his "site 1". In a *Pinus-Symphoricarpos* stand in Ferry County, Washington, the Hoodoo

soil profile studied by W. A. Starr was classified as a Prairie soil, and more recently as a Vitric Haploxeroll.

Vegetation similar to that described in the above ecosystem, some of it probably meriting identical classification, occurs in the foothills of the Cascade Mountains in western Okanogan County, Washington, and in the valleys of western Montana.

Pinus ponderosa-Physocarpus malvaceus h.t.

In the *Pinus ponderosa-Physocarpus* association *P. ponderosa* is the sole coniferous species. Beneath it are two shrub layers. The taller and definitely more obvious one is about 2m in height and is composed chiefly of *Physocarpus malvaceus,* sometimes with large amounts of *Holodiscus discolor* and occasionally some *Ceanothus sanguineus.* This group of indicators will be called the *Physocarpus* union. The lower and less conspicuous shrub layer is the *Symphoricarpos* union. *Purshia* is absent. The h.t. is almost wholly confined to northerly slopes.

The *Physocarpus* union has such high coverage that human progress across a stand is unpleasant, and photography is difficult (fig. 6). The *Symphoricarpos* union beneath is definitely attenuated, probably because two canopies shade it from above; the relatively poor development of the still-lower herb layer is understandable. Among the herbs, *Erythronium* and *Galium boreale* are better represented in the *Pinus-Physocarpus* association than in *Pinus-Symphoricarpos* stands (appendix B-1). *Lithophragma parviflora* and *Lithospermum* are less well represented, and *Collomia linearis* is absent. Thus, qualitative differences are smaller than quantitative differences in the herb layers of these two forests.

6. Edge of stand number 44 representing the *Pinus ponderosa-Physocarpus malvaceus* association. The person is 159 cm tall.

In August, *Physocarpus* leaves turn conspicuously purple so that union can easily be recognized at a distance. Early senescence of these leaves undoubtedly hastens the advent of the season of high fire hazard in h.ts. wherever this union is well represented.

The *Pinus-Physocarpus* h.t. is encountered on northerly slopes at those places along the climatic gradient where the climatic climaxes on surfaces better exposed to sun and wind are the *Festuca-Symphoricarpos, Pinus-Symphoricarpos* or *Pinus-Festuca* associations. As one follows north-facing slopes from the steppe into the mountains, he normally encounters in order, *Pinus-Symphoricarpos, Pinus-Physocarpus* and *Pseudotsuga-Physocarpus* h.ts. Thus one might predict that moisture relations in the *Pinus-Physocarpus* areas will be intermediate between the other two. McMinn's study (61) verified this prediction in part. He showed that although the soil profile dries to below the wilting point to a depth of at least a meter by the end of summer, the inception of drouth is consistently later than in the *Pinus-Symphoricarpos* h.t. However, in the one-summer study of three stands each, he found no consistent differences in the soil moisture relations in *Pinus-Physocarpus* and *Pseudotsuga-Physocarpus* stands.

No one of the chemical attributes of the soil studied shows statistically significant differences between *Pinus-Physocarpus* and *Pinus-Symphoricarpos* h.ts. (Appendix D). However, each nutrient, the pH, the cation exchange capacity, and degree of base saturation all average higher in the former, suggesting a slightly higher level of fertility.

The pine grows in height faster here than in any other h.t. where it is climax; the expected height at 50 years is 16.1 m (fig. 4).

The undergrowth of the h.t. under consideration seems not to differ consistently from that of the *Pseudotsuga-Physocarpus* h.t. Moreover, *Pinus ponderosa* may temporarily invade deforested sites in that h.t. before chance permits the reentry of *Pseudotsuga.* Therefore, identification of sites not supporting *Pseudotsuga* must often rest on their position in relation to the surrounding vegetation mosaic. A *Pinus-Physocarpus* habitat must be on a northerly slope, be bordered on the drier side by *Pinus-Symphoricarpos,* and on the wetter side by *Pseudotsuga-Physocarpus.* In contrast, a *Pseudotsuga-Physocarpus* habitat may be in any topographic position. It is bordered on the drier side by *Pinus-Physocarpus* and on the wetter side by *Abies grandis-Pachistima.*

Northerly slopes well below lower timberline have occasional small stands of *Holodiscus* and/or *Physocarpus* lacking any tree overstory or stumps. These stands are especially abundant about the Blue Mountains and are well exemplified by the upper part of Wawawai Canyon in Whitman County, Washington. They are probably relics of *Pinus-Physocarpus* (or possibly *Pseudotsuga-Physocarpus*) stands that occupied the sites in pre-Hypsithermal time. *Castilleja chromosa,* typically a forest species, occurs with *Holodiscus* in the Wawawai stand. If this interpretation is correct, a small amount of *Holodiscus* must have been the sole woody element of the *Physocarpus* union to survive the peak of heat and dryness. It probably expanded somewhat over more of

the sheltered slopes when the cool-moist trend subsequently set in.

All the woody undergrowth species, at least, regenerate promptly from subterranean organs following fire. Just below the soil surface, large, gnarled woody bases beset with charred stubs bespeak frequent fires endured by shrubs, most of which are older than the large trees that rise above them between holocausts. Among these shrubs, *Physocarpus* is unique for its regular propagation by sprouts rising from shallow roots. There is no special seral vegetation following fire.

Cooke (15) included three stands of *Pinus-Physocarpus* forest in his ecologic study of fungi, lichens and bryophytes in our core area. Data for small mammals are in appendix table C.

The palatability of the dominant *Physocarpus* and *Holodiscus* shrubs is low, but if domestic livestock are forced to graze stands of the association, the shrubs tend to be replaced by a *Poa* sward as in the *Pinus-Symphoricarpus* h.t. Here too, the amount of *Poa* can be taken as a criterion of the maximal intensity of past grazing use. *Ceanothus sanguineus* stems are highly palatable to browsing animals in winter, but *C. sanguineus* is only a minor member of the union as a rule. However, most of the seeds of this plant lie dormant in the soil surface for years, and are stimulated to germinate by heat (35) such as would be provided by a fire. Thus burning tends to increase *C. sanguineus* in the *Physocarpus* union.

Comparative data on soil chemistry (table 1) show that *Pinus-Physocarpus* soils have more humus but are not much more fertile than *Pinus-Symphoricarpos* soils. The lodging of pine needles in the shrub layers (another important factor in fire hazard) is even more conspicuous here than in the *Pinus-Symphoricarpos* forest, so the top of the litter horizon is again diffuse.

The profile at stand 43 is an intergrade between the Palouse-Larkin Series, thus a Prairie-Gray Brown Podzolic intergrade, and is also classified as a Typic Argixeroll:

A11 0-3″ Black (10YR 2/1m) silt loam; moderate medium and fine platy; slightly sticky, nonplastic, friable, soft; abundant roots; clear, wavy boundary

A12 3-9″ Very dark brown (10YR 2/2m) silt loam; moderate, medium and fine subangular blocky; slightly sticky, nonplastic, friable, slightly hard; numerous roots; clear wavy boundary

A13 9-17″ Very dark grayish brown (10YR 3/2m) silt loam; moderate, medium and coarse angular blocky; slightly sticky, nonplastic, friable, slightly hard; numerous roots; clear wavy boundary

A3 17-24″ Dark grayish brown (10YR 4/2m) silt loam; weak, medium and fine subangular blocky; slightly sticky, slightly plastic, friable, slightly hard; numerous roots; clear wavy boundary

B1 & A2 24-32″ Very dark grayish brown (10YR 3/2m) silt loam; moderate, medium and coarse subangular blocky; gray siliceous coatings and organic stains on ped faces; slightly sticky, slightly plastic, friable, hard; frequent roots; clear wavy boundary

B2 & A2 32″+ Dark grayish brown (10YR 4/2m) silty clay loam with 50% stones; moderate, medium and fine angular blocky; sticky, plastic, firm, hard; occasional roots. (by W. A. Starr)

Stand 71 is on a minimal Gray-Brown Podzolic profile:

01 1-3.5″ Pine needles, mostly unfragmented

02 0-1″ Fragmented pine needles

A1 0-3.5″ Dark brown (10YR 3/3d) or very dark brown (10YR 2/2m) silt; weak granular; friable

A3 3.5-7″ Brown to dark brown (10YR 4/3d) or dark brown (10YR 3/3m) silt, with pockets of very pale brown (10YR 7/4d) or brown (10YR 5/3m) material 1/16 to 1/4″ in diameter irregularly distributed in pockets in this and the subjacent horizon; weak subangular blocky

B2 7-18″ Dark yellowish brown (10YR 3/4d) or very dark brown (10YR 2/2m) silt with some tiny black Mn concretions and some basalt fragments; weak blocky; friable to firm

B3 18-22″ Brown to dark brown (10YR 4/3d) or dark brown (10YR 3/4m) silt; massive

C 22-36″+ Dark yellowish brown (10YR 4/4d or 10YR 3/4m) silt; massive (By R. L. Cunningham).

No stands of this association are known to occur outside our core area, and here they are abundantly represented only below the glacial border.

Pinus ponderosa-Festuca idahoensis h.t.

In undisturbed condition the vegetation in *Pinus ponderosa-Festuca* h.ts. includes but the single coniferous tree, with an herbaceous undergrowth in which *Festuca idahoensis* alone is conspicuous (fig. 7). Shrubs occur only as rare accidentals. *Stipa* and *Agropyron* are typically unrepresented.

In an earlier report, Daubenmire (23) grouped all *Pinus ponderosa* stands with xerophytic grasses dominating the herb layer into a "*Pinus ponderosa-Agropyron spicatum* association". Here that unit is subdivided into *Pinus-Festuca idahoensis, Pinus-Agropyron spicatum* and *Pinus-Stipa comata* associations. In places, *Stipa lemmoni, S. thurberiana,* or *Aristida longiseta* represent the large perennial bunchgrass element in essentially pure form. These might be considered as representing still other h.ts. worth recognition, but the total land area involved is quite small. The confinement of all members of the xerophytic grass group to glacial soils or lithosols, the episodic nature of the tree regeneration, the slow rates of tree growth, and the susceptibility of the tree to *Arceuthobium* were all indicated earlier; just those features distinctive to each remain to be indicated.

Physiognomically, all the pine stands with xerophytic grass as the ground cover are essentially identical. The grasses are all caespitose, and have much the same height and phenology. In the glaciated area they tend to alternate in short space. Evidently, either the environmental differences are small or the substrate is quite heterogeneous. Both alternatives seem involved. Among the group, the *Pinus-Festuca* association is the one that can be found on fairly deep, somewhat loamy soils. But where the soil texture is relatively heavy, it tends to have a high content of gravel or stones. For example, in stand 143 where the moisture equivalents of the upper 5 dm are 24.4, 19.8, 18.6, 19.6 and 11.3%, there is considerable gravel in this upper half meter and below is clean sand and gravel. At stand 141 the moisture equivalents are very low (7.5, 7.0, 6.2, 6.4 and

7. Stand 21 representing the *Pinus ponderosa-Festuca idahoensis* association.

7.6% for the same horizons) but the site is a protected northwest-facing slope. In sites that seem to be slightly more moist than those supporting *Pinus-Festuca* stands, the same till may support patches of *Pinus-Symphoricarpos* forest (fig. 5). The latter may be climatic climax, although the much more prevalent *Pinus-Festuca* association at least approaches this status in the Spokane Valley where most of the pine-with-grass complex occurs. Certainly the other pine-with-grass types (*Pinus-Agropyron* and *Pinus-Stipa*) must be interpreted as edaphic climaxes on drier soils.

Earlier studies where the pine-with-grass types were lumped showed a slower growth rate for pine in those h.ts. than in *Pinus-Symphoricarpos* habitats. The expected height at 50 years is 9.5 m (fig. 4).

There may well be subtle differences in rates of tree growth within the group that are correlated with differences in the species of grass dominating.

For data on small mammals trapped in stand 21, see appendix C.

Festuca idahoensis is the most highly palatable grass in any of our *Pinus* forests, and while it can withstand heavy grazing each year after the shoots have matured, it is seldom managed prudently. When improperly used, its place is preempted by weedy species such as *Bromus tectorum, Linaria dalmatica* and *Hypericum perforatum,* and shows no tendency to reclaim the habitat if grazing ceases. A heavy stand of weed-free *Festuca idahoensis* is therefore good evidence that the area has never been overgrazed.

Even light trampling can break up the crust of fine-textured lichens and bryophytes that everywhere seems to have covered the ground between vascular plants, and this allows small annuals to increase (e.g., *Draba, Festuca, Plantago*) or invade (*Agrostis, Bromus, Myosotis*). Probably the summed coverages of these annuals could be considered a guide to aligning stands to reflect varying amounts of trampling disturbance. The margins of trails through *Pinus-Festuca* stands commonly support lines of *Danthonia unispicata,* a native that is otherwise seldom encountered in these forests.

The *Pinus-Agropyron* and *Pinus-Stipa* stands to be discussed next do not show significantly more disturbance-indicators than *Pinus-Festuca* stands, which are certainly not products of heavy grazing. This fact makes it impossible for us to interpret either of the former as grazing disclimaxes, as has been done in other regions.

Three detailed profile descriptions for *Pinus-Festuca* stands are available. Stand 141 is on Marble coarse loamy sand, a Regosol in the Western Brown Forest Soil Zone and an Alfic Xeropsamment. Stand 142, in a swale in dune

topography, is on Marble fine sandy loam, also a regosol in the Western Brown Forest Zone, and now classed as an Alfic Xeropsamment. Stand 143, on an outwash train, is a Hesseltine gravelly silt loam, a Gray Brown Podzolic soil now classed as a Typic Argixeroll. The profile at stand 142 is:

01 ¾-0″ Needle litter and duff
A1 0-5″ Very dark brown (10YR 2/2m) loamy coarse sand; single grained; nonsticky, nonplastic, friable, loose; occasional roots, clear wavy boundary
AC 5-16″ Grayish brown (10YR 5/2m) loamy coarse sand; single grained; nonsticky, nonplastic, friable, loose; occasional roots; clear wavy boundary
C1 16″+ Light brownish gray (10YR 6/2m) loamy coarse sand; single grained; nonsticky, nonplastic, friable, loose; occasional roots. (by W. A. Starr)

The profile at stand 143 is:

01 ½-0″ Litter and duff from pine and grass
02 & A1 0-2″ Dark grayish brown (10YR 4/2d) or very dark brown (10YR 2/2m) loam; single grained; nonsticky, nonplastic, soft; pH 6.5; frequent pieces of charcoal; very abundant roots; abrupt smooth boundary
A2 2-5″ Brown (7.5YR 5/4d) or dark brown (7.5YR 3/2m) silt loam; weak, medium subangular blocky, reducing to very weak fine angular blocky and medium granular; considerable grit and pebbles; pH 6.6; frequent gray coatings on peds; slightly sticky, slightly plastic, friable, soft; plentiful roots, clear wavy boundary
B21 5-11″ Variegated dark reddish gray (5YR 4/2d) and light brown (7.5YR 6/4d) or reddish brown (5YR 4/4m) clay loam with about 15% gravel; moderate, medium and fine angular blocky; moderately sticky, moderately plastic, firm, slightly hard; pH 6.5; frequent roots; gradual irregular boundary
B22 11-17″ Variegated reddish brown (5YR 4/4d) and light brown (7.5YR 6/4d) or dark reddish brown (5YR 4/4m) silty clay loam with about 20% gravel; moderate, medium and fine angular blocky; sticky, plastic, firm, slightly hard; pH 6.3; frequent roots; gradual irregular boundary
II C2 17-21″ Multicolored loamy coarse sand, with appreciable very coarse sand and gravel; pH 6.4; single-grained; nonsticky, nonplastic, friable, loose; gradual irregular boundary
II C2 17″+ Multicolored clean sand and fine gravel, with 50% coarse gravel; pH 6.7; nonsticky, nonplastic, friable, loose. (by W. A. Starr)

The *Pinus ponderosa-Festuca idahoensis* association has been previously reported for central Oregon (32).

Pinus ponderosa-Agropyron spicatum h.t.

In *Pinus ponderosa-Agropyron spicatum* stands that have been relatively undisturbed, *Pinus ponderosa* is the only coniferous tree in the tallest layer. The only conspicuous plant in the understory is the caespitose ecotype of *Agropyron spicatum* (fig. 8). *Festuca idahoensis* and *Stipa* are unrepresented.

The physiognomy and responses to grazing and fire of vegetation in this h.t. are essentially as in the *Pinus-Festuca* h.t.

The *Pinus-Agropyron* h.t. is the only one of the pine-with-grass group that has been positively identified in the Clearwater and Snake River Valleys in the core area. There it is rather extensive on basaltic lithosols and stony colluvium that are well exposed to sun and wind, and there it appears everywhere to have been seriously depleted by overgrazing. It reappears as a somewhat minor component of the mosaic of grassy pine forests of the Spokane River drainage. This h.t. occurs there in basaltic lithosols (e.g., stand 183) or on outwash containing a high proportion of stones (stands 145, 146, 181, 182, 186 and Fig. 8).

Intergrades between *Pinus-Festuca* and *Pinus-Agropyron* are arranged in Appendix B-3 with increasing proportions of *Agropyron* toward the right. Stand 22 is only 200 m from *Pinus-Festuca* stand 21. Both are on Hesseltine gravelly sandy loams, shallow phase, in the Gray Brown Podzolic Zone and are Typic Argixerolls, but the one with an admixture of *Agropyron* is associated with a noticeable reduction in stickiness and plasticity in the B horizon. Apparently, the most important difference between *Pinus-Festuca* and *Pinus-Agropyron* h.ts. involves the moisture holding capacity of the substrate.

The profile of stand 145, a Hesseltine gravelly silt loam, a Gray Brown Podzol and a Typic Argixeroll, is:

01 ½-0″ Litter and duff from pine and grass
02 & A1 0-1″ Gray (10YR 5/1m) or black (10YR 2/1m) silt loam; single grain; nonsticky, nonplastic, friable, soft; pH 6.2, abundant roots; abrupt smooth boundary
A21 1-2″ Light brown (7.5YR 6/4m) or brown (7.5YR 4/2m) silt loam; weak medium and fine granular; slightly sticky, nonplastic, friable, soft; pH 6.6; abundant roots; abrupt smooth boundary
A22 2-5″ Light brown (7.5YR 6/4m) or dark brown (7.5YR 3/2m) silt loam with 15% gravel; mixed single grain and weak fine granular; pH 6.7; slightly sticky, nonplastic, friable, soft; clear wavy boundary
B21 5-12″ Variegated reddish brown (5YR 4/4m) or brown (7.5YR 4/4d) silt loam with 15% gravel; moderate medium and coarse subangular blocky; moderately sticky, moderately plastic, firm, slightly hard; pH 6.6; numerous roots; gradual irregular boundary
B22 12-20″ Variegated dark reddish brown (5YR 3/3d) or brown (7.5YR 4/4d) or dark brown (7.5YR 3/2m) clay loam with 50% gravel; moderate medium and fine angular blocky; sticky, moderately plastic, firm, slightly hard; pH 6.8; numerous roots; gradual irregular boundary
B23 20-22″ Variegated dark reddish brown (5YR 3/3d) or brown (7.5YR 4/4d) or dark brown (7.5YR 3/2m) clay loam containing 55% stone and boulders with considerable grit and gravel; moderate medium and fine angular blocky; sticky, moderately plastic, firm, slightly hard; pH 7.0; numerous roots; gradual irregular boundary
II C1 22-26″ Yellowish brown (10YR 5/4m) gravelly loamy coarse sand; single grain; nonsticky, nonplastic, friable, loose; pH 6.9; no roots; gradual irregular boundary

8. Stand number 182 representing the *Pinus ponderosa Agropyron spicatum* association.

II C2 26″+ Multicolored clean sand with 20% gravel; single grain; nonsticky, nonplastic, friable, loose; pH 7.1; no roots. (by W. A. Starr)

McLean and Holland (60) report a *Pinus ponderosa-Agropyron spicatum* type of forest in the valley about the head of the Columbia River in British Columbia, but give no details of its composition. Brayshaw (8) has recognized a "*Pinus ponderosa-Agropyron spicatum* var. *inerme* & *spicatum* association" in southcentral British Columbia. This unit includes *Festuca idahoensis, Stipa comata* and other species in both genera. Therefore, it is either a different type of community than we have defined under the same name here, or is much more broadly conceived as in the earlier paper by Daubenmire (23).

Mineral County, Montana, has *Pinus ponderosa* forests in which the undergrowth includes *Agropyron spicatum, Festuca idahoensis* and *Festuca scabrella.* In central Montana, from the Continental Divide eastward to Fergus (56) and Stillwater Counties, at least, occur *Pinus ponderosa-Agropyron spicatum* forests in which the minor species of forbs and shrubs are almost totally different from those in the core area. Thus it may prove desirable to recognize one or more distinct phases of the association in Montana.

The U.S. Forest Service (88, 89) has listed a "*Pinus ponderosa-Festuca-Agropyron*" association in the Blue Mountains of Oregon. They state that this category lumps *Pinus-Agropyron* and *Pinus-Festuca* stands together along with intergrades. It is further stated that the *Pinus-Agropyron* stands are found on poorer soils and have thinner tree cover. In both types, *Bromus tectorum* and *Poa secunda* increase with grazing. All these characters closely match the situation in eastern Washington; the principal difference is one of nomenclature.

Pinus ponderosa-Stipa comata h.t.

Stable vegetation in the *Pinus ponderosa-Stipa comata* h.t. consists of an overstory of *P. ponderosa* with *Stipa comata* as the only conspicuous vascular plant beneath (fig. 9). Shrubs are virtually lacking. *Festuca idahoensis* and *Agropyron spicatum* are not represented, and typically only the one species of *Stipa* is present. The soil is invariably sandy.

In the intricate mosaic of pine-with-grass forests in the Spokane Valley, *Pinus-Stipa comata* stands seem second in abundance only to *Pinus-Festuca idahoensis* stands. Forests in which the understory grass is *Stipa comata* (stands 138 & 185 in Appendix B-3), *Stipa thurberiana* (stands 139 and 184), *S. lemmoni, S. elmeri* (stand 140), or *Aristida longiseta* all occur on coarse sands that are moderately to strongly ex-

9. Stand representing the *Pinus ponderosa-Stipa comata* association, near Deep Creek, Washington.

posed to the sun. Only the first of these seems well enough represented in the core area to be recognized as a distinct association.

The coarse soils of the *Pinus-Stipa* h.t. might be expected to be less fertile than the heavier soils of the *Pinus-Festuca* h.t., but the data show no significant differences (appendix D).

One soil profile description is available for *Pinus-Stipa comata* stand 138. This is a Marble loamy very coarse sand, a regosol in the Western Brown Forest Zone, and an Alfic Xeropsamment:

01 0.5-0″ Litter and duff
A1 0-5″ Grayish brown (10YR 5/2d) or dark grayish brown (10YR 3/2m) loamy very coarse sand; single grain; nonsticky, nonplastic, friable, loose; numerous roots; clear wavy boundary
AC 5-13″ Brown (10YR 5/3d or 10YR 4/3m) loamy very coarse sand; single grain; nonsticky, nonplastic, friable, loose; numerous roots, clear wavy boundary
C1 13″+ Very pale brown (10YR 7/4d) or dark yellowish brown (10YR 4/4m) loamy very coarse sand; single grain; nonsticky, nonplastic, friable, loose; occasional roots. (by W. A. Starr)

Stand 139 had a pure stand of *Stipa thurberiana* beneath, and its similarity to the above is worth noting. This was on a Marble loamy coarse sand on the broad crest of an ancient dune. It is classed as a regosol in the Western Brown Forest Zone, and as an Alfic Xeropsamment. It is situated only about 100 m from *Pinus-Festuca* stand 142 which is at the northern base of the dune on Marble fine sandy loam. The profile of the *Stipa thurberiana* stand is:

01 0.5-0″ Litter and duff from grass and pine
A1 0-2″ Gray (10YR 5/1d) or black (10YR 2/1m) loamy coarse sand; single grain; nonsticky, nonplastic, friable, loose; pH 6.7; abundant roots; clear smooth boundary
AC1 2-14″ Light gray (10YR 7/2d) or dark grayish brown (10YR 4/2m) loamy coarse sand; single grain; nonsticky, nonplastic, friable, slightly compact; pH 6.7; frequent roots; clear wavy boundary
AC2 14-21″ Similar to above but with higher percentage of coarse sand and fine gravel; pH 6.8; occasional roots; gradual irregular boundary
C1 21″+ Multicolored very coarse sand and fine gravel; single grain; loose; pH 7.0; no roots. (by W. A. Starr)

Brayshaw (8) has recognized a *"Pinus ponderosa-Stipa*

spp. subassociation" in south-central British Columbia which differs from the *Stipa comata* association in our core area. In addition to *Stipa comata,* his subassociation includes *S. spartea, S. columbianum, S. richardsonii* and *Koeleria cristata,* all listed as being characteristic. It occurs on limey till or detritus fans having high pH, and is interpreted as a grazing disclimax. *Stipa richardsonii* and *S. spartea* certainly reflect the appreciably greater summer rainfall of that area, so that the two ecosystems differ as to flora, climate, soil and stability. The *S. comata* forest in our core area is interpreted as an edaphic climax for reasons given earlier.

Pinus ponderosa-Purshia tridentata h.t.

Stable vegetation in the *Pinus ponderosa-Purshia tridentata* h.t. is distinguished by an overstory of *Pinus ponderosa* with a shrub layer dominated by *Purshia tridentata* beneath. Xerophytic grasses are conspicuous among the herbaceous plants of the third layer.

Species lists for constancy comparisons, using plots 5 x 25 m each, were made in the reconnaissance study reported in 1952. Revisitation of those lightly disturbed stands revealed further deterioration, and no equally good new stands have been found. Therefore, the data so briefly summarized in the earlier report will be presented in full here, as they may be the best ever obtainable.

As in the *Pinus-Symphoricarpos* and *Pinus-Physocarpus* forests, pine seedlings tend to be rather uniformly distributed over a fairly uniform understory in forests of this h.t. However, the tree is here susceptible to *Arceuthobium* infection, and is almost as slow-growing as in the pine h.ts. lacking *Purshia* in the undergrowth; the expected height at 50 years is 13.8 m.

Although a fairly rich shrub flora is represented (appendix B-4), only *Purshia* is abundant. Beneath the *Purshia* layer, xerophytic grasses include *Festuca idahoensis, Agropyron spicatum* (caespitose ecotype), *Stipa comata* and *Aristida longiseta.* Forbs such as *Balsamorhiza sagittata, Fragaria* and *Erigeron compositus* are locally conspicuous in addition. There is good evidence that before the era of grazing, the species of large perennial grasses were often segregated so that different phases could be recognized in eastern Washington. Each was distinguished by the dominance of a single species in this life form.

In the core area, this h.t. has a very limited distribution. From the mouth of the Spokane River it extends eastward up the valley of that river almost to Nine Mile Falls, and extends northward up the Columbia River to a short distance above the town of Gifford. Within this range, the soil of the h.t. is well-drained sandy alluvium or thin stony soil over basalt. It is notable that in eastern Washington this h.t., though definitely not associated with subirrigation, is rather closely confined to a belt following rivers. Alluvial sands and stony soils similar to those supporting *Pinus-Purshia* forest occur over a much broader area in these low valleys.

The high species diversity of the *Pinus-Purshia* forest as compared with the pine-with-grass forests is notable (appendix E), since all are in the same geographic area, and most if not all are edaphic climaxes on sandy or stony soils.

The h.t. is used for grazing, timber production, grain, and orchard fruits. Fire eliminates only the *Purshia,* but the extensive movement of its achenes by rodents and birds ensures its prompt invasion of burned areas.

Pure forests of *Pinus ponderosa* with a conspicuous layer of *Purshia tridentata* beneath are widely distributed in arid parts of west central North America. In northwestern Montana, a few miles northwest of Eureka, we have noted *Pinus-Purshia* vegetation with *Stipa comata, Agropyron spicatum* and *Koeleria cristata* as the chief perennial grasses. McLean and Holland (60) mention *Pinus ponderosa-Purshia* forest about the headwaters of the Columbia River in southeastern British Columbia. In the south-central part of that province Brayshaw (8) has described a phase of the association on coarse sands and gravels of outwash terraces characterized by *Aristida longiseta* as the major perennial grass. Along the foothills of the Cascades from Washington to Oregon (5, 32, 95) and northwestern California (16) other phases of the *Pinus-Purshia* h.t. have been recognized. In the Blue Mountains of Oregon a *"Pinus ponderosa-Purshia tridentata-Carex rossii'* phase has been described (88, 89) on shallow, sandy and stony soils derived from rhyolite. As in Washington, the pine grows slowly in height.

From the above it is clear that there exists a broadly defined *Pinus ponderosa-Purshia tridentata* h.t. This h.t. could be divided into different phases, on the basis of differences in the graminoids, wherever such subdivisions might be useful.

The *Pseudotsuga menziesii* series

Upon entering the mountains from any point about the margin of the steppe and continuing along the gradient of increasing moisture and decreasing temperature, coniferous trees are encountered in a highly predictable order: *Pinus ponderosa, Pseudotsuga menziesii, Larix occidentalis, Pinus contorta, Abies grandis,* etc. The few climatic data from the mountainous regions do not indicate as consistent a change in water balance along this floristic gradient as the regularity of the sequential appearance of tree species and the topographic relations of the ecotones suggest. (See 28 and appendix F.) However, studies of the soil moisture regime (28, 61) have demonstrated remarkably consistent and ecologically significant differences among h.ts. in which *Pinus ponderosa, Pseudotsuga, Abies grandis, Thuja, Tsuga heterophylla* and *Abies lasiocarpa* are climax. In appendix F the relatively cold winters where forests of the *Pseudotsuga* series are climatic climax suggest better conservation of winter precipitation than in the *Pinus ponderosa* forests, although the annual precipitation is no greater in the former.

The pure forests of *Pinus ponderosa* that form the lowest forest belt give way to *Pseudotsuga* as moisture becomes adequate for seedlings of the latter to succeed. Although *Pseudotsuga* seedlings have shorter tap roots (28) and so are more sensitive to drouth, the tree is competitively superior to the pine in places moist enough for seedling establishment. In this second belt of forest, where *Pseudotsuga* is the climax dominant, population structure shows clearly that *Pinus ponderosa, P. contorta* and *Larix occidentalis* can play only the role of seral opportunists that readily invade deforested areas. Whether these invade before *Pseudotsuga* or concurrently depends mainly on which seed sources are available. Once the canopy closes over, only *Pseudotsuga*

can continue reproduction (appendix A). The upper limit of this *Pseudotsuga* belt is set in the same manner by a sufficient increase in moisture for *Abies grandis* seedlings to succeed, since that tree has still greater competitive abilities than *Pseudotsuga.*

The *Pseudotsuga* series embraces three distinctive h.ts. Each is easily recognized when supporting relatively undisturbed vegetation by differences in the dominants of the undergrowth. The distribution of the three seems controlled by differences in soil or in altitude within the area where the moisture regime favors *Pseudotsuga* as the climax dominant.

In the *Pseudotsuga* series it is easier to find stands lacking evidence of logging or grazing than in the *Pinus ponderosa* series. Everywhere but in the *Pseudotsuga-Calamagrostis* h.t., *Poa pratensis* and *Poa compressa* are the most reliable indicators of the heaviest grazing to which the stands have been subjected.

Pseudotsuga menziesii-Symphoricarpos albus h.t.

The *Pseudotsuga menziesii-Symphoricarpos* association is recognized by an overstory consisting entirely of *Pseudotsuga menziesii* and an undergrowth in which *Symphoricarpos albus, Spiraea betulifolia, Rosa woodsii* and *R. nutkana* (i.e., the *Symphoricarpos albus* union), singly or collectively, determine its physiognomy. *Physocarpus, Holodiscus* and *Ceanothus* are absent, and *Calamagrostis rubescens,* if present, is seldom well represented.

In *Pseudotsuga-Symphoricarpos* stands the shrubs are near the lower end of their size range under forest conditions, and this together with their sparsity provides a general aspect of impoverishment. Species diversity is also conspicuously reduced here in comparison with surrounding h.ts. (appendix E).

Chemical properties of the soils (appendix D) tend to differ between *Pseudotsuga-Symphoricarpos* and *Pseudotsuga-Physocarpus* h.ts., as between *Pinus-Symphoricarpos* and *Pinus-Physocarpus* h.ts., in that they suggest a slightly higher general level of fertility associated with the *Physocarpus* union. However, the disparity is still weaker here in the higher series. With chemical analyses offering little to explain the environmental difference between the *Pseudotsuga-Symphoricarpos* and *Pseudotsuga-Physocarpus* h.ts., a moisture difference might be sought. Yet the presence of *Pseudotsuga* suggests that at some season at least, moisture relations must be better here than in the *Pinus-Physocarpus* h.t. where *Physocarpus* grows luxuriantly yet *Pseudotsuga* cannot survive! Three miles westsouthwest of Garfield, Washington, a well-defined belt of *Pseudotsuga-Symphoricarpos* forest occurs between belts of *Pseudotsuga-Physocarpus* and *Pinus-Symphoricarpos,* suggesting intermediacy of moisture relations.

The altitudes of the *Pseudotsuga-Symphoricarpos* and *Pseudotsuga-Physocarpus* stands studied suggest an altitude difference in the two associations. This is more apparent than real, for we have seen stands of the former above the 506-716 m range (appendix B-5) and of the latter below the 630-1110 m range.

Seral trees on this h.t. appear to include only *Pinus ponderosa* and *Larix occidentalis* (appendix A-4). Grazing again favors *Poa pratensis* and *P. compressa.*

One soil profile description is available for a stand of *Pseudotsuga-Symphoricarpos* in Ferry County, Washington, which was not sampled. This was a Ryan silt loam in the Prairie Great Soil Group, now classified as a Mollic Vitrandept:

A11 0-7″ Very dark brown (10YR 2/2d) or black (10YR 2/1m) silt loam with 5% gravel; moderate medium and coarse angular blocky, medium platy near the surface; compact, slightly sticky, slightly plastic, slightly firm, slightly hard; abundant roots; smooth boundary

A12 7-13″ Very dark brown (10YR 2/2d) or black (10 YR 2/1m) silt load with 10% angular gravel; strong coarse granular and fine angular blocky; slightly sticky, slightly plastic, slightly firm, slightly hard; abundant roots; clear wavy boundary

A13 13-18″ Very dark gray (10YR 3/1d) or very dark brown (10YR 2/2m) silt loam with 10% angular gravel; strong medium and fine angular blocky; sticky, plastic, firm, hard; numerous roots; clear wavy boundary

B1 18-23″ Yellowish brown (10YR 5/4d) or dark yellowish brown (10YR 3/4m) gravelly clay loam with 15% angular gravel; strong medium and fine subangular blocky; sticky, plastic, firm, hard; frequent roots; clear wavy boundary

$B2_t$ 23-30″ Light yellowish brown (10YR 6/4d) or dark yellowish brown (10YR 4/4m) gravelly clay loam with 20% angular gravel; sticky, plastic, very firm, very hard; occasional roots; abrupt wavy boundary

$B2_{tca}$ 30-33″ Very pale brown (10YR 8/2d) or pale brown (10YR 6/2m) gravelly clay loam with 25% gravel; strong medium and fine subangular blocky; sticky, plastic, firm, hard; calcareous; occasional roots; abrupt wavy boundary

$B3_{ca}$ 33″+ Very pale brown (10YR 7/3d) or brown (10YR 5/3m) gravelly loam with 25% gravel; moderate medium and fine angular blocky; slightly sticky, slightly plastic, firm, hard; occasional roots; calcareous. (by W. A. Starr)

The *Pseudotsuga-Symphoricarpos* association has been reported in the valley about the headwaters of the Columbia River in British Columbia (60) as well as in the south central part of that province (8). Brayshaw lists as characteristic species *Symphoricarpos albus, Prunus virginiana, Crataegus douglasii, Acer glabrum, Berberis aquifolium, Spiraea betulifolia, Aster conspicuus* and *Salix bebbiana.* What he considers a geographic phase of this association characterized by the addition of *Physocarpus malvaceus* and *Clematis columbianum* may better be interpreted as an outlier of our *Pseudotsuga-Physocarpus* association, which is otherwise unrepresented in his area.

In the Crowsnest Pass area of Alberta, Ogilvie (67) has described a *Pseudotsuga menziesii-Symphoricarpos albus* association. He listed as the principal shrubs *Symphoricarpos albus, Spiraea betulifolia, Rosa acicularis, Amelanchier alnifolia* and *Prunus virginiana.* Typically, the herb layer there is dominated by *Arnica cordifolia, Aster ciliolatus, A. conspicuus, Smilacina racemosa, Disporum trachycarpum, Thallictrum occidentale, Osmorhiza chilense, Lathyrus ochroleucus* and *Erythronium grandiflorum.* This unit seems to correlate very closely with our Washington material.

We have seen stands that appear essentially identical to those of our core area as far west as the Cascade foothills in western Okanogan County, Washington, and as far east as Montana (Chouteau, Flathead, Judith Basin and Gallatin Counties). Others that represent at least a phase of the same association are as far south as the Wind River Mountains in west central Wyoming.

Pseudotsuga menziesii-Physocarpus malvaceus h.t.

The *Pseudotsuga menziesii-Physocarpus malvaceus* association is distinguished by a tree stratum composed entirely of *Pseudotsuga menziesii* at climax, with a shrub layer consisting chiefly of *Physocarpus malvaceus* and *Holodiscus discolor* in varying proportions (the Physocarpus union).

Previously it was pointed out that the *Pinus-Physocarpus* and *Pseudotsuga-Physocarpus* stands differ clearly in tree species, in positions in the vegetation mosaic that suggest a higher moisture status for the *Pseudotsuga* h.t., and in the confinement of the *Pinus-Physocarpus* h.t. to northerly slopes. In contrast, the *Pseudotsuga-Physocarpus* can be found on all exposures. At its lower limits the latter is invariably on northerly slopes that provide compensation for low rainfall. With higher rainfall it moves onto gentle slopes facing all directions (typically with the *Pinus-Symphoricarpos* h.t. on steep south-facing slopes and *Abies grandis-Pachistima* on the steep north-facing slopes). Still higher in the mountains, it becomes confined to slopes facing steeply to the south (figs. 10, 11), with all other topography pre-empted by forests with dominants that are competitively superior, such as *Abies grandis, Thuja plicata* or *Tsuga heterophylla.*

The *Physocarpus* union typically has less coverage and lower stature in the *Pseudotsuga-Physocarpus* than in the *Pinus-Physocarpus* forest at climax (fig. 10,11; Appendix B-5 and B-2). Also, that point on the moisture scale which so abruptly tips the balance in favor of *Pseudotsuga* is reflected in the subordinate vegetation, but less absolutely. *Rosa woodsii* and *R. nutkana* occur less regularly in the stands. Among the herbs are fewer of certain species (*Achillea, Besseya, Erythronium, Galium boreale, Veratrum speciosum* and *Vicia americana*), but an increase in others (*Arenaria, Arnica, Disporum* spp., *Mitella* and *Smilacina stellata*). In this association the herbaceous vegetation is at the peak of its development between about May 25 and June 10.

Data on fungi, lichens and bryophytes in three stands of *Pseudotsuga-Physocarpus* forest have been provided by Cooke (15). The results of mammal trapping are summarized in appendix table C.

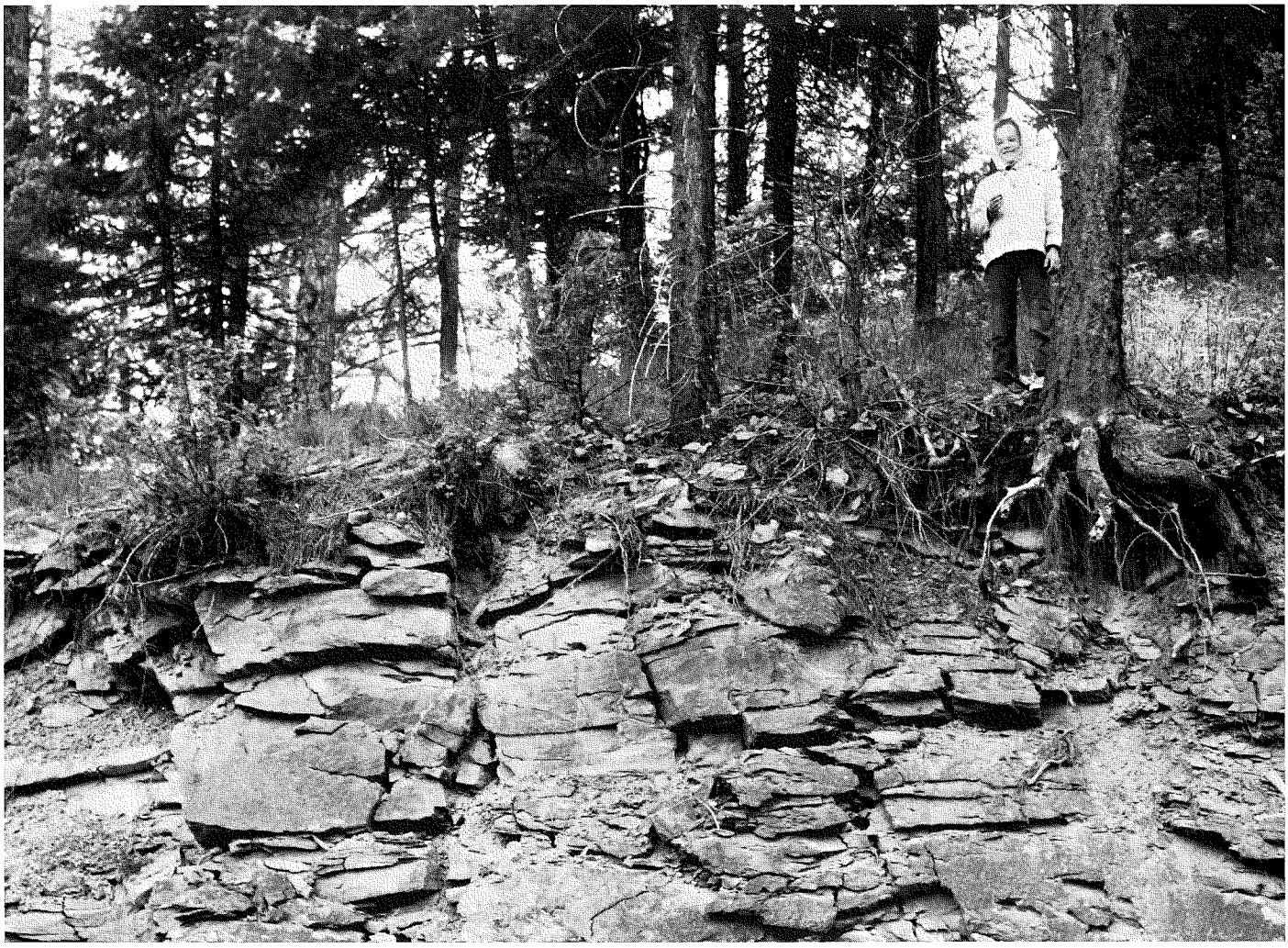
Heavy grazing by livestock converts this vegetation into a *Poa pratensis-P. compressa* disclimax. When burned, the shrubs all regenerate promptly from underground organs, and *Pseudotsuga* and the seral trees slowly invade in any order or combination up to the time of canopy closure, when further reproduction of all but the *Pseudotsuga* is precluded. *Crataegus douglasii* often invades in small numbers during the deforested period. *Pinus ponderosa* grows faster here than in the drier climates where it is climax. The expected height at 50 years is 17.1 m (fig. 4). *Larix occidentalis,* here at its lower altitude limits, grows relatively slowly; the expected height at 50 years is 19.0 m (table 1).

In pointing out the significance of deforested intervals for providing shrubs that are used by deer in winter, Pengelly (69, 70) presented some data on the seral roles of the shrub component of vegetation on *Pseudotsuga-Physocarpus* habitats in Kootenai County, Idaho (table 2). After logging, the residual shrub cover increases markedly, then declines as the new forest develops. A return to climax conditions in the shrub layer is estimated to require only 60-80 years after logging. During the period of expansion following tree harvest, *Holodiscus* grew to a height of 15 ft and *Ceanothus*

10. *Pseudotsuga menziesii-Physocarpus malvaceus* forest in the Priest River Experimental Forest near stand 150. In contrast with *Pinus-Physocarpus* forests (see fig. 6), *Physocarpus* may be reduced to a scattering of stunted bushes as a *Pseudotsuga-Physocarpus* stand matures. Physocarpus coverage in stand 150 was 7%.

Table 1. Mean height of *Larix occidentalis* at 50 years age in the northern Rocky Mountains. Data from Roe (75).

Habitat type	Height, meters	Confidence interval (P=0.99)
Abies lasiocarpa-Xerophyllum	15	± .635
Abies lasiocarpa-Pachistima	17.8	± .78
Tsuga heterophylla-Pachistima *Thuja plicata-Pachistima* *Abies grandis-Pachistima*	20.2	± .41
Pseudotsuga menziesii-Calamagrostis	16	± .45
Pseudotsuga-Physocarpus	18.9	±1.36



11. Road cut through *Pseudotsuga-Physocarpus* forest near stand 105, showing shallowness of soil associated with this h.t. where it occurs at its highest altitudes on southerly slopes. Priest River Experimental Forest, Idaho.

sanguineus to 12 ft, which is more than twice their normal stature in the forest. *Ceanothus velutinus* locally invades in quantity in this h.t. as well as in h.ts. in the *Pinus ponderosa* and *Tsuga* series, where fires come often (fig. 12).

Pinus ponderosa and *Larix occidentalis* are normally the only seral trees. The former is the more frequent in this role (appendix A-5). Seedlings of *Abies grandis* or *Tsuga heterophylla* may appear occasionally in the *Pseudotsuga-Physocarpus* h.t. if seed sources are abundant nearby. These are nearly always short-lived, presumably because the soil dries to a considerable depth each year.

Soils of this habitat vary from basaltic talus (mainly where confined to northerly slopes in dry climates) to deep loess with volcanic ash (at mid-altitudes where the *Pseudotsuga-Physocarpus* association is climatic climax), to thin residual soil over granitic or sedimentary rocks (on southerly slopes at high altitude; fig. 11). Fertility levels in all the stands tested proved to be quite high (appendix D). Indeed, much of the habitat where the association is climatic climax is cropped, producing barley, clover seed, strawberries, etc.

Two profile descriptions have been prepared. Stand 92, south of the glacial border, is on Spiegel silt loam, classified as a Prairie or a Typic Haploxeroll. The colluvial soil of this slope has been subject to slow movement at various times in the past.

01 ½-0″ Needle litter and duff

A1 0-3 Very dark grayish brown (10YR 3/2m) silt loam;

Table 2. Average percent "ground cover" of shrubs in groups of sites of varying ages since logging in the *Pseudotsuga-Physocarpus* h.t. in Kootenai County, Idaho. Data from Pengelly (69, 70).

Years since logging	13	20	26	40+
No. of sites averaged	2	4	1	3
Amelanchier alnifolia	6.5	2.7	0	5.6
Ceanothus sanguineus	18.4	2.9	4.3	3.3
Holodiscus discolor	21.4	26.8	48.0	8.0
Physocarpus malvaceus	2.1	12.9	5.3	4.3
Prunus virginiana	2.6	1.9	1.1	3.0
Symphoricarpos albus	18.4	12.5	5.1	8.8
Other species	17.5	13.4	10.6	8.0
Totals	86.9	73.1	74.4	41.0

12. *Pinus ponderosa* and *P. contorta* with *Ceanothus velutinus* on repeatedly burned *Pseudotsuga-Physocarpus* h.t. in the St. Regis Valley, Mineral County, Montana.

moderate, medium and fine granular; slightly sticky, slightly plastic, friable, slightly hard; abundant roots; clear wavy boundary

A3 & A2 3-7″ Dark grayish brown (10YR 4/2m) silt loam; mixed, moderate medium granular, and weak fine angular blocky; slightly sticky, slightly plastic, friable, slightly hard; numerous roots; streaks and seams of siliceous gray coatings throughout the mass; clear wavy boundary

B1 & A2 7-16″ Mixed matrix grayish brown (10YR 5/2 m) silt loam; moderate fine angular blocky; gray siliceous coatings on ped faces; slightly sticky, slightly plastic, friable, slightly hard; numerous roots, clear wavy boundary

B1 16-24″ Grayish brown (10YR 5/2d) or dark brown (7.5YR 4/2m) silt loam; weak fine angular blocky; slightly sticky, slightly plastic, firm, slightly hard; frequent roots; clear wavy boundary

B2 24-30″ Dark brown (10YR 4/2m) silty clay loam; moderate fine angular blocky; sticky, plastic, firm, hard; frequent roots; clear wavy boundary

B3 30″+ Dark brown (10YR 4/2m) silty clay loam; strong medium angular blocky; sticky, plastic, firm, hard; 25% stones; occasional roots. (by W. A. Starr)

Stand 107 in the glaciated region is on Skiffington loamy fine sand, a regosol in the Gray Wooded Zone, and a Typic Xerochrept:

01 ¼-0″ Litter

A21 0-7″ Light brownish gray (10YR 6/2d) or grayish brown (10YR 5/2d) mottled, or very dark gray (10YR 3/1m) gravelly fine sandy loam with 20% gravel; weak medium and coarse granular, with some tendency to very weak medium subangular blocky; nonsticky, nonplastic, friable, soft; pH 7.0; abundant roots; clear wavy boundary

A22 7-16″ Grayish brown (10YR 5/2d) or dark brown (10YR 4/2m) gravelly fine sandy loam; weak medium and fine subangular blocky; nonsticky, nonplastic, friable, soft; 20% gravel and very occasional stone; pH 6.5; numerous roots; clear wavy boundary

A23 16-23″ Pale brown (10YR 6/3d) or dark brown (10YR 4/3m) gravelly sandy loam with 20% gravel

and occasional stone; 40% mottles of brown (7.5YR 4/4d); weak medium and coarse subangular blocky; nonsticky, nonplastic, firm, slightly hard; pH 6.0; occasional roots; abrupt smooth boundary

A24-B22 23-40″ Mottled brown (7.5YR 4/2d) and grayish brown (10YR 5/2d) or dark brown (10YR 3/3m) gravelly fine sandy loam with 30% gravel and occasional stone; massive; nonsticky, nonplastic, firm, very hard; occasional roots; pH 6.5; clear wavy boundary

A25-B23 40-53″ Grayish brown (10YR 5/2d) or dark grayish brown (10YR 4/2m) gravelly loam with 20% gravel; 10% mottles of brown (7.5YR 4/2d); massive; nonsticky, nonplastic, firm, hard; occasional roots; pH 6.5; clear irregular boundary

B24 53″+ Dark brownish gray (10YR 4/2m) gravelly sandy clay loam with 20% gravel and 20% stone; massive; sticky, moderately plastic, firm, slightly hard; no roots, pH 7.0. (by W. A. Starr)

In another *Pseudotsuga-Physocarpus* stand that we examined in Ferry County, Washington, the soil profile had been classified by W. A. Starr as a Chernozem, the Molson Series, now classified as a Mollic Vitrandept. Hauxwell (42) has published a detailed description of the soil profiles in two seral forests in the *Pseudotsuga-Physocarpus* h.t. in Benewah (?) County, Idaho, his sites 2 and 3.

The *Pseudotsuga-Physocarpus* h.t. occurs throughout our core area but appears to have very little representation to the north in British Columbia. We have noted it also in Wallowa County, Oregon, near Payette Lakes, Idaho, and in Mineral, Ravalli and Sanders counties in western Montana.

Pseudotsuga menziesii-Calamagrostis rubescens h.t.

Climax stands of the *Pseudotsuga menziesii-Calamagrostis rubescens* association include no coniferous trees other than the *Pseudotsuga,* and have an undergrowth that is an essentially shrub-free sward dominated outstandingly by *Calamagrostis rubescens* (fig. 13).

A brilliant green sward, the uniformity of which is enhanced by the notable lack of inflorescences and uniform spacing of grass tillers, makes this h.t. easily recognizable from a distance. *Carex concinnoides* and *C. geyeri* are often codominants. The forb with the best representation is *Arnica cordifolia,* a species that is also the most characteristic forb of the *Pseudotsuga-Physocarpus* h.t.

The *Pseudotsuga-Calamagrostis* h.t. is the high-altitude representative of the *Pseudotsuga* series. The highest stand

13. *Pseudotsuga menziesii-Calamagrostis rubescens* stand 66. This stand was clear-cut shortly after it was analyzed.

of either of the other two associations was 1110 m above sea level. The range of the 15 *Pseudotsuga-Calamagrostis* stands was 1163-1875 m. Apparently this h.t. occurs where dryness extends relatively far up the gradient of decreasing temperature. At the cold-wet ecotone of the h.t. the contact is commonly with an *Abies lasiocarpa* h.t., without any member of the *Tsuga heterophylla* series intervening. The *Abies lasiocarpa* seedlings in stands 109 and 148 reflect constant invasion pressure from contiguous populations of that tree. Stand 114 is on a mesa next to a steep northerly slope supporting an *Abies grandis* climax, and accidentals of *Abies* in two sizes occurred in the *Pseudotsuga* h.t.

If species diversity can be considered a criterion of the general favorableness of a h.t., the *Pseudotsuga-Physocarpus* with a median of 28 spp./5m^2 is the most favorable environment in the *Pseudotsuga* series, with *Pseudotsuga-Symphoricarpos* intermediate (22 spp.) and *Pseudotsuga-Calamagrostis* least favorable (19 spp.). On the other hand, if basal area is any criterion, this h.t. is the most productive of the three (appendix H).

This is the only member of the *Pseudotsuga* series in which *Pachistima* occurs rather commonly.

Under a forest canopy, *Calamagrostis* populations maintain themselves by means of a rhizome system, with the grass rarely flowering. Following fire, however, inflorescences appear in quantity (93).

Seral trees (appendix A) include *Larix occidentalis, Pinus contorta* and *P. ponderosa.* Fires have been so extensive in this h.t., especially in south-central British Columbia (87) that climax stands of the association are rare. The most frequent cover type in the h.t. consists of *Pinus contorta* or *P. ponderosa* with an understory of *Calamagrostis.*

In south-central Idaho, *Ceanothus velutinus, Iliamna rivularis,* and *Moldavica parviflora* dominated the early stages of succession on a burned area belonging to this h.t. (55). All apparently developed from dormant seeds buried in the soil before the fire.

For the results of trapping for small mammals, see appendix C.

Calamagrostis rubescens is generally considered of low palatability to livestock, but locally at least it is well used. Perhaps the problem is mainly one of inappropriate herd management (59). A notable feature of the response of this vegetation to grazing is the failure of *Poa* spp. to invade.

In the core area, the lower limits of the h.t. are reached on coarse-textured outwash. Here the association intergrades with the two low-altitude members of the series, as in the valley system from approximately Newport, Washington, to Sandpoint and Bonner's Ferry, Idaho.

There is a statistically significant drop in soil pH from the *Pseudotsuga-Physocarpus* to the *Pseudotsuga-Calamagrostis* h.ts. (appendix D). Bases, the percent base saturation, and the cation exchange capacity tend to be reduced as well, all of which reflect a lower level of fertility.

A profile description is available for stand 111, which is on Merkle sandy loam in the Brown Podzolic Zone, and a Typic Xerochrept:

01 1-0″ Litter and duff

A21 0-0.5″ Discontinuous ashy bleicherde

$B21_{(ir)}$ 0.5-22″ Light brownish gray (10YR 6/2d) or grayish brown (10YR 5/2m) sandy loam with frequent boulders and stones; weak medium and fine granular; nonsticky, nonplastic, friable, soft; pH 6.2; numerous roots; abrupt wavy boundary

A22-B22 22-31″ Light gray (10YR 7/2d) or light brownish gray (10YR 6/2m) sandy loam, very stony; bands of brown (10YR 5/3d) and yellowish brown (10YR 5/4m); massive; slightly sticky, nonplastic, very firm, very hard; pH 5.7; intense bands 1-2" apart, ⅛-¼″ thick, 6-8 in number, in horizon; clear wavy boundary

A23-B23 31-47″ Light gray (10YR 7/2d) or brown (10YR 5/3m) sandy loam with frequent stones; massive; slightly sticky, nonplastic, firm, slightly hard; pH 6.8; 10-12 definite bands throughout horizon, 4-6″ apart, sharply undulating; frequent roots; clear irregular boundary

A24-B24 47″+ Light brownish gray (2.5Y 6/2m) sandy loam with frequent stones and boulders; mottles of light olive brown (2.5Y 5/4m) and spots of brown (10YR 5/3m); massive; firm, slightly hard; pH 6.8; very occasional roots. (by W. A. Starr)

Another stand, inspected but not sampled, was on a Skiffington gravelly fine sandy loam in the Gray Wooded Great Soil Group, and now classified as a Typic Xerochrept, in Ferry County, Washington.

01 1-0″ Litter and duff

A11 0-7″ Light brownish gray (10YR 6/2d) and grayish brown (10YR 5/2d) mottled, or very dark gray (10YR 3/1m) gravelly fine sandy loam with 20% gravel; weak medium and coarse granular, with some tendency to very weak medium subangular blocky; nonsticky, nonplastic, friable, soft; pH 7.0; abundant roots; clear wavy boundary

A12 7-16″ Grayish brown (10YR 5/2d) or dark brown (10YR 4/2m) gravelly fine sandy loam with 30% gravel and very occasional stone; weak medium and fine subangular blocky; nonsticky, nonplastic, friable, soft; pH 6.5; numerous roots; clear wavy boundary

AC 16-23″ Pale brown (10YR 6/3d) or dark brown (10YR 4/3m) gravelly sandy loam with 40% mottles of brown (7.5YR 4/4d), 30% gravel and occasional stone; weak medium and coarse subangular blocky; nonsticky, nonplastic, firm, slightly hard; pH 6.0; occasional roots; abrupt smooth boundary

IIC1 23-40″ Mottled brown (7.5YR 4/2d) and grayish brown (10YR 5/2d) or dark brown (10YR 3/3m) very gravelly loamy coarse sand, with 55% gravel and occasional stone; massive; nonsticky, nonplastic, firm, very hard; pH 6.5; occasional roots; clear wavy boundary

IIC2 40-53″ Grayish brown (10YR 5/d) or dark grayish brown (10YR 4/2m) gravelly sandy loam with 10% mottles of brown (7.5YR 4/2d), 55% gravel; massive; nonsticky, nonplastic, firm, hard; pH 6.5; occasional roots; clear irregular boundary

IIC3 53″+ Dark brownish gray (10YR 4/2m) very gravelly sandy loam with 55% gravel and 20% stone; massive; sticky, moderately plastic, firm, slightly hard; pH 7.0. (by W. A. Starr)

The *Pseudotsuga-Calamagrostis* h.t. has been recognized by several workers in southern British Columbia (8, 47, 87). We have noted its occurrence from Montana to Grand Teton National Park, Wyoming, to the Sawtooth Mountains west of Stanley, Idaho to the Wallowa Mountains of Oregon and the eastern foothills of the Cascade Mountains in Washington. In the Blue Mountains of central Oregon a "Conifer-*Calamagrostis* only" type correlates. There it is recognized that extensive and repeated burning in the past has in places eliminated sources of *Pseudotsuga* seed, allowing *Pinus ponderosa* to retain dominance with the typical *Calamagrostis* union beneath (88).

The *"Calamagrostis-Vaccinium scoparium* site type" of Illingsworth and Arlidge (47) contains *Abies lasiocarpa* as well as *Pseudotsuga.* Such vegetation in our core area has been interpreted as ecotonal between one of the *Abies lasiocarpa* h.ts. and the *Pseudotsuga-Calamagrostis* h.t., since this is the usual position of the type.

Arctostaphylos uva-ursi phase

A significant number of students of forest vegetation in areas surrounding our core area have not only recognized a *Pseudotsuga-Calamagrostis* unit, but have also seen fit to recognize a segregate of this in which the trailing evergreen shrub *Arctostaphylos uva-ursi* is the major indicator species.

In south-central British Columbia Brayshaw (8), for example, has recognized both a *Pseudotsuga menziesii-Calamagrostis rubescens* and a *Pseudotsuga menziesii-Arctostaphylos uva-ursi-Calamagrostis rubescens* association. The former completely lacks the *Arctostaphylos* and occurs on heavier textured soils.

In the same region Illingsworth & Arlidge (47) describe a *"Calamagrostis Arctostaphylos* site type" in which the *Calamagrostis* dominates. *Arctostaphylos* is abundant, even if only of secondary status. They interpret this segment as being distinctly more xerophytic than the *Calamagrostis* type of forest undergrowth which lacks *Arctostaphylos.*

Ogilvie (67) has described a *"Pseudotsuga menziesii-Calamagrostis rubescens* association" on coarse, podzolized glaciofluvial materials near Banff, Alberta. Since his unit includes both *Arctostaphylos* and *Vaccinium caespitosum,* it correlates well with the segregate in British Columbia where *Vaccinium* spp. enter the community in its upper altitudinal range (8). Ogilvie's *"Pseudotsuga menziesii-Calamagrostis rubescens-Lupinus sericeus"* association also includes *Arctostaphylos,* but this represents a distinctive ecosystem that is replete with plants of steppe affinity (*Festuca idahoensis, Lupinus sericeus, Balsamorhiza sagittata, Collinsia parviflora,* etc.). We can identify a similar unit with a fringe about our dry subalpine parks in the core area, but here it lacks enough representation to merit much attention.

In central Oregon a "Conifer-*Calamagrostis*-shrub type" is differentiated from a "Conifer-*Calamagrostis*-grass only type" on the basis of the presence of *Arctostaphylos uva-ursi, Spiraea betulifolia* and *Symphoricarpos albus* (88). It is stated that when overgrazed, the grass component is eliminated and the shrubs become dominant.

A segregate of *Pseudotsuga-Calamagrostis* forests defined botanically by the presence of *Arctostaphylos uva-ursi* can also be recognized in four of our stands (numbers 111, 112, 113 and 116 in Appendix B-7). All of them are close to the Canadian border. These occurrences of *Arctostaphylos* are also positively correlated with abnormal amounts of *Fragaria* and with the appearance of one or more species of *Vaccinium.* Further distinctiveness is afforded by the absence of *Carex geyeri, Erythronium, Berberis repens* and *Osmorhiza.*

Since the most consistent common denominator of the units scattered over the three states and two provinces is *Arctostaphylos,* we propose that the unit be referred to as the *Arctostaphylos uva-ursi* phase of the *Pseudotsuga menziesii-Calamagrostis rubescens* association.

The Tsuga heterophylla series

In forests of the foothills, soil drouth is severely limiting for mesophytes. At the opposite end of the climatic gradient where soil profiles remain moist throughout summer, inadequate heat imposes floristic limitations of a very different nature. At intermediate altitudes both extremes are mitigated, and there is a distinctive and floristically rich forest belt which is treated here as the *Tsuga* series.

Daubenmire (25) compared weather data from stations in the *Pseudotsuga* series and in the *Tsuga* series. Precipitation was consistently higher from June through September in the *Tsuga* series. Thornthwaite's moisture index values were consistently higher in July through October. Other climatic data representing only stations in the core area (appendix F) also show a distinctively higher rainfall and greater water surplus in the *Tsuga* series weather stations. On the other hand, at the upper limit of this series the ecotone cannot be correlated with any aspect of moisture. Here, summers are consistently warmer in the *Tsuga* than in the *Abies lasiocarpa* series.

More directly pertinent are the results of studies of soil moisture depletion in summer. Soils in the *Pseudotsuga* series dry to the wilting point to a considerable depth each summer. In contrast, soil drouth in the *Tsuga heterophylla* (and *Abies lasiocarpa*) series involves only the top few centimeters of the profile, except at intermediate stages of succession when the stands become too dense. The virtual disappearance of undergrowth shrubs and herbs during this stage may reflect dryness as much as deficient illumination.

Three species of trees in the *Tsuga* series show by their population structures an ability to continue reproduction in the face of severe competition. But all have distinctive autecologies, so usually only one is the climax dominant in any one h.t. Where they occur together in unstable mixtures, their competitive efficiency rating is *Tsuga heterophylla* (highest), *Thuja plicata* (intermediate) and *Abies grandis* (lowest).

Until population analyses were made, the slow decline of *Thuja* (and *Abies*) in habitats amenable to *Tsuga* was not detected, and a *"Thuja-Tsuga-Pachistima"* association was recognized (23). Similarly, earlier writers had recognized a "cedar-hemlock type" because of the very large individuals of *Thuja* that are usually found on sites where only the *Tsuga* shows clear evidence of maintaining its population. In habitats slightly too dry for *Tsuga, Thuja* slowly eliminates *Abies grandis,* this *Abies* finding freedom from displacement only in environments still drier.

On the basis of undergrowth differences, the habitats

where *Thuja* is a climax dominant can be divided into three clearly distinct h.ts. differentiated by either soil aeration or by macroclimate. No ecologically sound basis has been found that would warrant subdivision of upland forests where either *Tsuga heterophylla* or *Abies grandis* are the climax dominants.

Of the three upland habitats in the series (table 3), the one in which *Abies* is the climax dominant is the warmest and driest. The one with *Tsuga* as the climax dominant is coolest and wettest.

The reconnaissance study recognized a *"Pachistima myrsinites* union" that is well developed in all forests of the *Tsuga* series (and the lowest member of the *Abies lasiocarpa* series). This is a floristically rich and morphologically diverse mixture of perennial herbs, no one of which dominates. It varies considerably in composition among the six habitats in which it is found without showing discontinuities correlated with differences in the self-reproducing character of the trees. The present study has but reaffirmed the failure of this important and wide-spread sociologic unit to contribute much to the list of characters distinguishing ecosystems of well-drained soils of the mid-mountain slopes. However, the poorly-drained soils at the same altitudes are clearly differentiated from the uplands, and from each other, by the dominance of *Oplopanax* or *Athyrium.*

Reconnaissance in other parts of the Rockies as well as along the Pacific coast has shown that the *Pachistima* union occurs over a wide geographic range. Although its expression is variable, the union always indicates relatively moist upland environment in whichever forest mosaic it is represented. For example, certain forests along the Pacific coast of North America that are likewise dominated by *Abies grandis, Thuja plicata* or *Tsuga heterophylla* have the *Pachistima* union well represented in their undergrowth. Even as far south as the western slope of the Rockies in Colorado, the *Pachistima* union can be recognized in attenuated form by the occurrence of *Pachistima, Linnaea, Lonicera utahensis, Pyrola* (spp. other than *P. secunda*). These are commonly associated with a variety of mesophytic herbs (e.g., *Geranium, Smilacina stellata, Thallictrum* and *Trillium ovatum*). Thus, the community has a relatively lush appearance in comparison with other upland vegetation in the same region.

Since none of the species in this floristically complex union is evidently dominant over the others, the names of the associations in the upland h.ts. of the *Tsuga* series are not descriptive as elsewhere. *Pachistima* is not even present in many stands that contain the union that bears its name.

All upland h.ts. in which the *Pachistima* union characterizes the climax forest undergrowth share in common a rich assemblage of seral shrubby and herbaceous invaders during deforested phases. Mueggler (65) studied burned and logged h.ts. considered as belonging to h.ts. within this series without differentiating them. He found that shrubs attained maximum coverage 20-30 years after disturbance. If a new evergreen canopy does not form in this period, the climax herbs that sprouted after fire have almost disappeared.

Mueggler found that logging without subsequent burning favors an increase of *Vaccinium* spp. Burning was especially favorable to *Alnus sinuata, Ceanothus sanguineus, C. velutinus, Prunus emarginata, Salix scouleriana* and *Spiraea betulifolia.* Either logging or fire favors the increase of *Pachistima* and *Rubus parviflorus.*

Among herbs and dwarf shrubs, fire reduces the coverage of *Bromus vulgaris, Chimaphila* spp., *Clintonia uniflora, Coptis occidentalis, Goodyera oblongifolia, Pyrola secunda, Smilacina stellata, Streptopus amplexifolius, Tiarella unifoliata* and *Trillium ovatum.* Either fire or logging alone reduces *Adenocaulon, Anemone piperi, Asarum caudatum, Corallorhiza* spp. and *Thallictrum occidentale.* On the other hand, two species of the climax forest (*Phegopteris dryopteris* and *Linnaea borealis*) are benefitted by logging if fire does not follow. Burning is especially favorable to the invasion of *Achillea millefolium, Aster conspicuus, Calamagrostis rubescens, Carex* spp., *Epilobium angustufolium, Solidago* spp. and *Trifolium* spp.

Mueggler found that where climax species persisted abundantly on burned areas, the available K in the soil was low. This appears to indicate that the fire in these places did not so completely release the K immobilized in the organic layers.

As we found in the climax forests of this series, Mueggler was unable to recognize definable community types among the seral shrubs and herbs in the series.

Abies grandis-Pachistima myrsinites h.t.

The *Abies grandis-Pachistima myrsinites* association has *Abies grandis* as the sole dominant of the tree layer (fig. 14). In the *Pachistima* union that characterizes the undergrowth, no species is regularly dominant, but *Bromus vulgaris, Galium triflorum, Smilacina stellata* and *Thallictrum occidentale* were always present. The following were in at least 80% of the stands studied in the northern Rockies: *Adenocaulon bicolor, Amelanchier alnifolia, Clintonia uniflora, Disporum, Fragaria*

Table 3. Major characters distinguishing ecosystems in the *Tsuga heterophylla series.*

Soil drainage	Climatic relations	Distribution in core area	Self-reproducing trees	Undergrowth unions present	Association
Good	Warmest & dryest	Mainly southerly	*Abies grandis*	*Pachistima*	*Abies grandis-Pachistima*
	Intermediate	Mainly southerly	*Thuja plicata*	*Pachistima*	*Thuja plicata-Pachistima*
	Coolest & wettest	Mainly northerly	*Tsuga heterophylla*	*Pachistima*	*Tsuga heterophylla-Pachistima*
Poor	Intermediate	Mainly southerly	*Thuja plicata*	*Pachistima* & *Athyrium*	*Thuja plicata-Athyrium*
	Coolest & wettest	Mainly northerly	*Thuja* and/or *Tsuga*	*Pachistima, Athyrium* & *Oplopanax*	*Thuja plicata-Oplopanax*

14. *Abies grandis-Pachistima myrsinites* stand in Meadow Creek drainage east of Harpster, Idaho. This stand was clear-cut before it could be revisited and analyzed.

sp., *Goodyera oblongifolia, Linnaea borealis* and *Rosa gymnocarpa. Phegopteris* was consistently absent.

Climax forests dominated by *Abies grandis* occur west of the Cascade divide as well as to the east where we have sampled extensively. Because of some significant differences in the ecosystems, the inland stands should undoubtedly be recognized as distinctive. The climate is clearly different on the seaward side of the mountains. There, *Abies* is free of the heart-rot caused by *Echinodontium tinctorum,* which is so regularly present inland. *Bromus vulgaris* seems absent in the west whereas it was always present inland from Oregon to Montana. While these points serve to give unity to the inland series, we have found no significant basis for dividing the latter. The self-reproducing habit of the *Abies grandis* alone is sufficient as a character for recognizing the *Abies grandis-Pachistima* h.t. east of the Cascades.

Among trees in near-climax stands of *Abies-Pachistima* forest, *Picea engelmanni* is second only to the *Abies* in vitality. However, in every stand where it occurred it was at least reproducing less vigorously, if it had not stopped this function entirely (appendix A-8). The seral role of this species was especially conspicuous in stand 154. Seedlings were very abundant on the bare margins of a roadway crossing the stand, but seedlings were few, and had been failing regularly for a long time in the undisturbed parts.

The most common seral tree, but one distinctly less able to maintain its population in the *Abies* h.t. is *Pseudotsuga, Pinus ponderosa, P. contorta,* and *Larix* stop reproducing still earlier in the life history of the fire sere, but are common invaders during the first stages. The largest *Pseudotsuga* we have yet seen in the northern Rockies is the individual in stand 51 (117 cm DBH). The largest *Pinus ponderosa* was a cut stump 144 cm DBH, outside bark. Both individuals were in the *Abies-Pachistima* h.t. The largest *Abies grandis* we have seen is an individual 127 cm DBH, located south of Godman Springs in the Blue Mountains of Washington. *Pinus monticola,* always a seral tree in the Rocky Mountains, reaches its lowest altitude limits in the *Abies-Pachistima* h.t., and it is poorly represented here. *Taxus* is an understory tree with very high shade tolerance; individuals apparently reach great age. In parts of our area, especially eastward from Grangeville, Idaho, this plant attains unusually high densities, and here stems are not uncommonly in the 3-4 dm diameter class. *Tsuga heterophylla* occurred as an accidental

in stand 6; no other individuals were seen within several km of the site. In stand 13 it may be able to maintain a very low density indefinitely.

Basal area is definitely greater in the *Abies-Pachistima* h.t. than in any h.t. of the *Pseudotsuga* or *Pinus* series (appendix H). It is especially interesting to note that the range in elevation of the *Abies* stands largely coincides with the elevation range of *Pseudotsuga-Calamagrostis* stands. Neither is slope dependent, so the higher basal area of *Abies* is associated with more moisture; with no direct relationship to temperature (assuming that temperature and altitude bear a significant relationship).

The expected height of *Pinus ponderosa* on *Abies grandis* sites is 19.8 m at 50 years age. This is the best growth rate on any h.t. in the core area where this pine can be found in significant amounts. However, the superiority of the h.t. is limited to about the first 60 years of pine growth (fig. 4). Thus, the maximum return for a plantation of *Pinus ponderosa* would be in an *Abies-Pachistima* h.t., assuming a rotation of not more than 60 years, and assuming the use of an ecotype indigenous to this h.t. *Larix occidentalis* also grows faster here than in any of the *Pseudotsuga* h.ts., but this is not the environment for its best growth in the core area (table 1).

Satisfactory dates for analysis of the herbaceous undergrowth are between about June 23 and August 6.

Cooke's study of cryptogamic constituents of vascular plant associations included three stands of *Abies-Pachistima* forest in our core area.

Pengelly (69) showed that in one area, logging alone had negligible effect on shrub cover in the *Abies-Pachistima* h.t. Logging plus fire reduced shrub cover by one half, despite a heavy invasion of *Ceanothus sanguineus* (table 4). In another area, logging alone favored members of the *Symphoricarpos* union and led to a 64% increase in shrub cover by the seventh year.

Small mammals have been studied in one stand in this h.t. (appendix table C).

Soils of the *Abies grandis-Pachistima* stands tested had a statistically significant lower degree of base saturation than in the *Pseudotsuga-Physocarpus* h.t. (appendix table D), but were not different from *Pseudotsuga-Calamagrostis* soils in this respect.

Table 4. Average percent "ground cover" of shrubs in logged or logged and burned areas in the *Abies grandis-Pachistima* h.t., as compared with adjacent untreated areas in Shoshone County, Idaho. Data from Pengelly (69).

	Area A			Area B	
Shrubs	Not disturbed	1 yr. after logging	1 yr. after logging & burning	Not disturbed	7 yrs. after logging
Amelanchier alnifolia	2.5	3.5	+	2.0	6.0
Berberis repens	+	2.0	1.0	4.0	14.0
Ceanothus sanguineus	0.0	0.0	23.0	0.0	+
Holodiscus discolor	1.0	3.0	+	1.0	1.0
Pachistima myrsinites	39.0	27.0	+	4.0	1.0
Rosa spp.	5.5	4.5	3.0	10.0	6.0
Spiraea betulifolia	2.0	6 5	4.0	1.0	10.0
Symphoricarpos albus	1.5	2.0	2.0	4.0	14.0
Vaccinium membranaceum	12.5	9.0	0.0	9.0	5.0
Other species	2.0	4.2	0.0	7.0	9.0
Totals	66.0	61.7	33.0	42.0	66.0

Daubenmire (29) followed the annual cycle of soil moisture depletion and recharge in two stands of *Abies grandis-Pachistima* forest on Thatuna Ridge just northeast of Moscow, Idaho. The lower stand, near the dry ecotone of the h.t., was extremely dense. Many slender-stemmed trees formed a canopy so thick that all ground vegetation was excluded.

The other stand was near the upper altitude limits of the h.t. on this ridge. At the lower stand, soil drouth started at the surface in early August and descended to more than 50 cm by early September. This is judged to be unusually severe drouth for the h.t. Certainly the reproduction of the *Abies* (which had been interrupted there for many years) would be impossible under the dense forest condition except in an unusually wet summer. At the higher station, even the top decimeter of soil remained moist all summer. McMinn's (61) study of three additional stands of *Abies-Pachistima* forest in another season yielded data essentially identical to that from this second stand represented in Daubenmire's study (29).

Hauxwell (42) described the profile of a Santa silt loam, a Gray Wooded soil now classed as a Typic Fragiochrept, in an *Abies-Pachistima* stand in Benewah (?) County, Idaho. The following is from his "site 4" description:

01 3-2″

02 2-0″

A1 0-5″ Gray (10YR 6.4/1-1.4d) or dark grayish-brown (10YR 3.8/2m) silt loam; moderate thin platy structure; slightly hard, friable, slightly sticky, slightly plastic; abundant roots; very fine MnO_2 concretions; many very fine interstitial pores; clear smooth boundary

B1? 5-9″ Pale brown to very pale brown (10YR 6.5/2.8d) or grayish-brown to brown (10YR 4.5/2.5m) silt loam; weak fine and medium subangular blocky; hard, firm, slightly sticky, slightly plastic; plentiful roots; many fine black concretions; many very fine and fine tubular pores; gradual smooth boundary

B2? 9-15″ Pale brown to very pale brown (10YR 6.5/3d) or brown (10YR 4.5/3m) silt loam; weak medium and coarse subangular blocky; plentiful roots; concretions as in horizon above; many medium interstitial very fine and fine tubular pores; gradual wavy boundary

A′21 15-21″ Light gray to very pale brown (10YR 7/2.5d) or grayish-brown to brown (10YR 5.5/2.5m) silt loam; massive; very hard, firm, slightly sticky, slightly plastic; few roots; common very fine black concretions; common fine distinct mottles; many medium interstitial and common very fine tubular pores; gradual, wavy boundary

A′22 21-25″ Color, structure, texture, consistency, roots, concretions and mottles as above; common medium interstitial and very fine tubular pores; abrupt smooth boundary

B′21$_x$ 25-27″ This horizon is the very dense top of prisms, and is similar to the prism interior below except for a much higher concentration of fine A_2 filling in the pores

B′22$_x$ 27-38″ Pale brown to light yellowish-brown (10YR 6/3.5d) or brown to yellowish-brown (10YR 4.5/3.5m) silty clay loam; strong coarse and very coarse

prismatic; extremely hard, very firm, sticky, plastic; few roots compressed on ped surfaces; many soft brown concretions; strong brown to reddish-yellow mottles; continuous moderately thick clay films on ped surfaces; horizon is very dense with some A2 filling in pores and along ped surfaces; pores as in A'22; gradual wavy boundary

$B'23_x$ 38-46" Pale brown to light yellowish-brown (10YR 6/3.5d) or yellowish-brown (10YR 5/4m) silty clay loam; weak coarse prismatic, breaking to strong coarse angular blocks; extremely hard, very firm, sticky, plastic; concretions as in horizon above; thick A2 fillings along some ped surfaces and in pores; continuous, moderately thick clay skins along ped surfaces and in pores; extensive black Mn staining associated with clay films; roots as in horizon above; common very fine and fine tubular pores. Augered findings show at about 60" an older, buried B horizon, which is darker in color, higher in clay, has more Mn staining and some quartz gravels.

The *Abies grandis-Pachistima* association has not been reported for Canada. Our data document the type from Lake and Mineral Counties, Montana, to the Okanogan Mountains in Washington, thence southward to the northern flank of the Wallowa Mountains in Oregon. Stands have been seen in the western foothills of the Cascades in central Washington. In Idaho, we have noted its occurrence in typical form near McCall, farther south than we have seen any other association of the *Tsuga heterophylla* series. The "Fir-*Bromus vulgaris* type" recognized by the U.S. Forest Service in central Oregon correlates directly with the association we have described.

Thuja plicata-Pachistima myrsinites h.t.

The *Thuja plicata-Pachistima myrsinites* association is recognized by an overstory consisting entirely or almost so of *Thuja plicata,* with a ground cover in which the *Pachistima* union prevails. Species that occurred in 80% or more of the 11 stands sampled are: *Acer glabrum, Adenocaulon bicolor, Anemone piperi, Asarum caudatum, Athyrium filix-foemina, Bromus vulgaris, Coptis occidentalis, Disporum oreganum, Galium triflorum, Goodyera oblongifolia, Smilacina stellata, Tiarella unifoliata, Trillium ovatum* and *Viola orbiculata.* The coverage of the *Athyrium* never exceeded 13%; the fronds were usually 0.5 m tall or less. *Tsuga* and *Oplopanax* were not represented.

Most of the *Thuja-Pachistima* stands studied had trees well over 1 m in diameter at breast height. *Thuja* is slow-growing, but there are no standards for judging ages of such large trees, since heart rot usually invades boles when they reach a diameter of half a meter or so. An old trunk consists of a shell of sound wood only 1-2 dm thick. Despite its thin bark, the tree is moderately fire-resistant; old trees commonly are fire-scarred at the base (fig. 15). The largest individual found in the core area was 4.98 m in diameter at breast height. It is in an ecotone between stand 73 and an *Alnus sinuata* thicket that occupied a seepage area at the bottom of a ravine.

The paucity of small- and medium-sized individuals in old *Thuja-Pachistima* stands is notable. Owing to the prevalence of large individuals, the basal area is much greater in the *Thuja-Pachistima* than in the *Abies-Pachistima* association.

Abies grandis is but slightly less successful than *Thuja* where the two compete in the *Thuja-Pachistima* h.t. and is usually not eliminated between successive catastrophic fires on the same site. However, since its reproduction is definitely more discontinuous than that of *Thuja,* and *Thuja* stands can be found (e.g. stand 49) that are entirely free of *Abies,* the *Abies* is best considered a long-lingering seral species. Relics of more vulnerable competitors that were encountered in the old stands studied include *Pseudotsuga, Larix* and *Pinus monticola. Taxus* is a common member of the climax community here as it is in all upland associations containing the *Pachistima* union.

A high degree of floristic homogeneity characterizes the undergrowth of the *Thuja-Pachistima* association in that 9 species occurred in all 11 stands studied. Optimal dates for studying this undergrowth are between July 5 and August 11.

Eight genera of lichens have been found growing as epiphylls on conifer foliage in the *Thuja-Pachistima* h.t. in northern Idaho (21).

For small mammal components of the ecosystem see appendix C.

Daubenmire (29) followed the course of soil moisture depletion and recharge during one summer in two stands of *Thuja-Pachistima* forest in Latah County, Idaho. In the stand near the dry limit of the h.t., the soil dried to the wilting point to a depth of 1 dm during one of the summer months. At the more modal site, even the surface remained moist all summer.

Thuja-Pachistima h.ts. are mainly peripheral to areas where the *Tsuga-Pachistima* h.t. occurs. Where the two come into contact, the former is invariably on topography that would be interpreted as being warmer and drier. At its upper ecotone, the *Thuja-Pachistima* h.t. interfingers with either the *Tsuga-Pachistima* or *Abies lasiocarpa-Pachistima* h.ts., both of which follow ravine bottoms down into areas where the *Thuja-Pachistima* h.t. occurs on adjacent slopes. *Thuja-Pachistima* in turn extends far down ravines at its lower ecotone, interfingering into the *Abies grandis-Pachistima* h.t.

In comparison with *Abies grandis,* fresh *Thuja* leaf litter contains less K, Ca, P and N (23a). Soil analyses indicated lower average values for K, Ca and Mg in *Thuja* forests, but the differences were not statistically significant (appendix D).

A soil profile description is available for stand 3, which is on Vassar silt loam, a Typic Vitrandept in the Brown Podzolic Zone:

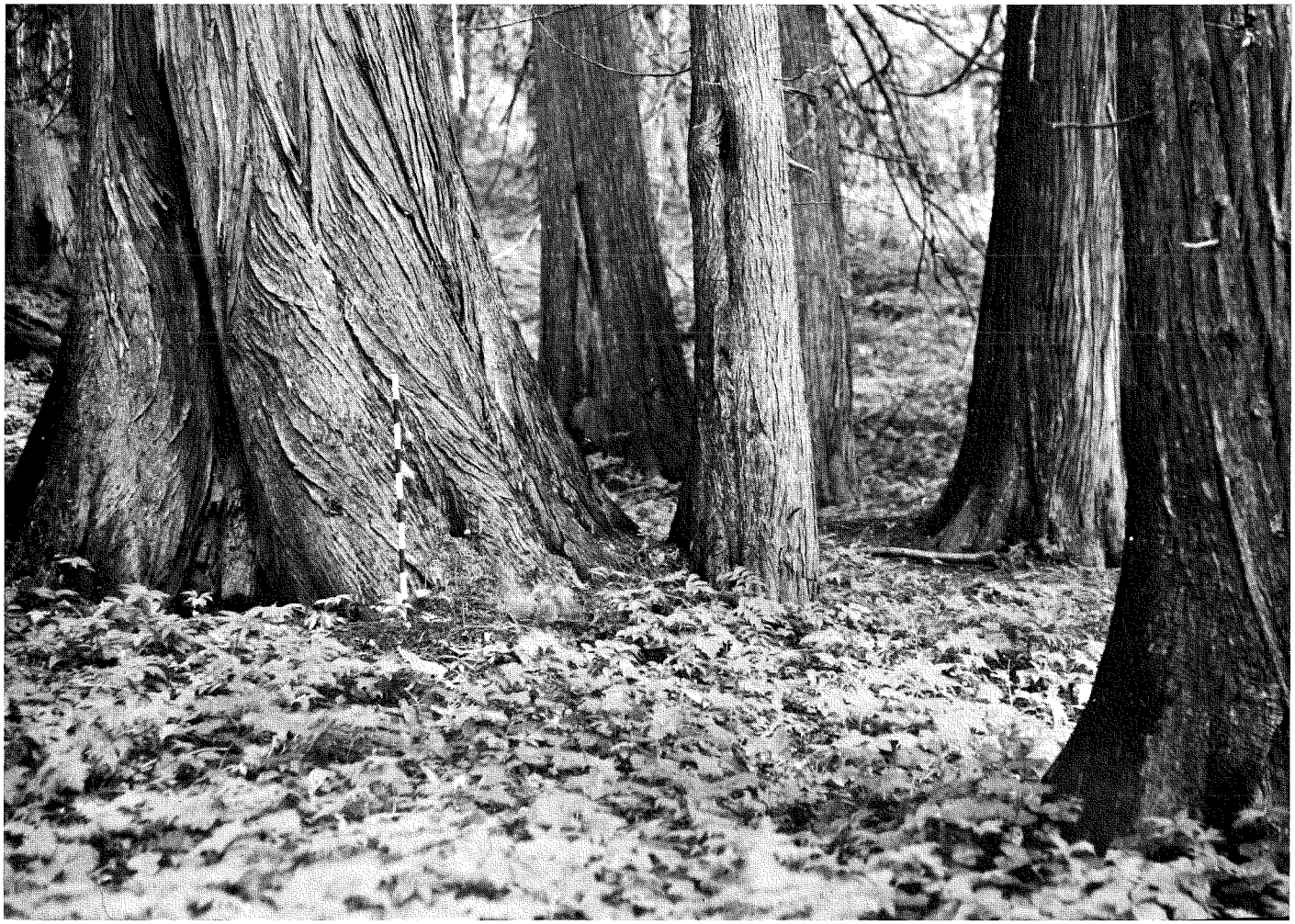
01 2.5-0" Mainly duff

A2 0-1" Dark gray (10YR 4/1m) silt loam; single grained; roots abundant; abrupt boundary

$B2_{ir}$ 1-3" Dark yellowish brown (10YR 4/4m) silt loam; single grained to weak granular; moderate roots

C1 3-8" Yellowish brown (10YR 5/8m) silt loam with pockets of yellow (10YR 8/6m) volcanic ash; massive; abundant roots; gradual boundary

C2 8-45" Yellowish brown (10YR 5/6m) silt loam; massive; slightly more firm than surjacent horizon; roots abundant; this and all horizons above are derived from volcanic ash



15. *Thuja plicata-Pachistima myrsinites* stand 170. Most old trees are fire-scarred, as these.

IIC 45″+ Rotten granite. (by R. Cunningham)

Another soil profile description refers to a stand visited but not studied in Ferry County, Washington. This is a Mattson loam, an intergrade between the Brown Podzolic and Gray Wooded Zones, now classified as a Typic Vitrandept.

01 1-0″ Litter and duff containing some roots, pH 6.0

A1 0-2″ Light brownish gray (10YR 6/2d) or dark grayish brown (10YR 4/2m) loam; fine weak granular; very friable, loose, slightly sticky, nonplastic; pH 6.6; abundant roots; clear, smooth boundary

$B2_{(ir)}$ 2-10″ Very pale brown (10YR 7/4d) or yellowish brown (10YR 5/4m) loam; loose, single grain; tendency to very weak medium and fine granular; very friable, loose, nonsticky, nonplastic; pH 6.1; abundant roots; clear, smooth boundary

A2 10-26″ White (10YR 8/2d) or light brownish gray (10YR 6/2m) fine sandy loam with 10% gravel; massive to weak fine and medium subangular blocky; slightly hard, firm, nonsticky, nonplastic; pH 6.0; numerous roots; clear, smooth boundary

B21 26-38″ Pale brown (10YR 6/3d) or brown (10YR 5/3m) sandy clay loam with few gravel and stones; massive, a fragipan, to flakes which reduce to moderate and fine subangular blocky; firm, hard, sticky, slightly plastic; pH 6.8; one 0.5″ dark grayish brown band, wavy in upper part of horizon; one reddish brown pocket in lower part of horizon; occasional roots; clear, smooth boundary

$B22_{ca}$ 28-44″ Pale brown (10YR 6/3d) or brown (10YR 5/3m) sandy clay loam; massive, a fragipan, bearing to stony medium platy; firm, hard, sticky, slightly plastic; pH 8.1; calcareous, strong effervescence; many pink and white very fine platy calcium carbonate seams between plates; occasional roots; clear, smooth boundary

$B3_{ca}$ 44-50″ Pale brown (10YR 6/3d, or m) sandy clay loam; massive to coarse platy; calcium carbonate seams on surfaces of plates; highly calcareous; main mass mildly calcareous; pH 8.3; no roots; gradual irregular boundary

C 52″+ Grayish brown (2.5YR 5/2 d, or m) sandy clay loam; massive to single grain; firm, slightly hard, slightly sticky, slightly plastic; occasional calcium carbonate seams; main mass calcareous; pH 8.2 (by W. A. Starr)

Garber (36) has described a soil profile representing the *Thuja-Pachistima* h.t. in Latah County, Idaho. It is a Vassar

silt loam, a Brown Podzolic and is now classified as a Typic Cryochrept.

The *Thuja-Pachistima* h.t. has been identified from the eastern foothills of the Cascades in central Washington to the Okanogan Mountains, to western Montana. In Idaho it extends southward to the Clearwater River drainage where it shows its greatest ecologic amplitude and becomes the prevailing constituent of the landscape over a large area.

The "*Pachystima* site type" recognized in British Columbia by Illingsworth & Arlidge (47) appears to correlate with our *Thuja-Pachistima* h.t.

Tsuga heterophylla-Pachistima myrsinites h.t.

The *Tsuga heterophylla-Pachistima myrsinites* association is distinguished by having *Tsuga heterophylla* as the most successful tree competitor. This species forms an essentially pure stand at climax. The undergrowth is a rich mixture of shrubs and herbs (the *Pachistima* union), none of which is regularly dominant. The species that occurred in 80% or more of the stands studied were *Clintonia uniflora, Phegopteris dryopteris, Linnaea borealis, Pachistima myrsinites, Tiarella unfoliata* and *Vaccinium membranaceum.*

From the population analyses in appendix A-9, it is easy to see why this phytosociologic unit was referred to in the reconnaissance paper as a "*Thuja-Tsuga*" forest, and why loggers have referred to it as a "cedar-hemlock" type; *Thuja* was found in 14 out of the 16 stands analyzed (fig. 16) and often was represented in the largest size class of trees present.

Neither is it difficult to see justification for the present change to an emphasis on *Tsuga* after having made the detailed population analyses, for *Thuja* seemed to be maintaining its population density only in stands 29 and 55. In the main, it must be considered a late-seral species, holding its place for a long time by virtue of great age potential. In dense stands, its reproduction becomes mainly vegetative, since any part of the stem system produces adventitious roots readily when pinned down by falling branches or trunks of other trees. Layering seems also important in maintaining populations of *Taxus*, and occasionally *Tsuga* layers, although reproduction by seed is by far more usual in this species.

The overwhelming superiority of the *Tsuga* when competing in this h.t. with still other trees that are climax in other h.ts. (i.e., *Pseudotsuga, Abies grandis, A. lasiocarpa* and *Picea*) is also clearly shown in appendix A-9.

The basal area in all our stands of *Tsuga-Pachistima* is greater than the value (39.04 m^2/ha) found by Lutz (54)

16. *Tsuga heterophylla-Pachistima myrsinites* stand 27. Relic *Thuja* on left, with *Tsuga* elsewhere represented by all size classes. This stand was clear-cut shortly after it was analyzed.

in a homologous climax forest dominated by the closely related *Tsuga canadensis* in Pennsylvania.

Species diversity was less in the *Thuja-Pachistima* association than in the *Abies grandis,* and much less in the cooler, wetter *Tsuga-Pachistima* association (appendix E). The herb and shrub coverage is thinner here, with the epigeous moss layer better developed. Optimal dates for studying the undergrowth for this and all the remaining forests to be treated are between mid-July and mid-August.

While digging soil samples, subterranean macrofungi commonly called "false truffles" were often found at the bottom of the duff layer in this habitat type, but in no other. Specimens obtained from stands 26 and 27 were identified by W. B. Cooke as *Scleroderma* nr. *arenicola* Zeller, and specimens obtained from stand 25 were identified by C. G. Shaw as *Rhizopogon piceus* B. & C.

At the upper altitudinal limits of *Tsuga-Pachistima,* it makes contact with the *Abies lasiocarpa-Pachistima* h.t.; at the warmer ecotone it is bounded by *Thuja-Pachistima* or *Abies grandis-Pachistima* h.ts. *Tsuga* occurs as a sparse accidental in the lower part of the *Abies lasiocarpa-Pachistima* h.t., penetrating farther across the ecotone than *Thuja.* On the margins of rivulets it has been found as much as 300 m above the normal ecotone of the *Tsuga-Pachistima* h.t., with the land on either side of such a rivulet supporting *Abies lasiocarpa-Xerophyllum* forest. In these riparian extensions of *Tsuga* into high altitudes it is often accompanied by members of the *Pachistima* union.

The two most abundant seral trees to invade burned areas in the *Tsuga-Pachistima* h.t. are *Pinus monticola* and *Larix occidentalis.* Of these two, *Larix* is much less tolerant of shade and so can seed into a burn only in the first few years as a rule. The pine appears much more shade-tolerant and can continue to produce successful seedlings until shade becomes rather dense. The absence of relic *Larix* from any of the old stands may reflect either the limited duration of its invasion span, or a shorter life-span, or both, in comparison with the pine. *Pinus monticola* is the most valuable timber species in the study area, and the greatest volume of such timber has undoubtedly been harvested from the *Tsuga-Pachistima* h.t. The largest individual of this species found in any of the study sites was a specimen 59.8 m tall and 120.3 cm D.B.H. in the margin of stand 28. When this stand was clear-cut, the tree proved too rotten to be useful below about the middle of the stem. In stand 29, the last relics of *Pinus monticola* have died so recently that standing snags and fallen logs can still be identified. The xylem layers of large *Tsuga* trees indicate a minimal stand age of 450 years. Thus the fire sere at this site required approximately 450 years to eliminate the *Pinus;* the *Thuja* shows little indication of decline as yet.

Larsen (51) pointed out that secondary succession on single burns proceeds rapidly. If two burns are separated by only a few years, both habitat deterioration and inadequate seed sources make secondary succession much slower. We studied two small burns in the Granite Creek drainage of Bonner County, Idaho. Both habitats had escaped fire for a number of decades previously. One of these was burned about 33 years ago. At the time of the study it supported 7.8 trees/m^2, 2.5% of which were between 0.5-1.0 dm in diameter (B.H.). The remainder were smaller. The species, in order of decreasing density, were *Tsuga, Thuja, Abies grandis, Salix* sp., *Pinus monticola, Populus tremuloides, Picea* and *Larix occidentalis.* The stand was so dense that no seedlings under 5 years of age had survived, and the sum of herb and shrub species coverages was only 20%. Percent light measurements (19 readings made at 0.5 m intervals along a line) below the tree canopy but above shrub and herb canopies gave a range of 1.6-14.0%, with a median value of 4.5%. Comparable light measurements in a climax stand (no. 27) nearby gave a range of 3.6-13.0% with a median of 7.7%. In contrast with the thicket, young tree seedlings were present in the climax stand and the sum of herb and shrub species coverages was 44%. Twelve of the species in the thicket were plants common in climax stands as listed in appendix table B-10, and had no doubt survived the fire. In addition, the following had become established but had not yet been eliminated: *Antennaria (rosea?), Ceanothus velutinus, Epilobium angustifolium, Fragaria, Holodiscus* and *Pteridium.* The soil profile (a minimal podzol and a Typic Cryochrept) reflected no influence of the fire except perhaps the relatively high pH of the B21, B22 and B3 horizons, all of which are in the range of pH 6.0-6.1.

The other young stand, burned 54 years before study, supported an approximately equally dense but older population of trees. The sum of herb and shrub coverages here was 57%, and 11 of the 20 species in the undergrowth have never been found in old climax stands. Soil pH throughout the mineral horizons ranged between 6.2 and 6.7. This soil, a minimal podzol, likewise showed no other apparent effects of the fire.

The above studies show clearly that many of the species of the *Pachistima* union that characterize old climax forests survive fires. A group of opportunistic seral species become established, many of which persist more than half a century. The climax dominant (*Tsuga heterophylla*) invades promptly, along with short-lived seral trees (*Populus tremuloides, Salix* spp.), intermediate (*Picea, Larix occidentalis, Abies grandis*), and long-lived ones (*Pinus monticola, Thuja*). Fire does not alter soil profiles much, except to remove the surface organic horizon and raise pH, presumably through the release of metallic cations in the organic matter consumed.

Frequently, one tree species invades a burned area in advance of another, but these sequences seem determined primarily by seed source availability and the density of the first invaders. Any species may follow another if the first one forms only an open stand that leaves environmental resources unclaimed until another species happens to have a good seed year.

When fires follow one another within a few decades, the proportion of *Larix* commonly increases. This species early develops a thick, fire-resistant bark that renders it far less susceptible to injury by surface fires than any of its associates (fig. 17).

In a denuded area formerly supporting a *Tsuga-Pachistima* forest, where several meters of glacial gravel had been removed as road-building material, young seedlings of the following species were found:

17. Repeated burning has produced a nearly pure stand of *Larix occidentalis* here in the *Tsuga-Pachistima* habitat type. The bark on the oldest trees here is charred up to a height of about 3 meters. Kaniksu National Forest, Idaho.

Amelanchier alnifolia	*Populus tremuloides*
Betula papyrifera	*Pseudotsuga menziesii*
Larix occidentalis	*Salix* sp.
Picea engelmanni	*Thuja plicata*
Pinus contorta	*Tsuga heterophylla*
Pinus monticola	

Tsuga and *Pinus monticola* were best represented. For several years these plants were observed. Their continuing success demonstrated that no soil modification whatsoever is required for trees to invade raw parent materials in the *Tsuga-Pachistima* h.t. Neither have we observed any limitation to the success of climax trees on freshly burned surfaces. Larsen (52) wrote that "as soon as" *Pinus monticola* "and its associates of intermediate light and moisture requirements reach maturity, begin to decay and thereby produce a broken forest canopy," *Tsuga heterophylla, Thuja plicata* and *Abies grandis* "begin underseeding." We are unable to confirm this. Climax and seral species commonly invade a fresh burn simultaneously, providing seed sources of both are available. The seral species quickly outstrip the climax species in height growth and reduce the latter to the role of a slow-growing understory.

While there are no restrictions as to the particular species invading burned areas, the wind-borne seeds upon which reforestation depends do not carry far from the parent tree. Large burned areas in which all trees are killed therefore become reforested by natural means only at a slow rate. This allows a variety of seral shrubs and herbs to invade and dominate until accidents of long-distance dispersal or gradual encroachment from the margins of the burn produce a new forest cover. The shrubs that invade include *Salix* spp., *Ceanothus sanguineus, C. velutinus, Sambucus caerulea, S. racemosa* var. *melanocarpa,* and members of the *Physocarpus* and *Symphoricarpos* unions. These mingle with the shoots of regenerated members of the *Pachistima* union (*Lonicera utahensis, Pachistima, Ribes lacustre, R. viscosissimum, Rosa gymnocarpa,* etc.) and provide a shrub cover that is excellent winter browse for deer, wapiti, and moose. This high potential of burned areas is characteristic primarily of only those h.ts. that have the *Pachistima* union as the major forest undergrowth (i.e., *Abies grandis-Pachistima, Thuja-Pachis-*

tima, Tsuga-Pachistima and *Abies lasiocarpa-Pachistima*), although some improvement in the forage quality of shrub cover following fire is evident in the *Pseudotsuga-Physocarpus* h.t. (69).

The small mammal population has been sampled in one stand of the *Tsuga-Pachistima* association (appendix C).

Low temperatures and the ever-present threat of frost throughout summer restrict land use over much of the h.t. to timber production. With heavy grazing, a *Poa pratensis* sod develops here, as elsewhere the *Pachistima* union forms the forest undergrowth. Owing to the shortness of the season and the expense of moving and managing livestock, the land is not grazed much.

Where valleys are broad and have been well cleared of forest, as about Sandpoint, Idaho, grain and a few other crops are grown.

Soil pH among the *Tsuga-Pachistima* stands varied from 4.0-6.4, a greater range than in any other association. The values show no tendency to cluster about a mode. In view of the chemical composition of the *Tsuga* litter, low values are much less surprising than the higher ones. When compared with the results for *Thuja-Pachistima* stands, however, the low nutrient content of *Tsuga* litter (23a) and its strong acidifying effect (72) are reflected in statistically significant reductions in pH and adsorbed Ca (appendix table C). Lower fertility in other respects is also suggested by the data, even though significance falls well below the 95% level. Raney (72) demonstrated a striking and consistent difference in chemical properties of the soil immediately below the canopies of individual trees of *Tsuga heterophylla* and *Thuja plicata.* Alban (1) has added further details of the phenomenon.

Soil profile descriptions for eight stands of *Tsuga-Pachistima* forest have been prepared by F. H. Peterson, and still another profile representing this forest has been presented by Hauxwell (42). The profiles described by Peterson represent minimal Podzols except for stand 26 which is a Brown Podzolic. In a more recent classification, these soils were divided between Typic Haplorthods (stands 25, 27, 29, 30) and Typic Vitrandepts (24, 26, 28), except for stand 33 which is an Andic Udifluvent. Two profile descriptions have been selected to illustrate the breadth of substratal conditions favorable to the *Tsuga-Pachistima* association. Stand 29, a minimal Podzol and a Typic Haplorthod, is as follows:

A01 1.5-1.0 cm Litter from *Tsuga* and *Thuja*

A02 1-0 cm Slightly matted black duff; pH 4.5; abrupt smooth boundary

A2 0-6 cm Light gray (10YR 5/2 - 8/1m) loam; very weak fine crumb; friable; continuous; pH 4.1; upper 5-10 mm consisting of very dark brown mixed 02 and A2 material; roots abundant; abrupt wavy boundary

B21 6-18 cm Dark brown (6.5YR 4/4m) stony loam; massive, breaking to very weak fine crumb and very weak medium subangular blocky; friable with some medium sized clods of slightly firm orterde; pH 5.1; roots abundant; clear wavy boundary

B22 18-29 cm Brown (6.5YR 4.5/6.5m) stony loam; massive, breaking to very weak fine crumb and very weak fine to medium subangular blocky; friable except for some coarse clods of slightly firm orterde; pH 5.2; roots few; clear wavy boundary

B23 29-42 cm Yellowish brown (10YR 5.5/6m) stony sandy loam; massive breaking to very weak crumb; slightly firm to firm; pH 5.3; roots few; abrupt wavy boundary

B3 42-53+ cm Brownish-yellow (10YR 6/8m) stony loamy coarse sand and fine gravel; massive; friable; pH 5.4; roots very few. (by F. H. Peterson)

Stand 33 was a Regosol-Podzol intergrade and an Andic Udifluvent:

0 1-0 cm Mostly litter from *Tsuga* and *Thuja;* pH 5.8; boundary abrupt

A1-A2 0-4 cm Dark grayish brown (10YR 3.5/2 very slightly moist, 10YR 2/2 wet) sandy loam speckled with clean white sand grains (A_2); weak to moderate to very fine medium crumb and granular, and fine to medium subangular blocky; friable; a few intermittent pockets of clean white sand (A_2); pH 5.4; roots progressively fewer in this and lower horizons; abrupt boundary

B 4-9 cm Brownish yellow (10YR 6/6 - 5/6 very slightly moist, 10YR 4/3 wet) relatively unaltered loamy sand alluvium; very weak medium to coarse crumb; friable; pH 5.8; abrupt boundary

A1-$A2_b$ 9-11 cm Dark gray (10YR 4/1.5 very slightly moist, 10YR 2/2 wet) sandy loam heavily speckled with clean, white sand grains (A2); very weak fine to coarse granular; friable; pH 5.7; abrupt boundary

$A2_b$ Thin (1-3 mm) intermittent, lenticular masses of clean white sand; abrupt boundary

B_b 11-20 cm Dark grayish brown (10YR 4/2 slightly moist, 10YR 3/1.5 wet) to yellowish brown (10YR 5/4 slightly moist, 10YR 3/2 wet) light sandy loam; massive, breaking into subangular clods; slightly firm; pH 5.9; clear boundary

$B3_b$ 20-30 cm Variegated dark grayish brown and brown light sandy loam; massive; very slightly firm; pH 5.8; diffuse boundary

C 30-95 cm Brown (10YR 4/3 - 5/3 slightly moist) light sandy loam with some streaks of darker colored B horizon material; massive; slightly firm; pH 5.8; clear boundary

C_g 95 cm+ Distinct and coarsely mottled gray (10YR 5/1m), dark brown (10YR 3/3m, or 7.5YR 3/2 - 4/4m) light sandy loam; massive; pH 6.0; very few roots. (by F. H. Peterson)

The distribution of our stands encompasses nearly all the known range of the *Tsuga-Pachistima* association—from Boat Encampment, British Columbia, to Clearwater County, Idaho (a north-south distance of 225 km), and from northeastern Washington to the continental divide in Montana (an east-west distance of 95 km). Analysis of the data representing 19 old virgin stands scattered over this area reveals no significant floristic gradients. However, minor floristic variation would permit regional subdivision if any purpose would be served by this. As a group, however, there are consistent similarities among the stands, and consistent differences between them as an association and other forests dominated at climax by *Tsuga heterophylla* that occur on the west slope

of the Cascade Mountains from British Columbia to Oregon. What we have called the *Pachistima* union also occurs in the coastal forests, but specific associations there have been recognized by the abundance of *Gaultheria shallon, Polystichum munitum,* etc. Such species are either rare or absent in the interior (2, 62). The ubiquity of *Acer circinatum* and the overriding importance of *Pseudotsuga menziesii* as a seral species also contribute much to the distinctiveness of the coastal *Tsuga* associations.

The *Tsuga-Pachistima* unit characterized above embraces both the *Aralieto-Gymnocarpietum* (including seven types) and the *Pachistimeto-Calliergonelletum* (including five types) of Bell (4) in eastern British Columbia.

Thuja plicata-Oplopanax horridum h.t.

Old virgin stands of the *Thuja plicata-Oplopanax horridum* association usually have *Thuja* as the most nearly self-regenerating tree, but some have *Tsuga heterophylla* sharing this role. In others, *Tsuga* alone is self-reproducing. The most diagnostic feature of the undergrowth (and indeed of the association) is a shrub layer in which *Oplopanax horridum* is dominant (fig. 18). The soils are poorly drained, and contiguous uplands always belong to the *Tsuga heterophylla-Pachistima* h.t.

In half of the stands studied, 53, 80, 81, 83, and 104, *Thuja* is clearly a more successful competitor than any other tree. In two stands, 79 and 82, *Thuja* and *Tsuga* are ecological equivalents. In two other stands, 51 and 56, *Tsuga* appears to be the climax dominant.

The recognition of a single association in which either of two tree species may be dominant is an exception to our usual procedure and so needs justification. In scores of places throughout the extent of the *Tsuga-Pachistima* h.t. we have seen the *Pachistima* union of the uplands continue beneath *Oplopanax* and *Athyrium* layers on approaching obviously wet lowlands. Occasionally, tongues of the *Oplopanax* and *Athyrium* layers extend up valley sides, but always in shallow ravines into which drainage collects. The discontinuity where the *Oplopanax* and *Athyrium* layers meet uplands is so obvious and so clearly related to soil drainage that all forests with these two plants conspicuous in their undergrowth must be segregated as a group. But as yet

18. *Thuja plicata-Oplopanax horridum* stand 82. This stand is included in a Natural Area established by the U.S. Forest Service. Tip of meter stake barely shows above *Oplopanax* leaves below to left of center. *Athyrium* has a cover of 53%, but shows beneath *Oplopanax* only in lower center and right corner. Young *Tsuga heterophylla* at base of central *Thuja,* with an older *Tsuga* at left.

there is no apparent intrinsic character of environment that can be related to the variations in their overstory.

The success of *Tsuga* seedlings on a forest floor (but not on denuded soil!) is intimately related to the availability of decaying logs as a substrate. Therefore it is hypothecated that *Tsuga* invades in quantity following a catastrophe that fells a number of trees in a short span of time, and that this species then retains dominance until complete decay of the logs reduces its reproductive potential and allows *Thuja* to supersede.

As an alternative to our interpretation we might have recognized separate *Thuja-Oplopanax* and *Tsuga-Oplopanax* associations, but the latter segregate would include but few stands and little area. The data for undergrowth (appendix B-11) are arranged for ease of verifying that there is no floristic differentiation between the *Thuja*-dominated and *Tsuga*-dominated stands.

The tree layer of old stands consists of a sprinkling of very large individuals, with *Thuja* exceeding 2 m D.B.H. in three of the stands and *Tsuga* exceeding 1 m in two of them, and a modest number of small individuals, with very few in intermediate size classes. Charcoal or fire scars on the tree bases show that on rare occasions surface fires have run through these communities despite the swampy nature of the ecosystem. However, there are no fire-killed individuals to suggest that population structure is materially altered by this habitat factor. The greater size of the *Thuja* in swamp environments than in uplands may reflect more rapid growth or longer intervals between truly devastating holocausts. The latter is judged to be more nearly correct.

The undergrowth of the *Thuja-Oplopanax* association may be tersely characterized as consisting of the *Pachistima* union with *Athyrium* and *Oplopanax* layers superimposed in turn above it. *Oplopanax* is the most conspicuous undergrowth species because of its large leaf blades, high coverage and tall stature (usually 1.5-2.5 m). *Athyrium filix-foemina,* growing about 1 m tall and in considerable abundance, usually forms another layer just beneath it. The distinctiveness of the latter is enhanced by *Drypteris dilitata,* which is similar in appearance and stature.

Other shrubs and herbs with 80% or more presence, these mostly well below the *Athyrium* layer and representing the *Pachistima* union, include *Acer glabrum, Actaea rubra, Circaea alpina, Clintonia uniflora, Disporum oreganum, Galium triflorum, Phegopteris dryopteris, Ribes lacustre, Rubus parviflorus, Streptopus amplexifolius, Tiarella unifoliata* and *Viola glabella.* The length of this list of 15 rather regular members of the undergrowth slightly exceeds that of the *Thuja-Pachistima* association, in which 14 species had 80% presence. This high degree of floristic homogeneity is, however, accomplished with a somewhat different list of species. It is also noteworthy that this outstanding homogeneity is attained even though the stands are scattered over parts of four states. Suitable dates for vegetation analysis fall between about July 19 to August 1.

Species diversity is approximately equal to that of the upland *Thuja-Pachistima* association, but it is 30% greater than that of the geographically more closely related *Tsuga-Pachistima* association (appendix E). This probably reflects better nutrition, as leachates from the *Tsuga-Pachistima* h.t. must drain through the *Thuja-Oplopanax* soils as they leave an area. Data on pH, with all values for the *Thuja-Oplopanax* h.t. falling within the range for the *Tsuga-Pachistima* h.t., show that bases do not accumulate in the latter. Plants can still be very well nourished by waters of low nutrient content if they are flowing so that a fresh supply continually moves past the roots.

For small mammal components of this forest, see appendix C.

The total area of the *Thuja-Oplopanax* h.t. in the northern Rockies is quite small. Throughout it is associated with *Tsuga-Pachistima* forest, never having been seen where adjacent upland supports *Thuja-Pachistima.*

Our *Thuja-Oplopanax* association appears to be the exact equivalent of the *Oplopanaceton* (including four subtypes) recognized by Bell (4) in eastern British Columbia.

Illingsworth and Arlidge (47) described an "*Oplopanax* site type" in east central British Columbia. It is characterized by an almost complete cover of *Oplopanax horridum* with the same ferns we find associated, and the *Pachistima* union beneath. *Picea glauca* and *Abies lasiocarpa* are listed as the most shade-tolerant trees for their type. This is therefore a distinctive association, for we have never seen *Abies lasiocarpa* or *Picea glauca* as more than accidentals south of the international border.

Thuja plicata-Athyrium filix-foemina h.t.

In old stands of the *Thuja plicata-Athyrium filix-foemina* association *Thuja* is the tree with the most stable population structure. The undergrowth appears as a nearly continuous layer of *Athyrium filix-foemina* (fig. 19). Usually, the soils are evidently wet. *Oplopanax* and *Tsuga* are unrepresented.

The tree stratum in the *Thuja-Athyrium* forest differs from that of the *Thuja-Oplopanax* forest only in the regular absence of *Tsuga.* Again, the dominant species attains great diameter; a specimen in one of the stands exceeds 2.3 m (appendix A-11).

In addition to the conspicuous *Athyrium* layer, a sprinkling of *Alnus sinuata* as a tall shrub is rather characteristic of the association. Fifteen other species, mostly representatives of the *Pachistima* union, were found in at least three of the four stands sampled: *Circaea alpina, Coptis occidentalis, Disporum oreganum, Galium triflorum, Mertensia paniculata, Montia sibirica, Osmorhiza chilense, Senecio triangularis, Smilacina stellata, Stellaria crispa, Streptopus amplexifolius, Tiarella unifoliata, Trautvetteria caroliniensis, Trillium ovatum* and *Viola glabella.* The absence of *Chimaphila* spp. from both *Thuja-Athyrium* and *Thuja-Oplopanax* h.ts. is notable.

In stand 75, a small rivulet crossed a corner of the central macroplot but there were no species of vascular plants restricted to that corner. In stand 120, several such rivulets crossed the stand and in addition a few spots of wet muck were marked by a mossy surface in which *Habenaria saccata* and *Glyceria pauciflora* were rooted. These spots were considered parts of another ecosystem type enmeshed in the type under study, and so were not sampled. Also, in this stand the mineral surface was not flat and duff had accumulated in the depressions. Soil sampling was restricted to areas where the duff was thin or absent. Stand 119 had a 15% slope and thus was sufficiently well drained that gophers had been actively burrowing in the soil there. Although no detailed

19. *Thuja plicata-Athyrium filix-foemina* stand 120.

notes were made, certain species, such as *Vaccinium membranaceum* in stand 118, appear only where they can be rooted on rotten logs that are well elevated above the wet soil beneath.

The pH range of *Thuja-Athyrium* soils was found always to be lower (4.2 - 5.3) than the range for the associated *Thuja-Pachistima* soils of the uplands (5.6 - 6.3).

An impression was gained that at appropriate elevations in the mountains, wet soil combined with good cold-air drainage produced either the *Thuja-Athyrium* or the *Thuja-Oplopanax* h.t., but within the same elevation range, wherever a constriction in the valley floor resulted in a frost-pocket, the wet bottomland was occupied by *Abies lasiocarpa-Pachistima* forest with negligible amounts of *Athyrium* or *Oplopanax* if these were represented at all.

As the *Thuja-Oplopanax* h.t. is paired with the *Tsuga-Pachistima* h.t., so is the *Thuja-Athyrium* h.t. usually associated with only the *Thuja-Pachistima* h.t. in landscape mosaics. The *Thuja-Athyrium* h.t. is even more sparingly represented in the core area than is the *Thuja-Oplopanax* h.t.

We have not seen the *Thuja-Athyrium* h.t. outside of Idaho, but a closely related community distinguished by the addition of *Lysichitum americanum* has been recognized in southern British Columbia (90).

The *Abies lasiocarpa* series

All forests in the core area that lie above the upper ecotone of the *Tsuga heterophylla* series will be treated as the *Abies lasiocarpa* series. A few of the highest peaks in eastern Washington and northern Idaho reach elevations of a little more than 2100 m. This is slightly below the average altitude of upper timberline at this latitude in the Rockies (24) and discontinuous clumps of dwarfed and misshapen trees continue up over these summits. The highest vegetation has a krummholz character with an abundance of species characteristic of upper timberline in higher mountains. These facts show that the subjacent forest belt that extends down to about 1300 m to form an ecotone with members of the *Tsuga heterophylla* series is subalpine in its broad geographic relations.

Abies lasiocarpa or *Tsuga mertensiana* are the only tree species present that can perpetuate themselves as climax dominants. The *Abies* occurs practically throughout, but the *Tsuga* is limited to discontinuous tracts within the vertical and horizontal range of the *Abies* (33). Where the two grow on the same site, population structure usually suggests that one or the other is the superior competitor. Thus, within what is here designated as the *Abies lasiocarpa* series, two

distinct types of climax forest overstory can be recognized on the basis of succession trends in the tree layer.

Most south-facing slopes above about 1600 m in these forests are so well removed from the protection of the next ridge to the south that they are exposed to the maximum insolation as well as to the prevailing southwest winds. In consequence, they have sufficiently distinctive microclimates that their herbaceous and shrubby floras differ markedly from those of nearly level areas and northerly slopes. The ground cover of these southerly slopes is dominated by *Xerophyllum tenax* and *Vaccinium membranaceum* (the *Xerophyllum* union) occurring together in varying proportions.

The two species are not restricted to southerly slopes, but also extend over the ridgetops and down onto northerly slopes. But once off the southerly slopes their populations become attenuated. Probably the reason is that they are overtopped by a tall (approx. 2 m) mainly deciduous shrubbery consisting of *Menziesia ferruginea, Rhododenron albiflorum* and *Ledum glandulosum* (evergreen) occurring singly or in varying combinations. It is convenient to refer to these taller species as the *Menziesia* union.

Progressing downward from altitudes at which the two above-described undergrowth types alternate in a predictable manner depending on topography, herbs and shrubs indicative of warmer climate (the *Pachistima* union) appear in gradually increasing amounts. At the same time, the *Xerophyllum* and *Menziesia* unions tend to diminish erratically in representation as well as to lose their close correlation with topography. Before reaching the lower limit of *Abies lasiocarpa* as a climax dominant on uplands, a relatively rich flora of low herbs and shrubs occurs beneath the trees. The ecologic significance of this lower aspect-independent element of the subalpine forest cannot be ignored, even though the flora that characterizes it blends gradually into the two sharply differentiated undergrowth types that occur in essentially pure form higher on the slopes.

In contrast with the relatively limited extent of ecotones elsewhere in this forest mosaic, the situation here poses a problem: what arbitrary characters might define the limits of this low-altitude member of the *Abies lasiocarpa* series. After we had completed our field work, analysis of the data permitted a rather definite statement of the criteria that we had judged useful in the field:

1. The following species occurred *only* in the stands we classed from general impression as belonging to the low-altitude member:

Acer glabrum
Amelanchier alnifolia
Actaea rubra
Adenocaulon bicolor
Arenaria macrophylla
Arnica cordifolia
Aster conspicuus
Clintonia uniflora
Coptis occidentalis
Galium triflorum
Hieraceum albiflorum
Mitella stauropetala
Viola glabella
Rubus parviflorus
Spiraea betulifolia

Among the foregoing, *Clintonia* and *Galium* are the most useful indicators. All but one of the stands contained one or both species. The name *Abies lasiocarpa-Pachistima myrsinites* association seems appropriate, since nearly all in this list belong to the *Pachistima* union.

2. The following species found at higher altitudes never occurred in the *Abies lasiocarpa-Pachistima* forest: *Cassiope mertensiana, Ledum glandulosum* and *Phyllodoce empetriformis.*

3. Plots of 125 m^2 in stands of *Abies lasiocarpa-Pachistima* forest contained 14-35 vascular species in the undergrowth; in stands of the higher associations, the range was 5-16. The close agreement of this species diversity difference with the floristic criteria is notable.

In terms of elevation above sea level, the upper ecotone of the *Abies lasiocarpa-Pachistima* h.t. is unusually variable. Although the usual range in the core area is between 1300-1500 m, it may extend to 1770 m, which is well above the lower limits (1500 m) of the *Abies-Xerophyllum* and *Abies-Menziesia* h.ts.

If each distinctive combination of unions is accorded the status of an association, then the above five h.ts. can be distinguished as in table 5.

The environmental factors confining *Tsuga mertensiana* to restricted areas in the subalpine forest present a challenging problem thus far unsolved. No species of herb or shrub shows a correlated pattern, and no aspect of slope exposure, snow depth, elevation or soil analysis seems consistently related. To facilitate checking the lack of distinctiveness among subordinates, *Abies-* and *Tsuga*-dominated stands have been grouped in appendixes B-14 and B-15. The stands trending toward pure *Abies* are separated from those trending toward pure *Tsuga,* and the most strongly contrasted stands at the extremes.

Butters (10) noted that in the Glacier Park area of British Columbia *Tsuga mertensiana* is conspicuously lacking on soils derived from limestone. In an effort to pursue this suggestion that soil parent materials may be responsible for this pattern in climax tree species, pebbles obtained when screening the soil samples were saved and classified as to rock types represented. The results (table 6) strongly suggest that the distribution of *Tsuga mertensiana* is restricted to parent material containing rock minerals low in bases, whereas *Abies lasiocarpa* is rather indifferent to this mineral factor. However, such a relationship was not reflected in the pH data, nor in any aspect of the chemical analyses of the upper decimeter of mineral soil. A quantitative determination of the pebble types might have been illuminating, since base-rich pebbles were always associated with base-poor, and the data give no hint of relative proportions.

Judging from the relatively high sensitivity of undergrowth species to soil and microclimate, it seems unlikely that either of these environmental categories is exclusively involved, for there is no taxonomic differentiation among herbs

Table 5. Major characters distinguishing ecosystems in the *Abies lasiocarpa* series.

	Strongly insolated slopes	Weakly insolated slopes
Upper slopes	*Abies lasiocarpa-Xerophyllum tenax* assoc.	*Abies lasiocarpa-Menziesia ferruginea* assoc.
	or	or
	Tsuga mertensiana-Xerophyllum tenax assoc.	*Tsuga mertensiana-Menziesia ferruginea* assoc.
Lower slopes	— *Abies lasiocarpa-Pachistima myrsinites* assoc. —	

Table 6. Pebble types found in soils as related to forest stands which contain both *Abies lasiocarpa* and *Tsuga mertensiana,* in contrast to stands with *Abies* but lacking *Tsuga.* Pebble types are arranged roughly in order of increasing Ca content from top to bottom.

Pebble type	Trees and stand numbers: *Abies* plus *Tsuga*											*Abies* only																					
	46	47	97	98	127	128	132	133	134	135	157	45	48	100	101	102	121	122	123	124	125	126	129	130	131	136	137	155	156	159	160	161
Quartzitic gneiss														+																		
Quartz pegmatite													+							+												
Quartzite														+			+		+						+							
Hyd. alt. fine sandstone						+																										
Very fine quartz sandstone									+																							
Fine quartz sandstone							+																									
Metamorphosed siltstone										+																						
Hyrd alt. quartz siltstone				+	+	+		+		+							+															
Quartz siltstone						+			+		+			+														+	+			
Aplite	+																															
Argillaceous siltstone																													+			
Hydro. alter. siltstone																												+				
Siltstone?																												+		+		
Siltstone			+								+											+										
Mudstone				+																												
Quartz biotite feldspar																							+									
Quartz biotite gneiss																		+						+								
Hydroth. altered granite		+											+																			
Granite porphry												+																		+		
Granite												+		+																+	+	
Argillite							+							+			+						+									
Biotite gneiss														+																		
Granodiorite gneiss	+																										+					
Granodiorite														+					+		+		+	+		+	+					
Diorite						+													+	+												
Basalt															+	+																

and shrubs in areas supporting *Tsuga mertensiana* in comparison with areas where it is lacking. (Species diversity seems clearly less in *Tsuga*-dominated than in *Abies*-dominated stands. See appendix A.) On the other hand, trees are relatively more sensitive to macroclimate. Good evidence that macroclimate may be involved is provided by an occasional observation of *Tsuga* on one slope of a ridge with none of the tree on the opposite side.

This species is far better represented in the subalpine belt of the high mountains that follow closely along the Pacific coast from Alaska to California than it is in the Rockies. This suggests that local intensification of oceanic aspects of climate might favor it. These might be places more prone to fog or mist showers carried by the Westerlies, but the weather data needed to pursue any climatic hypothesis are lacking.

In the reconnaissance study, *Tsuga mertensiana* and *Abies lasiocarpa* were treated as alternative dominants of the same climax association. Our separation here, although admittedly resting on slender grounds, is based on:

1. occasional contiguity of stands dominated by different members of the pair
2. geographic distinctiveness of the range of *Tsuga mertensiana* (restricted to discrete areas on the western slopes of mountains)
3. a suggestion of differences in soil parent materials.

All these suggest intrinsic differences in environment which, if real, warrant the separation.

In the Rockies beyond the core area, and occasionally extending into its margins, there is an extensive and distinctive h.t. in which *Abies lasiocarpa* is the major climax dominant with *Picea engelmanni* approximating self-perpetuation. The undergrowth is dominated by *Vaccinium scoparium.* Plants characterizing undergrowth types in the core area are almost wholly unrepresented in this *Abies lasiocarpa-Vaccinium scoparium* h.t. Our tables show that *Vaccinium scoparium* is often a minor member of the undergrowth in the *Abies* series throughout the core area. However, in the *Abies-Vaccinium* association, it is dominant, and provides about half the total cover of shrubs and herbs.

Daubenmire (25) compiled the available climatic data for several major vegetation units in forests centered on the core area. He found that except for a single station, mean monthly temperatures for both July and August are consistently lower in forests of the *Abies lasiocarpa* series than in forests of the *Tsuga heterophylla* series. Precipitation data were not different, although limited data representing just the core area indicate that water surpluses are greater in the subalpine forests (appendix F).

The single exception to the temperature difference was provided by the data from Cold Springs Lookout in what was considered the southwestern extremity of the core area. Subsequent visitation of this station to determine why it is so much warmer than the other *Abies lasiocarpa* stations was most illuminating. Its inclusion in the earlier study was influenced by its location on the Idaho side of the Snake River canyon, but investigation showed that the *Abies lasiocarpa* forests of that area, and presumably farther to the southwest, do not belong to the suite of associations in the subalpine zone of the core area. Furthermore, neither *Tsuga* nor *Thuja* forests are represented below, as in the core area.

Since the *Abies lasiocarpa* forests in the Cold Springs area extend lower down the temperature gradient for lack of a superior competitor, the core area land occupied by the *Tsuga heterophylla* series apparently represents area which in its absence would be occupied mostly if not entirely by *Abies lasiocarpa* forest. This interpretation is in harmony with the fact established earlier that soils of the *Tsuga* and *Abies lasiocarpa* series are both moist throughout summer, except in the upper few centimeters of the profile.

Abies lasiocarpa-Pachistima myrsinites h.t.

In the *Abies lasiocarpa-Pachistima myrsinites* association, *Abies lasiocarpa* is the most vigorously reproducing tree. *Thuja* and *Tsuga* are not represented, except by occasional nonreproducing accidentals. The undergrowth usually includes more than 14 species of herbs and shrubs in a plot area of 125 m^2. Members of the *Pachistima* union, especially *Clintonia uniflora* or *Galium triflorum,* are well represented (fig. 20). *Cassiope, Ledum* and *Phyllodoce* are absent.

Seral trees in the *Abies lasiocarpa-Pachistima* h.t. include *Picea engelmanni, Pseudotsuga menziesii, Pinus monticola, P. contorta* and *Larix occidentalis.* This is the highest h.t. in the ecologic series that supports the *Pachistima* union in abundance. It is the highest in which a *Poa pratensis* sod may develop in response to heavy livestock grazing, and the highest in which a rich mixture of seral shrubs and herbs becomes superimposed on survivors of the *Pachistima* union following fire. (In the remaining members of the *Abies lasiocarpa* series, the undergrowth plants regenerate new shoots promptly after burning; a negligible influx of seral opportunists gain a foothold.)

Earlier, we alluded to the frequency of frost pockets where topography in the mountains favors nocturnal impoundments of cold air. The most conspicuous vegetative indicators of such habitats are *Abies lasiocarpa* and *Picea engelmanni* growing on valley floors where the surrounding slopes support vegetation in the *Tsuga* or *Pseudotsuga* series. An especially interesting example of the latter occurs along Dry Creek between Troy and Deary, Idaho. There, the *Abies* and *Picea* are abundantly represented for at least .5 km above an abrupt constriction in an otherwise rather broad valley. Here during one week in early October, a minimal temperature of –8.4 C was recorded 10 cm above the ground. At the same altitude above the ground but in the bottom of a steeply descending V-shaped ravine (*Thuja-Pachistima* h.t.) on a mountainside a few kilometers distant, only –1.8 C was recorded. At Dry Creek, another thermometer station on a slope 24 m above the valley floor recorded –7.9 C for the same period, showing that the pool of cold air well exceeded 24 m in depth. The *Abies lasiocarpa-Picea* stand here is 808 m above sea level; the ecotone between forest and steppe a few kilometers to the west rises slightly above this altitude. This overlap in altitudes of subalpine forest and steppe emphasizes the limitation of altitude data in ecologic work in these mountains.

Frost-pocket stands of *Abies lasiocarpa* and *Picea* are very common in our core area. Most of them are badly disturbed by livestock, but all seem to fit the criteria of the *Abies lasio-*

20. *Abies lasiocarpa-Pachistima myrsinites* stand 155.

carpa-Pachistima h.t. However, they have an abundance of *Cornus stolonifera* and *Alnus sinuata* that are almost never found in the upland phase of this association (appendix B-13). It is interesting that *Xerophyllum* and *Menziesia* show negligible tendency to follow the *Abies* and *Picea* to these lower limits. In frost-pocket environments, *Picea* regularly extends to lower altitudes than *Abies lasiocarpa.*

On uplands, at the ecotone between the *Abies lasiocarpa-Pachistima* h.t. and the *Pseudotsuga-Calamagrostis* h.t. *Abies* often tends to migrate slowly downward into vegetation which in its absence would be classified as *Pseudotsuga-Calamagrostis* forest.

The results of analyses of small mammals in this forest are in appendix C.

Most h.ts. in the *Abies lasiocarpa* series are characterized by distinctly acid soils, usually in the range of pH 4.0 - 4.7. While the range for *Abies-Pachistima* soils extended as low as pH 4.5, they were mostly well above the pH limits of h.ts. in which the *Menziesia* and *Xerophyllum* unions constituted most of the undergrowth. Above the altitudinal limits of the *Tsuga heterophylla* forest, soils come under the influence of *Abies lasiocarpa* and litter has a higher nutrient content (23a). There, soil fertility seems ameliorated in every respect (appendix D) although only the K level proved to be significantly higher.

Two of Secor's (80) soil profile descriptions representing the *Abies lasiocarpa-Pachistima* association are abstracted below. His P-15, a Brown Podzolic and a Typic Cryandept, is very near our stand 65:

02 0.5-0″ Very dark grayish brown (10YR 3/2d) or black (5YR 2/1m) duff, overlain by mosses
A1 Absent or indistinct
A2 In pockets up to 10 mm thick
B21 0-8″ Brown (10YR 4/3d) or very dark grayish brown (10YR 3/2m) silt loam containing few Fe stains and charcoal; weak subangular blocky; roots abundant
B22 8-15″ Yellowish brown (10YR 5/4d) or brown (10YR 4/3m) silt loam containing charcoal; more compact than above; roots fewer
B3 15-29″ Brown (10YR 5/3d) or dark yellowish brown (10YR 4/4m) sandy loam, consisting of a mixture of volcanic ash and pockets of decomposing granite; no roots below this horizon
C-D 29-34″ Light yellowish brown (10YR 6/4d) or yellowish brown (10YR 5/4m) sandy loam; derived from weathered granite with a small amount of volcanic ash.

Secor's P-5, also a Brown Podzolic and a Typic Cryandept, is very near our stand 123:

02 1.5-0″ Very dark grayish brown (10YR 3/2d) or dark reddish brown (10YR 2/2m) duff, overlain by mosses

A1-A2 0-1″ Light gray (7.5YR 7/0d) or gray (5YR 5/1m) silt loam; A1 indistinct, A2 dominant but intermittent

B21 1-4″ Dark brown (10YR 4/3d) or dark reddish brown (5YR 3/2m) silt loam; blocky; more dense than surjacent horizon; roots numerous

B22 4-9″ Dark yellowish brown (10YR 4/4d) or dark reddish brown (5YR 3/3m) silt loam; few rocks in this and upper horizons; blocky; fewer roots

B3 9-14″ Yellowish brown (10YR 5/6d) or reddish brown (5YR 4/4m) sandy loam with high concentration of rocks 0.75-1″ x 2-6″; less dense and more fluffy than above

D1 14-20″ Yellowish brown (10YR 5/6d) or dark brown (7.5YR 4/4m) sandy loam containing schist rocks; weakly blocky; without fluffiness; roots fewer

D2 20-28″ Yellowish brown (10YR 5/6d) or dark brown (7.5YR 4/4m) loamy sand; weakly blocky; slightly less dense than above

D3 28-34″ Strong brown (7.5YR 5/6d) or dark brown (7.5YR 4/4m) loamy sand with slightly more gravel than above, and less compact

D4 34-41″ Strong brown (7.5YR 5/6d) or dark brown (7.5YR 4/4m) loamy sand with more gravel than above

D5 41-47″ Strong brown (7.5YR 5/6d) or dark brown (7.5YR 4/4m) sand, consisting of highly weathered schistose sand and gravel; roots not abundant.

In Ferry County, Washington, a stand of *Abies lasiocarpa-Pachistima* forest was examined. W. A. Starr had studied the soil profile and classified it as a Podzol, the Scar Series, now classified as a Typic Cryochrept. Garber (36) has described the profile in an *Abies lasiocarpa-Pachistima* stand in Valley County, Idaho that was classified as a Jughandle coarse sandy loam, a Brown Podzolic and a Typic Cryochrept.

The *Abies lasiocarpa-Pachistima* h.t. has been identified from the western foothills of the Cascade Mountains in central Washington to the southwestern corner of Alberta, to Valley County, Idaho.

Illingsworth and Arlidge's (47) "*Cornus*-moss site type," "*Disporum* site type," and "*Aralia-Dryopteris* site type" may be segregates of what we have described as the *Abies lasiocarpa-Pachistima* association, based on studies of seral stands. Their listing of *Picea glauca* instead of *P. engelmanni* is not the serious difference it may seem, since a large proportion of the *Picea* in the interior of British Columbia (excepting *P. mariana*) represents some degree of hybridization between *P. engelmanni* and *P. glauca* (37).

Abies lasiocarpa-Xerophyllum tenax h.t.

The *Abies lasiocarpa-Xerophyllum tenax* association is distinguished by having *Abies lasiocarpa* as the most important self-reproducing tree, and an undergrowth in which *Xerophyllum tenax* and *Vaccinium membranaceum* are the major dominants (fig. 21). *Tsuga mertensiana* and *Menziesia ferruginea* are absent, and the *Pachistima* union is virtually absent.

Picea engelmanni, a long-lived seral tree in most of the other h.ts. in the *Abies lasiocarpa* series, is almost unrepresented here where the forest undergrowth consists of the *Xerophyllum* union alone. While soils in the *Abies lasiocarpa* series appear to dry only a few centimeters deep each summer, the deepest extension of drouth undoubtedly occurs here. This may well account for the low adaptability of *Picea* to *Xerophyllum* sites despite the relative openness of the stands on south-facing slopes. The tap roots of *Picea* seedlings do not penetrate as deeply as those of *Abies lasiocarpa* during the critical first year (29). Just a few hours without water uptake are fatal (22). The occasional occurrence of *Menziesia* in ravines on south-facing slopes that otherwise support only the *Xerophyllum* union also suggests that soil drouth is critical here on southerly slopes, even though it involves only the upper few centimeters of the profile.

Pseudotsuga and *Pinus albicaulis* are mainly seral species. But where an *Abies-Xerophyllum* stand occurs on an abnormally exposed area, trees may remain spaced widely enough that these retain a minor place in the climax.

In the *Xerophyllum* union, most foliage of *Xerophyllum* is within 50 cm of the ground surface, but *Vaccinium membranaceum* commonly is almost twice this height. Normally, both species flower only sparingly under forest conditions, but following a fire both flower vigorously until a new tree canopy develops (fig. 22). Both of these species may occur erratically downslope as far as the *Pseudotsuga-Physocarpus* h.t. Only in the *Abies-Xerophyllum* association do they assume dominance over all other undergrowth plants. The median number of herbaceous and shrubby species found in the macroplots was 12 (range 5-15). After *Xerophyllum* and *Vaccinium membranaceum, V. scoparium* ranks third in importance in both coverage and regularity of occurrence in the stands. *Carex geyeri* is the only other undergrowth species regularly encountered.

For data on small mammals, see appendix C.

As a class, soils where the *Xerophyllum* union dominates undergrowth tend to be less fertile than soils of the *Abies lasiocarpa-Pachistima* forest below (table 1), although only the drop in pH proved to be statistically significant.

Two of Secor's (80) three soil profiles representing the *Abies lasiocarpa-Xerophyllum* ecosystem are abstracted below. His P-3, a Brown Podzolic and a Typic Cryorthod, is very near our stand 129:

01 1.5-0″ Dark brown (10YR 3/3d) or dark reddish brown (5YR 2/2m) duff overlain by a moss cover

A1 Absent, or present only in traces

A1-A2 0-0.5″ Dark grayish brown (10YR 4/2d) or dark reddish brown (5YR 3/2m) sandy loam; intermittent, but sharply defined where present

A3-B1 0.5-5.5″ Dark brown (10YR 4/3d) or dark reddish brown (5YR 3/2m) sandy loam with large gneissic rocks 2-4″ x 3-6″ that are not oriented with the land surface; crumb structure; fluffy

B21 5.5-12.5″ Dark brown (10YR 4/3d) or dark reddish brown (5YR 3/3m) silt loam with abundant stones;

21. When the *Xerophyllum* union occurs beneath a forest canopy, both the *Xerophyllum tenax* (with grass-like leaves) and the *Vaccinium membranaceum* rarely flower.

granular to faintly subangular blocky; fluffy; charcoal present

B22 12.5-19.5″ Yellowish brown (10YR 5/4d) or dark reddish brown (5YR 3/4m) sandy loam; granular to faintly subangular blocky

B3 19.5-27.5″ Dark yellowish brown (10YR 4/4d) or dark brown (10YR 3/3m) sandy loam with abundant rocks; faintly subangular blocky; fluffy; roots abundant

D1 27.5-39.5″ Yellowish brown (10YR 5/4d) or brown (10YR 4/3m) sandy loam; blocky peds moderately distinct and firm, fluffiness absent; roots fewer

D2 39.5-47.5″ Yellowish brown (10YR 5/4d) or dark yellowish brown (10YR 4/4m) sandy loam with numerous rocks; massive to somewhat blocky; not fluffy, harder than surjacent horizon; roots sparse.

Secor's P-19, also a Brown Podzolic and a Typic Cryorthod, is most comparable in location with our stand 156:

01 1.5-0″ Very dark grayish brown (10YR 3/2d) or dark reddish brown (5YR 3/2m) duff, overlain by a sparse moss cover

A3-B1 0-10″ Dark yellowish brown (10YR 4/4d) or brown (10YR 4/3m) coarse loam; crumb structure; roots very numerous

B2 10-18″ Yellowish brown (10YR 5/4d) or dark yellowish brown (10YR 4/4m) sandy loam, consisting of pockets of volcanic ash mixed with granitic material; weak subangular blocky; roots abundant; large boulders here and in lower horizons

B3-D 18-24″ Yellowish brown (10YR 5/4d) or dark yellowish brown (10YR 4/4m) sandy loam; massive; granitic material similar to subjacent horizon; boundary abrupt

D 24-28″ Very pale brown (10YR 7/3d) or light yellowish brown (10YR 6/4m) sandy loam from decomposing granitic material.

The *Abies lasiocarpa-Xerophyllum* h.t. is known from eastern Washington, northern Idaho, southwestern Alberta, and western Montana as far south as Granite County. Stands closely similar in physiognomy and in regard to the *Xerophyllum* union occur in the Cascade Mountains, but the tree union has a different composition where these communities have been seen.

Tsuga mertensiana-Xerophyllum tenax h.t.

The *Tsuga mertensiana-Xerophyllum tenax* association differs from the *Abies lasiocarpa-Xerophyllum* association only in that *Tsuga* is here a self-reproducing species. Usually,

22. The *Xerophyllum* union regenerates promptly from subterranean organs following fire and both dominants then flower abundantly until a new forest canopy develops. This old burn has undergone one major wave of invasion by *Abies lasiocarpa* and *Pinus albicaulis*. Note the absence of opportunistic shrubs and forbs that dominate after burning at lower altitudes where the *Pachistima* union is well represented.

Tsuga is associated with *Abies lasiocarpa,* but it may occur alone (e.g., stand 61 in appendix A-13).

Two of Secor's (80) soil profiles (his P-9 and P-10) represent the *Tsuga-Xerophyllum* h.t. They are about 8 km apart, and are in the general vicinity of our stand 61. His profile P-9 is a Brown Podzolic and a Typic Haplorthod:

01 0.75-0″ Very dark grayish brown (10YR 3/2d) or dark reddish brown (5YR 3/2m) litter and duff

A1-A3 0-8″ Dark grayish brown (10YR 4/2d) or very dark grayish brown (10YR 3/2m) loam, containing charcoal; A_1 very thin; crumb structure; roots very abundant

B2 8-11″ Dark yellowish brown (10YR 4/4d) or brown (10YR 4/3m) sandy loam containing charcoal; weak subangular blocky; roots fewer than in surjacent horizon

B-C 11-18″ Yellowish brown (10YR 5/4d) or dark yellowish brown (10YR 4/4m) sandy loam, composed of decomposing granite and volcanic ash; roots abundant

D 18-24″ Light yellowish brown (10YR 6/4d) or yellowish brown (10YR 5/6m) sandy loam composed of decomposing granite; roots sparse

Secor's profile P-10 is:

01 0.75-0″ Very dark grayish brown (10YR 3/2d) or dark reddish brown (5YR 3/2m) litter and duff

A1 and A2 virtually absent or indistinct

A3-B1 0-9″ Brown (10YR 4/3d) or dark brown (10YR 3/3m) silt loam with charcoal included; well developed crumb structure; roots abundant

B2 9-12″ Brown (10YR 5/3d) or dark brown (10YR 4/3m) silt loam; weak subangular blocky; more compact than surjacent horizon; roots relatively abundant

B3 12-21″ Yellowish brown (10YR 5/4d) or dark yellowish brown (10YR 4/4m) silt loam consisting of volcanic ash; faintly subangular blocky; roots sparse

C-D 21-27″ Light yellowish brown (10YR 6/4d) or yellowish brown (10YR 5/6m) sandy loam consisting principally of decomposing mica schist, with an occasional tongue of volcanic ash along the upper boundary; roots practically absent.

The *Tsuga mertensiana-Xerophyllum* h.t. has been observed only in northern Idaho, although it undoubtedly is also represented in western Montana as well.

Abies lasiocarpa-Menziesia ferruginea h.t.

Climax forests in the *Abies lasiocarpa-Menziesia ferruginea* h.t. have *Abies lasiocarpa* as the most strongly self-reproducing tree. In the undergrowth of dense shrubbery about 2 m tall (fig. 23), usually *Menziesia ferruginea,* but sometimes *Rhododendron albiflorum* and rarely *Ledum glandulosum,* is the most conspicuous dominant. *Tsuga mertensiana* is absent, and the *Pachistima* union is virtually unrepresented.

Slopes with a *Menziesia* union are difficult to analyze because the dense shrubbery is pressed against the soil for a long period by winter snows. Only the tips of the plants spring erect in summer, so that the bases of the stems remain permanently directed downslope. In summer the bark slips readily when one steps on the stems so that footing is precarious. To maintain one's position it is usually necessary to hold onto the stems of shrubs on the uphill side. Unlike *Xerophyllum* and *Vaccinium, Menziesia* and *Rhododendron* flower regularly under a forest canopy. *Ledum glandulosum* is mainly a bog margin shrub in the northern Rockies. Where it dominates a slope on which one would expect to find *Menziesia* instead, no other bogs species are present.

The median number of herbs and shrubs found in the macroplots was 10 (range 7-16). This decrease below the value for *Abies-Xerophyllum* stands probably reflects the colder microclimate.

Picea engelmanni is common in the forest and usually plays a seral role. *Pinus albicaulis, P. monticola, P. contorta* and *Larix occidentalis* are strictly seral. *Tsuga heterophylla* and *T. mertensiana* occur rarely as accidentals in random sizes.

Primary succession on granodiorite rubble has been described for one mountain in Bonner County, Idaho, where the *Abies-Menziesia* association is climax (30). Epilithic mosses confined to sheltered pockets between the rocks provide seed beds for crevice herbs and shrubs. The *Xerophyllum* and *Menziesia* unions together form the first consolidated cover; then the climax *Abies lasiocarpa* becomes superimposed (fig. 24). The precocity of these herbs and shrubs here, and the prompt regeneration of undergrowth following fire in other habitats, shows clearly that herb-shrub vegetation of these forests occupies the h.t. independent of the tree cover.

23. Interior of *Abies lasiocarpa - Menziesia ferruginea* stand. *Menziesia* and *Rhododendron albiflorum,* growing about 2 m tall, provide an almost complete cover. (Photo courtesy of H. W. Smith.)

In passing from the south side of a ridge where the *Xerophyllum* union alone comprises the vascular undergrowth, to the north slope where the *Menziesia* union becomes superimposed, there is a suggestion of less Ca (but not Mg or K) and lower base saturation of the colloids. Only the accompanying drop in pH proved to be statistically significant (appendix D). Secor (80) obtained a highly significant decline in both pH and Ca from *Abies-Pachistima* to *Abies-Xerophyllum* to *Abies-Menziesia* h.ts.

Secor (80) described four profiles from *Abies-Menziesia* stands (his P-1, P-2, P-3 and P-18). His P-1 is a Brown Podzolic now classified as a Typic Cryandept. It is located very near our stand 137:

01 1-0″ Dark brown (10YR 3/3d) to black (5YR 2/1m) duff overlain by moss
A1 Absent or indistinct
A2 0-0.5″ Light gray (7.5YR 7/0d) or gray (5YR 5/1m) silt loam; discontinuous, with the thickness normally between a trace and 0.75″, with an occasional tongue to 1″
B2 0.5-5.5″ Dark brown (7.5YR 4/4d) or (7.5YR 3/2m) silt loam with numerous slightly rounded stones; weak angular blocky; roots abundant
B22 5.5-11″ Brown (7.5YR 5/4d) or dark brown (7.5YR 3/2m) loam; faintly subangular blocky to blocky; peds not as well defined nor as stable as in B21
B3 11-20″ Brown (7.5YR 5/4d) or dark brown (7.5YR 4/2m) loam with rocks and stones still abundant; peds more distinct than in B22 but less stable; roots fewer
D1 20-28″ Light brown (7.5YR 6/4d) or dark brown (7.5YR 4/4m) coarse sandy loam; blocky with peds more distinct than in B3 but not more stable; not developed from same fluffy material as above; roots fewer
D2 28-34″ Light brown (7.5YR 6/4d) or dark brown (7.5YR 4/4m) coarse sandy loam; roots essentially absent.

Secor's P-18 is very near our stand 131:

01 Very thin moss cover
02 2-0″ Very dark grayish brown (10YR 3/2d) or dark reddish brown (5YR 3/2m) duff
A2 Intermittent; generally in pockets 1-2mm thick
B21 0-4″ Yellowish brown (10YR 5/4d) or brown (10YR 4/3m) coarse silt loam; faintly subangular blocky; roots relatively abundant; large irregularly shaped boulders occur here and in all the lower horizons
B22 4-14″ Yellowish brown (10YR 5/4d) or dark yellowish brown (10YR 4/4m) loam; faintly subangular

24. *Menziesia* and *Xerophyllum* unions invading rubble in advance of *Abies lasiocarpa.*

blocky; more compact than surjacent horizon; roots abundant

B3D 14-22″ Light yellowish brown (10YR 6/4d) or yellowish brown (10YR 5/4m) sandy loam containing pockets of volcanic ash mixed with decomposing granitic material; roots definitely fewer

D 22-27″ Light yellowish brown (10YR 6/4d) or yellowish brown (10YR 5/4m) sandy loam consisting of rotten granitic material; roots very sparse.

We have seen the *Abies lasiocarpa-Menziesia* h.t. from southwestern Alberta to northeastern Washington and from the Boise National Forest east-northeast of Cascade, Idaho, to Skalkaho Pass in Granite County, Montana.

Tsuga mertensiana-Menziesia ferruginea h.t.

In the *Tsuga mertensiana-Menziesia ferruginea* association *Tsuga mertensiana* is an obviously self-reproducing tree. The undergrowth consists of the *Menziesia* and *Xerophyllum* unions.

Two of Secor's soil profiles (his P-11 and P-12) refer to this h.t. They are about 3 miles apart near our stand 63. P-11 is a Brown Podzolic soil, now classified as a Typic Vitrandept.

0-1 1-0″ Very dark grayish brown (10YR 3/2d) or dark reddish brown (5YR 3/2m) litter and duff with incorporated charcoal

A1 Absent or indistinct

A2 Grayish brown (10YR 5/2d) or (10YR 3/1m) material varying from 0-2 mm thick

B21 0-8″ Dark yellowish brown (10YR 4/4d) or dark brown (10YR 3/3m) silt loam; faint subangular blocky; highly micaceous; roots abundant

B22 8-16″ Light yellowish brown (10YR 6/4d) or brown (10YR 4/3m) loam; faintly subangular blocky; more compact than surjacent horizon and with fewer roots

B3 16-22″ Light yellowish brown (10YR 6/4d) or dark yellowish brown (10YR 4/4m) loam; massive; roots not abundant

D 22-30″ Light yellowish brown (10YR 6/4d) or dark yellowish brown (10YR 4/4m) structureless decomposing granite; roots sparse.

Profile P-12 is a Brown Podzolic soil, now classified as a Lithic Vitrandept.

01 1.5-0″ Very dark grayish brown (10YR 3/2d) or dark reddish brown (5YR 3/2m) litter and duff

A1 Absent or indistinct

A2 Grayish brown (10YR 5/2d) or very dark gray (10YR 3/1m) material occurring only in pockets

B2 0-9″ Dark brown (10YR 4/3d) or dark grayish brown (10YR 3/2m) silt loam; very faint subangular blocky; Fe stains numerous, especially in lower part; roots present

B3 9-15″ Light yellowish brown (10YR 6/4d) or dark

yellowish brown (10YR 4/4m) loam; massive to subangular blocky; few Fe stains; roots present

D 15-20″ Very pale brown (10YR 7/4d) or yellowish brown (10YR 5/6m) granitic, highly micaceous sandy loam; massive; roots almost absent.

The *Tsuga mertensiana-Menziesia* h.t. has been observed only in northern Idaho, but it is probably in western Montana also.

Abies lasiocarpa-Vaccinium scoparium h.t.

In the *Abies lasiocarpa-Vaccinium scoparium* association both *Abies lasiocarpa* and *Picea engelmanni* are self-reproducing, but the former maintains the denser population. Typically the undergrowth is quite sparse. *Vaccinium scoparium* provides about half the total canopy cover of the shrubs and herbs combined (fig. 25).

Both *Pinus contorta* and *Larix occidentalis* were encountered as seral trees in all three stands that were analyzed in the margin of the core area. Elsewhere throughout the extensive range of the h.t., *Larix* is not encountered.

The undergrowth of stand 101 (appendix B-16) is atypically rich. Of the total list of 34 species of undergrowth vasculares in the three stands, this one had 18 not found in either of the other two. Stands 100 and 102 are much more typical of the forest over an extensive area. Oosting and Reed (68) presented detailed analyses of this association in southern Wyoming. Their eight stands are closely comparable to our numbers 100 and 102 in physiognomy and dominants, although many of the poorly represented species are different.

Vaccinium scoparium is a subordinate in about 80% of the stands in our core area where the *Xerophyllum* or *Menziesia* unions dominate. There is no recognizable pattern to its variation as a subordinate. If a rigorous analysis of its coverage is made by restricting consideration to a limited area, such as the 13 stands of subalpine forest in Shoshone County, Idaho, the variation in coverage of this plant is not related to altitude, direction or percent slope. About the periphery of our core area, hybrid stands in which *Xerophyllum* and *Vaccinium scoparium* share dominance are abundant.

Owing perhaps to the fewness of samples, soils of the *Abies-Vaccinium* h.t. did not prove different from those of

25. Unusually dense stand of *Vaccinium scoparium* in an old burn still supporting *Pinus contorta* rather than *Abies lasiocarpa*. Only the lowest (white) decimeter segment of the stake is obscured by the dwarf shrub.

h.ts. where the *Xerophyllum* or *Menziesia* unions dominate (appendix D).

We have seen the *Abies-Vaccinium scoparium* association over an area from central British Columbia to central Montana and north-central Oregon to Colorado. In all this range, it appears to be most poorly represented in that part of the Rockies where the oceanic climatic influence is strongest, i.e., in the core area.

Illingsworth and Arlidge's (47) "*Vaccinium scoparium* site type" as described for southern British Columbia would be closely matched by our *Abies lasiocarpa-Vaccinium scoparium* h.t. where it had been burned over recently. The "fir-*Vaccinium scoparium* type" and "lodgepole pine-*Vaccinium scoparium* type" recognized by the U.S. Forest Service (88) in Oregon are climax and seral expressions of the same ecosystem, and correlate directly with our *Abies-Vaccinium* h.t.

Pinus albicaulis-Abies lasiocarpa h.t.

The dwarfed and wind-deformed trees of *Pinus albicaulis* and *Abies lasiocarpa* that are scattered singly or in small groves on the highest peaks and ridges of our core area are recognized as indicating a distinctive h.t. in which these two species share climax status, but no quantitative analyses of the small and heterogeneous stands have been made. *Larix lyallii,* a rare tree in the core area, may also occur here. In contrast with other trees at timberline, it has not been seen in krummholz form. To the east of our core area *Picea engelmanni* may also ascend to upper timberline, and *Pinus flexilis* is often added. The discontinuous ground cover between the trees or groves is commonly dominated by *Vaccinium scoparium, Xerophyllum tenax, Carex* spp. and *Luzula. Erigeron peregrinus* and *Polygonum bistortoides* are characteristic also.

The rust *Cronartium ribicola* has for some time been a serious cause of disease on *Pinus monticola* at lower altitudes. In the past decade or so it has spread rapidly through *Pinus albicaulis-Abies* stands with devastating effect on the pine. Cones of this pine were usually demolished by Clarks nutcrackers well before the large seeds were ripe. When cone crops were heavy, squirrels came from nearby forests and cut many cones, the caches of which were then pilfered by black bears. With so much animal pressure on the seed crops previously, and the fungal devastation now added, tremendous reduction in the pine population, if not extinction, seems inevitable.

The soils of this h.t. are almost invariably thin, coarse and stony. The h.t. is often interrupted by rock outcropping or rubble.

The "alpine fir-whitebark pine type" recognized by the U.S. Forest Service (88) in central Oregon correlates directly with the unit described above.

KEY TO CONIFEROUS FOREST HABITAT TYPES
IN EASTERN WASHINGTON AND NORTHERN IDAHO

The following key is applicable to stands that have not been very seriously disturbed in recent years. To identify others, the broad geographic position together with the position in the local vegetation mosaic is an additional criterion that is highly useful.

1. *Pinus ponderosa* present; other conifers absent
    2. Undergrowth dominated by caespitose grasses; shrubs inconspicuous; *Arceuthobium* usually abundant
        3. *Festuca idahoensis* the principal grass ..... PINUS PONDEROSA-FESTUCA IDAHOENSIS H.T.
        3. *Agropyon spicatum* the principal grass; soil usually with high stone content ..... PINUS PONDEROSA-AGROPYRON SPICATUM H.T.
        3. *Stipa comata* the principal grass; soil conspicuously sandy ..... PINUS PONDEROSA-STIPA COMATA H.T.
    2. Shrubs conspicuous in undergrowth
        4. *Purshia tridentata* well represented; soil sandy or stony; *Arceuthobium* usually present ..... PINUS PONDEROSA-PURSHIA TRIDENTATA H.T.
        4. *Purshia* and *Arceuthobium* absent; soil a loam or stony loam
            5. *Physocarpus* and/or *Holodiscus* well represented .. PINUS PONDEROSA-PHYSOCARPUS MALVACEUS H.T.
            5. *Physocarpus* and *Holodiscus* absent; undergrowth dominated by *Symphoricarpos, Rosa woodsii, Rosa nutkana, Spiraea betulifolia* or *Prunus virginiana* ..... PINUS PONDEROSA-SYMPHORICARPOS ALBUS H.T.
1. Coniferous trees other than *Pinus ponderosa* present and reproducing
    6. *Thuja, Tsuga* and *Abies lasiocarpa* absent, or at least not reproducing
        7. *Abies grandis* absent; undergrowth lacking *Clintonia, Linnaea, Pyrola* spp., *Vaccinium membranaceum,* and *Viola orbiculata*

8. *Calamagrostis rubescens,* often with much *Carex geyeri* or *C. concinnoides,* very conspicuous in the undergrowth; shrubs other than *Arctostaphylos* or *Vaccinium inconspicuous*

9. *Arctostaphylos* and *Vaccinium* unrepresented ..... PSEUDOTSUGA MENZIESII-CALAMAGROSTIS RUBESCENS H.T.

9. *Arctostaphylos* present; *Vaccinium* usually present ..... PSEUDOTSUGA-CALAMAGROSTIS H.T., ARCTOSTAPHYLOS PHASE

8. *Calamagrostis, Carex geyeri* and *C. concinnoides* poorly represented, if at all present; shrubs other than *Arctostaphylos* or *Vaccinium* dominant

10. *Physocarpus* and/or *Holodiscus* well represented ..... PSEUDOTSUGA MENZIESII-PHYSOCARPUS MALVACEUS H.T.

10. *Physocarpus* and *Holodiscus* absent; *Symphoricarpos* and/or *Spiraea betulifolia* abundantly represented ..... PSEUDOTSUGA MENZIESII-SYMPHORICARPOS ALBUS H.T.

7. *Abies grandis* present and reproducing successfully ..... ABIES GRANDIS-PACHISTIMA MYRSINITES H.T.

6. *Thuja, Tsuga* or *Abies lasiocarpa* present and reproducing

11. *Thuja* or *Tsuga heterophylla* reproducing successfully

12. Uplands; *Oplopanax* absent; *Athyrium filix-foemina,* if present, scarcely half a meter tall

13. *Tsuga* absent; *Thuja* reproducing successfully ..... THUJA PLICATA-PACHISTIMA MYRSINITES H.T.

13. *Tsuga* present and reproducing well ..... TSUGA HETEROPHYLLA-PACHISTIMA MYRSINITES H.T.

12. Moist bottomlands or slopes with seepage; *Athyrium* usually abundant and well over half a meter tall

14. *Oplopanax* abundant; contiguous uplands belonging to the *Tsuga-Pachistima* h.t. ..... THUJA PLICATA-OPLOPANAX HORRIDUM H.T.

14. *Oplopanax* absent; contiguous uplands usually belonging to the *Thuja-Pachistima* h.t. ..... THUJA PLICATA-ATHYRIUM FILIX-FOEMINA H.T.

11. *Thuja* and *Tsuga heterophylla* present as nonreproducing accidentals if at all; *Abies lasiocarpa* and/or *Tsuga mertensiana* reproducing well

15. *Clintonia* and/or *Galium triflorum* usually present; usually with more than 14 undergrowth spp./375m^2; *Cassiope, Ledum* and *Phyllodoce* absent ..... ABIES LASIOCARPA-PACHISTIMA MYRSINITES H.T.

15. *Clintonia* and *Galium* absent; usually with fewer than 14 undergrowth spp./375m^2

16. *Tsuga mertensiana* reproducing more vigorously than *Abies lasiocarpa*

17. Undergrowth with *Menziesia* well represented ..... TSUGA MERTENSIANA-MENZIESIA FERRUGINEA H.T.

17. Undergrowth lacking *Menziesia, Rhododendron* and *Ledum; Xerophyllum* or *Vaccinium membranaceum* dominant ..... TSUGA MERTENSIANA-XEROPHYLLUM TENAX H.T.

16. *Tsuga mertensiana* absent

18. Trees tall, not wind-deformed, forming a closed forest

19. Undergrowth with *Menziesia, Rhododendron* or *Ledum glandulosum* conspicuous ..... ABIES LASIOCARPA-MENZIESIA FERRUGINEA H.T.

19. *Menziesia, Rhododendron* and *Ledum* absent

20. *Xerophyllum* or *Vaccinium membranaceum* dominant beneath the trees ..... ABIES LASIOCARPA-XEROPHYLLUM TENAX H.T.

20. *Vaccinium scoparium* dominant beneath the trees ..... ABIES LASIOCARPA-VACCINIUM SCOPARIUM H.T.

18. Trees dwarfed and wind-deformed, occurring as well separated groups or individuals ..... PINUS ALBICAULIS-ABIES LASIOCARPA H.T.

OTHER VEGETATION TYPES

The above classification accounts for practically all types of conifer-dominated vegetation that have been encountered in the core area. Other vegetation types dominated by angiosperms occur enmeshed in this conifer matrix. These have not yet been studied in detail, so only their general nature can be suggested at this time.

Alnus sinuata scrub

Where upland forests have the *Pachistima* union as their undergrowth (*Abies grandis-Pachistima* to *Abies lasiocarpa-Pachistima* h.ts.), seepage areas in shallow but steeply sloping ravines support a climax deciduous scrub about 4 m tall in which *Alnus sinuata* is dominant. *Alnus* stems, even more than *Menziesia,* lie prostrate at the base with the lower limbs directed downslope and the tips springing erect after the heavy snow cover melts in spring. *Alnus* bears a profusion of branches so low as to make the stands almost impenetrable. Minor woody associates of about the same stature include *Acer glabrum, Sambucus caerulea, Sorbus scopulina* and *Salix* spp. In the undergrowth, the *Pachistima* union is often very well developed. The h.t. is also characterized by a special abundance of such plants as *Aconitum columbianum, Montia* spp., *Senecio triangularis, Veratrum viride,* and large ferns including *Athyrium filix-foemina.*

Other than the wetness of the soils from seepage, the substrate is not manifestly different from soils of contiguous uplands.

Slopes with limited seepage often support a thin stand of *Alnus* growing beneath conifers characteristic of contiguous habitats lacking seepage. These hybrid stands might appropriately be recognized as an "*Alnus sinuata* phase" of such an upland association.

Parks

Locally there are permanent openings in the forest that support herbaceous vegetation rooted in mineral soil. These seem to fall into four major categories:

1. In *Pinus ponderosa* forests with grass undergrowth that occupied most of the gravelly floors of valleys of the Spokane River and Purcell Trench that branches off northward just above Spokane, there were local openings lacking woody plants when white man first came into the area. Such parks were basically outliers of steppe communities that covered a greater area beyond lower timberline.

2. In areas with more rainfall than the above, especially where the *Abies grandis-Pachistima* h.t. characterizes the uplands, there are aggraded valleys supporting grass. *Juncus* and other marsh plants line the drainage ways. These parks are almost universally devastated by excessive grazing. The least-disturbed of them seem to indicate that *Deschampsia caespitosa* was a major dominant before the white man arrived.

3. At altitudes where members of the *Abies lasiocarpa* series occupy most of the land, there are situations where topography channels air flow so that excessive wind transfers most of the annual snowfall off southerly slopes.

As a result, the soils here dry deeply each summer (29). The xerophytic parks that mark such places are dominated by some of the same herbs found in the steppes of the basal plain (e.g., *Agropyron spicatum, Festuca idahoensis, Senecio integerrimus*), yet contain a flora characteristic of only these habitats in the core area (e.g. *Festuca viridula, Arenaria capillaris americana, Polygonum phytolaccaefolium*).

4. Precipitation transferred by wind from southerly slopes, which leaves the latter moisture-deficient in summer, may be dissipated widely over the contiguous northerly slopes. But commonly it comes to rest just over the ridge crest and accumulates as excessively deep drifts that persist into summer. If the drift melts fairly early in summer, its most conspicuous influence is to dwarf the trees, produce crooked boles and shear off limbs. *Abies lasiocarpa* may never exceed 2 m in height here, even when a century old. Where drifts are deeper and persist well into July, there occur small treeless parks dominated by truly alpine herbs such as *Carex nigricans, C. tolmei, Deschampsia atropupurea, Polygonum bistortoides, Sibbaldia procumbens,* etc.

Fen and bog

Where uplands support forest of either the *Tsuga heterophylla* or *Abies lasiocarpa* series, there are poorly drained valley floors or morainic ponds where peat accumulates and the associated vegetation is either fen or bog. *Carex* determines the physiognomy of herbaceous fens, with a low scrub of *Spiraea douglasii* on slightly better drained peat surfaces; *Alnus sinuata* thicket represents the ultimate stage of fen development.

Elsewhere, presumably where the peat is more base-deficient, dominants including *Sphagnum, Kalmia polifolia* and *Betula glandulosa* characterize bog communities.

Populus trichocarpa forest

Populus trichocarpa may appear as an early seral tree in either the *Tsuga heterophylla* or *Thuja plicata* h.ts. It is a very minor species in this role. Most conspicuous populations of the tree occur on short-lived gravelly terraces associated with these h.ts. or at lower altitudes including the margins of the steppe. Conifers may occur with the *Populus,* but their dynamic status has not been studied.

DISCUSSION OF CERTAIN CONCEPTS

Our major objective was to determine the nature of ecosystem patterns in essentially pristine forests of the northern Rocky Mountains and provide criteria for recognizing equivalence among the elements of the pattern. In addition, this study has furnished a body of data conducive to generalizations that bear on ecologic theory. This section will consider the generalizations that require immediate availability of the data.

Validation of classification

There are many possible ways of classifying or ordinating vegetation; each tends to produce somewhat different groupings. When only one basis (e.g., physiognomy, floristic list, fused analytic data, etc.) is used, the probability is high that the resulting system will be an "artificial" rather than a "natural" one, in that it will allow prediction of scarcely more than the defining character itself. That system may be considered the closest to a natural one that allows the most predictions about a unit from a mere knowledge of its position in the system. Our objective has been to develop a classification of the forested parts of our core area on an ecosystem basis in which not only vegetation but climate, soil, fire, grazing and the time factor are all taken into account. Vegetation characters are generally the most convenient ones to use in recognizing such ecosystemic units; this is the chief justification for the title of this study.

Two previously published studies using this ecosytem-based classification seem especially to indicate that a natural system has been approached. One of these (27) showed that the rate of growth of *Pinus ponderosa* differs to a statistically significant degree among the seven h.ts. in the core area in which this pine occurs either as a seral or climax species (fig. 4). Furthermore, the configuration of the ontogenetic growth curve of this pine usually differs from one h.t. to another. Incidental to this study it was also discovered that the susceptibility of the pine to *Arceuthobium* infection is very closely related with h.ts. so defined (27).

A second study made by an independent investigator (75) applied the same h.t. classification to the growth of *Larix occidentalis* (table 1). Here too it was found that not only does growth differ among h.ts., but the shape of the growth curve differs as well. Since much of the study was done in Montana, it shows that the classification is sufficiently objective that the h.ts. are identifiable in Montana even though the defining characters were not based on material from that state!

In addition to allowing predictions about productivity of at least two major species, the ecosystem approach to landscape classification also allows prediction of soil moisture regime (29, 61), response of vegetation to fire and grazing, and succession trends in the absence of disturbance. An ability to predict diverse attributes would not be expected if the basis of h.t. differentiation were unsound. However, this is not to deny the possibility that a better system may be found, or that the present system can not be improved.

It would not be difficult to defend a system of classification if wide diversity of vegetation were involved and gross environmental characters (e.g. soil properties differing at the Great Soil Group level) were correlated. In this way *any* system would tend to bear a degree of relationship with environment that might seem to validate it ecologically. A much more critical test would involve floristically small differences among associations within an intricate vegetation mosaic, and a diverse array of ecosystem attributes. Some critics of this ecosystem approach (91) have objected to recognizing landscape units that differ vegetationally by scarcely more than one species of plant.

However, single-species differences can be ecologically quite different. Note for example the different growth rates of *Pinus ponderosa* in *Pinus-Symphoricarpos* and *Pinus-Physocarpus* h.ts., or in *Pinus-Physocarpus* and *Pseudotsuga-Physocarpus* h.ts. Another example is the difference in *Larix occidentalis* growth in *Tsuga-Pachistima* and *Abies lasiocarpa-Pachistima* h.ts. Further evidence is provided by the fact that *Thuja-Pachistima* and *Tsuga-Pachistima* h.ts. occur in almost mutually exclusive geographic areas despite the fact that the presence or absence of *Tsuga* is the only easy and infallible vegetation basis for distinction. There seems to be no valid argument against recognizing community types that differ by only a single dominant species, providing there is evidence of correlated environmental difference, or against the ecosystem-oriented practice of taking into account characters other than vegetation when defining ecologic segments of landscapes.

Relation between undergrowth and overstory

Clements (12, p. 236) stated that subordinate vegetation has indicator value resulting from its association with the major dominants. Later this idea was stated more clearly by Weaver and Clements (96). They wrote that subordinates are "subject, in large measure, to the control of" the dominants. Curtis (18) expressed belief in the hypothesis and suggested a way to test it: "It should be possible to arrange a given series of forest stands into discrete groups or along a vegetational gradient or cline on the basis of trees alone. When this is done, it is expected that the understory plants will exhibit similar patterns of distribution."[6]

Exactly the opposite view has long been the basic premise of the Finnish system of forest classification. That system considers the pattern of undergrowth to be determined directly by intrinsic physical factors of the habitat rather than a reflection of differences in the nature of the tree cover from place to place.

The data in this report provide an unequivocable answer to this controversy. In the northern Rockies, forest overstory and undergrowth occupy the land independently. The same tree canopy can exist over almost wholly different ground floras (e.g., *Pinus-Stipa* and *Pinus-Physocarpus* associations, *Pseudotsuga - Symphoricarpos* and *Pseudotsuga - Calamagrostis* associations, *Abies lasiocarpa-Vaccinium* and *Abies lasiocarpa-Pachistima* associations). Likewise, essentially identical undergrowth types can exist beneath different overstory species

[6] It is not clear how this can be reconciled with Gleason's "individualistic concept" of the plant community, which Curtis also accepted.

(e.g., *Pinus-Physocarpus* and *Pseudotsuga-Physocarpus* associations; *Tsuga mertensiana-Xerophyllum* and *Abies lasiocarpa-Xerophyllum* associations. One also finds a lack of corresponding undergrowth discontinuities in passing from areas dominated in turn by *Abies grandis, Thuja plicata,* and *Tsuga heterophylla* as upland climaxes). Certain it is, that when a tree overstory is removed, a few of the understory species may disappear. Many opportunists (some of which are members of the climax understory in other h.ts.) become superimposed temporarily over the persisting climax herbs and shrubs, especially where the *Pachistima* union occurs. But in the main, overstory and understory unions occupy their areas independently, responding more directly to abiotic than to biotic influences. The composition of the tree stratum at climax is more closely relatable to macroclimate than to soil. The undergrowth unions are relatively more sensitive to soil and microclimate than are the trees.

Thus, specific combinations of unions (the associations) make it possible to recognize more ecologically distinct areas than would be possible if only understory or overstory were considered. Our evidence is therefore in accord with the Finnish viewpoint rather than with the Clements-Curtis hypothesis. Whittaker (98) states that his unpublished data also support the independence of overstory and understory.

The above point is also well illustrated in another way. Common observation shows that in the secondary succession following fire, climax equilibrium is approximated much earlier in the undergrowth than in the overstory. For example, the herbaceous and shrubby vegetation beneath a moderately dense old stand of *Pinus monticola* may be indistinguishable from that beneath a pure *Tsuga heterophylla* overstory that occupies a contiguous part of the same h.t.

Finally, each component of the vegetation mosaic, overstory or undergrowth, has its own geographic range. The vegetation of our core area "intergrades" with surrounding areas by means of differential interpenetration of the unions. The farther from the core area, the fewer of its components one finds in the landscape. In no case do the associated unions reach their limits simultaneously. However, the associations as described here extend across hundreds of kilometers without losing their identity. No example has yet been found where an association of one region passes imperceptibly over a long gradient into another association that is primarily characteristic of another region. However, if one or more of our associations should eventually prove to be clinal, this would be significant only in a broad geographic sense. In no way would it reduce the great practical and theoretical value of the ecosystem pattern that is consistently differentiated throughout our core area.

There seems little doubt but that all layers of the phytocoenosis must be seriously considered in order to distinguish among the ecosystem types in the Rocky Mountain region. There is a difference of opinion as to whether the dominant or the subordinate layer is to be emphasized in drawing these ecosystem types together in a classification. Cajander (11), Mueller-Dombois (66) and others have used the subordinate vegetation for this. Our classification instead gives the trees primary consideration and undergrowth secondary emphasis. This preference is founded on the fact that only this alternative leads to a comprehensive climate-vegetation-soils classification. For example, from Canada to Mexico, climax *Pinus ponderosa* forests as a class occupy climates drier and warmer than climax *Pseudotsuga menziesii* forests. Both categories are susceptible to subdivision based on subordinate vegetation that reflects local variation in soils, microclimate or macroclimate. A comprehensive vegetation classification based on subordinate layers would not permit the climax *Pinus ponderosa* forests to be drawn together as a single extensive vegetation belt bearing constant ecological relationships to climax *Pseudotsuga* forests above. In our region, several of the *Pinus ponderosa* associations would instead have to be grouped with associations of the local steppe vegetation. Moreover, one climax pine forest (*Pinus-Physocarpus*) would have to be grouped with the *Pseudotsuga-Physocarpus* forest and would thus appear wholly unrelated to climax *P. ponderosa* forests in other parts of the Rockies. Giving major emphasis to undergrowth would also segregate the *Abies lasiocarpa-Pachistima* forest from other members of the *Abies lasiocarpa* series, all of which lie beyond the minimal heat requirements of *Tsuga heterophylla* and *Thuja plicata.*

On the other hand, any consideration of the trees alone would not allow distinction among associations in the *Pinus ponderosa, Pseudotsuga* and *Abies lasiocarpa* series, nor between swamp members of the *Tsuga heterophylla* series.

In eastern North America, Monk (64) also concluded that understory vegetation may indicate ecologic conditions to which the floristic composition of the arborescent stratum seems insensitive.

Relation between vegetation classification and soil classification

Relatively little of the soil profile data available are included in this report. However, it is clear from what are presented that no useful correlation exists between vegetation types as defined herein and profile types distinguished on the basis of color, texture, structure, depth, sequence of horizons, etc. Closely similar stands of climax forest occur on soils with very different profile characteristics, and different climax forests may have similar profiles. These conclusions have been reached by others (6, 38, 43, 57, 58).

There is no intent here to deny that soil conditions are very important in determining the mosaic of habitat types. Rather, we emphasize that plant roots are sensitive to moisture, solutes and temperature, whereas soil classification is based mainly on characters to which the human eye is sensitive.

Continuity of variation

As a prelude to this discussion, three principles are worthy of note:

1. Not all species are equally useful in ecosystem classification. For example, *Amelanchier alnifolia* occurs from our driest steppe area at about 100 m above sea level to mountain ridges over 1900 m, but nowhere is it a major vegetation component. It is no more useful in classifying our vegetation than is the occurrence of winged seeds in distinguishing species of *Picea.*

2. A species showing a significant discontinuity at one ecotone of an association may not shown discontinuity at

another. Thus *Physocarpus malvaceus* is useful for distinguishing a class of low-altitude *Pseudotsuga* stands (comprising the *Pseudotsuga-Physocarpus* association) from a class of high-altitude *Pseudotsuga* stands (comprising the *Pseudotsuga-Calamagrostis* association). But it is worthless for distinguishing *Pseudotsuga-Physocarpus* from *Pinus-Physocarpus* stands. The last two, however, can be distinguished by the presence or absence of *Pseudotsuga* and by a difference in the intensity of soil drouth.

3. Small floristic differences among stands of vegetation are important if they are regularly associated with the same character of environment. It is customary to emphasize a *few* differences that distinguish *Picea engelmanni* from *P. sitchensis,* rather than dwell on the *many* similarities. In the same way we should accept the fact that the most conspicuous and reliable botanical difference between the *Abies lasiocarpa-Menziesia* ecosystems on cold northerly slopes and *Abies lasiocarpa-Xerophyllum* forests on warm southerly slopes is the presence of *Menziesia* in quantity, or its absence.

The above points show that in grouping units of vegetation into ecologically meaningful classes, it is unsound to give all species equal weight under all circumstances. If one rejects this principle, emphasizes the total floristic list, and considers all species of equal value in vegetation classification, the data in our tables can be arranged to demonstrate continuous variation throughout the forest mosaic of our core area. This is the aspect of plant life that is emphasized by continuum methodology.

Most species have individualistic ranges within the mosaic, so that contiguous communities tend to share most of their species. This is especially well illustrated in our upland forests in which the *Pachistima* union constitutes the undergrowth—the *Abies grandis-Pachistima, Thuja-Pachistima, Tsuga-Pachistima* and *Abies lasiocarpa-Pachistima* associations. The reproductive success of single tree species is the only constant and reliable character distinguishing each of these community types from the others. Thus, if one accepts the continuum doctrine there is no more basis for separating this sequence based on four trees than for segmenting the same vegetation into different associations defined by another group of species.

But to lump this sequence, or to segment it differently, one would have to demonstrate advantages superior to those provided by the present system. For example, the *Abies grandis-Pachistima* h.t. provides optimal growing conditions for *Pinus ponderosa,* whereas this tree is rare and grows poorly in the other three h.ts. listed above. Also, this sociologic unit occupies a distinctive segment of the temperature gradient that is warmer than the segments represented by the other three. In consequence, the total geographic range is distinctive. *Pinus monticola,* on the other hand, is an uncommon tree in the *Abies grandis-Pachistima* h.t. but is an abundant and characteristic seral dominant in the other three.

Equivalent differences in environment and species behavior coinciding with the other three phytosociologic units show clearly that these discontinuities do not represent arbitrary selections made intuitively from a long list of possibilities. Instead, the discontinuities reflect significantly different ecosystem types. In defense of the continuum doctrine, Curtis and McIntosh (19) wrote: "If the boundaries between communities are actually distinct, then the species of one group should never occur as important members of another group."

This is an original definition, so far as we know, and one so extremely restrictive that if it were considered the only possible way of defining associations, then one would be forced to accept the continuum doctrine. It is obvious that we subscribe to a viewpoint quite different, one that is flexible and emphasizes the whole ecosystem rather than emphasize a mechanical treatment of species lists and analytic data. We consider even a *single* floristic difference sufficient basis for recognizing a different classificatory unit providing:

1. it reflects, or is strongly suspected of reflecting, a difference between two types of environments (rather than representing its own chance presence or absence)
2. the correlation between this vegetal-environmental discontinuity is repeated at different places over a vegetation mosaic
3. the unit so defined, in our opinion, covers enough of the total area treated to be worthy of recognition.

To ignore such nodes, which are far less subtle in the field than they might seem, would obscure important vegetation-environment relations that are difficult to emphasize in any other manner. The application of this information to land management would be impossibly complicated.

For our analyses we chose very small spots indeed in this vast expanse of forest. These spots were rarely places where a contiguous sample on one side would show a clear trend in one direction, with a contiguous sample on the other side showing a clear trend in the opposite direction. In the high country where fire, logging, and grazing are at minimum we sometimes found areas several kilometers across within which innumerable spots would have suited our purpose just as well. But even in these areas we chose a single sampling site, using care to avoid variations due to relief, windfalls, etc. Thus the single values representing soil pH and fertility status, the central soil pit, the exposure record, etc., could be considered closely representative of the mean coverage and frequency figures and the tree density data.

One of us has shown elsewhere (28) how the existence of discontinuities such as we have described can be completely obscured, either by the methods of gathering field data or by their subsequent manipulation. Some additional points may be added to that commentary.

A basic aim of synecology is to predict the potentialities of disturbed areas from inspection of their current, usually disturbed, plant cover. To do this, any units of classification or ordination must emphasize trends rather than take a static view that emphasizes only current vegetation composition.

Buell, et al. (9) have tested the Curtis (18) continuum methodology. They calculated separate continuum indices for old trees that are currently dominant in each stand and for the young trees that will be dominant in the future. They found the continuum index nearly always higher in the younger age-classes. This result not only reflects the prevailing seral nature of their stands but emphasizes the failure of the Curtis method to indicate site potentialities.

The same point is even more strikingly apparent in data furnished by Cottam (17). He found that a site once sup-

porting an open savanna dominated by *Quercus macrocarpa* and consequently meriting a rating at the bottom of the Wisconsin continuum index had, since regular burning ceased, been replaced by trees (*Quercus alba, Q. velutina,* etc.) characteristic of a much higher index number. That site now promises to be superseded by still other trees (*Acer* and *Tilia*) that approximate the highest rating on that scale.

Clearly, the continuum index in no way reflects habitat potential. A simple subjective observation as to which species is most successfully reproducing in a stand would provide more useful information than mechanically adding relative dominance, relative frequence and relative density for young and old trees collectively, a practice that Lambert and Dale (50) reject as "pseudo-quantitative". It is also noteworthy that Strickler and Stearns (86) found that "importance values" derived by this technique were unrelated to differences between grazed and ungrazed stands of herbaceous vegetation as shown by coverage and productivity data.

A fair appraisal of the situation, as we see it, is that strictly floristic discontinuities are legion. When the dynamic behavior of dominants in the different layers is emphasized and physical environment is brought into consideration (i.e., when one takes a dynamic and ecosystemic view), some of these discontinuities become important and compel the segmentation of the landscape into categories that are objective in that different workers commonly recognize the same discontinuities independently.

Gleason (39, p. 106) hypothecated that in addition to chance variations among stands representing an association, there "are other variations of a cumulative nature," which, "increasing in importance and conspicuousness as more distant communities are considered, finally lead to vegetation of such unlike character that they would never be classed in the same association-type."

Curtis (18, p. 479) stated the same idea in different words: "Any given community shows a great stand to stand variability, with greatest resemblance to be expected only in local areas and with progressively greater floristic changes with increasing distance, such that remote areas on opposite peripheries of a community range show low floristic similarities. . ."

This characterization may be true of classification units defined differently than we have defined them, or perhaps true in other regions even if our approach to classification were followed. But in associations as we have defined them, our data for mostly undisturbed forests in the northern Rockies fail to substantiate the hypothesis.

Our most complete series of data, representing the *Tsuga-Pachistima* association, were obtained from an area about 95 x 225 km that includes most of the known range of that association. Yet floristic differences among the stands (appendix B-10) are clearly more random than clinal. Our association with second largest geographic representation, the *Pseudotsuga-Calmagrostis* association, with stands distributed from Montana to Idaho, Washington and Oregon, likewise shows no recognizable geographic gradient. These and data for all the other associations are presented in straight-forward form. Any reader can verify the failure of our efforts to arrange them in a linear ordination that reflects environmental gradients, or to subdivide them further with ecologic justification.

Principle of competitive exclusion

In 1904, Joseph Grinnell, a vertebrate zoologist, hypothecated that two species requiring approximately the same environmental resources "are not likely to remain long evenly balanced in numbers in the same" habitat. Later, other zoologists studied invertebrate populations with limited species diversity that were confined to environments likewise characterized by limited diversity. They showed that if two such organisms compete for the same food, one always eliminates the other. Botanists have also experimented in this area. Harlan and Martini (41) mixed equal proportions of seeds of 11 strains of barley. These were sown at 12 stations distributed widely over the U.S.A. Seed from successive generations was harvested in bulk from each plot and each year the proportions of each variety in the mixed population was determined. After several years, a single variety had achieved dominance at all but one station.

Hutchinson and Deevey (46) were sufficiently impressed by such evidence that they considered the principle of competitive exclusion "perhaps the most important theoretical development in general ecology" and "one of the chief foundations of modern ecology". But other biologists (13, 77) are not at all convinced that the principle is so universally operable and rigorous as to lead to the elimination of all but one organism of a particular ecologic type.

Our analyses of tree populations imply strongly that although several tree species usually find the physical conditions of each h.t. within the range of their ecologic amplitudes, there is nearly always evidence that one of them is competitively superior to all the others. Monospecific stands that are self-reproducing have been found, and these seem to demonstrate the validity of the trends inferred from population structure in mixed stands. Ecologic amplitudes are diverse, and weather and perhaps zootic variables favor first one species then another in their production of seeds and establishment of seedlings. Therefore, one can expect the trend to monospecific dominance to be obscured at times by conditions of ephemeral and hence minor significance.

But in general, the principle of competitive exclusion seems rather well exemplified in the tree layer of most stands of coniferous forest in the northern Rocky Mountains. In the earlier study, no population analyses were made. Hence, the subtle trend toward the elimination of *Picea engelmanni* from most of the h.ts. in the *Abies lasiocarpa* series and the same trend for *Thuja* in the *Tsuga heterophylla-Pachistima* h.t. were overlooked. It is clear that any statements regarding successional relations or the climax status of trees need backing with population analyses to demonstrate their reliability.

The rule of monospecific dominance among trees in the northern Rockies definitely does not extend to the shrubs and herbs beneath. Many of the species in one union may live with their roots and shoots intermingled, drawing from the same pool of nutrients during the same short summer, and enduring the same shade from an overhead canopy. Competitive elimination does not appear operative for the species that regularly appear in climax undergrowth, even though there is no reason to suspect more ecologic diversity here than among the tree species.

In the 350 or more years required for the tree stratum

of a *Tsuga-Pachistima* forest to eliminate seral relics and become self-regenerating, there is no hint of a progressive purge among undergrowth shrubs and herbs that might leave even a few in control. On approaching extremely dry or cold forest limits (e.g., the *Pinus-Agropyron* or the *Abies-Vaccinium* h.ts. at lower and upper timberlines, respectively) the relatively few undergrowth species that occur together differ so much in form or phenology that they can be looked upon as inhabiting complementary niches separated in either time or space. Monospecific dominance is approximated, even if it never proceeds so far that only a single species of each life form persists. But between these extremes, most of the undergrowth species regenerate directly from subterranean organs after each fire, and many persist through the seral to the oldest stands to be found. Competitive elimination involves only the opportunists that invade while the tree canopy is incomplete. Thus the hypothesis that species with essentially the same environmental requirements (as shown by consistent recurrence in mixed populations over the range of one or several h.ts., and by intermingled root and shoot systems) seems clearly invalid insofar as forest undergrowth is concerned.

Gradients in competitive potential

If we exclude from consideration the species that in our core area are always seral (i.e., *Larix occidentalis, Pinus contorta* and *P. monticola*), successional relations among the coniferous trees show a gradient of increasing competitive potential from the lower timberline upwards to habitats where *Tsuga heterophylla* occurs. A reversed gradient is then recognizable on up the altitudinal series. *Pinus ponderosa, Pseudotsuga, Abies grandis* and *Thuja* each in turn invades upwards temporarily in deforested areas. *Picea engelmanni, Abies lasiocarpa* and *Pinus albicaulis* tend to invade downward in consequence of disturbance. *Tsuga mertensiana,* confined to limited areas at high altitude, is the chief exception to this generalization.

Among undergrowth plants, the principle holds clearly for only the plants that grow in habitats regularly subject to soil drouth. Steppe species appear temporarily in deforested h.ts. in the *Pinus ponderosa* and *Pseudotsuga* series. The undergrowth plants in these series are in turn frequently found in h.ts. of the *Tsuga heterophylla* series following fire or logging. Within the relatively mesophytic *Tsuga heterophylla* and *Abies lasiocarpa* series, however, there is no evident tendency for undergrowth species to invade h.ts. where they cannot persist into the climax.

We agree with Steenis (85), Kalela (49), and others that reproductive success of a species is a factor of paramount importance in judging the status of vegetation types. We cannot agree with Steenis' statement that seral and climax species are distinct groups without intergrades. As our data clearly show, some trees are strictly seral in one h.t. and climax in another (e.g., *Pinus ponderosa* is the sole climax dominant in the *P. ponderosa* series, but strictly seral elsewhere; *Picea engelmanni* is a climax dominant in the *Abies lasiocarpa-Vaccinium scoparium* h.t., but seral in the *Abies grandis-Pachistima* h.t.). Some trees are *almost* climax in certain h.ts. (e.g., *Abies grandis* in the *Thuja-Pachistima* h.t.; *Thuja* in the *Tsuga-Pachistima* h.t.). Thus we find a gradient connecting species that are invariably seral (e.g., *Larix occidentalis* and *Ceanothus velutinus*) to those that are invariably self-reproducing wherever they occur (*Tsuga heterophylla* and *Xerophyllum tenax*).

Regeneration patterns

A pattern of regeneration common among higher organisms with stable populations is especially well exemplified by *Abies grandis* in the *Abies grandis-Pachistima* h.t. Following abundant germination, density declines at a geometrically decreasing rate through successively larger size-classes. The strikingly episodic character of reproduction in *Pinus ponderosa* forests having the xerophytic grass type of undergrowth presents a superficially different appearance, but the data from a large stand still show the geometric rate of decline in density with increasing size. Most climax species tend to be intermediate between *Abies grandis* and *Pinus ponderosa.*

Thuja plicata is distinctive from the other trees in that younger age-classes often seem inadequate to guarantee replacement of larger individuals in stands where only this tree occurs. The longevity of the species, and perhaps its ability to layer where a branch is pinned down by heavy debris, or to root when a broken branch falls, is probably a key to understanding its climax status. Short-lived species must maintain vigorous reproductive pressure as compensation if they are to meet the competition of longer-lived associates. Each tree needs to produce but a single successful offspring during its entire life span to maintain its population density. Thus, the longer it lives, the more sparse the reproduction can be and yet suffice. *Thuja* has a potential life span of at least 1,000 years, so it could maintain dominance without producing a replacement for centuries.

Any hypothesis that *Thuja* is not climax in *Thuja-Pachistima, Thuja-Athyrium* and *Thuja-Oplopanax* h.ts. is embarrassed by the facts that:

1. No other species of tree appears beneath even the oldest stands in sufficient numbers and vigor to seem a likely successor
2. The sparsity of *Thuja* reproduction is no more pronounced in stands where this tree is relatively large (and hence presumably older) than where the trees are smaller
3. There are no *Oplopanax* or *Athyrium* stands lacking an overstory that might have deteriorated.

Trees in the *Pinus-Symphoricarpos* and *Pinus-Physocarpus* stands were also notably deficient in the small size classes, even if this is not quite so striking as in the *Thuja* h.ts. We have seen vigorous reproduction in these h.ts. only following thinning of the overstory. This suggests that population density may be regulated by the sum of tree-plus-shrub competition. An elimination or thinning of the upper layer raises the probability of seedling success beneath the residual shrubbery significantly above zero.

Schenck (78) stated that he had never seen a pure stand of trees being replaced by the same species except following fire. Our data show that in the northern Rockies, most climax species form pure stands that replace themselves directly, and can do so indefinitely without the influence of fire or other disturbance. Thus his statement definitely does not apply to our forests.

Without indicating the supporting evidence, Raup (73) wrote: "Wherever old American forests dating back to pre-settlement time have been studied historically they have failed to satisfy the requirements of the self-perpetuating 'climax.' One of the most important of these requirements is that the trees shall be all-aged. . . . I believe . . . that probably there is no consistent trend towards balance" in vegetation dynamics. These comments are definitely at odds with conditions we have studied.

The bulk of evidence provided by our data supports the concept clearly expressed by Anton Kerner in 1863 (14) that succession leads to an equilibrium. It does not support Clements' hypothesis of convergence in that one type of community represents this equilibrium throughout a macroclimatic belt. Those who might criticize the climax concept because the frequency of fire prevents most seres from actually reaching equilibrium should note that:

1. Old monospecific self-reproducing stands of trees have been documented in nearly all h.ts.

2. The differences between these and the more abundant near-climax stands is mainly a technicality (a few large persistent relics).

3. With the data now available, the nature of both overstory and understory in the monospecific and self-reproducing stands can be predicted from the composition of stands considerably less than a century old.

Furthermore, from a practical land-management point of view, the rarity of attainment of climax owing to frequent interruptions of natural succession is totally inconsequential. On the other hand, knowledge of direction and rate of trend, and of regeneration processes to be expected following fire or other treatment are of very great importance.

Problems at least superficially similar to the scarcity of reproduction of *Thuja* have been noted elsewhere in coniferous forests. Siren says that in northern Finland the slow accumulation of duff in *Picea abies-Hylocomium-Myrtillus* forests makes seedling establishment progressively more difficult (79). At an age of about 250 years the old trees die; then the duff decays progressively until it becomes thin enough for a mixed stand of *Picea* with *Betula pubescens* to become established. This again becomes a pure *Picea* stand that once more builds up duff to bring about its demise. In northern Alberta, Plochmann (71) has hypothecated a spot-wise replacement of *Picea glauca* under which duff accumulates to the point of inhibiting its seedlings. He states that where old *Picea* dies, its place is taken first by grasses and shrubs, then by *Populus* spp. and *Betula papyrifera.* Finally, *Picea* replaces the dicot trees. However, other interpretations seem possible for his data (76).

In both of the above hypothecated sequences, an excessive accumulation of duff is the central consideration. An inhibitory influence is suspected of being either purely mechanical, or possibly a result of the immobilization of critical nutrient resources of the habitat. In both localities an alternation of trees with contrasting autecologies is involved. Neither of these key characters is involved in our *Thuja* forests. While duff may accumulate in very small depressions, there remain abundant intervening areas of exposed mineral soil and fallen logs available for seedling establishment. The most critical aspect of surface organic matter appears to be the smothering effect of the annual blanket of litter accruing from the deciduous foliage of shrubs and herbs.

As we pointed out earlier, because lightning-induced fires are very frequent in the northern Rockies, few of our stands exceed about 500 years age unless they are in wet lowlands. The ages of most of the old stands we have found are indeterminable. Heart-rots usually prevent one from counting xylem layers along any one radius, especially in the largest individuals, where such determinations would be most desirable.

The replacement series of small trees that we have recorded in most old climax stands consists of individuals much older than individuals of the same species and size when the same stands were young. The following data for two representative *Tsuga heterophylla* trees, one each from contiguous old forest and young burn, illustrate the point:

	Dominant in young forest	*Suppressed in old forest*
Diameter (BH) in cm	8.2	7.8
Xylem layers at BH	31	83
Height in meters	6.8	4.6

Altitude versus aspect

Long ago Blumer (7) pointed out that on mountains in Arizona at the lower limits of a plant species, the individuals are confined to relatively moist north-facing slopes. At somewhat higher elevations they spread out onto all exposures. At their uppermost limits they become confined to south-facing slopes. Slope-dependence seems to be a consequence of topographic compensation for worsening moisture deficit below the altitude of optimal climate, and for increasing heat-deficiency above. As a principle, this observation holds widely in the Rocky Mountains (20), but in the northern Rockies some limitations have become evident.

Reversal of aspect with altitude generally holds for each zonal association from lower timberline up through the *Abies grandis-Pachistima* forest. Above, the *Tsuga-Pachistima* and *Thuja-Pachistima* forests follow the expected pattern in that at their lower limit the stands are confined to northerly slopes. At their upper limit the ecotones formed with the *Abies lasiocarpa-Pachistima* forest show no clear topographic control other than elevation limits. It has also been noted elsewhere in this report that the lowest extremity of the *Abies lasiocarpa* forest is more closely related to streambanks and frost pockets than to direction of exposure.

Since the above exceptions to the rule have not been pointed out elsewhere in the Rockies, they may be peculiar to this part of the mountain system that lies athwart the center of the Westerlies. Here, the belt of perpetually moist soil is not restricted to a narrow, very cold belt (*Abies lasiocarpa* series) just below upper timberline, but extends well down the mountain slopes. If this is an appropriate interpretation, the pattern of topographic relations from our *Tsuga-Pachistima* or *Thuja-Pachistima* forests upward should be the pattern characteristic of montane forests in still wetter climates such as the west slope of the Cascade Mountains or the Appalachians.

Species diversity

Species diversity in climax and near-climax stands representing each association is shown in appendix E. Tree values represent the total number of species of trees encountered in all the stands representing each association as recorded in appendix A. Herb plus shrub values are the median numbers of species that occurred in the central macroplots ($125m^2$ each) of stands representing each association as shown in appendix B.

Alien species would bias the data both by being better represented in the lower, more disturbed h.ts., and by being mainly annuals. Therefore, they have been omitted in evaluating species diversity. They are so sparingly represented that it is extremely unlikely that they have displaced any indigenes. Therefore the data as presented are the closest possible estimate of conditions just prior to the advent of white man in these forests.

Whittaker (99) drew certain conclusions regarding species diversity based on studies in three mountain ranges in North America. Despite wide differences between his methods and objectives and ours, four comparisons with the present study seem valid.

1. He found diversity in the tree stratum decreasing upslope in the Smoky Mountains. The most valid arrangement of our data for comparison seems to be to list all tree species encountered in our sample plots in each h.t. and arrange these in the closest approximation of an altitude sequence. If this comparison is legitimate, our results for the northern Rockies (appendix E) are the reverse of Whittaker's. We found the fewest tree species in the lowest series, and the most in the highest (excluding the three peripheral stands in the *Abies lasiocarpa-Vaccinium scoparium* h.t.). The downward increase in severity of drouth through our forest series patently explains the difference. In the Smokies, the basal plain combines abundant rainfall with warmth, and supports a tree flora of maximum richness. In the northern Rockies, drouth progressively eliminates tree species until the ecologic amplitude of the most drouth-tolerant one is exceeded at lower timberline. However, if only climax conditions are considered, there is no significant vertical gradient in tree diversity. Nearly everywhere the forest tends to be dominated by one tree species at climax.

2. In the Smoky Mountains, diversity among herbs and shrubs showed no altitude trend below 1400 m. In the Siskiyou and Santa Catalina Mountains, diversity was maximum at intermediate altitudes. Our data for herbs and shrubs are most definitely in accord with the data for the Siskiyou and Santa Catalina Mountains if edaphic and topographic climaxes are ignored and species diversity in the major climatic climaxes is examined:

Pinus-Festuca	20 spp./$125m^2$
Pinus-Symphoricarpos	22
Pseudotsuga-Physocarpus	28
Abies grandis-Pachistima	28
Thuja-Pachistima	23
Tsuga-Pachistima	18
Abies lasiocarpa-Pachistima	17
Abies lasiocarpa-Menziesia	7

Species diversities for edaphic and topographic climaxes appear as erratic deviations from this clear altitude trend. Some are outstandingly low (*Pinus-Agropyron* and *Pseudotsuga-Calamagrostis*); others are outstandingly high (*Pinus-Physocarpus* and *Thuja-Athyrium*).

3. Whittaker found diversity in forest undergrowth highest in "moist," in contrast with "intermediate" and "dry" sites. Our data reflect the same trend when comparisons are drawn between swampy and contiguous upland h.ts., e.g., between *Thuja-Pachistima* and *Thuja-Athyrium,* and between *Tsuga-Pachistima* and *Thuja-Oplopanax* h.ts. Furthermore, the species-rich *Pinus-Physocarpus* association has been shown to develop less intense soil drouth in summer than the relatively poor *Pinus-Symphoricarpos* association. Finally the *Pinus ponderosa* forests with xerophytic grasses beneath have less species diversity than the *Pinus-Symphoricarpos* and *Pinus-Physocarpus* forests, and the latter appear to be less drouthy.

4. Diversity trends in the different vegetation strata were found by Whittaker to be unrelated. This is likewise confirmed by our data (appendix E). Maximum tree diversity was in the *Abies lasiocarpa* series, but maximum diversity of undergrowth was in the *Abies grandis-Pachistima* and *Pseudotsuga-Physocarpus* associations if climatic climaxes alone are considered. Maximum undergrowth diversity was even less when all associations are considered.

Ecologic significance of basal area

Variation in basal area exhibits a pronounced relation to an ecologic ordination of forest climaxes. It peaks in the *Tsuga* series and is accentuated in swamps where wet soils minimize fire hazard and death and so permits *Thuja* to attain great size (appendix H). The decline in basal area below the *Tsuga* series cannot be attributed simply to a limitation in the size attainable by the tree species. If one compares stands in which the largest tree is always in the 9-10 dm diameter class, basal areas in the two *Pseudotsuga-Calamagrostis* stands that fall into this category were 56.5 and 70.5 m^2/ha, whereas basal areas in the six *Tsuga-Pachistima* stands in this category were 65.0, 74.1, 81.3, 102.2, 121.2 and 144.8. The more mesic ecosystem clearly can support more large trees per unit land area.

If we omit from consideration forests in which *Thuja* occurs, *Tsuga-Pachistima* stands have the most basal area potential, *Pseudotsuga-Calamagrostis* and *Abies grandis-Pachistima* are next, and forests at still higher or lower elevations least. Thus it may be concluded that basal area is at maximum on midmontane slopes, even if swampy habitats are excluded from consideration.

Whittaker (98) reports a maximal basal area of 66 m^2/ha for the forests of the southern Appalachians. This value is exceeded in 51 of our stands, and by most of our associations. As noted earlier, the values for *Tsuga heterophylla* in the Rockies exceed values for stands of *Tsuga canadensis* in Pensylvania (54). While it is possible that our field methods may have tended to bias basal area values upward, it is significant that our data for stands of *Pinus ponderosa* agree closely with data gathered by Behre (3) for the same species in the same area.

Basal area is commonly used as a criterion of dominance in plant sociology. But if dominance is interpreted as involving completeness of use of environmental resources, and it can be assumed that variations in the amount of undergrowth are attributable to light, then basal area is unrelated to the degree of interception of light by tree canopies in our forests, although such a correlation has been reported elsewhere (48). When all stands of the *Tsuga-Pachistima* association are plotted to show the relation between basal area and herb+shrub coverage, there is patently no correlation. We are inclined to believe that light may actually be a critical factor, with basal area being an unrelated variable. Throughout the life of a tree, its basal area increases year by year without fail, but after it matures, the top dies limb by limb until just before death the individual may be intercepting relatively little light.

Huberman (45) studied three stands in different succession stages in the *Tsuga-Pachistima* h.t. in northern Idaho. He found that basal area increased from young to intermediate to old stands. Our data cannot be used to check this point since all of our stands are in the old category. But within the age range of our stands, there seems to be no relation between basal area and age, if the size of the largest *Tsuga* is a criterion of the relative age of the stand.

From an ecologic standpoint, the significance of basal area as an attribute of a stand is obscure. Perhaps it is so often measured chiefly because this is so easily accomplished in extra-tropical forests.

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APPENDIX A. TREE POPULATION ANALYSES

Population structure of trees in stands, by habitat type. Figures represent numbers of individuals per 375 m^2, with basal area for the stand as m^2/ha given below the stand number. Presence in the stand, but not in the 375 m^2 sample, is indicated by +. Abbreviations:

Ab g—Abies grandis
Ab l—Abies lasiocarpa
Be p—Betula papyrifera
La l—Larix lyallii
La o—Larix occidentalis
Pc e—Picea engelmanni
Pc g—Picea glauca
Pn a—Pinus albicaulis
Pn c—Pinus contorta
Pn m—Pinus monticola
Pn p—Pinus ponderosa
Ps m—Pseudotsuga menziesii
Ta b—Taxus brevifolia
Th p—Thuja plicata
Ts h—Tsuga heterophylla
Ts m—Tsuga mertensiana

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm: 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)
1. Pinus ponderosa-Symphoricarpos albus habitat type														
68	Pn p	3	1	5	2	9	3	1	1					
56.2														
69	Pn p		4	14	17	3	1							
41.3														
70	Pn p			19	17	7	2							
57.7														
87	Pn p		+	2	4	8	1							
31.0														
88	Pn p		1		1	5	5							
35.5														
147	Pn p	2		3	1	5	1							
19.8														
162	Pn p	50	34											
39.9														
187	Pn p	1	13	26	22	3	2							
58.8														
2. Pinus ponderosa-Physocarpus malvaceus h.t.														
43	Pn p		1	11	11	4	2							
38.5														
44	Pn p	5	3	11	2	6	2							
32.1														
71	Pn p		1	6	10	9	2							
47.7														
89	Pn p		1	7	5	4	1							
24.5														
163	Pn p		7	7	2		+	1	2					
30.8														
164	Pn p			5	7	4	1							
26.1														
165	Pn p		+	1	2	1	5	1						
33.2														
3. Pinus ponderosa-Festuca idahoensis h.t.														
20	Pn p	193				2		1						
11.5														
21	Pn p	15	4		1	2	2	1						
21.8														
22	Pn p	51	3	3	9	4								
24.2														
142	Pn p	86	11	6	1	3								
13.6														
4. Pseudotsuga menziesii-Symphoricarpos albus h.t.														
172	Ps m	2401	3	6	8	2								
29.5	Pn p	53	2	2	2	1	1							
173	Ps m	573	3	7	6	2								
51.5	Pn p			1										
174	Ps m	25	11	12	8	5	1							
54.5	Pn p	1	2	3										
175	Ps m	19	19	21	4									
37.2	Pn p		1	10	8									
	Pn c			1	2									
176	Ps m	36	20	19	9	6	1							
55.2	Pn p			4	1	1								
	La o					1								
	Pn c			2		1								
177	Ps m	39	10	31	11	2								
35.4														
178	Ps m	1	1	+	2	1	+							
36.0	Pn p		3	11	2	2	2	+	1					
179	Ps m	396	2	+	+									
29.9	Pn p	90		4	3	3	1							
5. Pseudotsuga menziesii-Physocarpus malvaceus h.t.														
2	Ps m		7	15	13	5		1						
44.1														
4	Ps m	2	11	29	20	1	4	1			1			
98.8	Pn p			1					1					
	La o						1	1						
72	Ps m	4	9	9	2	12	1							
43.0														
92	Ps m	175	7	14	16	4								
38.7	Pn p											1		
105	Ps m			14	12	6								
55.5	Ab g	8												
	Ts h	8												
	Pn p								2					
106	Ps m	17	15	5	4	1			1					
22.3	Pn p	2												
	La o				1				+					
107	Ps m	195		6	4	2	3		+					
26.0	La o	2												
108	Ps m		2	6	21	6	2							
54.5														

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)
149	Ps m	1	1	3	7	5	2							
47.2														
150	Ps m	18		4	2	5	5							
39.9	Pn p				1	+								
161	Ps m	+	+	2	2	2	2	+	1					
46.6	Pn p			1	1	4	2							
168	Ps m		+	2	1	1	3							
30.7	Pn p						1		1					
169	Ps m	130	1	5	1	4								
14.6	Pn p			1										

6. Pseudotsuga menziesii-Calamagrostis rubescens h.t.

66	Ps m	48	14	4	2	+	1	2	1	1	+		+	10-11
160.8	La o		+	+										
90	Ps m	2		1					1	1	2	1		
70.5	Pn p	8	1											
91	Ps m	4			2	4		4	2					
56.5	Pn p											+		
	Pn c			1										
108	Ps m	62	12	9	5	2	2	1		1	1			
55.2	Ab l	1												
	Pn c			1										
110	Ps m	107	4	8	2	8	9	2						
78.3														
111	Ps m	119	39	8			1		1					
29.8	La o					1								
	Pn c					2								
112	Ps m	287			4	8	3	1						
48.8	La o				3									
113	Ps m	16	2	9	5	7	4							
46.0	La o								+					
114	Ps m			+	1	1	1	2	1		1			
60.5	Ab g				+	+								
	Pn p						1		1					
	La o					1								
148	Ps m	31	1	+	+	+	2		1	1				
29.4	Ab l		1											
	Pn c		+											
166	Ps m	395	6	+	+	2	+		+		+			
33.4	La o	4	2	1				+	+					
	Pn c	13	5	4										
167	Ps m	31	1	2	+	3	2	2	1					
57.1	Pn p		+			2			1					
	La o	+	+				1							

7. Abies grandis-Pachistima myrsinites h.t.

1	Ab g	105	24	5	5	2	1	1		1				
45.8	Ps m	8							1					
5	Ab g	1148	29	2	3	1	3							
20.9	Ps m	300	+				+							
	Ta b			1										
	Pn m	22	+	+										
	Pn c	8			+	+								
	Pn p								+					

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)
6	Ab g	330	1	7	8	2	1		1					
65.6	Ps m	+	+	+	1		1	4						
	Ts h					1								
	Pc e				+									
	Pn m	+												
	Pn c				+									
	La o	+						+						
7	Ab g	90	16	6	5	1	3	3						
45.9	Ta b		+											
8	Ab g	308	6	8	7	3	1	1						
38.0	Pc e						1							
	Ps m							+						
	Ta b	300	10	1		+								
11	Ab g	82	2	6	5	6	2	1	1	1				
60.6	Pc e						+							
13	Ab g	1372	5	8	3	1	2	1			1		1	11-12
79.0	Ts h	8	1	1	1									
	Pc e						1							
	Ps m					1								
18	Ab g	52	7	12	6	4								
33.8	Ps m	8		3	1			1						
50	Ab g	338	15	18	5	1								
26.3	Pc e	+												
	Ps m	22		1				1						
	Pn p	+												
93	Ab g	165	27	19	10	2	2		1	1	+			
68.7	Ta b	4		+										
	Pc e	15	1	5	2	1		1						
	Ps m			1										
	Pn c			2	1									
	La o			+	+									
94	Ab g	82	4	12	7	2	2							
41.6	Ps m				1	1								
	Pn c			2	2	1								
	Pn p					1								
151	Ab g	75	10	7	5	5	1		1	1	1			
64.2	Ps m			+									1	11-12
152	Ab g	128	10	1	2	3	3		1	1				
72.3	Pc e	15		2	1	2	1	1	1					
153	Ab g	30	6	3	2	1		1	1		1			
54.7	Ps m	+			3		1		1					
	La o					+								
154	Ab g	45	2	1	+	3	+	+	+		1	1		
42.6	Ta b		+											
	Pc e	8						+						
	Ps m	+					+						+	10-11
	La o							+						
	Pn p												+	10-11

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)
		8. Thuja plicata-Pachistima myrsinites h.t.												
3	Th p	1					1	1	1		1		4	16-17
220.2	Ab g	172												
	Ta b		+											
49	Th p						3	1				2	3	12-13
150.0														
62	Th p	14				1	1		1	1		1	4	12-13
158.1		5		1										
65	Th p	112	+	1	1							1	4	11-12
220.9	Ab g	264		1		1								
	Pn m	+												
	La o												2	12-13
73	Th p	+	1	1				1		1	1		3	13-14
179.7	Ab g	22			2			1			1			
	Ta b	+	+											
	Pn m											+		
74	Th p	3		1			1		1	1	5	5	1	11-12
231.4	Ab g	220	2	2				1						
	Ta b	14	1											
115	Th p	6	3	4	2	1		2	1	2			1	10-11
86.6	Ab g	120		1					1	+		+		
	Ta b	17	5	1	+									
	Pc e							+						
116	Th p	38	1	3	+	4	1	4		1	1	1	+	12-13
161.7	Ab g	82								1			+	13-14
	Ta b				1									
	Ps m												1	10-11
117	Th p	+		1	2	1	1	2	3		1	1		
121.1	Ab g	+										1		
	Ta b		1											
	Pn m											1		
170	Th p	15	+	+	+	1	2		1		1		3	15-16
162.0	Ab g	8100						1						
		9. Tsuga heterophylla-Pachistima myrsinites h.t.												
14	Ts h	5223		8	3						1	2		
60.9	Th p	+		+										
	Ab g	135												
	Pn m	45											+	11-12
15	Ts h	169	+	+	2	2	+	+	+	1				
53.4	Ta b	80	4	1										
	Ab g	480							1				1	10-11
16	Ts h	44	6	2					1	2		1		
65.0	Ab g		16											
	Pn m		4							1				
25	Ts h	80	1	1	1	4	+	1						
88.9	Th p	101						2	2		2			
	Ta b	+												
	Ab g	44		3	2	2								
	Pn m	1												
26	Ts h	109	30	21	1	2		1		5	3	2		
74.1	Th p	38	3	1										
	Ta b	181	4											
	Pn m	1												
27	Ts h	9999	19	8	1	1	2	2	2	7	1	1	1	10-11
236.1	Th p	5146	6				2		5	1				
	Ta b	60												
	Pc e	15												
28	Ts h	2132	4	2		1			1	3		1		
105.6	Th p	1262												
	Pn m	45											1	12-13
29	Ts h	625	44	26	6		1				1	2		
121.2	Th p	391	9	11	1	1	2	1		1				
	Ab g	10		1										
	Pn m	10												
33	Ts h	60	6	4	1	2	2	1		1		1		
81.3	Th p	3	2	3	4	2	2	1		1		1		
	Ta b	37	4											
	Ab g	348												
	Pc e	1		1										
	Ps m	2												
	Pn m	15												
52	Ts h	128	14	13	1				2	1				
41.9	Th p	5	1	1		1								
	Pn m	1							+					
	Be p	1												
54	Ts h	69	34	6		2		2	1	1	2			
82.4	Th p	+											+	10-11
	Ps m							1						
55	Ts h	8		2		1	1							
144.8	Th p	8	1	8	2	5	3	1	5		1	2		
	Ab l				+									
	Pc e		+	+						+				
	Be p				1									
	Ps m								+					
60	Ts h	436	20	6	2		1	1	1				1	10-11
129.4	Th p	16					2		1		1	1	1	10-11
	Ta b	+	+	+										
	Ab g	31	4		1	1				+				
	Pn m												+	10-11
76	Ts h	475	10	2	2	1	3	2	1	2				
102.2	Th p	171	1	1	2	1				1				
	Ab l	1	1											
	Pc e	+												
	Ps m											1		
77	Ts h	279		2	2		3	4	2					
126.9	Th p	109	1										2	14-15
	Ta b	+												
	Pc e	+												
78	Ts h	3125	3		2	1	2	2	3		1			
69.8	Th p	227	3	1				+						
	Ta b	+												
	Pn m						+							

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	>.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)
		10. Thuja plicata-Oplopanax horridum h.t.												
53	Th p	1	2	2				1				1	4	21-22
292.6	Ts h		1					1						
	Ab l				+									
	Pc g						1							
	Be p								+					
	La o												+	10-11
80	Th p	429	4	3			1	1		3			4	11-12
149.6	Ts h	+												
	Pc ?	+												
81	Th p	2	2						1	1			4	18-19
252.6	Ts h	3	1	1										
	Pc e		1											
83	Th p	212	1				1		1			1	3	22-23
293.0	Ts h	16		1										
	Ta b	+												
	Pn m												+	10-11
104	Th p	4						1		1			8	20-21
503.8	Ts h												+	11-12
	Ab g	+												
79	Th p	46	4	1	1	1				1	2	2	1	10-11
112.8	Ts h	19	5	2		2	1	1						
	Ab l	15	2	1										
	Pc e			1		2								
	Pn m						+							
82	Th p	102	1	1									2	16-17
180.5	Ts h	72	2	1						1	1		2	11-12
51	Th p	29			1									
60.1	Ts h	247	2	4		1	2		1	1			1	10-11
	Ab g	8			1									
	Pc g	6	2											
	Be p	48	1											
	Ps m											+		
56	Ts h	1	1	4				2	1	1	1			
85.0	Ab l		1	2	2									
	Pc e				1		1	1						
	Ps m											1		
		11. Thuja plicata-Athyrium filix-foemina h.t.												
75	Th p	24		1					1				2	16-17
213.1	Ab g	40		1			3	1		1				
	Ta b	1												
	Pc e						+		+					
	Ps m						1							
	Pn m								+					
120	Th p	+		1								1	2	23-24
252.0	Pc e				+									
	Pn m	+												
		12. Abies lasiocarpa-Pachistima myrsinites h.t.												
48	Ab l	4			1	1								
51.1	Pc e	8		2		3	1	1	1					
	Ps m				1			1	1					
	Pn c					1								
59	Ab l	169	6	7	2	2								
56.4	Pc e	77	2	3	1	1	1	3		1	1			

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	>.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)
64	Ab l	56	3	8	4	1	3	1						
45.0	Ts m				1									
	Pc e	3				3								
	La o		1	1			1		+					
85	Ab l	68							+					
84.5	Ts m	1												
	Th p				1									
	Ab g	188				2				+				
	Pc e					3	7	3	1					
	Pn m	8			1	1			1					
95	Ab l	129	6	7	2		1	+						
60.0	Ab g	141	20	11	4		1	+						
	Pc e	95	10	15	5	2			1				+	11-12
	Ps m	8		1		1								
	La o						+							
96	Ab l	319	+	4	3	2	1	+	+					
66.8	Ts m	+		+	1	1	1							
	Pc e	+	+	2	3		4	1						
	Ps m	+			+		+		+					
	Pn m						+	1	1					
121	Ab l	201	9	12	6	4	4	+						
77.9	Pc e	6	2		1	4	2	1	1					
122	Ab l			1										
54.5	Ab*	30	6	5	2	1								
	Ab g						1		+					
	Pc e	3	3	2	1			2		2				
	Pn c					1								
123	Ab l	32	+	2	2	2	2							
37.9	Ts h	30		+		+		+						
	Th p	+	+											
	Ab g	+												
	Pc e										+			
	Ps m	22						1	1					
	Pn m	8							+					
124	Ab l	58	19	15	3									
60.0	Ts h	1												
	Th p	+												
	Pc e	26	2			1				+				
	Ps m			1					1				+	10-11
	Pn m								1		+			
	Pn c						2	2						
	La o						1							
125	Ab l	423	23	8	11	4	1							
62.0	Ts h	1	2											
	Pc e	11	4	1										
	Ps m				1		1			1				
	Pn m	+												
	Pn c			1										
	La o					1	1							
155	Ab l	72	7	8	5	2	2	2	+					
69.4	Ps m			1			1			1	1		+	11-12
	Pn m					+								
160	Ab l	192	3	13	15	2								
32.3	Pc e	24	+	2	4	1								
	Pn m	+												

* Apparently hybrids between A. lasiocarpa and A. grandis.

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)
171	Ab l	999	14	28	7	4	1							
52.4	Ps m	22		5	5		+							
	Pn c				1									
	La o		1	3	4	1		+						

13. Abies lasiocarpa-Xerophyllum and Tsuga mertensiana-Xerophyllum h.ts.

130	Ab l	67	5	7	11	5	5	1						
58.9														
57	Ab l	76	13	10	2									
14.7	Pc e	1		1	2									
	Pn a	10	2	2	1									
45	Ab l	78	2	13	10	+								
27.1	Pc e	8	1	2		1								
	Pn c	1			3									
126	Ab l	252	2	5	6	2								
22.1	Pc e	1	1	1										
	Pn m		5	5	1									
	Pn c	7					1							
	La o		1											
156	Ab l	207	14	12	6	5	1			+				
51.5	Pc e	32	2					3						
129	Ab l	8	5	10	7	5	1	1		1				
73.7	Pc e						+							
	Pn m				1		+							
	Pn a	1	2	1	4	3		1						
	Ps m					1	+				+			
127	Ab l	558	1	2	5	8	1							
36.7	Ts m	1	+	+	+	+	+							
	Pc e	1		+	+		1							
	Pn a	1												
47	Ab l	62	1	2										
49.4	Ts m	44	9	8	1	6	4	1						
	Pc e	2												
	Pn m	1	2	1		1								
97	Ab l	16	2	4	3	1								
45.0	Ts m	658	9	10	3	1	2	1						
	Pn a	18				1		1						
128	Ab l	52	3		1		+							
67.5	Ts m	26	16	7	2	3	4	5				+		
	Pc e				1									
	Pn a	+					+							
157	Ab l	14	5	7	8	1								
67.6	Ts m	90	10	9	6	7	3	1						
98	Ab l	4	1	+		+								
45.0	Ts m	131	22	5	1	2	1	2		1				
	Ps m						+			+				
	Pn m	1				+			+	+				
	Pn a						1							
	La o								+					
61	Ab l	10												
49.1	Ts m	62	3	6	3	1	1			1			1	10-11

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Max. diam. (dm)

14. Abies lasiocarpa-Menziesia and Tsuga mertensiana-Menziesia h.ts.

58	Ab l	15	7	7	2	1	1							
26.6	Pc e	8								+				
	Pn a						1		1					
131	Ab l	290	22	15	3		3	1	+					
33.5	Pc e	8			+	+		+						
	Pn c						+							
136	Ab l	160	27	18	11	2								
42.8	Pc e	18	7	3	1									
	Pn m	3						1						
159	Ab l	20	9	5	2	1	3	1						
51.2	Pc e			1	1	1	3	1						
137	Ab l	380	15	17	10	2	1							
40.7	Ts h	3												
	Pc e	17	3	2	1									
	Pn m	1		3	2									
134	Ab l	1810	2	9	16	3								
48.3	Ts m				1									
	Pc e	5	1	2	5	2								
	Pn m	1		2										
135	Ab l	38	2	1	1	8	2							
62.0	Ts m	1					+							
	Pc e				1	4	3	1						
63	Ab l	46			2	2	+							
97.3	Ts m	8				1		1		2	1	1	1	10-11
132	Ab l	482	10	9	5									
48.0	Ts m	54	7	15										
	Pc e	88			1		3	2						
	Pn c	+												
133	Ab l	142	2	3	5	3								
46.5	Ts m	27	9	7	3	5	2							
46	Ab l	5	2			1	1	2						
79.8	Ts m	42	6		2	1		1	1	2	1		+	10-11
99	Ab l	4	6		1									
50.2	Ts m	38	15	17	9	5	1		1			+		
158	Ab l	52	2											
61.2	Ts m	15	1				1	1		1	1		1	10-11
12	Ab l	114				1								
77.2	Ts m	18	1	1	3	1	2		2		2			
	Pc e						1							
	La o					1	1							

15. Abies lasiocarpa-Vaccinium scoparium h.t.

100	Ab l	251	13	28	4	+								
63.4	Pc e	77	3	9	4	1								
	Pn c		1	6	3		+							
	La o							1	2					
101	Ab l	724	18	5	3	1	+							
37.9	Pc e	10	4	6	4									
	Pn c	15	3	4										
	La o	+												
102	Ab l	999	27	22	6	1								
56.7	Pc e	30	1			1	1	+						
	Pn c				6	1								
	La o					1				1				

APPENDIX B. FOREST UNDERGROWTH AND OTHER STAND DATA

Number to left of dot is percent coverage where the value exceeded 0.5%, with + to left of dot indicating coverage of 0.5% or less.

Number to right of dot is percent frequency.

+.+ indicates presence in macroplot, but outside of microplots.

+ indicates presence in stand but only outside of macroplot.

* after soil pH indicates availability of complete profile description in master files.

† indicates alien taxa.

Table B-1. *Pinus ponderosa-Symphoricarpos albus and Pinus ponderosa-Physocarpus* associations.

	Pinus ponderosa-Symphoricarpos albus								*Pinus ponderosa-Physocarpus malvaceus*						
Stand number	68	69	187	87	88	147	162	70	43	44	71	89	163	164	165
State and county	ILata	WWhit	WStev	WSpok	WWhit	WWhit	WSpok	WAsot	WWhit	ILata	WAsot	WWhit	INezp	INezp	ILata
Township and section	41N9	16N36	28N18	22N12	15N36	20N18	24N22	8N32	16N25	41N9	8N32	15N16	36N3	37N33	40N25
Range	5W	44E	41E	44E	43E	43E	43E	46E	44E	5W	46E	43E	2W	2W	6W
Altitude in meters	772	699	---	772	702	652	559	876	708	819	876	---	423	234	853
Aspect and percent slope	SSW9	WNW49	SE7	NE10	N26	ENE56	ESE30	NNW29	NNW60	NW40	N27	N55	N27	NE46	N25
Mean pH upper dm of soil	6.1	6.1*	---	6.0*	5.7	---	6.0	5.9*	6.6*	6.5	5.8*	6.1	6.1	6.4	6.3
TALL SHRUBS															
Acer glabrum	.	.	.	.	.	.	.	.	.	.	.	.	.	+.+	.
Amelanchier alnifolia	+.2	+.4	2.6	+	.	1.2	11.12	1.6	1.15	2.26	6.16	3.8	2.4	7.14	+.2
Crataegus columbiana	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Crataegus douglasii	+	.	.	.	4.4	.	+	.	+	+.+	+.+	2.2	4.6	.	+
Holodiscus discolor	.	.	.	.	.	.	.	.	8.12	+	+	.	45.66	43.56	+
Philadelphus lewisii	.	.	3.4	.	.	.	.	.	.	.	.	.	.	24.26	.
Prunus emarginata emarginata	.	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.
Prunus virginiana melanocarpa	.	1.6	+.2	.	.	2.14	+	.	.	4.12	.	.	+.+	5.8	11.30
Rhamnus purshiana	.	.	.	.	.	.	.	.	.	.	.	+.2	+.+	4.14	.
Salix	+	.	.	.	.	.	.	.	.	+	.	1.2	.	.	.
Sambucus caerulea	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
MEDIUM SHRUBS															
Ceanothus sanguineus	.	.	.	.	.	.	.	.	.	+.4	.	.	.	.	+
Lonicera ciliosa	.	.	.	.	.	.	.	.	.	.	.	.	.	2.4	.
Physocarpus malvaceus	.	.	.	.	.		.	+	75.94	63.92	79.96	66.84	34.44	35.42	86.99
Ribes aureum	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Ribes cereum	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Rosa woodsii + R. nutkana	1.2	16.52	3.16	6.22	6.18	18.52	1.8	1.12	2.12	9.46	4.32	+.2	6.14	+	2.16
Rubus parviflorus parviflorus	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Spiraea betulifolia lucida	1.10	3.16	9.48	.	4.16	.	.	27.84	6.40	13.72	3.18	18.72	+.10	2.8	7.14
Symphoricarpos albus	42.98	19.86	14.50	49.94	88.99	68.99	59.88	28.74	24.80	29.80	16.48	4.22	67.90	82.70	3.12
LOW SHRUBS															
Berberis repens	.	+.4	.	.	.	.	.	.	.	3.28	.	+.6	.	1.12	1.8
Chimaphila umbellata occidentalis	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Eriogonum heracleoides	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	.
Pentstemon	+.4	.	.	.	.	.	.	5.14	.	.	3.12	.	.	.	.
Phlox speciosa	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.
Vaccinium caespitosum	1.4	.	.	.	.	.	.	.	+	+.+	.	+.2	.	.	.
PERENNIAL GRAMINOIDS															
Agropyron spicatum	13.22	10.14	+.2	.	.	3.16	6.10	+.2	.	3.12	.	1.4	.	.	.
†*Bromus (perennial)*	.	+.2	.	.	.	.	.	.	+.+	.	.	.	.	.	.
Bromus vulgaris	.	.	.	.	.	.	.	+.+	1.5	1.6	.	.	4.20	2.8	+.+
Calamagrostis rubescens	7.20	20.26	.	9.18	13.14	.	.	+.+	16.42	3.8	+.2	11.24	1.80	.	+.+
Carex geyeri	37.66	.	.	.	3.4	.	.	.	29.24	13.48	.	4.34	.	.	3.8

(Continued)

Table B-1. *Pinus ponderosa-Symphoricarpos albus and Pinus ponderosa-Physocarpus* associations. continued

	Pinus ponderosa-Symphoricarpos albus								*Pinus ponderosa-Physocarpus malvaceus*						
Stand number	68	69	187	87	88	147	162	70	43	44	71	89	163	164	165
Carex rossii	·	·	·	·	·	1·4	·	1·6	·	·	1·2	·	·	·	·
Carex	·	·	1·6	+·4	·	+·2	·	·	·	·	·	·	·	·	·
†*Dactylis glomerata*	·	·	·	·	·	·	·	·	·	·	·	·	+·+	·	·
Deschampsia danthonioides	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·
Deschampsia elongata	·	·	·	·	·	·	·	·	+·2	·	·	·	·	·	·
Elmyus glaucus	·	8·18	+·+	+·4	24·62	2·4	+	1·4	·	+·2	+	4·24	·	·	·
Festuca idahoensis	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Festuca occidentalis	+·2	2·4	·	·	·	+·2	1·2	·	·	1·4	·	·	·	4·8	·
Festuca scabrella	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Luzula comosa	+·2	·	·	·	·	·	·	·	+·+	·	·	·	+·4	+·+	·
Melica bulbosa	·	·	·	·	·	·	·	·	·	·	·	·	·	+·6	·
Poa ampla	9·32	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Poa canbyi	·	2·10	·	·	·	·	+·2	1·2	·	·	+·2	·	·	·	·
†*Poa compressa*	·	4·14	·	15·44	·	+·2	·	7·12	·	+·2	3·12	·	·	·	·
Poa gracillima	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
†*Poa pratensis*	·	·	·	·	4·12	·	+·4	·	2·8	·	·	1·4	+	+	·
Trisetum cernuum	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
PERENNIAL FORBS															
Achillea millefolium lanulosa	1·6	+·+	+·4	+	·	+·2	+	+·+	+·2	1·8	+·2	1·2	·	+·+	·
Agastache urticifolia	·	·	·	·	·	1·8	·	·	·	·	·	·	·	·	·
Allium acuminatum	·	·	·	·	·	·	+·2	·	·	·	·	·	·	·	·
Allium	·	·	·	·	·	+·2	·	·	·	·	·	·	·	·	·
Anemone piperi	·	·	·	·	·	·	·	·	·	+·4	·	·	·	·	·
Antennaria luzuloides	·	·	·	·	·	·	·	+·2	·	·	+·2	·	·	·	·
Antennaria neglecta	·	·	·	·	·	·	·	·	·	+·6	·	·	·	·	·
Apocynum androsaemifolium	1·8	·	·	·	·	1·10	·	·	·	·	·	·	·	·	·
Arabis hoboellii	·	·	·	·	·	+·2	·	·	·	·	·	·	·	·	·
Arenaria macrophylla	·	·	·	·	·	·	·	·	·	3·46	·	·	20·66	4·30	·
Arnica cordifolia	·	·	·	·	·	·	·	·	·	·	·	·	·	2·22	·
Arnica sororia	·	·	+·+	·	·	·	·	·	·	·	·	·	19·50	·	·
†*Asparagus officinalis*	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·
Aster conspicuus	·	·	·	·	·	·	·	·	·	·	·	2·8	·	·	·
Balsamorhiza sagittata	·	·	·	·	·	1·4	11·28	·	·	·	·	·	·	·	·
Besseya rubra	+·+	·	·	1·12	·	+·2	·	4·38	+·2	+·10	+·+	+·2	·	·	+·2
Brodiaea douglasii	1·6	+·6	·	+·2	+	+	·	·	+·2	+·7	·	·	+·2	+·6	·
Calochortus elegans	+·23	+	·	·	·	+	·	1·24	+·2	+·10	+·4	·	·	·	·
Calochortus macrocarpus	·	·	+·+	+	·	·	·	·	·	·	·	·	·	·	·
Calypso bulbosa	·	·	·	·	·	·	·	·	·	+·+	·	·	·	·	·
Camassia quamash	+·+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Campanula rotundifolia	·	·	·	·	·	·	·	·	·	·	·	·	·	+·+	·
Circaea alpina	·	·	·	·	·	·	·	·	·	·	·	·	+·+	+·+	·
†*Cirsium vulgare*	·	+·+	·	·	·	·	·	·	+·+	·	·	·	·	·	·
Claytonia lanceolata	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Crepis barbigera	·	·	·	·	·	·	·	+·+	·	·	·	·	·	·	·
Crepis	·	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·
†*Cynoglossum officinale*	·	·	·	·	·	·	·	·	·	·	·	·	+·6	+·4	·
Cypripedium montanum	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Cystopteris fragilis	·	+·4	·	·	·	1·4	·	·	1·24	·	+·+	·	·	1·2	·
Delphinium nuttallianum	+	·	+	·	·	+·2	·	·	·	·	·	·	·	·	·
Dodecatheon pauciflorum cusickii	·	·	+·2	·	·	·	·	·	·	·	·	·	·	·	·
Dodecatheon pauciflorum pauciflorum	+·+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Dodecatheon	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·	·
Epilobium angustifolium	·	·	·	·	·	·	·	·	+	12·14	·	1·6	·	·	·
Erigeron corymbosus	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·
Erythronium grandiflorum	14·96	·	+·2	·	·	·	·	1·14	7·68	10·92	4·48	1·26	+·6	·	4·56

(Continued)

Table B-1. *Pinus ponderosa-Symphoricarpos albus and Pinus ponderosa-Physocarpus* associations. continued

	Pinus ponderosa-Symphoricarpos albus								*Pinus ponderosa-Physocarpus malvaceus*						
Stand number	68	69	187	87	88	147	162	70	43	44	71	89	163	164	165
Fragaria	+•+	•	+•2	+	•	•	•	•	+•2	2•24	+•+	1•18	3•28	1•6	•
Frasera fastigiata	+•+	•	•	•	•	•	•	•	•	4•24	•	•	•	•	+•+
Fritillaria lanceolata	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•
Fritillaria pudica	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•
Galium boreale	1•26	•	•	1•18	•	•	•	•	5•26	1•24	+•4	3•34	+•+	+•6	+•2
Galium triflorum	•	•	•	•	•	•	•	•	•	•	•	+•12	•	•	•
Gentiana affinis	+•+	•	•	•	•	•	•	•	•	+	•	+•2	•	•	•
Geranium viscosissimum	1•6	•	•	•	•	+	•	•	+•+	+•2	•	+•2	•	+•+	•
Geum triflorum ciliatum	+	•	•	+	•	+	•	+•+	•	+•+	•	•	•	•	•
Habenaria unalascensis	+•2	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Habenaria	•	+•+	•	+•+	+	•	•	•	•	•	•	•	+•+	+•4	•
Haplopappus liatriformis	•	•	•	•	•	•	+	•	•	•	•	•	•	•	•
Helianthella uniflora douglasii	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•
Heuchera cylindrica glabella	1•14	+•2	•	1•4	•	+	•	•	+•+	+•6	+•+	+•2	•	•	•
Hieracium albertinum	•	•	•	•	•	+	•	+•+	+•2	•	•	+•+	•	•	•
Hieracium albiflorum	•	•	•	1•2	•	•	•	•	•	+•4	•	+•4	•	•	•
Hieracium	•	•	+•+	•	•	•	•	•	•	•	•	•	•	•	•
Hydrophyllum capitatum capitatum	•	2•28	+•+	•	+•2	•	•	2•24	+•2	•	1•18	•	•	•	+
†*Hypericum perforatum*	•	•	•	•	•	•	•	•	•	•	•	•	+•2	•	•
Iris missouriensis	+•+	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Lathyrus bijugatus	2•16	16•50	•	•	•	•	•	•	1•8	2•18	•	1•14	•	•	•
Lathyrus nevadensis	•	•	•	•	•	•	•	+•+	•	•	•	•	•	•	•
Lathyrus pauciflorus	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Lithophragma parviflora	3•12	3•60	+•4	+	•	3•50	+•6	+•+	+•10	•	1•2	•	•	•	•
Lithospermum ruderale	+•+	+	+	+•+	•	+	•	•	•	+	•	•	•	•	•
Lomatium dissectum multifidum	•	•	+	+	2•6	•	•	+•4	•	•	+	•	+•2	+•2	+•+
Lomatium macrocarpum	•	•	•	•	•	•	+•2	•	•	•	•	•	•	•	•
Lomatium triternatum	•	•	•	•	+	+	+•+	•	•	•	•	•	•	•	•
Lupinus laxiflorus laxiflorus	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•
Lupinus leucophyllus	+	•	•	•	•	•	•	•	•	+•+	•	+•+	•	•	•
Lupinus sericeus	+•+	1•4	+	•	•	+	+	•	•	•	•	•	•	•	•
Mertensia longiflora	•	1•10	+•+	•	•	•	•	•	•	•	•	•	•	•	•
Microseris nutans	•	+•+	•	•	•	•	•	+•+	•	•	•	•	•	•	•
Osmorhiza chilensis	•	1•8	•	•	+	•	•	•	+•5	•	•	+•4	9•52	+•2	+•+
Osmorhiza occidentalis	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•
Perideridia gairdneri	1•8	+•2	•	•	•	•	•	+•2	+•2	+•8	•	•	•	•	•
Polystichum munitum	•	•	•	•	•	•	•	+	+	•	•	+	•	•	•
Potentilla arguta	+•2	•	•	+	•	+	•	•	+	•	•	+	•	•	•
Potentilla gracilis	2•14	•	1•6	+	•	+	•	+•2	•	1•10	+•+	1•6	•	•	•
†*Prunella vulgaris*	+	•	•	•	•	+	•	•	+•+	+•+	•	•	•	•	•
Pterospora andromedea	•	•	•	•	•	•	•	•	•	+	•	+•+	•	•	•
Ranunculus glaberrimus	+•2	1•32	•	•	•	•	•	•	•	•	•	•	•	•	•
Ranunculus uncinatus	•	•	•	•	•	•	•	•	+•+	•	•	•	•	•	•
†*Rorippa nasturitium-aquaticum*	•	•	•	•	•	•	•	•	•	•	•	•	1•8	1•12	•
Scutellaria	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•
Senecio integerrimus exaltatus	•	2•24	•	+	+	+•2	•	•	1•5	+•4	•	+	•	•	•
Senecio serra	•	•	•	•	•	•	•	•	•	•	•	+•+	•	•	•
Silene douglasii douglasii	•	•	•	•	•	•	•	1•6	•	•	•	•	•	•	•
Silene menziesii	•	•	•	+•6	•	•	•	•	+•10	•	•	1•8	•	•	•
Silene (oregana?)	•	•	•	•	•	+•4	•	•	•	•	•	•	•	•	•
Sisyrinchium inflatum	+•2	+•6	•	•	•	+	•	•	•	•	•	•	•	•	•
Smilacina racemosa	•	•	•	•	•	•	•	•	•	•	•	•	•	+•+	•
Solidago missouriensis missouriensis	1•10	+	+•2	+	•	•	•	•	•	+•+	•	•	•	•	•
Solidago	•	•	•	•	•	•	•	•	•	•	•	+•2	•	•	•
Stellaria crispa	•	•	•	•	•	+•2	•	•	•	•	•	•	•	•	•
Synthyris missurica	•	•	•	•	•	•	•	•	•	•	•	•	•	+•+	•

(Continued)

Table B-1. *Pinus ponderosa-Symphoricarpos albus and Pinus ponderosa-Physocarpus* associations. continued

	Pinus ponderosa-Symphoricarpos albus								*Pinus ponderosa-Physocarpus malvaceus*						
Stand number	68	69	187	87	88	147	162	70	43	44	71	89	163	164	165
†*Taraxacum*	·	·	+	·	·	+	·	·	+·2	+·+	·	·	·	·	·
Thalictrum occidentale	·	·	·	·	·	·	·	·	·	3·18	·	11·42	·	·	6·12
Thermopsis montana montana	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·
†*Tragopogon dubius*	·	·	·	+	·	+	+·2	+·2	·	·	+·2	·	·	·	·
Trillium petiolatum	·	·	·	+	+	+	·	·	+·6	+·2	·	+·8	·	2·4	+·2
Veratrum californicum	+	·	·	·	·	·	·	·	+·+	+	·	·	+	·	+·+
†*Verbascum thapsus*	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·
Veronica?	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Vicia americana	4·16	3·12	·	·	+	·	·	·	1·10	5·44	·	1·8	+	·	·
Viola adunca	·	·	·	·	·	+	·	+·6	+·2	+·2	+·+	+·4	·	·	·
Wyethia amplexicaulis	·	·	·	·	·	·	·	·	·	+·+	·	·	·	·	·
Zygadenus venenosus gramineus	·	+·4	+·4	·	·	·	·	·	·	·	·	·	·	·	·
ANNUALS															
†*Bromus anomalus*	2·18	·	·	·	·	·	·	·	·	·	·	·	·	·	·
†*Bromus brizaeformis*	·	·	·	·	·	+·2	+	·	·	·	·	·	·	·	·
†*Bromus japonicus*	3·10	·	·	·	·	·	·	·	·	·	·	·	·	·	·
†*Bromus racemosus*	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
†*Bromus tectorum*	·	·	·	+	·	1·32	+·+	+	·	·	·	·	·	·	·
†*Bromus (annual)*	+·2	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Collinsia parviflora	+·10	+·10	·	·	+	·	+·+	+·8	+·+	+·4	+·6	·	·	·	·
Collomia linearis	·	1·28	·	+	+·4	2·42	+·2	·	·	·	·	·	·	·	·
†*Draba verna*	·	·	·	·	·	·	·	·	·	+·+	·	·	·	·	·
Galium aparine	·	1·48	·	2·28	32·88	1·28	+·2	+·22	1·45	·	7·58	·	2·24	8·46	+·2
†*Lactuca serriola*	·		·	·	+·2	+·2	·	·	·	·	·	·	·	+·4	·
Montia linearis	+·6	+·4	·	·	·	·	·	·	·	·	·	·	·	·	·
Montia perfoliata	+·2	3·60	·	3·48	5·62	3·22	+·2	7·66	2·32	+·2	12·42	·	+·8	1·12	+
†*Myosotis micrantha*	·	·	·	·	·	·	+·2	·	·	·	·	·	·	·	·
Plectritis macrocera	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·	·
†*Polygonum convolvulus*	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+·2
INDIGENOUS SPECIES IN MACROPLOT	42	36	24	15	12	26	15	31	37	45	25	38	24	33	20

Table B-2. *Pinus ponderosa-Festuca idahoensis* association.

Stand number	103	141	142	19	143	20	21	144	22
State and county	WSpok	WSpok	WSpok	WSpok	WSpok	WSpok	WSpok	WSpok	WSpok
Township and section	25N19	24N6	27N1	23N17	24N6	24N5		24N6	
Range	41E	43E	41E	43E	43E	43E		43E	
Altitude in meters	738	741	490	747	741	572	564	741	564
Aspect and percent slope	0	NW23	NE16	0	0	0	0	0	0
Mean pH upper dm of soil	6.1	6.4*	6.3*	6.0*	6.2*	5.9*	5.9*	6.2*	6.1*
TALL SHRUBS									
Amelanchier alnifolia	·	·	·	·	·	+	·	·	·
Amelanchier alnifolia cusickii	·	·	·	·	·	·	+	·	·
MEDIUM SHRUBS									
Ribes aureum	·	·	·	·	·	+	·	·	·
Symphoricarpos albus	·	·	·	+	·	·	·	·	·
LOW SHRUBS									
Arceuthobium campylopodum	·	+	·	+	+	·	+	+	+
Erigeron filifolius filifolius	+·5	+	+	·	·	·	·	·	·
Eriogonum niveum	·	+·8	·	·	·	·	·	·	·

(Continued)

Table B-2. *Pinus ponderosa-Festuca idahoensis* association. continued

Stand number	103	141	142	19	143	20	21	144	22
Pentstemon confertus	·	·	+	·	·	·	·	·	·
Phlox caespitosa	·	·	1·20	·	·	·	2·14	·	1·18
Phlox speciosa	·	·	·	·	·	+		·	·
PERENNIAL GRAMINOIDS									
Agropyron spicatum	·	·	·	·	+·1	1·6	1·4	2·12	44·80
Carex filifolia	·	·	·	·	·	·	·	·	6·20
Carex rossii	+·5	+·5	·	·	·	·	·	·	+
Danthonia unispicata	·	·	+·8	+·4	·	+	·	·	·
Festuca idahoensis	95·99	58·98	87·99	59·99	91·99	81·99	92·99	78·99	48·90
Festuca occidentalis	·	·	+	·	·	·	·	·	·
Koeleria cristata	12·80	2·12	6·20	+	·	1·14	2·18	·	5·28
Poa scabrella	·	·	·	·	·	·	·	·	+
Poa secunda	1·20	·	·	·	2·53	·	+	1·25	2·34
Sitanion hanseni	·	+	+	·	·	·	·	·	·
Sitanion hysterix	·	·	·	·	·	+	·	·	·
Stipa californica	·	1·10	·	·	·	·	+·6	·	·
Stipa elmeri	·	·	+	·	·	·	·	·	·
Stipa lemmoni	·	·	·	1·4	·	·	·	·	·
PERENNIAL FORBS									
Achillea millefolium lanulosa	+	+·5	1·10	+·4	+·8	+·6	+·4	+	·
Allium acuminatum	·	·	·	+·2	·	·	·	·	·
Allium geyeri	·	·	·	·	·	·	·	·	·
Antennaria dimorpha	·	+·2	1·10	+	·	·	+·2	·	1·26
Antennaria geyeri	·	+	·	·	·	·	·	·	·
Antennaria luzuloides	·	+·2	1·12	+	·	3·28	·	·	·
Antennaria neglecta	·	·	+	·	·	·	·	·	·
Antennaria parvifolia	+·5	·	·	·	·	·	·	·	·
Antennaria rosea	+·2	+	·	·	·	·	·	·	·
Apocynum androsaemifolia	·	·	·	·	·	7·44	·	·	·
Apocynum medium	·	·	·	+·2	·	·	·	·	·
Arenaria congesta cephaloidea	·	+·12	+·10	·	·	+	+·6	·	·
Aster occidentalis intermedius	·	+·1	+·10	·	·	·	·	·	·
Aster pansus	·	·	1·12	·	·	·	·	·	·
Balsamorhiza sagittata	+	+	·	+	+·5	9·26	7·30	+·2	14·42
Brodiaea douglasii	·	·	+·2	·	·	·	·	·	·
Calochortus elegans	·	+·2	·	·	·	·	·	·	·
Calochortus macrocarpus	·	·	+·5	+·2	·	·	·	·	·
Cirsium undulatum	·	·	·	·	·	·	·	·	+·2
Comandra umbellata	·	·	·	·	·	·	·	·	+
Delphinium nuttallianum	+·8	·	+	·	·	·	·	·	·
Dodecatheon pauciflorum cusickii	·	·	1·45	·	·	+·2	·	·	·
Equisetum laevigatum	·	+·2	·	·	·	·	·	·	·
Erigeron compositus compositus	·	·	·	·	·	+	·	·	·
Fragaria	·	·	+	1·14	·	·	·	·	·
Frasera albicaulis	·	·	+	·	·	·	·	·	·
Fritillaria pudica	·	·	+·2	+	+	+·6	·	·	+·2
Gaillardia aristata	·	+·2	+·12	+·2	·	2·26	·	·	·
Gilia aggregata	·	+	·	·	·	·	·	·	·
Haplopappus carthamoides	·	·	·	·	·	·	·	·	+
Haplopappus integrifolius	·	·	·	·	+·5	·	+	+	·
Hesperochiron	1·20	·	·	·	·	·	·	·	+
Hieracium albertinum	·	+·2	·	·	·	·	+	·	·
Hieracium albiflorum	2·20	·	·	·	·	·	·	·	·
Lithophragma bulbifera	4·99	·	+·18	1·36	2·80	+·14	4·78	2·70	2·78
Lithophragma parviflora	·	+	+	·	·	·	·	·	+
Lithospermum ruderale	·	·	·	+	·	·	+	·	2·4

(Continued)

Table B-2. *Pinus ponderosa-Festuca idahoensis* association. continued

Stand number	103	141	142	19	143	20	21	144	22
Lomatium triternatum	+	.	.	+	.	.	.	.	+·2
Lotus nevadensis	.	.	.	4·12	+·2	+·12	16·44	2·28	.
Lupinus laxiflorus laxiflorus	1·10	.	.	.	.	.	.	.	.
Lupinus leucophyllus	.	.	.	.	.	.	.	.	3·16
Lupinus sericeus	.	.	.	+·2	.	.	.	.	+
Mertensia longiflora	+·2	+	.	.	.	.	.	.	.
Microseris nutans	.	.	.	+	.	+	.	.	.
Potentilla arguta	.	.	+	+	.	.	.	.	.
Potentilla gracilis	.	.	.	+	.	.	.	.	.
Ranunculus glaberrimus	1·32	.	1·55	3·56	10·99	2·70	.	4·98	1·44
†*Rumex acetosella*	.	2·32	.	.	.	.	.	.	.
Saxifraga integrifolia leptopetala	.	.	+·5	+	+	+	.	.	.
Sedum stenopetalum	.	.	+·5	.	.	.	.	.	+
Senecio canus	.	+·2	+·2	.	.	+·2	.	.	.
Silene oregana	.	+	.	.	.	.	.	.	.
Sisyrinchium inflatum	+·2	3·88	+·8	2·62	+·5	1·36	3·50	.	+·10
†*Tragopogon dubius*	.	.	.	+·8	.	+·4	+	.	+·8
Zigadenus venenosus gramineus	.	.	.	.	.	+	.	.	.
ANNUALS									
Agroseris heterophylla	.	.	.	+·2	.	.	.	.	.
†*Agrostis interrupta*	.	.	.	+·8	1·28	+·4	+	+·20	+·6
†*Bromus commutatus*	.	.	+	.	.	.	.	.	.
†*Bromus japonicus*	.	.	+·12	.	.	.	.	+	.
†*Bromus mollis*	.	.	.	.	.	.	+	.	.
†*Bromus tectorum*	+·2	1·42	.	+·14	+·20	.	+·6	+·2	+·6
Clarkia pulchella	.	.	.	+	.	.	.	.	.
Collinsia parviflora	1·30	+·8	+·15	+·16	1·48	2·64	1·30	2·60	+
Collomia linearis	+·2		+·15	1·58	.	.	.	.	.
†*Draba verna*	+·15	1·32	+·2	1·42	1·32	2·66	2·66	1·25	5·98
Epilobium paniculatum	+·2	+·2	+·20	3·92	+·5	1·22	.	+·7	+·4
Festuca pacifica	.	.	.	+·20	+·2	.	.	.	1·28
Gayophytum nuttallii	.	+	.	.	.	.	.	.	.
†*Holosteum umbellatum*	.	.	.	.	.	.	+·2	.	1·34
Madia exigua	.	.	.	3·42	+·15	+·2	.	.	.
Microsteris gracilis	.	.	.	+	.	.	.	.	.
Montia linearis	+·40	.	+	3·78	2·95	2·72	1·34	2·85	2·52
Montia perfoliata	.	.	.	+·16	.	.	.	.	.
†*Myosotis micrantha*	4·78	2·50	1·40	+	+	2·64	9·88	+	6·98
Plagiobothrys tenellus	.	.	.	.	.	.	.	.	+
Plantago patagonica	.	.	1·40	.	.	.	.	.	.
Polygonum douglasii (+P. majus)	.	+·8	.	+·2	.	.	.	.	+·4
Stellaria nitens	+·2	.	.	+·14	1·50	+·10	+·18	+·20	2·68
INDIGENOUS SPECIES IN MACROPLOT	20	19	24	24	16	20	15	11	21

Table B-3. *Pinus ponderosa* forests with undergrowth dominated by xerophytic grasses other than *Festuca idahoensis*.

	Pinus-Agropyron spicatum ⟶					*Pinus-Stipa comata--Pinus-Stipa thurb*[1]					*elm.*[2]	*lem.*[3]
Stand number	145	146	181	182	183	138	185	180	139	184	140	86
State and county	WSpok	WSpok	WSpok	WSpok	WSpok	WSpok	WStev	WSpok	WSpok	WStev	WSpok	WSpok
Township and section	23N23	23N23	26N18	26N17	26N18	26N6	27N23	26N18	26N	27N9	27N36	25N24
Range	41E	41E	42E	42E	42E	43E	41E	42E	41E	41E	41E	40E
Altitude in meters	741	741				709			496	557	490	738
Aspect and percent slope	0	0	WSW4	0	SSW21	WNW7	0	E3	0	0	0	0
Mean pH upper dm of soil	6.3*	6.2	---	---		---*	6.3	6.4	6.2*	---	6.4*	6.0
TALL SHRUBS												
Amelanchier alnifolia	·	·	·	·	·	·	·	·	+	·	+	·
Holodiscus discolor	·	·	·	·	·	·	·	·	·	·	+	·
Salix	·	·	·	·	·	·	·	·	·	·	+	·
MEDIUM SHRUBS												
Ceanothus sanguineus	·	·	·	·	·	·	·	·	·	·	+	·
Rosa woodsii	·	·	·	+	·	·	·	·	·	·	·	·
LOW SHRUBS												
Arabis holboellii	·	·	·	·	·	·	·	·	·	+	·	·
Arceuthobium campylopodum	+	+	·	·	·	+	+	·	·	·	·	+
Erigeron filifolius filifolius	·	·	·	·	·	·	·	·	+	·	·	·
Eriogonum heracleoides	·	·	·	+	·	·	·	·	·	·	·	·
Eriogonum niveum	·	·	+	·	·	1·20	+·10	+	+	·	·	3·32
Leptodactylon pungens	·	·	·	·	·	·	·	·	·	·	·	+
Pentstemon confertus	·	·	·	·	·	·	·	·	·	·	4·50	·
Phlox caespitosa	·	·	+	+	·	·	·	+	+	·	5·48	·
PERENNIAL GRAMINOIDS												
Agropyron spicatum	80·99	64·99	57·95	58·95	44·99	·	·	·	+	·	1·2	·
Aristida longiseta	·	·	+·2	·	·	·	·	·	+	·	·	·
Danthonia unispicata	·	+·2	+·5	·	·	·	·	·	+	+·2	·	·
Festuca idahoensis	·	·	·	·	·	·	·	·	·	·	3·10	·
Koeleria cristata	·	·	·	3·22	·	·	·	·	·	·	·	·
Poa secunda	18·90	10·88	9·88	5·92	13·88	+	50·99	21·99	+	11·98	·	2·35
Sitanion hanseni	·	·	·	·	·	·	·	·	1·15	·	·	·
Sitanion hysterix	·	·	·	·	·	·	·	+·2	·	+·2	·	·
Stipa columbiana	·	·	·	·	·	·	·	·	·	·	8·34	·
Stipa comata	·	·	+·2	·	·	·	·	31·68	·	·	·	·
Stipa elmeri	·	·	·	·	·	36·98	43·99	3·18	·	·	74·92	·
Stipa lemmoni	·	+·15	·	·	·	·	·	·	·	·	·	38·98
Stipa thurberiana	·	·	·	·	·	·	·	23·55	67·99	28·95	·	·
Stipa williamsii	·	·	·	·	·	·	·	·	·	·	+	·
PERENNIAL FORBS												
Achillea millefolium lanulosa	·	·	2·10	+·2	4·52	·	+	+·4	+	+	+·8	·
Allium geyeri	·	+·10	·	·	·	·	·	·	·	·	·	·
Antennaria dimorpha	·	·	+·5	+	·	2·28	1·2	+·4	1·28	2·25	·	+
Antennaria luzuloides	·	·	·	+	·	·	+	·	1·10	+·5	·	·
Antennaria rosea	·	·	·	·	·	·	·	·	·	·	4·38	·
Apocynum	·	·	·	·	·	·	·	·	·	·	+	·
Arabis holboellii	·	·	·	·	·	·	·	·	·	·	·	+
Arenaria congesta cephaloidea	·	·	+·2	·	·	·	+·15	·	·	·	·	·
Aster occidentalis intermedius	·	·	·	·	·	·	·	·	·	·	+	·
Aster pansus	·	·	·	·	·	·	·	·	·	·	+·10	·
Astragalus miser miser	·	·	·	·	·	·	·	+	·	·	·	·
Balsamorhiza sagittata	·	+	+	6·12	+	5·12	+	+	+·2	·	·	·
Brodiaea douglasii	·	·	+·8	·	·	·	·	+·4	·	·	·	·
Campanula rotundifolia	·	·	·	·	·	·	·	·	·	·	+	·
Castilleja lutescens	·	·	·	·	·	·	·	·	·	·	+	·

(Continued)

Table B-3. *Pinus ponderosa* forests with undergrowth dominated by xerophytic grasses other than *Festuca idahoensis*. continued

	Pinus-Agropyron spicatum					*Pinus-Stipa comata--Pinus-Stipa thurb*[1]					*elm.*[2]	*lem.*[3]
Stand number	145	146	181	182	183	138	185	180	139	184	140	86
Chaenactis douglasii	•	•	+·8	•	•	•	•	+	•	•	•	•
Cirsium undulatum	•	•	•	•	•	•	•	+	•	•	•	•
Crepis barbigera	•	•	•	•	•	•	•	•	•	•	•	+
Cryptantha celosioides	•	•	+	•	•	•	•	•	•	•	•	•
Delphinium nuttallianum	•	•	+	+·2	•	+·12	•	+·4	•	•	•	•
Epilobium angustifolium	•	•	•	•	•	•	•	•	•	•	+	•
Equisetum laevigatum	•	•	•	•	•	•	•	•	•	•	•	+
Erigeron compositus compositus	•	•	+	•	•	•	1·5	+	+·2	1·18	•	4·40
Erigeron corymbosus	•	•	•	•	•	•	•	•	•	•	1·12	•
Fragaria	•	•	•	•	•	•	•	•	+	•	+	•
Frasera albicaulis	•	•	•	•	•	•	•	•	+	•	7·52	•
Fritillaria pudica	+·5	•	+·2	+·32	•	+·15	•	+·8	+·2	+·2	•	+·2
Gaillardia aristata	•	•	•	+·8	•	•	•	•	+	+·12	+·22	•
Hieracewm cynoglossoides	•	•	•	•	•	•	•	•	+	•	1·12	•
Lewisia rediviva	•	•	+	•	•	•	+	•	•	•	•	+·2
†*Linaria dalmatica*	•	•	+	+	•		•	•	+	•	•	•
Lithophragma bulbifera	5·99	5·99	•	2·68	1·40	•	1·52	+·2	1·28	•	•	•
Lithophragma parviflora	•	+·5	•	•	•	•	•	•	+·5	•	•	•
Lithospermum ruderale	+	+	•	+	•	•	•	•	•	•	1·6	•
Lomatium ambiguum	•	•	•	•	•	•	•	•	•	1·10	•	•
Lomatium geyeri	•	•	•	•	•	•	•	•	•	•	•	+·5
Lomatium gormanii	•	•	+·2	•	•	•	•	•	•	•	•	•
Lomatium macrocarpum	•	•	+·12	6·52	•	•	•	•	•	1·18	•	•
Lomatium triternatum	•	•	•	+	•	•	•	•	•	•	•	•
Lotus nevadensis	1·18	+·2	•	+	•	•	•	•	•	•	•	•
Lupinus leucophyllus	•	•	•	•	•	•	•	+·2	•	•	•	•
Lupinus sericeus	•	•	+·8	1·32	1·15	+·5	+·5	•	2·18	+·10	•	•
Mertensia longiflora	•	•	•	•	•	•	+	•	•	•	•	•
Microseris nutans	•	•	•	•	•	•	•	•	•	•	+	
Phacelia hastata leucophylla	•	•	•	•	•	•	+	•	•	+	•	•
Phacelia linearis	•	•	•	•	•	•	•	•	•	•	•	+·8
Potentilla arguta	•	•	•	•	•	•	•	•	•	•	+	•
Potentilla gracilis	•	•	•	•	•	•	•	•	•	•	4·36	•
Ranunculus glaberrimus	14·99	10·99	+·12	+·18	•	1·22	+·2	•	1·40	•	+·8	•
Saxifraga	•	•	•	+	2·60	•	•	•	+	•	•	•
Sedum stenopetalum	•	•	•	•	•	•	•	•	+	•	•	•
Senecio canus	•	•	•	+	•	•	•	•	•	+·2	•	•
Sisyrinchium inflatum	+	•	•	2·62	•	•	•	+·2	+·12	•	•	•
Solidago missouriensis	•	•	•	•	•	•	•	•	•	•	2·26	•
†*Tragopogon dubius*	•	+	+·8	+·2	•	•	•	+	+	•	•	•
ANNUALS												
Agoseris heterophylla	•	+·2	•	•	•	•	•	•	•	•	•	•
†*Agrostis interrupta*	1·30	2·62	•	•	•	•	•	•	•	•	•	•
†*Bromus japonicus*	+	+·10	•	•	•	•	•	•	+·2	•	•	•
†*Bromus mollis*	•	•	+·5	•	+·2	•	•	•	+·2	+	•	•
†*Bromus tectorum*	1·38	2·95	1·28	•	+·2	6·99	+·20	+·2	3·68	+·2	•	4·95
Collinsia parviflora	3·99	1·22	+·5	2·78	2·98	1·32	+·2	2·72	1·25	+·15	+·2	2·60
Collomia linearis	•	•	•	•	•	+·2	+·2	•	•	1·30	•	1·28
Cryptantha celosioides	•	•	+	•	•	•	•	•	•	•	•	3·98
†*Draba verna*	2·90	1·52	4·99	5·99	2·99	2·90	3·99	7·99	2·78	2·98	•	1·40
Epilobium paniculatum	+·2	+·10	+·10	+·8	+·15	•	1·28	+·18	+·12	2·98	•	2·78
Festuca pacifica	1·55	+·30		•	+·2	•	1·35	•	2·68	•	•	•
†*Holosteum umbellatum*	•	•	2·65	+·10	+·2	1·28	•	2·88	•	•	•	•
†*Lactuca serriola*	•	+·2	•	•	•	•	•	•	•	•	•	•

(Continued)

Table B-3. *Pinus ponderosa* forests with undergrowth dominated by xerophytic grasses other than *Festuca idahoensis*. continued

	Pinus-Agropyton specatum					*Pinus-Stipa comata--Pinus-Stipa thurb*[1]					*elm.*[2]	*lem.*[3]
Stand number	145	146	181	182	183	138	185	180	139	184	140	86
Lagophylla ramosissima	·	·	·	·	·	·	·	·	·	·	+·2	·
Madia exigua	·	·	·	·	1·35	1·45	2·90	+·10	2·62	2·75	·	·
Microsteris gracilis	·	·	2·70	·	·	1·48	+·8	1·30	·	1·50	·	2·99
Montia linearis	2·90	2·88	+·5	1·38	+·20	2·75	1·30	3·98	1·48	1·35	·	2·98
†*Myosotis micrantha*	·	·	2·75	2·99	3·99	2·99	+·20	2·98	4·99	2·99	·	+·15
Plagiobothrys tenellus	·	·	·	·	1·22	·	·	·	·	+·5	·	·
Plantago patagonica	·	·	·	·	1·38	+·8	·	+·20	·	·	·	·
Polygonum douglasii (+ *P. majus*)	1·28	1·45	·	·	·	·	+·5	+·10	·	·	·	·
Stellaria nitens	2·85	1·35	1·22	·	·	1·22	1·22	+·5	+·12	1·40	·	·
INDIGENOUS SPECIES IN MACROPLOT	12	15	20	16	13	15	18	21	18	21	19	14

[1]*Pinus-Stipa thurberiana*
[2]*Pinus-Stipa elmeri*
[3]*Pinus-Stipa lemmoni*

Table B-4. *Pinus ponderosa-Purshia tridentata* association. In this table (only) + is used to indicate presence in the single 5x25m plot in each stand.

State and county	WLinc	WStev	WStev	WStev	WStev	WStev
Township and section	27N12	31N5	32N33	32N27	33N34	33N34
Range	36E	37E	37E	37E	37E	37E
TALL SHRUBS						
Amelanchier alnifolia	+	+	+	+	·	+
Crataegus douglasii	+	·	·	·	·	·
Holodiscus discolor	·	·	·	·	·	+
Prunus virginiana melanocarpa	+	+	+	+	+	+
Salix	·	·	·	·	·	+
Sambucus caerulea	·	·	·	·	+	+
MEDIUM SHRUBS						
Berberis aquifolium	+	·	·	·	·	·
Ceanothus sanguineus	·	·	·	·	·	+
Purshia tridentata	+	+	+	+	+	+
Rosa woodsii + *R. nutkana*	+	+	+	·	·	+
Symphoricarpos albus	+	+	+	+	·	+
LOW SHRUBS						
Arceuthobium campylopodum	·	·	+	+	·	+
Erigeron filifolius filifolius	·	+	·	·	·	·
Eriogonum heracleoides	+	·	·	·	+	+
Eriogonum niveum	·	·	·	·	+	·
Pentstemon confertus	·	·	+	+	·	·
PERENNIAL GRAMINOIDS						
Agropyron spicatum	+	+	+	+	+	+
Calamagrostis rubescens	·	·	+	·	·	·
Carex praegracilis	·	·	·	+	·	·
Carex rossii	·	·	+	+	·	·
Festuca idahoensis	·	+	+	+	·	+
Koeleria cristata	·	+	+	+	·	+
Poa ampla	·	·	+	+	·	·
†*Poa pratensis*	·	·	+	·	·	+
Poa secunda	+	+	·	·	+	+
Stipa elmeri	·	·	·	+	·	·

(Continued)

Table B-4. *Pinus ponderosa-Purshia tridentata* association. continued

State and county Township and section Range	WLinc 27N12 36E	WStev 31N5 37E	WStev 32N33 37E	WStev 32N27 37E	WStev 33N34 37E	WStev 33N34 37E
PERENNIAL FORBS						
Achillea millefolium lanulosa	+	+	+	+	+	+
Antennaria dimorpha	.	.	.	.	.	+
Antennaria neglecta	.	.	+	.	.	.
Antennaria parvifolia	.	.	.	.	.	+
Apocynum androsaemifolium	+	.	+	.	.	+
Arabis holboellii pendulocarpa	+	+	.	+	+	.
Aster canescens	.	+	.	.	.	.
Balsamorhiza incana	+	.	.	.	.	.
Balsamorhiza sagittata	+	+	.	+	+	+
Besseya rubra	.	.	+	.	.	.
Brodiaea douglasii	.	+	.	.	+	+
Chaenactis douglasii	.	.	.	.	+	.
†*Cirsium vulgare*	.	+	.	+	.	.
Delphinium nuttallianum	+	+	.	.	+	.
Epilobium angustifolium	.	.	.	+	.	.
Erigeron compositus	.	.	.	.	+	.
Erigeron pumilus	.	+	.	.	.	.
Fragaria	.	+	+	+	.	.
Frasera albicaulis	.	+	+	.	.	+
Fritillaria pudica	.	+	.	.	.	.
Gaillardia aristata	.	+	.	+	+	+
Geranium viscosissimum	.	+	.	.	.	+
Geum triflorum ciliatum	+	.	.	.	.	.
Gnaphalium microcephalum	.	+	+	+	.	.
Heuchera cylindrica glabella	.	.	.	+	.	.
Hieracium albertinum	.	.	.	.	+	.
Hydrophyllum capitatum capitatum	+	.	.	.	.	.
Lithophragma bulbifera	+	+	.	.	.	.
Lithophragma parviflora	+	.	.	.	.	+
Lithospermum ruderale	+	+	.	.	+	+
Lomatium geyeri	+	.	.	.	.	.
Lomatium macrocarpum	+	.	.	.	.	.
Lomatium triternatum	.	.	.	.	+	.
Lupinus	+	.	.	.	+	.
†*Marrubium vulgare*	.	+	.	.	.	.
†*Medicago lupulina*	.	.	.	.	.	+
†*Melilotus alba*	.	.	+	.	+	+
†*Melilotus officinale*	.	.	.	.	.	+
Mertensia oblongifolia	+	.	.	.	.	.
Potentilla arguta	.	.	+	.	+	+
Ranunculus glaberrimus	.	+	+	+	.	+
†*Rumex acetosella*	.	.	.	+	.	+
Scutellaria angustifolia	.	.	.	.	+	.
Silene douglasii douglasii	.	.	.	+	.	.
Solidago missouriensis missouriensis	.	.	.	.	.	+
†*Taraxacum*	+	+	+	.	.	.
†*Tragopogon dubius*	+	+	.	.	+	+
†*Verbascum thapsus*	.	.	.	.	+	+

(Continued)

Table B-4. *Pinus ponderosa-Purshia tridentata* association. continued

State and county Township and section Range	WLinc 27N12 36E	WStev 31N5 37E	WStev 32N33 37E	WStev 32N27 37E	WStev 33N34 37E	WStev 33N34 37E
ANNUALS						
†*Bromus commutatus*	+	+	+	·	·	+
†*Bromus japonicus*	+	·	·	+	·	+
†*Bromus mollis*	·	·	·	+	·	·
†*Bromus tectorum*	+	+	+	+	+	·
†*Capsella bursa-pastoris*	+	·	·	·	·	·
Clarkia pulchella	·	·	·	·	·	+
Collinsia parviflora	+	+	+	+	+	+
Collomia grandiflora	·	+	·	+	+	·
Collomia linearis	+	·	·	·	·	·
Conyza canadensis	·	+	·	+	·	·
†*Draba verna*	·	+	·	·	+	+
Epilobium paniculatum	+	+	·	+	+	+
Festuca pacifica	·	+	+	·	+	+
Galium aparine	·	·	·	·	·	+
†*Lactuca serriola*	+	+	·	·	·	·
Lotus purshianus	·	·	·	·	·	+
Madia exigua	·	+	+	·	·	+
Microsteris gracilis	+	+	·	·	+	·
Montia perfoliata	·	·	·	+	·	+
Plantago patagonica	·	·	·	+	·	+
Stellaria nitens	·	·	·	+	+	+

Table B-5. *Pseudotsuga menziesii-Symphoricarpos albus* association.

Stand number State and county Township and section	172 WStev 34N36	173 WStev 33N2	174 WStev 29N23	175 WStev 29N26	176 WStev 28N12	177 WSpok 26N23	178 WWhit 17N6	179 INezp -----
Range	39E	39E	40E	40E	40E	41E	45E	---
Altitude in meters	524	506	574	582	716	---	709	---
Aspect and percent slope	W4	N20	NW48	W21	WSW11	NNE46	NNW6	-----
Mean pH upper dm of soil	6.8	6.3	6.4	6.2	6.1	6.4	5.8	5.9
TALL SHRUBS								
Amelanchier alnifolia	+·2	1·12	+·+	+·+	·	·	2·4	2·6
Crataegus douglasii	·	+	·	·	·	·	·	·
Philadelphus lewisii	·	+·+	·	+·+	·	·	·	·
Sambucus caerulea	·	·	+·+	·	·	·	·	·
MEDIUM SHRUBS								
Berberis aquifolium	+·6	11·56	+·+	·	·	·	·	·
Pachistima myrsinites	·	·	·	·	+·2	·	·	·
Physocarpus malvaceus	·	·	·	·	+·+	·	·	·
Prunus virginiana melanocarpa	+·+	+·2	+	·	·	·	·	·
Rosa gymnocarpa	·	·	·	·	+·2	·	·	+·+
Rosa woodsii + R. nutkana	6·34	1·6	·	+·2	·	·	5·38	3·8
Spiraea betulifolia lucida	+·6	8·32	5·22	11·66	+·2	19·60	22·90	11·60
Symphoricarpos albus	32·82	16·76	1·10	1·6	4·38	·	45·99	12·76
DWARF SHRUBS								
Berberis repens	·	·	·	·	·	·	5·46	·
Chimaphila menziesii	·	·	·	·	+·6	·	·	·

(Continued)

Table B-5. *Pseudotsuga menziesii-Symphoricarpos albus* association. continued

Stand number	172	173	174	175	176	177	178	179
PERENNIAL GRAMINOIDS								
Agropyron spicatum	+•+	•	+•+	•	•	•	3•6	•
Bromus vulgaris	•	•	•	•	•	•	8•22	2•18
Bromus (marginatus?)	•	•	•	•	•	•	•	+•2
Calamagrostis rubescens	•	+•+	+•4	8•28	2•14	+•+	+•4	•
Carex geyeri	•	•	•	•	•	•	52•80	17•24
Carex rossii	•	•	+•6	+•4	•	•	•	+•8
Elymus glaucus	•	+•+	•	•	•	•	•	•
Festuca occidentalis	•	+•4	•	•	9•22	1•2	•	31•74
Luzula comosa	•	+•2	+•2	+•2	+•2	•	•	1•10
†*Poa compressa*	•	+•+	•	•	•	1•2	2•2	+•4
†*Poa pratensis*	•	•	•	•	•	•	•	2•8
PERENNIAL FORBS								
Achillea millefolium lanulosa	+•2	•	•	•	•	•	•	1•10
Antennaria neglecta	•	•	•	+•2	•	+•+	•	•
Apocynum androsaemifolium	•	•	•	•	+•2	•	+•8	+•2
Arenaria macrophylla	•	•	•	•		•	•	6•74
Arnica cordifolia	•	2•6	•	•	6•36	1•4	•	40•90
Calochortus elegans	•	•	•	•	•	•	+•2	•
Campanula rotundifolia	•	+•2	•	•	+•2	+•+	•	•
Claytonia lanceolata	•	•	+•8	•	•	•	•	•
Corallorhiza striata	•	•	•	•	•	•	•	+
Corallorhiza	•	•	•	•	•	•	+•2	•
Cystopteris fragilis	•	•	5•40	+•+	+	+•+	•	•
Delphinium nuttallianum	•	•	+•+	+•4	•	•	•	•
Dodecatheon pauciflorum pauciflorum	•	•	•	+•2	•	•	•	•
Erythronium grandiflorum	10•60	1•28	+•+	+•8	+•6	•	3•54	1•8
Fragaria	2•14	2•14	+•2	+•4	•	•	•	+•4
Galium boreale	•	+•10	+•2	•	+•2	•	1•26	•
Geranium viscosissimum	+•2	•	•	•	+•2	•	+•+	•
Geum triflorum ciliatum	•	•	+	•	•	•	•	2•8
Goodyera oblongifolia	•	•	•	+•+	•	+	•	•
Habenaria	•	•	•	•	+	•	•	•
Heuchera cylindrica glabella	•	+•2	+•+	•	+•+	•	•	•
Hieraceum albiflorum	•	•	•	•	•	4•4	•	+•8
Hieraceum cynoglossoides	•	•	•	•	•	•	•	+•4
Hieraceum	•	•	•	•	+•2	+•+	•	•
Hydrophyllum capitatum capitatum	•	•	+•2	•	+•+	•	•	•
Lathyrus bijugatus	•	+•2	•	•	•	•	+•4	•
Lithophragma parviflora	•	•	1•20	4•28	•	•	•	•
Lithospermum ruderale	+•+	•	•	•	•	•	•	•
Lomatium dissectum multifidum	•	•	+•2	•	•	•	•	•
Lupinus laxiflorus pseudoparviflorus	•	•	•	•	•	•	•	9•18
(Mertensia?)	•	•	•	•	+•2	•	•	•
Microseris nutans	•	•	•	•	•	•	•	+•4
Osmorhiza chilensis	•	•	•	•	+•+	•	+•+	•
Pentstemon	•	•	•	+•+	•	•	•	•
Potentilla arguta	•	•	•	•	•	•	+	•
Potentilla gracilis	+•2	•	+•+	•	•	•	•	+•+
Ranunculus glaberrimus	•	•	•	+•4	•	•	•	•
Sedum stenopetalum	•	•	•	+•2	•	•	•	•
Senecio integerrimus exaltatus	•	•	•	•	•	•	•	+•4

(Continued)

Table B-5. *Pseudotsuga menziesii-Symphoricarpos albus* association. continued

Stand number	172	173	174	175	176	177	178	179
Silene menziesii	.	.	.	.	.	.	+.8	.
Smilacina racemosa	.	+.+	+.2	+.+	+.2	2.12	.	+.+
Solidago canadensis salebrosa	.	.	.	.	.	.	.	+.+
†*Taraxacum*	.	1.8	.	.	+.2	+.2	.	.
†*Trifolium (repens?)*	+.+	.	.	.	.	.	.	.
Trillium petiolatum	.	.	.	.	.	.	+.8	.
Veratrum californicum	.	.	.	.	.	.	+.2	.
Vicia americana	.	.	+.2	.	.	.	4.32	.
Viola adunca	.	.	.	.	+.2	.	.	.
Viola	.	.	.	.	.	+.+	.	.
Zigadenus venenosus gramineus	.	.	.	+.4	.	+	.	.
ANNUALS								
Collinsia parviflora	+.+	.	.	+.8	.	.	.	.
Collomia linearis	+	+.+	.	.	.	.	.	.
Galium aparine	.	+.4	+.6	.	.	.	.	+.6
Montia perfoliata	.	.	+.8	+.8	2.18	.	.	.
INDIGENOUS SPECIES IN MACROPLOT	14	21	24	23	23	11	21	28

Table B-6. *Pseudotsuga menziesii-Physocarpus malvaceus* association.

Stand number	2	4	72	92	105	106	107	108	149	150	161	168	169
State and county	ILata	ILata	ILata	WSpok	IBonn	WFerr	WFerr	WFerr	INezp	IBonn	ILata	ILata	WSpok
Township and section	39N9	39N19	41N12	23N25	58N25	30N31	34N2	37N6	33N9	58N26	39N5	38N15	24N32
Range	3W	4W	5W	44E	4W	34E	39E	37E	4W	4W	4W	3W	42E
Altitude in meters	858	878	805	---	927	1029	1110	554	1044	793	914	630	767
Aspect and percent slope	WNW35	NNE47	N13	NE35	SW47	W17	SSW37	NE27	NE46	SSW37	NW20	NE54	NE40
Mean pH upper dm of soil	6.5	6.4	6.0	6.0*	6.2	6.4	6.8*	6.3	6.2	6.1	5.7	6.2	6.4
TALL SHRUBS													
Acer glabrum	.	.	.	.	.	.	.	.	+.+	.	+	17.18	.
Amelanchier alnifolia	+.+	2.6	1.6	1.4	3.14	3.6	.	6.8	+.2	11.14	1.14	5.6	.
Holodiscus discolor	+.+	.	8.10	+.+	3.4	+	+.2	2.6	6.6	26.40	17.26	+	.
Philadelphus lewisii	.	.	.	.	.	.	.	36.30	.	.	.	28.42	.
Prunus virginiana melanocarpa	.	.	.	.	.	.	+.2	2.6	.	.	+.2	15.20	.
Rhamnus purshiana	.	.	.	.	.	.	.	.	.	1.10	.	.	.
Salix	.	.	3.4	.	.	1.4	2.6	.	.	.	.	.	.
Sambucus caerulea	.	.	.	.	.	.	.	.	.	.	.	1.2	.
Sorbus scopulina	.	.	+	.	.	.	.	.	.	.	.	.	.
MEDIUM SHRUBS													
Berberis aquifolium	.	.	.	.	.	.	1.8	3.12	.	.	.	.	.
Ceanothus sanguineus	.	.	.	.	.	6.14	.	.	.	.	.	.	.
Clematis columbianum	.	.	.	.	.	.	.	.	.	+	.	.	.
Lonicera ciliosa	.	.	1.14	.	+.2	.	.	.	.	2.10	4.24	8.14	.
Pachistima myrsinites	.	.	.	.	+	.	+.2	.	.	+.2	.	.	.
Physocarpus malvaceus	1.4	11.18	62.88	18.34	16.36	69.94	72.92	16.22	38.50	7.20	44.64	48.64	27.46
Ribes niveum	.	.	.	.	.	.	.	.	4.6	.	.	.	.
Rosa gymnocarpa	+	5.14	22.54	.	20.50	.	.	.	.	10.30	1.10	.	.
Rosa woodsii + R. nutkana	.	.	.	1.8	.	4.22	5.16	+.2	+.2	.	1.14	13.26	+.2
Rubus parviflorus parviflorus	.	.	.	.	.	.	.	.	.	.	.	+.+	.
Shepherdia canadensis	.	.	.	.	.	.	+.2	.	.	.	.	.	.
Spiraea betulifolia lucida	+.2	5.22	2.14	3.8	+.8	1.8	2.14	.	14.46	+.4	2.30	+.8	15.70
Symphoricarpos albus	+	4.18	30.80	8.32	7.16	3.16	10.30	46.72	3.28	15.40	16.70	15.60	2.10

(Continued)

Table B-6. *Pseudotsuga menziesii-Physocarpus malvaceus* association. continued

Stand number	2	4	72	92	105	106	107	108	149	150	161	168	169
LOW SHRUBS													
Arabis holboellii	·	·	·	·	·	·	+·+	·	·	·	·	·	·
Arctostaphylos uva-ursi	·	·	·	·	·	·	7·30	·	·	·	·	·	·
Berberis repens	·	·	·	3·18	2·14	·	·	·	·	4·12	+·2	+	·
Pentstemon (wilcoxii?)	·	·	·	·	·	+·2	·	·	·	·	+	·	·
Pyrola virens	·	·	+·2	·	·	·	·	·	·	·	·	·	·
Satureja douglasii	·	+·2	·	·	·	·	·	·	·	·	+	·	·
Sedum stenopetalum	·	·	·	·	·	·	·	·	·	·	·	·	+·6
PERENNIAL GRAMINOIDS													
Agropyron spicatum	·	·	·	·	·	·	+·+	·	·	·	1·16	·	·
Bromus vulgaris	2·14	1·10	9·46	16·38	+	+·+	·	·	·	2·16	3·28	10·38	·
†*Bromus inermis*	·	·	·	+·4	·	·	·	·	·	·	·	·	·
Calamagrostis rubescens	·	·	2·6	25·42	2·6	20·50	2·6	1·4	·	·	·	2·6	3·10
Carex concinnoides	·	·	·	·	·	+·2	·	·	·	·	·	·	·
Carex geyeri	2·12	·	55·88	2·6	+	·	·	·	58·76	·	77·96	+·2	·
Carex rossii	·	·	·	·	+·+	1·4	1·4	·	·	+·2	·	·	+
Carex saximontana	·	·	·	·	·	·	·	+·+	·	·	·	·	·
Deschampsia elongata	+·8	·	·	·	·	+·2	2·6	·	+	·	·	·	·
Elymus glaucus	·	·	2·6	·	·	·	1·4	·	11·34	·	·	·	·
Festuca occidentalis	3·14	1·6	3·14	1·6	2·14	·	·	·	·	+·2	+·+	2·6	·
Koeleria cristata	·	·	·	·	·	·	·	·	·	·	·	·	+·2
Luzula comosa	+·4	·	+·+	+·2	·	·	·	·	·	+	+	·	+
Luzula multiflora	·	·	·	·	·	+·+	·	·	·	·	·	·	·
Melica bulbosa	·	·	·	·	·	·	·	·	·	·	1·8	·	·
Melica subulata	·	·	·	·	·	·	·	·	·	17·34	·	·	·
Poa ampla	·	·	·	·	·	·	·	·	·	·	·	·	+·2
†*Poa compressa*	·	·	·	·	·	·	·	·	·	·	·	·	1·6
†*Poa pratensis*	·	·	·	7·16	·	·	·	+·2	+	·	·	·	·
Trisetum cernuum	+·2	·	·	·	·	·	·	·	·	·	·	·	·
PERENNIAL FORBS													
Achillea millefolium lanulosa	·	·	·	·	·	·	·	·	·	·	+	·	+·+
Adenocaulon bicolor	·	·	·	·	+·+	·	+·+	·	·	6·40	+·+	·	·
Anemone piperi	+·4	6·46	3·68	3·42	·	·	·	·	·	·	1·24	·	·
Antennaria anaphaloides	·	·	·	·	·	+·2	·	·	·	·	·	·	·
Antennaria neglecta	·	·	·	·	·	·	·	·	·	·	·	·	+
Antennaria racemosa	·	·	3·14	·	·	+·2	·	·	·	·	·	·	·
Arabis crucisetosa	·	·	·	·	·	·	·	·	+	·	·	·	·
Arenaria macrophylla	14·44	21·98	5·75	11·72	12·80	·	·	·	4·54	9·70	10·84	8·42	
Arnica cordifolia	23·66	13·78	17·72	3·90	+	27·74	·	·	30·74	1·22	15·62	8·40	12·78
Asarum caudatum	·	·	·	·	·	·	·	·	·	+·+	·	·	·
Aster conspicuus	+	·	·	·	·	+·4	1·10	+·2	·	·	·	+·+	·
Astragalus canadensis mortoni	·	·	·	·	·	+	+	·	·	·	·	·	·
Balsamorhiza sagittata	·	·	·	·	·	·	·	·	·	·	·	·	+·+
Besseya rubra	·	·	·	·	·	·	·	·	·	·	1·12	·	·
Brodiaea douglasii	·	·	·	·	·	·	·	·	·	·	+·2	·	·
Calochortus elegans	·	·	+·2	·	·	·	·	·	·	·	+·16	·	·
Campanula rotundifolia	·	·	·	·	·	+·2	·	·	·	·	+·+	·	·
Circaea alpina	·	+·2	·	·	·	·	·	·	·	·	·	·	·
†*Cirsium vulgare*	+·6	·	·	·	·	·	·	·	·	·	·	·	·
Corallorhiza striata	·	+	+·+	·	·	+·+	·	·	·	·	·	·	·
Cypripedium montanum	+·+	·	·	·	·	+	·	·	·	·	·	·	·
Cystopteris fragilis	+·2	·	·	+·4	·	·	·	·	+·4	+·+	·	+·8	+·+
Delphinium nuttallianum	·	·	·	·	·	+	·	·	+·2	+	·	·	+·+
Disporum oreganum	·	·	1·6	·	1·6	+·+	·	·	·	21·62	·	1·8	·

(Continued)

Table B-6. *Pseudotsuga menziesii-Physocarpus malvaceus* association. continued

Stand number	2	4	72	92	105	106	107	108	149	150	161	168	169
Disporum trachycarpum	+•+	1•10	•	+•4	+	•	•	+	+•+	•	+•2	•	•
Dodecatheon pauciflorum cusickii	•	•	•	•	•	•	•	•	+•2	•	•	•	•
Dodecatheon pauciflorum pauciflorum	•	•	•	•	•	+•+	•	•	•	•	+•4	•	•
Epilobium angustifolium	•	•	•	•	•	+•2	1•14	•	•	•	•	•	•
Erythronium grandiflorum	•	+•10	•	+•8	•	5•48	•	•	2•40	•	7•74	•	3•30
Fragaria	•	+•2	1•18	1•16	+•2	2•22	3•36	+•+	•	2•36	3•54	+•+	•
Frasera fastigiata	•	•	1•6	+•+	•	•	•	•	•	•	•	•	•
Fritillaria lanceolata	•	•	•	+•2	•	•	•	•	•	•	•	•	•
Galium boreale	•	•	+•+	1•4	•	+	•	+	1•12	•	1•12	•	•
Galium triflorum	+•+	1•40	+•2	•	•	•	•	+•+	•	2•20	•	+•6	•
Geranium viscosissimum	•	•	•	•	•	•	•	•	•	•	+	•	•
Goodyera oblongifolia	+	+•2	•	•	•	+	•	•	•	•	•	•	•
Habenaria unalascensis	+	•	•	•	•	•	•	•	•	•	•	•	•
Habenaria	•	•	•	•	•	•	•	+•+	•	•	•	•	+•2
Heuchera cylindrica glabella	•	•	•	•	•	•	•	•	•	•	+	•	+•+
Hieracium albertinum	•	•	•	•	•	•	•	•	•	•	+	•	+
Hieracium albiflorum	•	•	1•4	+•2	+•8	8•10	•	•	•	2•24	•	•	•
Hieracium scouleri	•	•	•	•	•	1•4	•	•	•	•	•	•	•
Hydrophyllum capitatum capitatum	•	+	•	•	•	+	•	•	1•8	+•4	+	•	+•2
Lathyrus bijugatus	•	•	•	•	•	•	•	•	•	•	1•6	•	•
Lathyrus nevadensis	•	•	2•20	5•1	•	•	•	•	•	•	•	•	•
Lithophragma parviflora	•	+•4	•	•	•	+•2	•	•	+•2	•	•	•	+
Lithospermum ruderale	•	•	•	•	•	•	•	•	•	•	+	•	•
Lomatium dissectum multifidum	•	•	•	•	•	•	•	•	+•2	•	•	•	•
Lomatium triternatum	•	•	•	•	•	•	•	•	•	•	+	•	•
Lupinus sericeus	•	•	•	•	•	2•12	•	•	•	•	•	•	•
Microseris nutans	•	•	•	•	•	+•+	•	•	•	•	+	•	•
Mitella stauropetala	+•6	+•8	12•62	2•12	•	•	+•4	•	•	•	•	+	•
Osmorhiza chilense	+	+•+	1•18	4•28	2•6	+•+	•	•	2•16	4•62	+•10	+•+	•
Pedicularis bracteosa	•	•	•	•	•	+•2	•	•	•	•	•	•	•
Pedicularis racemosa	•	•	+	•	•	•	•	•	•	•	•	•	•
Perideridia gairdneri	•	•	•	•	•	•	•	•	•	•	1•14	•	•
Potentilla arguta	+•+	•	•	•	•	+•+	•	+•+	•	•	•	•	•
Potentilla gracilis	•	•	•	•	•	•	•	•	•	•	+•2	•	•
†*Prunella vulgaris*	•	•	1•12	•	•	•	+•+	•	•	•	•	•	•
Senecio integerrimus exaltatus	•	•	•	•	•	+•2	•	•	+	•	1•12	•	•
Silene menziesii	•	•	•	•	•	+•6	•	•	•	•	•	•	•
Silene	•	•	•	1•4	•	•	•	•	•	•	•	•	•
Smilacina racemosa	•	8•20	2•12	3•8	+•+	+•4	+•+	2•20	+•+	+•2	+•+	+•8	•
Smilacina stellata	+	•	+	•	+•+	•	•	•	•	8•38	•	1•6	•
Streptopus amplexifolius	•	•	•	•	•	•	•	•	•	+•+	•	•	•
Synthyris missurica	•	•	•	•	•	•	•	•	1•16	•	•	•	•
†*Taraxacum*	•	•	+•+	•	•	•	•	•	1•4	+	•	•	+•+
Thallictrum occidentale	+•2	4•14	1•12	4•20	+	9•40	•	+•+	6•20	2•8	4•20	•	•
†*Tragopogon dubius*	+•2	•	•	•	•	•	•	•	•	•	•	•	•
Trillium ovatum	+•+	•	1•10	•	•	•	•	•	•	•	+•+	•	•
Trillium petiolatum	•	+•+	•	•	•	+•+	•	•	•	•	•	+•4	•
Veratrum californicum	+•2	•	+•+	•	•	•	•	•	•	•	+	•	•
Vicia americana	•	•	+•2	•	•	•	•	•	•	•	+•2	•	•
Viola adunca	•	•	+•+	•	•	•	•	+	+•2	1•4	•	•	•
Zygadenus venenosus gramineus	•	•	•	•	•	•	+	•	•	•	+•4	•	•
ANNUALS													
†*Bromus japonicus*	•	•	•	•	•	•	•	+	•	•	•	•	•
†*Bromus tectorum*	•	•	•	•	•	•	•	•	•	•	•	•	+•+
Collinsia parviflora	+•6	•	•	•	•	1•12	•	•	•	+•6	+	•	+•+
Collomia linearis	•	•	•	•	•	+•4	•	•	+	•	•	•	+•2

(Continued)

Table B-6. *Pseudotsuga menziesii-Physocarpus malvaceus* association. continued

Stand number	2	4	72	92	105	106	107	108	149	150	161	168	169
Galium aparine	+·4	·	·	3·38	·	+·2	·	·	1·42	·	+	+·10	·
†*Lactuca serriola*	+·14	·	·	·	·	·	·	·	·	·	·	·	·
Microsteris gracilis	·	·	·	·	·	+·+	·	·	·	·	·	·	·
Montia perfoliata	3·28	+·2	·	6·50	·	+·2	·	·	+·12	·	·	4·10	+·+
†*Myosotis micrantha*	·	·	·	·	·	·	·	·	·	·	·	·	+·2
Plectritis macrocera	·	·	·	·	·	·	·	·	·	·		·	+
INDIGENOUS SPECIES IN MACROPLOT	25	23	36	31	19	43	23	17	28	31	38	28	20

Table B-7. *Pseudotsuga menziesii-Calamagrostis rubescens* association. The last four stands on the right represent the *Arctostaphylos uva-ursi* phase.

Stand number	90	91	167	67	66	109	110	114	148	113	112	166	111
State and county	OWall	OWall	WOkan	WYaki	WOkan	MMiss	MMiss	WYaki	IIdah	WFerr	WFerr	WOkan	WFerr
Township and section	5S?	4S9	35N2	15N5	36N7	12N5	12N14	15N5	27N6	36N24	38N8	34N11	39N20
Range	47E	46E	29E	14E	25E	14W	15W	14E	12E	34E	32E	29E	35E
Altitude in meters	1771	1646	1336	1321	----	1875	1862	1341	1570	1357	1451	1163	1308
Aspect and percent slope	S37	WSW41	W26	NE13	----	SE20	NNE20	NE11	W36	NE40	E39	ESE20	SSE44
Mean pH upper dm of soil	5.8	6.4	6.0	---	---	5.6	5.9	5.6	---	5.9	5.9	6.1	5.8*
TALL SHRUBS													
Acer glabrum	·	·	·	·	·	·	·	·	+·+	·	·	·	·
Alnus sinuata	·	·	·	·	·	·	·	·	·	+·+	·	·	·
Amelanchier alnifolia	·	+·2	+	·	·	·	·	+	+·6	·	·	+	·
Holodiscus discolor	·	·	+	+	·	·	·	4·6	·	·	·	·	·
Salix	·	·	·	·	·	·	·	·	+	·	·	·	·
MEDIUM SHRUBS													
Berberis aquifolium	·	·	·	·	+	·	·	·	·	·	·	·	·
Ceanothus velutinus	2·4	·	·	·	·	·	·	·	+	·	·	·	·
Lonicera utahensis	·	·	·	·	·	1·2	+·+	·	·	·	1·4	·	·
Pachistima myrsinites	·	·	·	+·2	+·8	·	·	·	·	+·10	8·70	·	2·32
Physocarpus malvaceus	·	·	·	·	·	·	·	·	·	+·+	·	·	·
Ribes cereum	·	+	·	·	·	·	·	·	·	·	·	·	·
Ribes lacustre	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Ribes viscosissimum	·	+	·	+	·	·	·	·	·	·	+·+	·	·
Rosa gymnocarpa	·	·	·	·	·	·	·	·	·	·	·	+·4	·
Rosa woodsii + R. nutkana	·	·	·	·	·	·	·	·	·	+·+	·	·	·
Shepherdia canadensis	·	·	·	·	·	·	·	·	·	·	·	+	·
Spiraea betulifolia lucida	·	·	·	·	·	1·12	+	·	1·18	1·8	3·16	·	11·80
Symphoricarpos albus	+·+	2·24	+·+	·	+·+	·	·	·	+·4	·	·	+·2	1·4
Vaccinium membranaceum	·	·	·	·	·	·	·	·	·	+·+	+·2	·	·
Vaccinium myrtillus	·	·	·	·	·	·	·	·	·	+	·	·	·
LOW SHRUBS													
Arabis holboellii	+·2	+·2	·	·	·	·	·	·	·	·	·	·	·
Arctostaphylos uva-ursi	·	·	·	·	·	·	·	·	·	2·12	5·28	21·66	22·76
Berberis repens	1·12	+·+	·	·	·	1·16	+·4	·	+·2	·	·	·	·
Chimaphila umbellata occidentalis	·	·	+	·	+	·	·	·	·	+	1·12	·	+·2
Chimaphila	·	·	·	·	·	+	·	·	·	·	·	·	·
Eriogonum heracleoides	+·2	·	·	·	·	·	·	·	·	·	·	·	·
Linnaea borealis longiflora	·	·	·	·	+	·	·	·	·	·	1·14	38·72	·
Pentstemon albertinus	·	·	·	·	·	+·2	·	·	·	·	·	·	·
Pentstemon attenuatus attenuatus	·	·	·	·	·	·	·	·	+·4	·	·	·	·
Pentstemon globosus	+·2	·	·	·	·	·	·	·	·	·	·	·	·
Pentstemon wilcoxii	+·6	1·14	·	·	·	·	·	·	·	·	·	·	·
Pyrola picta	·	·	·	·	·	·	·	·	·	+	·	·	·

(Continued)

Table B-7. *Pseudotsuga menziesii-Calamagrostis rubescens* association. The last four stands on the right represent the *Arctostaphylos uva-ursi* phase. continued

Stand number	90	91	167	67	66	109	110	114	148	113	112	166	111
Pyrola secunda	.	.	.	.	+.+	.	+.+	.	.	+.+	+.+	.	.
Pyrola virens	.	.	.	.	.	.	.	.	.	.	.	+	.
Pyrola	.	.	.	.	+	.	.	.	.	.	.	+.+	.
Sedum stenopetalum	.	1·31	.	.	.	+.+	.	.	.	.	.	.	.
Vaccinium caespitosum	.	.	.	.	.	.	.	.	.	+	.	.	.
Vaccinium scoparium	.	.	.	.	.	.	.	+	.	.	.	.	10·42
PERENNIAL GRAMINOIDS													
Bromus vulgaris	+	.	+.+	.	.	.	.	.	.	.	.	.	.
†*Bromus*	.	+	.	.	.	.	.	.	.	.	.	.	.
Calamagrostis rubescens	86·98	60·94	92·99	92·99	96·99	14·50	60·98	92·99	74·88	74·98	83·99	80·98	81·99
Carex concinnoides	+	+·2	1·14	.	1·4	10·44	5·12	.	3·8	1·6	7·54	4·32	1·6
Carex geyeri	+	6·22	.	3·22	.	47·92	11·26	32·94	2·12	.	.	.	.
Carex rossii	+·6	.	.	.	.	.	.	.	.	.	.	+.+	.
Elymus glaucus	.	.	.	.	.	.	.	.	.	.	.	+	1·4
Festuca occidentalis	.	.	.	.	+.+	6·20	+·2	.	.	.	.	.	+·2
Poa gracillima	.	1·4	.	.	.	+·2	.	.	.	.	.	.	.
Trisetum spicatum	.	.	.	.	.	.	.	.	.	.	.	+	.
PERENNIAL FORBS													
Achillea millefolium lanulosa	2·12	+·2	2·14	+·4	+·2	+·+	.	+·6	2·20	.	.	1·28	1·2
Agoseris elata	.	.	.	.	.	.	.	+	.	.	.	.	.
Allium cernuum	.	.	.	.	.	+·4	.	.	.	.	.	.	.
Anemone piperi	.	3·48	.	.	.	.	.	.	1·26	.	.	.	.
Antennaria anaphaloides	.	.	1·6	.	.	.	.	.	.	.	.	1·8	.
Antennaria neglecta	.	.	.	.	+	.	.	.	.	.	.	.	.
Antennaria racemosa	.	.	.	.	+	4·32	.	+.+	14·62	4·20	2·24	.	.
Antennaria rosea	.		.	.	.	.	.	.	.	.	.	.	4·32
Arenaria macrophylla	+	4·74	.	.	.	.	.	.	+·6	.	.	.	.
Arnica cordifolia	.	31·98	.	24·96	+.+	6·64	23·96	15·82	+	1·14	11·52	.	+.+
Arnica latifolia latifolia	.	.	.	.	.	1·10	.	.	.	.	.	.	.
Aster conspicuus	.	+	.	.	1·14	.	+·6	.	.	.	.	.	.
Astragalus miser hylophilus	.	.	.	.	.	.	1·2	.	.	.	.	.	.
Astragalus miser serotinus	.	.	1·2	.	5·14	.	.	.	.	.	.	1·2	.
Calochortus lyallii	.	.	.	.	+·2	.	.	.	.	.	.	.	.
Calypso bulbosa	.	.	.	.	+	.	.	.	.	.	+	.	.
Campanula rotundifolia	.	.	+·14	.	.	.	.	.	.	.	.	+·4	.
Castilleja hispida	.	+·4	.	.	.	.	.	.	.	.	.	.	.
†*Cerastium vulgatum*	.	.	.	.	+.+	.	.	.	.	.	.	.	.
†*Cirsium vulgare*	.	.	+	.	.	.	.	.	.	.	.	.	.
Claytonia lanceolata	+	.	.	.	.	.	.	.	.	.	.	.	.
Clematis columbiana	.	.	.	.	.	.	.	.	.	+·2	+	.	.
Crepis atribarba originalis	.	.	.	.	+·4	.	.	.	+·+	.	.	.	.
Cypripedium montanum	.	.	.	.	+·4	.	.	.	.	.	.	.	.
Cystopteris fragilis	.	.	.	.	.	.	.	.	.	+·+	.	.	.
Disporum trachycarpum	.	.	.	.	.	.	+	.	.	+·+	.	.	.
Epilobium angustifolium	.	+	+·6	.	.	+	.	.	.	.	.	4·32	.
Erythronium grandiflorum	.	.	.	6·82	.	2·22	6·84	+	+·+	.	.	.	.
Fragaria	+	2·26	3·26	.	+·6	+	+·2	.	+·+	+·10	+·8	5·56	13·82
Fraser albicaulis	+	.	.	.	.	.	.	.	.	.	.	.	.
Frasera fastigiata	.	.	.	+	.	.	.	+·+	.	.	.	.	.
Galium triflorum	.	.	+·+	.	+	.	.	.	.	.	.	+·4	.
Gentiana amarella	.	.	.	.	1·18	.	.	.	.	.	.	+·6	.
Goodyera oblongifolia	.	.	.	.	+·2	+·2	.	.	+·2	+·+	+·2	.	.
Habenaria sparsiflora	.	.	.	.	.	.	.	+·2	.	.	.	.	.
Habenaria unalascensis	.	.	.	.	.	+·2	.	.	+·+	.	.	.	.

(Continued)

Table B-7. *Pseudotsuga menziesii-Calamagrostis rubescens* association. The last four stands on the right represent the *Arctostaphylos uva-ursi* phase. continued

Stand number	90	91	167	67	66	109	110	114	148	113	112	166	111
Habenaria	+·2	+·+	·	·	+	·	·	·	·	·	·	+	·
Heuchera cylindrica glabella	·	·	·	·	·	+·4	+	·	+	+·2	·	·	·
Hieraceum albertinum	+·4	·	·	·	·	·	·	·	·	·	·	·	·
Hieraceum albiflorum	·	·	·	·	+·+	+·+	·	·	·	·	·	+·6	1·22
Hieraceum cynoglossoides	·	·	·	·	·	·	·	·	+	·	·	·	·
Hieraceum (scouleri ?)	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Hydrophyllum capitatum	+	·	·	·	·	·	·	·	·	·	·	·	·
Lilium columbianum	·	·	·	·	+	·	·	+·+	·	+·+	·	·	+·2
Lilium	·	·	·	1·10	·	·	·	·	·	·	·	·	·
Lithophragma parviflora	+·6	·	·	·	·	·	·	·	·	·	·	·	·
Lupinus laxiflorus laxiflorus	·	·	·	·	6·26	·	·	·	·	·	·	·	·
Lupinus laxiflorus pseudoparviflorus	·	5·42	·	·	·	+·2	+	·	·	·	·	·	·
Lupinus sericeus	·	·	1·8	·	·	·	·	·	·	·	4·34	5·16	·
Lupinus sulphureus subsaccatus	·	·	·	+	·	·	·	6·22	·	4·24	·	·	16·70
Lupinus	+	·	·	·	·	·	·	·	·	·	·	·	·
Microseris nutans	2·20	·	·	·	·	·	·	·	·	·	·	·	·
Mitella stauropetala	·	·	·	·	·	·	·	·	+·4	+·2	·	·	·
Osmorhiza chilense	·	+·2	·	+	+	·	+·+	·	·	·	·	·	·
Osmorhiza depauperata	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Osmorhiza occidentalis	·	·	·	·	·	·	·	·	·	·	·	+·2	·
Pedicularis bracteosa	·	·	·	·	·	+	·	·	·	·	·	·	+·2
Pedicularis racemosa	·	·	·	+·2	·	·	·	1·2	+·2	·	·	·	·
Perideridia gairdneri	·	·	·	·	+	·	·	·	·	·	·	·	·
Petasites	·	·	·	+	·	·	·	·	·	·	·	·	·
Potentilla arguta	+·+	·	·	·	·	·	·	·	·	·	·	·	·
Pterospora andromedea	·	·	·	+·2	·	·	·	·	·	·	·	·	·
Ranunculus ?	+·2	·	·	·	·	·	·	·	·	·	·	·	·
Senecio integerrimus exaltatus	+	·	·	·	·	·	·	·	·	·	·	·	·
Silene scouleri scouleri	·	·	·	·	·	+·+	·	·	·	·	·	·	·
Smilacina racemosa	·	·	·	+	·	+	+·+	·	·	+·+	1·14	·	+·+
Smilacina stellata	·	·	+·4	·	+	·	·	·	·	·	·	+·+	·
Stellaria calycantha bongardiana	·	·	·	·	·	·	·	·	·	·	·	1·8	·
Stenanthium occidentale	·	·	·	·	·	·	1·18	·	·	·	·	·	·
†*Taraxacum*	·	+	·	·	1·14	·	·	·	·	·	·	·	·
Thallictrum occidentale	·	+·2	2·16	·	4·12	+	2·12	·	·	+·+	·	1·20	+
†*Tragopogon dubius*	·	·	·	·	+·+	·	·	·	·	·	·	·	·
Valeriana dioica sylvatica	·	·	·	·	·	1·6	+·+	·	·	·	·	·	·
Veratrum	·	+	·	·	·	·	·	·	·	·	·	·	·
Viola adunca	·	+	+·+	·	+	·	·	·	·	·	·	+·+	·
Viola purpurea venosa	+·6	·	·	·	·	+·+	·	·	·	·	·	·	·
Xerophyllum tenax	·	·	·	·	·	·	·	·	12·22	·	·	·	·
ANNUALS													
Collinsia parviflora	3·34	2·52	+	·	+	·	·	·	·	·	·	·	·
Collomia linearis	·	·	+	·	·	·	·	·	·	·	·	·	·
Galium bifolium	+·2	·	·	·	·	·	·	·	·	·	·	·	·
†*Lactuca serriola*	·	·	·	·	+	·	·	·	·	·	·	·	·
Microsteris gracilis	·	+·10	·	·	·	·	·	·	·	·	·	·	·
†*Poa annua*	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Polygonum watsonii	+·14	·	·	·	·	·	·	·	·	·	·	·	·
INDIGENOUS SPECIES IN MACROPLOT	20	22	18	9	19	24	17	11	21	23	17	23	19

Table B-8. *Abies grandis-Pachistima myrsinites* association.

Stand number	1	5	6	7	8	11	13	18	34	50	93	94	151	152	153	154
State & county	ILata	ILata	ILata	IIdah	IIdah	IIdah	IShos	ILata	ILata	MLake	OWall	OWall	IIdah	WColu	WColu	OWall
Township & section	40N5	42N24	41N9	29N10	29N23	30N33	24N34	39N5	40N17	25N9	-----	-----	34N11	8N2	7N6	-----
Range	1E	3W	3W	2E	3E	5E	2E	3W	4W	19W	---	---	2W	40E	39E	---
Altitude in meters	1060	830	815	1269	1214	----	1361	823	1476	1086	1435	-----	1011	1476	1145	1370
Aspect & percent slope	S23	W6	---	N14	ENE23	W11	SE48	NE39	----	W19	SE9	ENE13	NW13	ENE30	NE8	SE11
Mean pH upper dm of soil	6.7	5.5	5.6	6.4	6.0	6.1	6.7	6.3	5.8	6.3	5.4	5.8	6.1	6.1	6.1	6.1
TALL SHRUBS																
Acer glabrum	+	.	.	+•+	.	+•+	+•+	+•2	.	2•6	.	.	+•2	+	.	1•8
Amelanchier alnifolia	+	+	2•22	+•+	+	.	+	+•+	.	2•6	+•2	.	+•2	+•+	15•18	+•+
Crataegus douglasii	.	.	+•+	.	.	.	.	.	.	.	.	.	.	.	.	.
Holodiscus discolor	3•4	.	.	.	.	.	.	.	.	2•6	.	.	1•10	.	4•4	.
Philadelphus lewisii	.	.	.	.	.	.	.	.	.	+•+	.	.	.	.	.	.
Salix	1•2	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+•2
Sambucus racemosa melanocarpa	.	.	.	.	.	.	.	.	+•2	.	.	.	.	.	.	.
Sorbus scopulina	.	+	.	.	+	+•+	+•+	.	+•+	.	.	.	.	.	.	1•6
Taxus brevifolia	.	+	.	+	.	.	+	.	.	.	+	.	.	.	.	.
MEDIUM SHRUBS																
Clematis columbiana	.	.	.	+•+	+•+	.	.	.	.	.	.	.	.	.	.	.
Lonicera ciliosa	.	+	9•34	2•18	1•8	.	.	+•8	.	5•42	.	.	6•38	.	4•14	.
Lonicera utahensis	1•4	+	.	+•2	.	3•12	+	.	+•+	.	+•2	+•2	.	.	.	3•16
Menziesia ferruginea	.	.	.	.	.	10•18	.	.	.	.	.	.	.	.	.	.
Pachistima myrsinites	1•16	.	.	.	.	.	12•56	.	+•+	.	.	.	.	.	.	1•10
Physocarpus malvaceus	3•10	.	.	.	.	.	.	+•2	.	.	.	.	1•4	.	.	.
Ribes lacustre	.	.	.	+	1•4	.	+•+	.	2•6	.	+•+	+	+•2	.	.	.
Ribes viscosissimum	.	.	.	.	.	+	.	.	.	.	.	+	.	+•2	.	1•4
Rosa gymnocarpa	3•16	6•36	.	2•12	7•22	2•6	+•+	4•16	.	3•20	.	1•14	2•14	+•2	4•16	17•70
Rubus parviflorus parviflorus	+	.	.	2•2	+•2	.	+		+•6	+	+	+	+•+	.	.	1•10
Spiraea betulifolia lucida	1•10	+•4	.	+	+•2	+•4	.	2•10	.	8•30	.	5•34	+•6	+•2	+•2	.
Symphoricarpos albus	8•38	18•64	2•4	7•22	3•6	.	.	2•6	.	9•24	.	+•2	6•28		3•18	+•6
Vaccinium membranaceum	.	+•4	.	+	1•2	28•54	+•2	.	.	.	2•20	7•40	.	22•54	.	47•98
LOW SHRUBS																
Berberis repens	.	+	.	1•10	.	.	.	1•2	.	5•38	1•14	.	.	+•+	.	.
Chimaphila menziesii	+•4	.	.	+•10	+•+	.	+•2	.	.	+•+	.	.	.	+•8	+	+•2
Chimaphila umbellata occidentalis	1•14	.	.	+•10	+•2	2•22	+•+	+•+	.	+	1•16	.	.	+•8	.	6•16
Linnaea borealis longiflora	16•62	3•50	30•78	10•82	5•34	7•70	.	5•12	.	1•20	15•66	19•60	.	62•99	.	18•84
Pyrola asarifolia	.	.	.	.	.	1•14	.	.	.	.	+•6	.	.	.	.	+•10
Pyrola picta	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+•2
Pyrola secunda	+•2	.	.	.	.	1•14	+•+	.	+•4	+	1•16	1•22	.	1•8	.	+•2
Pyrola uniflora	.	.	.	.	.	.	.	.	.	.	+	.	.	+•4	.	.
Pyrola virens	.	.	.	.	+•+	.	.	.	.	.	.	.	.	.	.	.
Pyrola	.	.	.	+•2	.	.	.	+	.	.	.	.	.	.	.	.
Xerophyllum tenax	.	.	.	.	.	58•70	+•+	.	.	.	.	.	.	.	.	.
PERENNIAL GRAMINOIDS																
Bromus vulgaris	2•18	8•64	7•40	+•+	4•26	9•42	+•+	+•4	+•2	+•6	+•4	1•10	1•8	+•2	1•14	6•58
Calamagrostis rubescens	.	4•34	.	.	.	.	.	.	.	3•6	.	.	.	.	.	.
Carex concinnoides	.	+	2•10	.	+•2	.	.	.	.	.	+•2	+•2	.	.	.	.
Carex geyeri	.	.	2•12	.	.	.	+•+	3•4	.	.	+	+•+	1•2	.	2•8	.
Carex rossii	.	.	.	+•2	.	.	+•+	.	.	.	.	.	.	+	.	+•2
Carex	.	1•4	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deschampsia elongata	.	2•18	.	.	.	.	.	.	.	+	.	.	.	+•+	+•+	.
Festuca occidentalis	.	.	4•18	1•6	.	.	.	1•4	.	.	+	.	.	.	.	.
Luzula comosa	.	.	+•+	+	.	.	.	1•2	.	.	.	.	.	.	+	.
Luzula parviflora	.	+•12	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Melica subulata	.	.	.	.	.	.	.	4•12	.	.	.	.	4•32	.	+•2	.
Melica	.	+•6	.	.	.	.	.	.	.	.	+•6	+•4	.	.	.	.

(Continued)

Table B-8. *Abies grandis-Pachistima myrsinites* association. continued

Stand number	1	5	6	7	8	11	13	18	34	50	93	94	151	152	153	154
Oryzopsis asperifolia	·	·	·	·	·	·	·	·	·	+·2	·	·	·	·	·	·
†*Poa pratensis*	·	·	·	·	·	·	·	·	·	+·2	·	·	·	·	·	·
PERENNIAL FORBS																
Actaea rubra	·	·	·	·	+·2	+·2	·	·	1·8	·	·	·	·	·	·	·
Adenocaulon bicolor	1·10	2·38	+·4	1·12	7·32	21·70	1·6	+·2	·	+·2	·	+·2	3·30	·	1·4	12·70
Anemone piperi	3·36	3·58	2·32	2·32	1·28	+·10	·	+·8	4·48	·	1·28	·	·	6·44	4·30	4·64
Antennaria neglecta	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Arenaria macrophylla	1·4	3·54	2·36	1·28	·	1·14	+·6	4·40	·	·	·	·	1·22	1·6	1·28	+·14
Arnica cordifolia	·	3·50	3·34	+·4	·	·	·	13·50	·	+·6	1·18	+	+·2	32·72	+·8	+·2
Asarum caudatum	·	·	·	·	·	+·6	+·+	·	·	·	·	·	·	·	·	·
Aster conspicuus	·	·	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·
Athyrium filix-foemina	·	·	·	·	+·+	+	·	·	+·+	·	·	·	·	·	·	·
Calypso bulbosa	·	·	·	·	·	·	·	·	·	·	+·4	+·4	·	·	·	+·+
Campanula rotundifolia	·	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·	·
Cephalanthera austinae	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·
†*Cerastium vulgatum*	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+·2	·
Circaea alpina	·	·	·	·	+·6	·	·	·	·	·	·	·	+·2	·	+	·
Clintonia uniflora	2·12	3·54	1·8	2·26	5·44	3·46	2·12	+·+	4·34	1·16	1·16	+	6·46	+·16	·	20·99
Coptis occidentalis	7·46	12·76	4·78	18·92	8·62	18·98	14·38	8·34	19·80	·	·	·	·	·	·	·
Corallorhiza maculata	·	·	·	·	·	+·+	·	·	·	·	·	·	·	·	+·2	·
Corallorhiza mertensiana	·	·	·	·	·	+	·	·	·	·	·	·	·	+	·	+·+
Corallorhiza striata	+	·	·	·	·	·	+·2	·	·	·	·	·	·	·	+	·
Cornus canadensis	·	·	·	·	7·52	·	·	·	·	·	·	·	·	·	·	·
Cypripodium montanum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+·+
Cystopteris fragilis	·	·	+·2	·	·	·	·	·	·	·	+	·	·	·	·	·
Disporum oreganum	1·12	3·22	6·36	+·+	+·2	+	1·12	5·20	12·42	6·40	·	+·2	7·42	·	+·+	4·22
Epilobium watsonii	·	+·2	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Epilobium angustifolium	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Fragaria	·	+·10	1·34	+·2	+·2	·	·	+·8	·	+·4	+·6	+·+	1·12	+	+·2	4·32
Frasera fastigiata	·	+		+	·	·	·	·	·	·	·	·	·	·	·	·
Galium triflorum	1·8	1·26	1·16	+·4	+·8	1·6	1·8	1·10	4·38	+·+	+	1·6	1·16	1·40	1·16	2·38
Goodyera oblongifolia	+·4	+	1·6	+·12	+·+	+·8	+·4	·	·	1·12	1·10	·	+·4	+·6	1·16	+·+
Hieraceum albiflorum	·	+·14	+·6	+·2	·	·	+·2	·	·	+·10	+·6	·	·	+	+·6	2·12
Lathyrus bijugatus	·	·	+·2	·	·	·	·	·	·	·	·	·	·	·	·	·
Lathyrus nevadensis	·	+	18·76	2·8	·	·	·	2·12	·	+	·	·	·	·	+·6	·
Listera caurina	·	·	·	·	·	·	+·+	·	·	·	·	·	·	+	·	·
Mertensia paniculata	·	·	·	·	·	·	·	·	2·4	·	·	·	·	·	·	·
Mitella stauropetala	·	1·12	1·6	+·2	+·2	+·2	·	+	+·2	·	+·6	·	·	+·6	+·4	·
Monotropa uniflora	·	·	·	+·+	·	·	·	·	·	+·2	·	·	·	·	·	·
Osmorhiza chilense	+·6	5·62	·	·	1·12	·	+·+	1·10	4·38	·	·	·	3·46	2·32	4·52	3·42
Osmorhiza	·	·	8·62	+·2	·	+·+	·	·	·	·	+·10	+·8	·	·	·	·
Pedicularis bracteosa	·	·	+	·	·	·	·	·	·	+·+	·	·	·	·	·	·
Pedicularis racemosa	·	·	·	·	·	+·+	·	1·2	·	+·+	+·+	·	·	·	·	+·+
Perideridia gairdneri	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Polemonium pulcherrimum calycinum	·	·	·	·	·	·	+·+	·	·	·	·	·	·	+·2	·	·
Polystichum munitum	·	+	·	·	+	·	·	+	·	·	·	·	·	·	·	·
†*Prunella vulgaris*	·	1·26	+·4	·	·	·	·	·	·	·	·	·	·	·	·	·
Pteridium aquilinum languinosum	·	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·	6·12
Pterospora andromedea	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+
Ranunculus uncinatus	·	1·14	·	·	+·2	·	·	·	·	·	·	·	+	·	·	·
Seneco triangularis	·	·	·	·	·	·	·	·	1·4	·	·	·	·	·	·	·
Smilacina racemosa	·	·	·	·	·	·	·	1·4	·	·	·	+·2	·	·	·	·
Smilacina stellata	25·86	3·32	2·18	4·36	16·50	1·10	5·16	2·50	51·84	2·18	+·4	14·54	8·54	+·+	1·12	5·60
Streptopus amplexifolius	·	·	·	·	+	·	·	·	·	·	+·2	·	·	·	·	·
Synthyris missurica	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
†*Taraxacum*	·	+·4	+·4	·	+·2	·	·	·	·	+·2	·	·	·	·	·	·
Thallictrum occidentale	1·6	+·8	1·16	2·8	3·8	5·16	+·2	2·8	15·60	+·2	+	6·28	+·+	4·14	+·2	6·24
Thermopsis montana ovata	·	·	·	+	·	·	·	·	·	·	+	·	·	·	·	·

(Continued)

Table B-8. *Abies grandis-Pachistima myrsinites* association. continued

Stand number	1	5	6	7	8	11	13	18	34	50	93	94	151	152	153	154
Tiarella unifoliata	·	+·8	·	·	11·72	1·18	+·+	·	·	·	·	·	1·20	+	·	+·+
Trauvetteria caroliniensis	·	+	9·42	·	·	·	·	·	·	·	·	·	·	·	·	·
Trientalis latifolia	·	·	·	·	·	·	·	·	·	·	·	·	·	·	7·46	·
Trifolium latifolium	·	·	·	·	·	·	·	·	·	·	+·2	·	·	·	·	·
†*Trifolium pratense*	·	5·76	·	·	·	·	·	·	·	·	·	·	·	·	·	·
†*Trifolium*	·	·	·	·	·	·	·	·	·	·	·	1·8	·	·	·	·
Trillium ovatum	+·4	1·18	1·10	+·+	1·12	+·2	+·2	1·16	2·18	·	+·+	·	2·20	·	·	+·2
Valeriana sitchensis	·	·	·	·	·	·	·	·	·	·	·	1·2	·	·	·	+·2
Veratrum californicum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+·+	·
Veratrum	·	·	·	·	+·+	+	·	·	·	·	·	·	·	·	·	·
Vicia americana	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+·4
Viola adunca	·	+	·	·	·	·	·	·	·	+·6	·	·	·	·	·	·
Viola glabella	·	+·6	+·18	·	·	·	·	+·4	7·62	·	·	·	2·42	3·44	·	1·10
Viola orbiculata	2·28	+·8	·	3·44	3·44	3·52	1·24	+·2	·	1·24	1·14	1·40	·	·	·	2·50
ANNUALS																
Collinsia parviflora	·	+	·	·	·	·	·	·	·	·	·	+·2	·	·	·	·
†*Lactuca serriola*	·	·	·	+·2	·	·	·	·	·	·	·	·	·	·	·	·
Montia sibirica	·	+	·	·	·	·	·	·	3·22	·	·	·	·	·	·	·
INDIGENOUS SPECIES IN MACROPLOT	26	31	30	28	29	26	16	33	24	29	29	23	28	25	27	44

Table B-9. *Thuja plicata-Pachistima myrsinites* association.

Stand number	3	23	49	62	65	73	74	115	116	117	170
State and county	ILata	ILata	IIdah	IShos	IClea	IClea	IIdah	IIdah	IIdah	IClea	IIdah
Township and section	40N16	40N14	37N16	44N32	41N13	13N5	34N30	32N23	32N--	39N19	37N22
Range	4W	4W	14E	5E	4E	4E	7E	6E	7E	7E	14E
Altitude in meters	1379	1413	1359	1456	872	1250	1380	1425	1418	1082	1091
Aspect and percent slope	WNW32	NNW31	33E	N23	E28	SE48	SE30	SW24	WSW28	SE20	E32
Mean pH upper dm of soil	6.2*	6.0	5.8	5.6	6.1	6.2	6.1	6.1	6.0	5.7	6.3
TALL SHRUBS											
Acer glabrum	+·+	3·8	1·4	·	+·+	12·16	+	10·12	+·+	1·2	1·4
Amelanchier alnifolia	·	·	·	·	1·2	1·2	+·+	·	·	·	·
Sambucus	·	·	6·16	1·2	·	·	·	·	·	·	·
Sorbus scopulina	·	1·2	·	·	·	+	·	·	·	·	+
Taxus brevifolia	+	·	·	1·2	17·20	39·54	+·+	·	·	2·4	5·6
MEDIUM SHRUBS											
Clematis columbianum	+	1·4	·	·	·	·	·	·	+·+	·	·
Lonicera ciliosa	·	·	·	·	1·8	·	·	·	·	·	·
Lonicera utahensis	·	4·10	·	2·12	4·10	+·4	1·4	+·2	+	·	·
Menziesia ferruginea	·	·	·	·	·	·	·	·	·	+·+	·
Pachistima myrsinites	·		·	+·+	+	4·16	1·10	+·+	·	·	+
Physocarpus malvaceus	·	+·2	·	·	·	·	·	·	·	·	·
Rhamnus purshiana	·	·	·	·	+	+	·	·		·	·
Ribes lacustre	+	9·20	+·+	·	·	·	·	·	·	·	+·2
Rosa gymnocarpa	+	·		·	1·4	+·+	·	+·+	·	·	·
Rubus parviflorus parviflorus	·	19·44	2·10	·	+·2	+·+	·	2·12	·	·	·
Rubus (nivalis?)	·	·	·	·	2·22	·	·	·	·	·	·
Symphoricarpos albus	·	1·2	+	·	·	·	·	1·4	+·2	+·+	+·+
Vaccinium membranaceum	+·2	·	·	6·14	2·4	1·4	1·2	+·2	·	1·2	·
LOW SHRUBS											
Chimaphila menziesii	·	·	·	·	·	+·+	·	1·4	·	·	·
Chimaphila umbellata occidentalis	·	·	·	·	1·8	·	+	+·+	·	·	·
Linnaea borealis longiflora	·	·	·	·	6·44	·	1·6	+·10	·	·	+·2

(Continued)

Table B-9. *Thuja plicata-Pachistima myrsinites* association. continued

Stand number	3	23	49	62	65	73	74	115	116	117	170
Pyrola asarifolia	.	.	.	.	.	.	+.+	.	.	.	.
Pyrola picta	.	.	.	.	+.4	+	+	+.2	.	.	.
Pyrola secunda	.	.	.	.	1.12	+	3.20	+.2	.	+.+	.
Symphoricarpos mollis	.	.	.	.	34.58	.	.	.	.	.	.
Xerophyllum tenax	.	.	.	.	.	.	.	+.+	.	.	.
PERENNIAL GRAMINOIDS											
Bromus vulgaris	+	.	+.2	2.18	1.8	+.+	+.2	.	+.2	+.2	+.2
Carex bolanderi	.	.	1.12	.	.	.	.	.	.	.	.
Carex laeviculmis	.	.	.	.	.	+	.	.	.	.	+.+
Carex rossii	.	.	.	.	.	.	+	.	.	.	.
Carex	.	.	.	.	+.2	.	.	.	.	.	.
Luzula parviflora	.	.	.	.	+	.	.	.	.	.	.
Luzula wahlenbergii	.	.	.	.	.	.	.	.	.	+.2	.
PERENNIAL FORBS											
Aconitum columbianum columbianum	+.2	+.+	.	.	.	.	.	.	.	.	.
Actaea rubra	32.54	7.14	2.4	2.4	.	.	.	.	4.6	+.2	+.+
Adenocaulon bicolor	7.28	10.48	4.36	+.+	2.26	+.2	1.16	+.+	13.50	1.12	7.30
Adiantum pedatum	.	.	.	.	+	.	.	.	.	4.6	4.8
Anemone piperi	2.36	2.22	1.24	5.58	1.12	1.20	2.42	1.26	3.50	1.26	1.34
Aquilegia formosa	.	.	.	.	.	.	.	.	.	+.+	.
Arenaria macrophylla	.	.	+.2	+.8	+.2	.	2.38	+.4	+.2	.	.
Arnica cordifolia	.	+.2	.	.	.	.	.	.	.	.	.
Arnica latifolia	.	.	.	.	.	.	.	.	.	1.6	.
Arnica	.	.	.	.	.	.	+.2	.	.	.	.
Asarum caudatum	3.34	2.14	11.34	5.40	5.38	4.34	2.20	1.18	3.36	2.12	13.66
Athyrium filix-foemina	+	5.10	25.38	.	.	+	.	+	+	13.26	+.+
Calypso bulbosa	+	.	.	.	.	.	.	.	.	.	.
Circaea alpina	5.30	1.12	32.92	.	.	.	.	.	.	.	2.24
Clintonia uniflora	+.2	5.42	+.4	4.44	9.66	2.26	1.10	1.14	+.6	4.36	10.56
Coptis occidentalis	23.98	38.90	4.22	14.94	10.52	8.36	5.36	8.90	6.64	3.30	23.96
Coralorhiza maculata	.	.	.	.	.	.	.	+.+	.	.	.
Cornus canadensis	.	.	.	.	8.76	.	.	+.6	.	.	1.3
Cystopteris fragilis	.	.	2.10	.	.	.	.	.	.	.	.
Disporum oreganum	31.78	5.28	6.30	17.62	15.56	5.32	1.6	+.2	26.64	6.28	1.5
Dryopteris filix-mas	.	.	+	.	.	.	.	.	+.+	.	2.4
Dryopteris dilitata	.	.	+.2	+.2	.	.	.	.	.	1.2	+
Fragaria spp.	.	.	.	.	.	.	.	.	.	.	+.+
Galium triflorum	+.4	4.40	1.12	1.26	2.30	+.2	1.20		1.10	+.+	1.22
Goodyera oblongifolia	.	+.+	+.4	1.10	+.4	+.4	1.10	+	+	+.2	+.+
Habenaria	.	.	.	.	.	.	+.+	.	.	.	.
Hieracium albiflorum	.	.	.	.	.	.	+.2	.	.	.	.
Lathyrus nevadensis	.	.	.	.	1.6	.	.	+.2	+	.	.
Listera cordata	.	.	.	.	.	.	.	.	.	+.6	+.2
Mertensia paniculata	.	.	.	.	.	.	.	.	.	+.2	.
Mitella stauropetala	+.2	+.2	.	.	.	.	1.6	.	.	.	1.4
Monotropa uniflora	.	.	.	.	.	.	.	+	.	.	.
Montia cordifolia	.	.	.	.	.	.	.	.	.	.	+.10
Osmorhiza chilense	.	.	1.16	1.16	+.2	.	.	.	+.6	+.2	2.4
Osmorhiza purpurea	6.62	.	.	.	.	.	.	.	.	.	.
Osmorhiza	.	4.28	.	.	.	+.+	+.2	.	.	.	.
Phegopteris dryopteris	.	.	.	.	+	+	+	.	+.+	49.90	31.68
Polystichum lonchitis	.	.	.	.	.	+	.	.	.	.	.
Polystichum munitum	.	.	.	.	+.+	+.+	+	+.+	+	+.2	2.4
Pteridium aquilinum languinosum	.	.	.	.	+.+	+.+	.	+	.	.	.
Scrophularia lanceolata	.	.	1.4	.	.	.	.	.	.	.	.
Senecio triangularis	+	+.2	+.+	.	.	.	.	.	.	.	+.4

(Continued)

Table B-9. *Thuja plicata-Pachistima myrsinites* association. continued

Stand number	3	23	49	62	65	73	74	115	116	117	170
Smilacin racemosa	·	·	+·2	·	+	+·+	·	·	·	·	·
Smilacina stellata	30·96	13·66	10·56	6·60	29·99	4·32	1·8	+·8	13·48	1·12	31·88
Streptopus amplexifolium	·	·	+·+	·	·	·	·	·		+·2	1·2
Synthyris platycarpa	·	·	·	·	·	·	·	·	1·12	·	·
Thallictrum occidentale	+·2	3·12	2·2	·	·	·	+·+	·	1·2	+·+	·
Tiarella unifoliata	2·52	18·76	6·62	7·66	8·46	1·14	4·46	4·38	3·36	14·86	4·44
Trautvetteria caroliniensis	·	·	·	1·6	·	·	·	·	·	·	1·4
Trillium ovatum	3·34	2·18	3·18	1·12	+·+	+·6	+·4	1·26	1·14	2·26	1·14
Veratrum viride	+·+	·	·	·	·	·	·	·	·	·	·
Viola glabella	·	3·36	1·18	1·18	·	·	·	·	·	1·8	1·16
Viola orbiculata	2·22	·	·	1·24	1·22	1·24	5·68	+·4	+·4	1·22	4·66
ANNUALS											
Montia sibirica	+·8	+·2	4·50	+·2	·	·	·	·	·	·	·
INDIGENOUS SPECIES IN MACROPLOT	21	30	31	25	34	26	28	28	22	34	36

Table B-10. *Tsuga heterophylla-Pachistima myrsinites* association.

Stand number	14	15	16	17	24	25	26	27	28	29	30	33	52	54	55	60	76	77	78
State & county	IShos	IShos	IKoot	ILata	IBonn	WPend	IBonn	IBonn	WPend	IBonn	IBonn	ILata	MFlat	MFlat	MFlat	ILata	B.C.	B.C.	B.C.
Township & section	52N32	51N15	53N36	42N14	62N36	34N19	62N34	62N33	38N23	62N27	62N23	42N29	34N30	34N29	34N29	42N16	--	--	--
Range	3E	1E	2W	3W	5W	46E	5W	5W	45E	5W	5W	24W	17W	17W	17W	24	--	--	--
Altitude in meters	854	1189	1151	837	889	823	905	884	1067	1023	1030	---	1035	1037	1108	930	602	555	561
Aspect & % slope	NE29	ENE60	W59	E16	SSE1	NNE29	NW23	0	SE28	WNW11	WSW12	0	0	NE16	SW19	W2	0	WNW11	S13
Mean pH upper dm of soil	6.4	6.0	5.4	5.7*	--*	5.0*	4.1*	4.1*	4.7*	--*	--*	5.0*	4.6	4.4	6.0	5.0	4.5	4.0	4.6
TALL SHRUBS																			
Acer glabrum	·	+	+·+	·	·	·	+	·	·	·	+·+	+	+	+·+	4·16	·	+·+	2·6	·
Amelanchier alnifolia	·	·	+	·	+·2	+·2	+·+	+	·	·	+·+	·	+	+	+	·	+·+	·	+·+
Cornus stolonifera	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+·+	·	·	·	·
Corylus cornuta californica	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+·2	3·4	+
Sambucus racemosa melanocarpa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Sorbus scopulina	·	·	·	·	+·+	·	·	·	·	·	+·2	·	·	·	·	·	·	·	+
Sorbus sitchensis	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1·8	·
Sorbus	·	·	+·+	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Taxus brevifolia	·	·	·	·	·	·	·	·	·	·	·	·	8·12	46·58	6·8	+·+	·	·	·
MEDIUM SHRUBS																			
Lonicera utahensis	+	4·6	+·+	+·10	1·4	+·4	+·2	1·2	3·8	1·8	1·6	+	+	·	·	+·+	·	·	+
Menziesia ferruginea	+	+·+	+	+	+·+	·	·	·	·	·	·	+	·	·	·	·	·	2·6	·
Oplopanax horridum	·	·	·	·	·	+	·	·	+	·	·	·	+·2	·	2·4	·	·	+·+	·
Pachistima myrsinites	1·2	13·36	19·48	3·16	5·20	4·26	+·2	1·6	+·2	4·14	5·18	+·+	+·+	+·+	·	1·2	14·50	·	5·16
Rhododendron albiflorum	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Ribes lacustre	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Rosa gymnocarpa	+·2	+·2	2·4	5·26	1·2	2·4	·	+·2	·	+·2	+	+·6	+	·	·	+·4	·	·	·
Rubus idaeus schalinensis	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	+	·	·
Rubus leucodermis	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·

(Continued)

Table B-10. *Tsuga heterophylla-Pachistima myrsinites* association. continued

Stand number	14	15	16	17	24	25	26	27	28	29	30	33	52	54	55	60	76	77	78
Rubus parviflorus parviflorus	·	+	6·16	+·2	+·2	·	·	·	·	·	·	+·2	·	+	1·2	·	·	+·+	·
Spirea betulifolia lucida	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Symphoricarpos albus	·	·	·	+	·	·	·	·	·	·	·	·	·	·	2·2	·	·	·	·
Vaccinium membranaceum	1·8	1·4	12·24	+	6·16	+	1·8	6·22	31·54	6·20	16·46	+	+	+	·	·	·	4·10	+·6
Vaccinium ovalifolium	·	·	·	·	4·8	·	+	+·+	·	+	2·6	·	·	·	·	·	+·2	13·28	+·4
Viburnum edule	·	·	·	·	·	·	·	·	·	·	+·2	+·+	·	·	·	·	·	·	·
LOW SHRUBS																			
Chimaphila menziesii	·	+·2	+·2	·	+·+	+	·	·	·	+·+	·	·	·	·	·	·	·	·	·
Chimaphila umbellata occidentalis	6·58	·	·	+	1·6	+·2	1·12	1·32	·	3·36	+·+	·	+	+	·	·	1·14	·	+·+
Gaultheria ovatifolia	+	·	·	·	·	·	·	·	·	·	+·6	·	·	·	·	·	·	·	+
Linnaea borealis longiflora	26·99	·	4·27	4·58	24·74	14·66	11·74	23·96	4·38	18·74	27·92	13·56	+·2	+	+·2	7·70	4·22	+·2	2·12
Lycopodium annotinum	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Lycopodium clavatum	·	·	·	·	·	·	·	·	1·6	·	·	·	·	·	·	·	·	·	·
Lycopodium selago	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Pyrola asarifolia	1·14	·	1·8	+·4	+·8	1·10	1·4	·	·	1·12	·	·	+	+	·	·	·	·	+·2
Pyrola picta	·	+·2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Pyrola secunda	+·6	·	+·4	·	+·8	·	+·2	2·2	2·26	1·12	+·4	·	+·2	+·+	·	·	1·16	·	·
Pyrola uniflora	·	·	·	·	·	·	·	·	·	·	·	·	+·2	+·+	·	·	·	+·4	·
Rubus pedatus	·	·	·	·	·	·	+	+·8	+·4	·	·	·	4·14	·	·	·	1·6	3·28	·
Vaccinium scoparium	1·6	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Xerophyllum tenax	·	+·+	2·4	·	·	·	·	+	+·2	+·+	·	·	+	·	·	·	·	·	·
PERENNIAL GRAMINOIDS																			
Bromus vulgaris	·	+·2	1·8	3·16	+·6	·	·	+	+·+	+	+·+	+	·	·	1·4	·	·	·	·
Carex concinnoides	·	·	·	1·4	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·
Carex geyeri	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Carex leptopoda	·	·	+·2	·	·	·	·	·	·	·	·	·	·	·	2·4	·	·	·	·
Carex rossii	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Carex illota	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Cinna latifolia	·	·	·	·	·	·	+·+	+	+·+	·	·	·	·	·	·	·	·	·	·
Deschampsia elongata	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Festuca occidentalis	·	·	·	+·2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Luzula comosa	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Luzula divaricata	·	·	+·2	1·4	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Luzula parviflora	·	·	·	·	·	+·2	·	+·2	·	·	+·2	·	·	·	·	·	·	·	·
Luzula	·	·	·	·	·	·	·	·	·	·	·	+·2	·	·	·	·	·	·	·
Oryzopsis asperifolia	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Trisetum cernuum	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·
PERENNIAL FORBS																			
Actaea rubra	·	+	·	·	·	+·+	·	·	·	·	·	·	·	·	+·2	·	·	·	·
Adenocaulon bicolor	·	·	+·6	2·20	·	·	+·2	+·4	+·2	·	+·2	+·2	+·+	+	6·38	·	·	·	·
Adiantum pedatum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Anemone piperi	·	·	·	+·10	·	·	·	·	·	·	·	1·10	·	·	·	+·2	·	·	·
Aquilegia flavescens	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Aralis nudicaulis	·	·	·	·	1·6	1·2	·	·	·	·	14·52	·	+·+	·	+	·	7·28	6·32	·
Asarum caudatum	·	5·32	2·30	+·12	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Athyrium filix-foemina	·	+·+	·	1·6	·	+·+	·	+	·	·	·	+·+	+·+	+	+	+·4	·	·	·
Circaea alpina	·	·	·	·	·	·	·	·	·	·	·	·	·	·	10·50	·	·	+·2	·

(Continued)

Table B-10. *Tsuga heterophylla-Pachistima myrsinites* association. continued

Stand number	14	15	16	17	24	25	26	27	28	29	30	33	52	54	55	60	76	77	78
Clintolia uniflora	3•34	3•20	7•56	3•32	2•22	11•52	3•28	4•44	5•48	2•19	12•76	2•12	4•32	+	3•16	1•26	11•56	8•56	1•12
Comandra livida	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+
Coptis occidentalis	16•78	28•82	22•80	5•50	•	•	•	•	•	•	•	12•64	•	•	•	9•74	•	•	•
Corallorhiza mertensiana	+•+	+	•	•	+•+	•	+•2	•	•	+•+	+•+	+	•	•	•	•	+•+	•	+•+
Corallorhiza	•	•	+•+	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Cornus canadensis	•	•	•	4•34	7•58	•	3•30	+•4	•	•	3•22	6•62	•	•	•	1•14	4•32	8•60	+
Cystopteris fragilis	•	+•2	•	•	•	•	•	•,	+•2	•	•	•	•	•	+•2	•	•	•	•
Disporum oreganum	+•+	7•34	+•2	2•8	1•6	+•+	+	+•+	+•2	+•+	+•4	3•14	•	•	+•4	+•2	•	+•+	•
Dryopteris dilitata	•	+•2	•	•	•	•	+	•	+•+	•	•	•	1•2	•	1•4	•	•	27•56	•
Dryopteris filix-mas	•	•	2•8	•	•	•	•	•	•	•	•	•	•	•	4•8	•	•	•	•
Epilobium angustifolium	•	•	•	•	+•+	•	•.	•	•	•	•	•	•	+	•	•	•	•	•
Equisetum sylvaticum	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Fragaria	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Galium triflorum	•	+•4	•	+•8	•	+•6	•	+	+	•	+•2	+•4	+	+	+•6	•	•	+•2	•
Goodyera oblongifolia	•	+•2	+•+	+•2	+•+	+•2	+•2	+•+	+•2	+•4	1•16	•	•	•	•	+•4	•	+•+	+•2
Goodyera repens	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	2•24	•	•
Habenaria orbiculata	•	•	•	•	+	•	+	•	•	•	•	•	•	•	•	•	+	•	+•2
Habenaria saccata	•	•	•	+	+	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Hieracem albiflorum	+•4	•	+•6	•	•	•	+•+	+•2	+•2	+•4	1•6	•	+	•	+•+	•	•	•	•
Hypopitys monotropa	+	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Lathyrus nevadensis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+•4	•	•	•
Lilium columbianum	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•	•
Listera caurina	•	•	•	•	•	+	•	•	•	•	+•2	•	•	•	•	•	•	•	•
Listera cordata	•	•	•	•	•	•	•	•	•	•	+•+	•	•	•	•	+•2	•	+•2	•
Listera	•	•	+•2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Maianthemum dilitatum	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	5•84	•	•
Mitella breweri	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•
Mitella stauropetala	•	•	•	•	•	•	•	•	+•+	•	•	+•2	•	•	•	•	•	•	•
Monotropa uniflora	•	+	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	+
Osmorhiza chilense	•	•	1•6	•	+•2	•	•	+	1•6	•	•	1•12	•	•	+•8	+•2	•	•	•
Pedicularis racemosa	•	•	•	+•2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Phegopteris dryopteris	+•2	1•12	11•34	4•32	1•4	4•16	+•+	+	11•52	•	15•66	10•32	+•4	+	3•14	9•60	+•6	28•78	•
Polystichum andersoni	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Polystichum lonchitis	•	+	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Polystichum munitum	•	1•2	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•
Pteridium aquilinum languinosum	•	2•6	+•+	2•6	•	•	•	•	•	•	•	•	•	•	•	•	•	1•2	12•1
Pterospora andromedea	+	•	•	•	•	•	+	+	•	+	•	•	•	•	•	•	•	•	•
Ranunculus uncinatus	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Sanicula marilandica	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Smilacina racemosa	•	+•2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	2•8	+•2	+
Smilacina stellata	+•4	2•18	1•6	3•30	+•2	1•10	•	1•4	2•10	+•+	1•14	+•2	+	+	1•4	2•20	•	•	•

(Continued)

Table B-10. *Tsuga heterophylla-Pachistima myrsinites* association. continued

Stand number	14	15	16	17	24	25	26	27	28	29	30	33	52	54	55	60	76	77	78
Spiranthes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+·8	.	.
Streptopus amplexifolius	.	.	+	.	.	.	.	.	+·+	.	.	1·2	.	.	.	.	.	.	.
Streptopus roseus curvipes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6·36	.
Thallictrum occidentale	.	2·2	.	.	.	.	.	.	.	.	.	.	.	.	+·+	.	.	.	.
Tiarella trifoliata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2·8	.
Tiarella unifoliata	1·12	3·40	3·56	3·54	+·+	+·6	1·6	4·84	16·72	2·42	7·78	4·34	19·62	+	3·38	9·74	1·14	27·90	.
Trautvetteria caroliniensis	.	.	.	1·12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium	.	.	.	+·2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trillium ovatum	+	.	+·+	+·4	+·2	+·4	.	+·+	+·+	+·+	+·4	+·2	.	.	+·+	+·2	.	.	.
Urtica dioica gracilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+·+	.	.	.	.
Valeriana sitchensis	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veratrum viride	.	.	.	+·2	.	.	+·6	.	.	.	.	.	.	.	.	.	.	.	.
Viola glabella	.	1·14	+·4	+·18	.	.	.	1·20	.	.	.	.	+·2	.	3·34	+·2	.	.	.
Viola orbiculata	+·6	1·16	1·28	2·30	1·12	3·44	.	.	4·38	.	2·34	.	+·+	.	+·+	+·10	.	.	+·+
Viola	.	.	.	.	.	.	.	.	.	+·16	.	1·8	.	.	.	.	.	.	.
ANNUALS																			
Montia perfoliata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+·2	.	.	.	.
INDIGENOUS SPECIES IN MACROPLOT	17	28	33	--	28	20	18	20	25	19	30	22	16	5	29	21	19	26	13

Table B-11. *Thuja plicata-Oplopanax horridum* association. The stands are arranged from left to right in order of increasing proportions of *Tsuga heterophylla*.

Stand number	53	80	81	83	104	79	82	84	51	56
State and county	MFlat	B.C.	B.C.	IBonn	MLinc	B.C.	WPend	IClea	MFlat	MFlat
Township and section	34N31	----	----	37N24	28N10	----	38N23	41N26	34N31	34N32
Range	17W	----	----	5W	34W	----	45E	4E	17W	17W
Altitude in meters	1022	553	648	1210	849	693	1113	497	1000	1220
Aspect and percent slope	NW2	0	E14	ESE31	0	SW8	0	0	0	NE19
Mean pH upper dm of soil	5.7	----	4.8	5.6	5.9	5.4	4.9	---	5.2	4.9
TALL SHRUBS										
Acer glabrum	+	+	+·+	+	+·+	+·+	+	+·+	7·16	+·+
Alnus sinuata	.	.	.	.	.	.	11·12	.	.	.
Amelanchier alnifolia	+	.	.	.	.	+	.	+	.	.
Cornus stolonifera	.	1·2	.	.	+	1·2	.	.	+	.
Corylus cornuta californica	.	+	15·22	.	.	+·+	.	+·+	.	.
Sambucus	+·2	.	.	.	.	.	.		2·2	+
Sorbus scopulina	.	.	.	.	.	+	.	+	+	+·2
Taxus brevifolia	.	.	6·8	+	.	.	14·14	.	.	12·18
MEDIUM SHRUBS										
Lonicera utahensis	.	.	+·+	+	.	+·+	+	+·4	.	.
Menziesia ferruginea	.	+·+	.	.	.	+·+	1·2	.	.	2·2
Oplopanax horridum	13·22	77·96	48·88	42·52	16·36	74·92	36·58	83·93	34·48	32·44
Pachistima myrsinites	.	.	.	.	.	3·12	.	.	.	.
Ribes lacustre	+·+	9·34	+	2·4	.	1·6	+	.	+·2	+·2
Rosa gymnocarpa	.	.	+·+	.	.	.	.	+	.	.
Rubus idaeus sachalinensis	+·+	+·4	.	.	.	.	.	.	5·18	+·2
Rubus leucodermis	.	.	.	.	+·+	.	.	.	.	.
Rubus parviflorus parviflours	1·6	+·2	.	2·6	.	18·36	+·2	4·15	24·40	+·2

(Continued)

Table B-11. *Thuja plicata-Oplopanax horridum* association. The stands are arranged from left to right in order of increasing proportions of *Tsuga heterophylla*.

Stand number	53	80	81	83	104	79	82	84	51	56
Rubus pubescens	·	·	·	·	·	·	·	+	·	·
Symphoricarpos albus	+	·	·	·	·	·	·	·	2·6	·
Vaccinium membranaceum	·	·	·	·	·	·	3·6	·	·	+·+
Vaccinium ovalifolium	·	·	+·2	·	·	1·4	·	·	·	·
Viburnum edule	·	·	·	·	·	+·2	·	5·7	·	·
LOW SHRUBS										
Linnaea borealis longiflora	·	·	·	·	·	+·6	+	·	+·+	·
Lycopodium annotinum	·	·	·	·	·	·	·	·	·	1·6
Lycopodium selago	·	·	+	·	·	·	·	·	·	·
Rubus nivalis	·	·	·	·	·	·	·	+·4	·	·
Rubus pedatus	·	1·2	+	·	·	+·2	3·36	·	·	·
Symphoricarpos mollis	·	·	·	·	·	·	·	2·7	·	·
PERENNIAL GRAMINOIDS										
Bromus vulgaris	+·2	·	·	1·8	+·4	·	1·4	1·4	1·18	+·2
Carex amplifolia	·	·	·	·	·	·	·	3·7	·	·
Carex bolanderi	·	·	·	·	+	·	·	·	·	·
Carex laeviculmis	2·8	·	·	·	·	·	·	2·7		·
Carex leptopoda	·	·	·	·	·	·	·	·		·
Cinna latifolia	2·6	·	·	·	·	·	·	·	4·16	·
Deschampsia elongata	·	·	·	·	·	·	·	·	+·6	·
Festuca subulata	+·2	1·2	·	·	·	·	·	3·15	·	1·6
Glyceria pauciflora	·	·	·	·	·	·	·	1·4	·	·
Luzula divaricata	·	·	·	·	·	·	·	1·22	·	·
Trisetum cernuum	·	·	·	·	+·+	·	·	·	3·22	1·10
PERENNIAL FORBS										
Aconitum columbianum	·	·	·	+	+	·	·	·	·	·
Actaea rubra	+	·	+·+	+·+	+·+	+·+		+·+	1·2	+·4
Adenocaulon bicolor	8·30	·	+·+	+·8	1·14	·	2·10	+·4	6·24	·
Adiantum pedatum	·	·	·	·	·	·	·	24·44	·	·
Aneone piperi	·	·	·	·	·	·	·	+·+	·	·
Aralia nudicaulis	2·6	+	+·4	·	+·2	7·30	·	·	6·22	·
Asarum caudatum	·	·	+·+	13·58	16·72	·	+·2	+·11	·	·
Athyrium filix-foemina	49·62	28·44	19·28	34·40	22·30	1·2	53·58	24·44	6·10	9·12
Botrychium virginianum	·	+·+	+·2	·	·	·	·	1·4	+	·
Circaea alpina	12·56	8·64	1·10	+·+	2·26	+·4	·	2·7	4·42	+
Clintonia uniflora	2·22	+	+·2	2·32	13·60	3·20	7·50	+	9·50	8·46
Coptis occidentalis	·	·	·	·	23·78	·	·	12·48	·	·
Cornus canadensis	·	1·6	+·+	·	·	4·28	·	3·18	·	·
Cystopteris fragilis	·	·	·	·	·	·	·	·	1·4	·
Disporum oreganum	+·+	·	+·+	12·46	23·50	22·46	6·20	3·18	1·4	·
Disporum trachycarpum	·	·		·	·	·	·	·	1·2	·
Dryopteris dilitata	8·20	10·30	7·22	+·4	3·6	·	5·8	1·4	13·30	10·20
Dryopteris filix-mas	+	+	·	·	·	·	·	·	·	·
Epilobium watsonii	·	·	·	·	·	·	·	+·+	·	·
Equisetum arvense	·	·	·	·	·	1·2	·	·	1·2	·
Equisetum sylvaticum	·	+·+	·	·	·	·	·	·	·	·
Equisetum	+	·	·	·	·	·	·	·	·	·
Fragaria	·	·	·	·	·	·	·	·	+·2	·
Galium triflorum	+·10	2·10	1·8	1·16	4·36	2·14	8·40	3·44	1·16	1·10
Geum macrophyllum	·	·	·	·	·	·	·	+	·	·
Goodyera oblongifolia	+·6	+·+	+	·	·	+·6	+·2	·	·	·
Heracleum lanatum	·	·	·	·	·	·	·	·	2·2	·
Hieraceum albiflorum	·	·	·	+	·	·	·	+·4	+·2	·
Lathyrus nevadensis	·	·	·	·	·	·	·	+	·	·

(Continued)

Table B-11. *Thuja plicata-Oplopanax horridum* association. The stands are arranged from left to right in order of increasing proportions of *Tsuga heterophylla*. continued

Stand number	53	80	81	83	104	79	82	84	51	56
Listera convallarioides	·	·	·	·	·	·	·	+·+	·	·
Mertensia paniculata	·	·	·	+	·	·	1·2	·	·	·
Mimulus guttatus	·	·	·	·	·	·	·	+	·	·
Mitella breweri	·	1·26	·	·	·	·	·	·	·	·
Mitella stauropetala	·	·	·	·	·	·	1·10	1·11	·	·
Montia	·	·	·	+·2	·	·	7·30	·	·	·
Osmorhiza chilense	+·8	·	·	+·2	+·2	+·2	·	·	1·8	+·2
Phegopteris dryopteris	10·52	35·74	43·84	38·78	30·72	18·78	44·88	26·81	20·72	52·92
Polystichum munitum	·	·	·	·	·	·	·	6·11	·	·
Pteridium aquilinum languinosum	·	·	·	·	1·4	·	·	·	·	·
Ranunculus uncinatus	+·+	·	·	·	·	·	·	+	+·6	·
Senecio triangularis	·	·	·	·	·	·	·	13·30	·	·
Silene menziesii	·	·	·	·	·	·	·	+	·	·
Smilacina racemosa	·	1·6	3·14	·	·	6·34	·	·	·	·
Smilacina stellata	1·8	·	·	4·30	16·64	·	10·40	1·7	10·52	·
Stellaria crispa	·	+·4	·	·	·	·	·	+·4	·	·
Streptopus amplexifolius	·	2·4	2·10	1·4	2·8	·	4·22	3·18	+·+	3·8
Streptopus roseus curvipes	·	·	+·8	·	·	+·2	·	·	·	·
†*Taraxacum*	·	·	·	·	·	·	·	·	+·2	·
Thallictrum occidentale	+·+	·	·	+	·	·	+·+	·	3·14	+·+
Tiarella trifoliata	·	·	+·+	·	·	·	+·4	7·56	·	·
Tiarella unifoliata + T. trifoliata	·	·	·	·	·	14·76	·	·	·	·
Tiarella unifoliata	10·78	17·76	14·84	4·32	14·80	·	16·92	·	19·78	34·96
Trautvetteria caroliniensis	·	·	·	·	·	·	·	1·4	·	·
Trillium ovatum	·	·	·	1·12	4·32	·	5·40	·	1·10	·
Urtica dioica gracilis	+·+	·	·	·	1·4	·	·	·	+	·
Veratrum viride	+·+	·	·	+	+	·	·	5·7	·	+·4
Viola glabella	·	·	1·6	1·12	6·60	·	10·62	2·26	2·44	2·24
Viola orbiculata	1·14	+·14	+	+·2	·	·	+·2	·	·	1·20
INDIGENOUS SPECIES IN MACROPLOT	27	23	26	22	25	28	28	41	36	26

Table B-12. *Thuja plicata-Athyrium filix-foemina* association.

Stand number	75	118	119	120
State and county	IClea	ILata	IIdah	IClea
Township and section	41N-?	43N34	32N-?	39N17
Range	3E	3W	7E	7E
Altitude in meters	1172	912	1418	1159
Aspect and percent slope	NNE5	0	ESE15	0
Mean pH upper dm of soil	5.3	---	4.9	4.2
TALL SHRUBS				
Acer glabrum	20·24	·	19·22	·
Alnus sinuata	+	20·24	45·56	46·58
Cornus stolonifera	·	14·18	·	·
Sambucus racemosa melanocarpa	·	·	6·10	+·+
Sorbus scopulina	·	·	+	+
MEDIUM SHRUBS				
Lonicera involucrata involucrata	·	+	·	·
Lonicera utahensis	1·4	+	·	+·2
Menziesia ferruginea	1·6	·	·	·
Pachistima myrsinites	+·+	·	·	·
Ribes lacustre	·	·	+	+·2
Rubus parviflorus parviflorus	+·+	·	·	2·4

(Continued)

Table B-12. *Thuja plicata-Athyrium filix-foemina* association. continued

Stand number	75	118	119	120
Symphoricarpos albus	·	1·4	·	·
Vaccinium membranaceum	·	1·2	·	·
Viburnum edule	·	1·4	·	·
LOW SHRUBS				
Linnaea borealis longiflora	+·2	·	·	·
PERENNIAL GRAMINOIDS				
Bromus vulgaris	+·+	·	1·6	+
Carex arctica	·	2·14	·	·
Carex laeviculmis	·	6·12	·	2·2
Glyceria elata	·	5·22	·	·
Luzula parviflora	·	·	·	+
Luzula wahlenbergii	·	+	·	·
Trisetum canescens	·	·	·	+·2
PERENNIAL FORBS				
Aconitum columbianum columbianum	·	2·14	·	·
Actaea rubra	+·+	·	21·38	·
Adenocaulon bicolor	3·8	·	2·2	+
Anemone piperi	2·32	·	+·8	·
Asarum caudatum	3·26	·	4·24	2·14
Athyrium filix-foemina	66·78	86·99	87·98	86·96
Boykinia	·	·	·	2·6
Circaea alpina	1·8	·	3·38	+·6
Clintonia uniflora	3·46	·	·	5·30
Coptis occidentalis	10·46	1·4	·	+
Cornus canadensis	·	+·2	·	+
Disporum oreganum	7·32	·	+·2	+
Dryopteris dilitata	·	·	4·8	6·8
Dryopteris filix-mas	·	·	+·2	·
Epilobium watsonii occidentale	·	+·2	·	·
Epilobium watsonii parishii	·		·	+
Equisetum	·	+·4	·	·
Fragaria	·	+	·	·
Galium triflorum	2·20	1·8	2·30	4·30
Goodyera oblongifolia	+·2	·	·	·
Habenaria	·	2·20	·	·
Hydrophyllum fendleri	·	1·10	·	·
Ligusticum canbyi	·	5·22	·	·
Ligusticum verticillatum	·	+	·	·
Listera	+·2	+·8	·	·
Mertensia paniculata	+·4	·	1·6	4·12
Mimumus guttatus	·	+·2	·	·
Mitella pentandra	·	·	30·94	28·90
Mitella stauropetala	+·2	·	·	·
Osmorhiza chilense	+·2	·	+·8	+·2
Phegopteris dryopteris	·	1·4	·	·
†*Prunella vulgaris*	·	+·2	·	·
Pteridium aquilinum languinosum	·	1·2	·	+·+
Ranunculus uncinatus	·	1·4	·	·
Senecio triangularis	2·12	1·14	+·6	3·16
Smilacina stellata	2·14	·	2·18	14·60
Stellaria crispa	·	+·2	+·2	+·2
Streptopus amplexifolius	1·6	3·24	·	3·14

(Continued)

Table B-12. *Thuja plicata-Athyrium filix-foemina* association. continued

Stand number	75	118	119	120
†*Taraxacum*	·	+·2	·	·
Tiarella unifoliata	4·60	4·24	+·6	2·14
Trautvetteria caroliniensis	+·2	8·36	16·50	·
Trillium ovatum	2·16	+	+	+·4
Veratrum viride	+·+	·	+	·
Veronica americana		2·26	·	·
Viola glabella	5·44	9·48	6·52	1·24
Viola orbiculata	+·+	·	·	·
ANNUALS				
Montia sibirica	+·6	·	18·66	7·64
INDIGENOUS SPECIES IN MACROPLOT	32	30	24	26

Table B-13. *Abies lasiocarpa-Pachistima myrsinites* association.

Stand number	48	59	64	85	95	96	121	122	123	124	125	155	160	171
State and county	IIdah	Albta	IShos	IClea	WAsot	IShos	MMine	IIdah	IBonn	IBoun	WPend	IBene	IClea	WStev
Township and section	37N9	-----	42N20	40N9	8N35	48N14	43N12	31N14	58N29	60N18	35N21	46N11	36N	32N12
Range	14E	---	5E	3E	43E	5E	28W	6E	3W	3W	45E	1W	7E	41E
Altitude in meters	1620	1682	1624	1442	1655	1444	1659	1771	1509	1550	1516	1570	1608	1552
Aspect and percent slope	NW44	W20	SSW20	0	NNE16	NW11	WNW35	NW17	NW37	WSW37	WSW28	SW26	N29	0
Mean pH upper dm of soil	5.1	4.5	5.3	5.3	5.8	4.6	5.7	5.1	5.1	5.1	5.3	5.1	4.9	5.7
TALL SHRUBS														
Acer glabrum	·	·	·	4·6	+·+	·	·	·	·	·	·	+	·	·
Alnus sinuata	+	·	·	·	·	·	·	·	+	+	12·14	·	·	·
Amelanchier alnifolia	+	·	+	·	·	·	·	·	·	2·6	·	·	·	+·+
Holodiscus discolor	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Salix (scouleriana?)	·	·	·	·	·	·	·	·	·	·	·	+·+	·	·
Sambucus racemosa melanocarpa	·	·	·	·	·	·	+·+	·	·	·	·	·	+	·
Sorbus scopulina	6·18	·	5·10	+·+	+·+	·	+·+	4·4	3·8	+·+	+·+	+·2	+·+	+·+
Sorbus sitchensis sitchensis	·	+	·	·	·	·	+·+	·	1·2	·	·	·	+	·
MEDIUM SHRUBS														
Clematis columbiana columbiana	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Lonicera utahensis	2·6	+·2	14·40	7·18	+·+	5·12	+·+	·	17·34	2·8	3·12	+·+	+·2	2·4
Menziesia ferruginea	28·42	52·88	·	28·38	+·+	26·44	+·+	63·74	24·36	+	·	·	52·76	·
Pachistima myrsinites	·	·	·	+·+	+	3·10	·	·	25·62	5·18	8·30	+	·	2·10
Physocarpus malvaceus	·	·	·	·	1·2	·	·	·	·	·	·	·	·	·
Ribes lacustre	+	+	+·2	+·+	+·+	·	+·4	+	+	·	+·+	·	+	·
Ribes viscosissimum	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Rosa gymnocarpa	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Rubus parviflorus parviflorus	·	·	7·26	+·2	·	·	+·8	·	·	+	+·2	+	+	1·2
Spiraea betulifolia lucida	·	·	4·22	·	·	·	·	·	·	2·12	·	·	·	·
Vaccinium membranaceum	56·88	7·26	21·64	13·32	7·44	9·28	1·4	31·66	45·70	40·78	8·48	4·62	22·66	2·14
LOW SHRUBS														
Chimaphila menziesii	+·4	·	+·4	+·4	+·+	·	·	+	·	·	+·2	+·2	·	+·+
Chimaphila umbellata occidentalis	+·+	·	2·8	·	+	·	·	·	+·2	+·2	1·14	·	·	+·2
Linnaea borealis longiflora	·	·	·	·	·	·	·	·	·	·	2·22	·	·	·

(Continued)

Table B-13. *Abies lasiocarpa-Pachistima myrsinites* association. continued

Stand number	48	59	64	85	95	96	121	122	123	124	125	155	160	171
Lycopodium annotinum	·	+·8	·	·	·	·	·	·	·	·	·	·	·	·
Pyrola asarifolia	+·4	·	·	·	·	·	·	·	2·14	·	·	·	·	·
Pyrola minor	·	·	·	·	·	·	·	·	·	·	+	·	·	·
Pyrola picta	·	·	·	·	·	·	·	·	·	·	+	·	·	·
Pyrola secunda	1·24	+·+	3·26	1·18	+·6	2·16	+·8	3·18	5·46	1·22	2·16	·	·	2·34
Pyrola uniflora	·	+·6	·	·	·	·	+·2	·	·	·	+	·	·	·
Vaccinium scoparium	56·88	+·4	·	·	·	+·+	+·2	·	·	·	·	·	·	2·10
Xerophyllum tenax	66·84	+	50·72	+	·	6·8	1·4	18·34	23·40	14·69	46·58	18·44	40·72	·
PERENNIAL GRAMINOIDS														
Bromus vulgaris	1·14	·	+·2	2·24	+	·	+·+	·	1·10	6·32	+·+	2·28	·	1·8
Calamagrostis rubescens	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Carex concinnoides	·	·	·	·	·	·	·	·	·	·	+·2	·	·	+·+
Carex geyeri	·	·	3·6	·	·	·	·	·	2·2	1·2	·	2·4	·	·
Carex rossii	·	·	+·4	+·2	·	·	·	·	·	·	·	3·8	·	+·2
Deschampsia elongata	·	·	·	·	·	·	·	·	·	·	1·2	·	·	+
Luzula parviflora	·	·	·	·	·	·	+	·	·	·	·	·	·	·
Trisetum cernuum	·	·	·	·	·	·	·	·	·	+	·	·	·	·
PERENNIAL FORBS														
Actaea rubra	·	·	·	·	·	·	1·6	·	·	+	·	·	·	·
Adenocaulon bicolor	·	·	·	+·2	·	·	·	·	·	+·6	·	+·+	·	·
Anemone piperi	4·76	·	3·42	15·92	3·42	·	5·50	1·28	+	·	·	5·60	·	·
Antennaria racemosa	·	·	·	·	·	·	·	·	·	·	·	·	·	+·2
Aquilegia flavescens	·	·	·	·	·	·	+·2	·	·	·	·	·	·	·
Aquilega formosa	·	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Arenaria macrophylla	·	·	+·2	6·48	+	·	1·16	+·4	·	·	·	3·50	·	·
Arnica cordifolia	15·52	·	·	16·64	·	·	·	·	·	·	+·2	·	·	+
Arnica latifolia	·	22·54	·	·	·	10·58	22·44	6·26	2·14	·	·	·	·	·
Arnica	·	·	·	·	6·42	·	·	·	·	·	·	·	·	·
Asarum caudatum	·	·	·	1·6	·	·	·	·	·	·	·	·	·	·
Aster conspicuus	·	·	·	·	·	·	·	·	·	+·+	·	+	·	·
Athyrium filix-foemina	·	1·4	·	·	·	·	+	·	·	·	·	·	·	·
Botrychium lunaria	·	·	·	·	·	·	·	·	+·2	·	·	·	·	·
Boykenia major	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Clintonia uniflora	4·36	8·62	7·68	17·86	·	8·52	7·32	+·+	1·8	15·68	7·60	·	1·4	·
Coptis occidentalis	·	·	·	2·14	·	·	·	19·86	·	·	·	·	·	·
Corallorhiza maculata	+·+				+							+·+		
Corallorhiza mertensiana	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Corallorhiza striata	·	·	·	+·6	·	·	·	·	·	·	·	·	·	·
Cystopteris fragilis	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Disporum oreganum	·	·	·	3·10	·	·	·	·	·	·	·	·	·	·
Epilobium angustifolium	·	·	·	·	·	·	·	·	·	+	·	·	+	·
Erigeron peregrinus callianthemus	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Fragaria	·	·	·	·	+·6	·	·	·	·	·	·	·	·	+·+
Frasera fastigiata	·	·	·	·	·	·	·	·	·	·	·	2·2	·	·
Galium triflorum	+·4	+·+	·	1·14	·	+	+·6	·	+·+	+·+	·	3·44	·	+·2
Goodyera oblongifolia	1·8	+	1·4	·	+·2	+·4	+·4	+·6	·	·	+·2	·	+·8	·
Habenaria unalascensis	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Habenaria	·	·	·	·	·	·	+·6	·	·	·	·	·	·	·
Hieracium albiflorum	1·14	·	·	+·16	·	·	+·4	·	·	2·14	+·2	1·14	·	+·+
Hypopitys monotropa	·	·	·	·	·	·	·	·	·	·	·	·	+·2	·
Lilium columbianum	·	·	·	·	·	·	·	·	·	+·2	·	·	·	·
Listera caurina	·	·	·	·	·	+·4	·	·	·	·	·	·	·	·
Listera cordata	·	+·10	·	·	·	·	·	·	·	·	·	·	·	·
Mitella breweri	·	1·14	·	·	·	·	·	·	·	·	·	·	·	·

(Continued)

Table B-13. *Abies lasiocarpa-Pachistima myrsinites* association. continued

Stand number	48	59	64	85	95	96	121	122	123	124	125	155	160	171
Mitella stauropetala	.	.	.	2·12	.	.	1·16	.	.	.	.	+·2	.	.
Osmorhiza chilense	+·2	+·+	.	2·10	.	.	+·18	.	.	.	.	2·42	.	1·6
Osmorhiza occidentalis	.	.	.	.	+	.	1·4	.	.	.	.	.	.	.
Osmorhiza	.	.	.	.	+·2	.	.	+	+·+	+·+	.	.	.	.
Pedicularis bracteata	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Pedicularis racemosa	2·12	.	.	1·4	.	.	+·4	.	.	+·+	.	.	+·2	+·+
Phacelia heterophylla	+	.	.	.	.	.	.	.	.	.	.	.	+·2	+·+
Phegopteris dryopteris	.	32·80	.	.	.	7·24	.	.	.	.	.	.	.	.
Polemonium pulcherrimum calycinum	.	.	.	.	+	.	.	.	.	.	.	.	+	.
Pteridium aquilinum languinosum	.	.	5·10	+	.	.	.	.	.	.	.	.	+·2	.
Senecio triangularis	.	.	.	.	.	+·+	1·4	.	.	.	.	.	.	.
Smilacina racemosa	.	.	.	.	.	.	.	.	.	.	+	.	.	+·2
Smilacina stellata	+·10	.	4·28	8·62	.	.	1·12	.	.	+	.	1·12	+·2	.
Streptopus amplexifolius	.	2·10	.	.	.	+·+	.	.	.	.	.	.	.	.
Synthyris platycarpa	.	.	.	.	.	.	.	4·26	.	.	.	.	.	.
Thalictrum occidentale	1·6	.	2·10	5·28	4·30	+·2	1·4	1·8	2·6	1·10	+	3·42	.	2·10
Thermopsis montana ovata	.	.	3·12	.	.	.	.	.	.	.	.	.	.	.
Tiarella unifoliata	.	20·88	.	.	.	4·32	.	.	+·+	+	.	.	.	.
Trautvetteria caroliniensis	.	.	.	9·24	.	.	.	.	.	.	.	.	.	.
Trillium ovatum	+·10	.	+	1·8	.	+·6	3·32	2·20	.	1·4	.	+·2	+	.
Valeriana sitchensis	+	.	.	+·+	.	.	2·18	+·+	.	.	+·+	1·12	.	3·14
Veratrum viride	.	+·+	.	.	.	.	+·2	+	.	.	.	.	2·16	.
Viola glabella	+·8	.	.	1·14	.	.	+·6	.	.	.	.	+·+	.	.
Viola orbiculata	1·34	+·2	1·10	1·38	4·44	3·46	1·16	1·12	2·22	1·14	3·30	4·62	+·2	6·57
ANNUALS														
Collinsia parviflora	.	.	.	.	.	.	.	.	.	.	.	+·2	.	.
INDIGENOUS SPECIES IN MACROPLOT	25	19	22	34	16	18	35	16	20	22	21	25	14	24

Table B-14. *Abies lasiocarpa-Xerophyllum tenax and Tsuga mertensiana-Xerophyllum tenax* associations. The stands are arranged from left to right in order of decreasing proportions of *Abies lasiocarpa* and increasing proportions of *Tsuga mertensiana*.

	Abies-Xerophyllum								*Tsuga-Xerophyllum*					
Stand number	130	40	57	45	126	156	129	127	47	97	128	157	98	61
State and county	IBoun	WPend	Albta	IIdah	IShos	IIdah	IBonn	IShos	IIdah	IShos	IShos	IBene	IShos	IShos
Township and section	60N18	35N18	-----	36N17	43N30	27N10	58N29	45N6	36N34	53N32	45N3	47N31	51N5	43N28
Range	3W	45E	---	7E	10E	10E	3W	9E	7E	4E	8E	1E	5E	4E
Altitude in meters	1674	----	1967	1632	1755	2040	1671	1829	1662	1883	1921	1738	1563	1860
Aspect and percent slope	W25	W	SSW23	SW18	WSW48	0	S38	S22	W41	SE27	SSE36	SSE24	SE34	SSE44
Mean pH upper dm of soil	4.1	---	4.0*	4.6	4.7	4.8	4.6	4.4	5.0	4.6	4.2	4.4	4.7	4.2
TALL SHRUBS														
Sorbus scopulina	.	+	.	.	+·+	.	.	.	1·8	.	.	.	+·+	.
Sorbus sitchensis sitchensis	.	.	+	.	.	.	.	.	.	.	.	1·2	.	.
Sorbus	.	.	.	1·4	.	.	.	.	.	.	.	.	.	.
MEDIUM SHRUBS														
Lonicera utahensis	+·+	+·+	.	.	2·2	1·4	+·+	5·8	.	.	.	.	+·+	.
Menziesia ferruginea	.	.	+·+	.	.	.	.	.	+	.	.	.	.	.
Pachistima myrsinites	.	+	.	.	.	.	1·2	.	.	.	.	.	.	.
Phyllodoce empetriformis	.	.	+·+	.	.	.	.	.	.	.	+	.	.	.
Ribes viscosissimum	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Spiraea betulifolia lucida	.	.	.	+·4	.	.	.	.	.	.	.	.	.	.

(Continued)

Table B-14. *Abies lasiocarpa-Xerophyllum tenax and Tsuga mertensiana-Xerophyllum tenax* associations. The stands are arranged from left to right in order of decreasing proportions of *Abies lasiocarpa* and increasing proportions of *Tsuga mertensiana*. continued

	Abies-Xerophyllum								*Tsuga-Xerophyllum*					
Stand number	130	40	57	45	126	156	129	127	47	97	128	157	98	61
Spiraea densiflora	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Vaccinium membranaceum	46·76	18·46	42·82	47·90	61·99	20·52	1·4	42·72	29·74	·	+	12·42	56·68	14·30
Vaccinium myrtillus	·	·	13·48	·	·	·	·	·	·	·	·	·	·	·
LOW SHRUBS														
Chimaphila menziesii	+	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Chimaphila umbellata occidentalis	·	+·4	·	·	·	4·32	·	·	2·14	·	·	+	+	·
Luzula	·	1·6	·	·	·	+	·	·	·	·	·	·	1·2	·
Pyrola asarifolia	·	·	·	·	·	·	·	·	+·+	·	·	·	+·6	·
Pyrola picta	·	·	·	·	·	·	+·+	·	·	·	·	·	·	·
Pyrola secunda	·	+·+	+·2	·	+·+	·	·	4·14	+·+	·	·	·	+·4	·
Vaccinium scoparium	·	13·46	4·34	·	1·4	16·76	+·4	5·22	1·2	23·82	3·26	+·2	4·12	14·44
Xerophyllum tenax	86·98	87·99	88·99	47·56	58·76	55·80	61·84	73·86	67·86	58·76	54·76	24·96	81·74	84·94
PERENNIAL GRAMINOIDS														
Bromus vulgaris	·	·	·	·	·	·	3·20	·	·	·	·	·	·	·
Calamagrostis rubescens	·	·	·	9·26	·	·	4·16	·	·	·	·	·	·	·
Carex geyeri	1·4	·	+·2	27·34	+·2	1·2	29·46	6·12	2·14	2·6	1·4	·	+·2	·
Carex rossii	+·+	·	+	·	+·+	·	·	·	·	·	·	·	·	·
Deschampsia atropurpurea	·	·	+·6	·	·	·	·	·	·	·	·	·	·	·
Luzula divaricata	·	·	·	·	·	·	·	7·16	·	·	16·40	·	·	·
Luzula glabrata	+	·	5·34	·	·	·	·	·	·	7·32	·	+·+	·	15·40
PERENNIAL FORBS														
Achillea millefolium lanulosa	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Anemone piperi	·	·	·	+·2	·	·	·	1·18	·	·	·	·	·	·
Aquilegia flavescens	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Arnica latifolia	·	·	6·60	·	+	·	·	·	·	+·+	+·2	·	·	4·16
Arnica mollis	·	·	·	·	·	·	·	9·20	·	·	·	·	·	·
Aster conspicuus	·	·	·	·	·	·	+·2	·	·	·	·	·	·	·
Athyrium filix-foemina	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Campanula rotundifolia	·	·	·	·	·	·	+·+	·	·	·	·	·	·	·
Corallorhiza mertensiana	·	·	·	·	·	·	·	·	·	·	·	·	+·+	·
Epilobium angustifolium	·	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Epilobium alpinum lactiflorum	·	·	·	·	·	·	·	·	·	·	·	·	·	+·2
Erigeron peregrinus callianthemus	·	·	·	·	·	·	·	+·+	·	·	·	·	·	·
Erythronium grandiflorum	·	·	1·22	·	·	+	·	·	·	·	·	·	·	·
Goodyera oblongifolia	+	·	·	·	·	+	+·+	+·4	·	·	·	·	+·+	·
Hieraceum albiflorum	·	1·6	·	·	·	·	·	·	·	·	·	·	+·2	+·2
Hieraceum gracile	·	·	+·6	·	+·+	·	·	·	·	·	·	·	·	+·6
Hypopitys monotropa	·	·	·	+	·	+	·	·	·	·	·	·	·	·
Listera caurina	·	+·2	·	·	·	+	·	·	·	·	·	·	·	·
Lomatium sandbergii	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Lupinus laxiflorus laxiflorus	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Mitella	·	·	·	·	·	·	·	·	·	·	·	·	+	·
Pedicularis bracteata	·	+·2	+·+	·	·	·	·	·	·	·	·	·	·	·
Pedicularis contorta	·	·	·	·	·	·	·	·	+·+	·	·	·	·	·
Pedicularis racemosa	·	+·+	·	·	·	·	·	1·4	·	·	·	·	·	·
Polemonium pulcherrimum calycinum	·	·	·	·	·	·	·	·	·	·	·	+	·	2·2

(Continued)

Table B-14. *Abies lasiocarpa-Xerophyllum tenax and Tsuga mertensiana-Xerophyllum tenax* associations. The stands are arranged from left to right in order to decreasing proportions of *Abies lasiocarpa* and increasing proportions of *Tsuga mertensiana*. continued

	Abies-Xerophyllum													
	Tsuga-Xerophyllum													
Stand number	130	40	57	45	126	156	129	127	47	97	128	157	98	61
Senecion triangularis	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Smilacina stellata	·	·	·	·	·	·	·	·	·	·	·	·	+·2	·
Synthyris missurica	·	+·+	·	·	·	·	·	·	·	·	·	·	·	·
Thallictrum occidentale	·	+·+	·	·	·	·	2·6	·	·	·	·	·	·	·
Thermopsis montana ovata	·	·	·	+·+	·	·	·	·	·	·	·	·	·	·
Trillium ovatum	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Valeriana sitchensis	·	2·10	·	·	·	·	·	·	·	·	·	·	·	·
Veratrum viride	·	·	·	·	·	·	·	+	·	·	·	·	·	·
Viola orbiculata	·	·	·	+·2	·	+	·	1·14	+·+	·	·	·	·	·
Viola	·	1·12	·	·	·	·	·	·	·	·	·	·	·	·
INDIGENOUS SPECIES IN MACROPLOT	5	15	14	11	9	6	13	13	10	5	5	5	13	9

Table B-15. *Abies lasiocarpa-Menziesia ferruginea and Tsuga mertensiana-Menziesia ferruginea* associations. The stands are arranged from left to right in order of decreasing proportions of *Abies lasiocarpa* and increasing proportions of *Tsuga mertensiana*.

	Abies-Menziesia										*Tsuga-Menziesia*			
Stand number	58	131	136	159	134	137	135	63	132	133	46	99	158	12
State and county	Alber	IIdah	IBoun	IIdah	IShos	IBoun	IShos	IShos	IShos	IShos	IIdah	IShos	IBene	IShos
Township and section	-----	30N18	60N20	27N10	43N19	58N28	45N5	43N21	43N36	43N26	36N28	53N19	47N31	23N30
Range	---	6E	3W	10E	10E	3W	9E	5E	10E	7E	7E	4E	1E	3E
Altitude in meters	1952	1988	1751	2043	1837	1636	1837	1708	1546	1827	1769	1779	1750	1561
Aspect and percent slope	W12	---	N20	NW15	NW52	N53	W27	NE13	NW38	NNE35	NW16	ENE12	NE50	NNE18
Mean pH upper dm of soil	4.1*	4.6	4.2	4.7	4.5	4.1	4.5	4.5	4.2	4.2	4.4	4.4	4.4	4.5
TALL SHRUBS														
Alnus sinuata	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Sambucus racemosa melanocarpa	·	·	·	·	+·+	·	·	·	·	+	·	·	·	·
Sorbus scopulina	·	·	9·12	·	·	2·2	·	·	·	·	·	·	·	+
Sorbus sitchensis sitchensis	+	·	·	·	·	+·2	1·2	·	·	·	·	·	7·8	·
Sorbus	·	·	·	·	·	·	·	+	·	·	·	·	·	·
MEDIUM SHRUBS														
Ledum glandulosum glandulosum	·	·	·	·	·	·	·	·	9·34	·	·	·	·	·
Lonicera involucrata	·	·	·	·	·	·	·	·	+·+	·	·	·	·	·
Lonicera utahensis	·	+·2	·	1·2	1·2	·	8·12	5·12	+	·	·	·	5·14	·
Menziesia ferruginea	86·98	75·90	39·70	80·98	68·86	60·82	62·76	86·98	41·72	73·90	60·80	77·72	66·76	45·68
Pachistima myrsinites	·	·	·	·	·	2·4	·	·	·	·	·	·	·	·
Phyllodoce empetriformis	+·+	·	·	·	+	·	·	·	+	4·6	·	·	·	·
Rhododendron albiflorum	·	·	48·82	·	·	+·2	·	·	·	·	·	·	·	·
Ribes lacustre	·	·	·	·	·	·	·	·	+·+	·	·	·	·	·
Vaccinium membranaceum	21·74	14·50	16·54	14·38	45·88	39·82	10·22	17·36	15·48	3·6	23·58	·	11·26	49·78
Vaccinium myrtillus	1·6	·	+·2	·	·	·	·	·	·	·	·	·	·	·
LOW SHRUBS														
Cassiope mertensiana	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Chimaphila umbellata occidentalis	·	+·+	·	·	·	·	·	·	·	·	·	·	·	+·+

(Continued)

Table B-15. *Abies lasiocarpa-Menziesia ferruginea and Tsuga mertensiana-Menziesia ferruginea* associations. The stands are arranged from left to right in order of decreasing proportions of *Abies lasiocarpa* and increasing proportions of *Tsuga mertensiana*. continued

	Abies-Menziesia										*Tsuga-Menziesia*			
Stand number	58	131	136	159	134	137	135	63	132	133	46	99	158	12
Gaultheria humifusa	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Pyrola asarifolia	.	.	.	.	.	.	.	+	+.+	.	.	.	.	.
Pyrola seconda	.	+.2	.	.	+.2	+.2	+	1.12	.	.	1.5	.	.	1.10
Vaccinium scoparium	1.2	1.6	.	1.8	+.2	+.2	+	.	9.44	3.12	+	11.44	2.14	.
Xerophyllum tenax	45.66	69.86	60.80	29.52	22.44	51.80	71.88	4.4	11.22	4.6	29.48	26.34	+.+	56.78
PERENNIAL GRAMINOIDS														
Carex geyeri	.	+.2	.	+.+	.	.	.	.	.	.	.	.	+	.
Carex rossii	.	+.+	.	.	.	.	.	.	.	.	.	.	.	+
Carex	.	.	.	.	.	.	.	+.+	.	.	.	.	.	.
Deschampsia atropurpurea	1.12	.	.	.	.	.	.	.	.	.	.	.	.	.
Elymus glaucus	.	.	.	.	+.+	.	.	.	.	.	.	.	.	.
Luzula divaricata	.	.	.	+	.	+.2	8.18	.	.	.	.	.	.	.
Luzula glabrata	7.36	.	9.28	.	.	.	.	.	.	.	39.70	.	17.42	.
Luzula	.	1.4	.	+.+	+.6	.	.	+	+.+	13.30	.	+.6	.	+.+
PERENNIAL FORBS														
Anemone piperi	.	.	.	+.+	.	.	1.6	.	.	.	.	.	.	.
Arnica latifolia	14.64	.	.	1.6	7.42	.	.	.	.	+	.	.	2.10	.
Arnica mollis	.	.	.	.	.	.	1.6	.	.	.	.	.	.	.
Athyrium filix-foemina	.	.	.	.	.	.	.	+	.	.	.	.	.	+
Cystopteris fragilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Epilobium angustifolium	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Erigeron peregrinus callianthemus	+.6	.	.	.	.	.	.	.	.	.	.	.	.	.
Erythronium grandiflorum	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Goodyera oblongifolia	.	.	.	+	+.+	.	+.2	+.4	.	.	.	+	.	.
Listera caurina	.	.	.	.	.	.	+.+	.	.	+.+	.	.	.	.
Listera cordata	.	.	.	.	.	.	.	+.+	.	.	.	.	+	.
Lupinus laxiflorus pseudoparviflorus	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Mitella breweri	1.26	.	.	.	.	.	+	.	.	.	.	.	1.4	.
Osmorhiza	.	+.+	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis bracteosa	+	.	.	.	+.2	.	.	.	.	.	.	.	.	.
Phegopteris dryopteris	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Polemonium pulcherrimum calycinum	.	.	.	+	.	.	.	.	.	+	.	1.2	+	.
Pterospora andromedea	.	.	.	.	.	.	.	+.+	.	.	.	.	.	+
Senecio triangularis	1.6	.	.	.	.	.	.	.	.	.	.	.	.	.
Streptopus amplexifolius	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.
Thallictrum occidentale	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Tiarella unifoliata	1.6	.	.	.	.	.	.	.	.	.	.	.	.	.
Trollius laxus	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Valeriana sitchensis	.	.	.	+	+.2	.	.	.	.	.	.	.	.	.
Veratrum viride	1.14	.	.	.	.	.	+	.	.	+	+.4	.	1.4	.
Viola orbiculata	+.8	.	.	+.10	2.32	.	+.2	.	+.+	.	.	.	.	+.+
INDIGENOUS SPECIES IN MACROPLOT	16	11	7	10	14	10	11	9	10	7	6	5	10	7

Table B-16. *Abies lasiocarpa-Vaccinium scoparium* association.

Stand number	101	102	100
State and county	OWall	WGraf	WFerr
Township and section	21N12	8N36	40N33
Range	46E	42E	35E
Altitude in meters	1713	1839	1604
Aspect & percent slope	N7	15	NW25
Mean pH upper dm of soil	5.5	5.0	4.8
TALL SHRUBS			
Alnus sinuata	·	·	+
Sorbus scopulina	·	+	·
MEDIUM SHRUBS			
Lonicera involucrata	+·2	·	·
Lonicera utahensis	+·2	3·8	+·+
Pachistima myrsinites	·	·	+·2
Shepherdia canadensis	+·2	·	·
Vaccinium membranaceum	+·2	2·12	·
LOW SHRUBS			
Berberis repens	+·+	·	·
Chimaphila menziesii	·	+	·
Pyrola secunda	+·+	+	1·14
Vaccinium scoparium	38·88	41·88	3·32
PERENNIAL GRAMINOIDS			
Bromus vulgaris	1·4	·	·
Calamagrostis rubescens	10·38	·	·
Carex concinnoides	4·32	·	+·+
Carex rossii	·	·	+·+
Festuca occidentalis	1·10	·	·
PERENNIAL FORBS			
Achillea millefolium lanulosa	2·6	·	·
Anemone piperi	3·44	·	·
Arnica cordifolia	17·58	10·72	·
Arnica latifolia	1·8	·	·
Astragalus alpinus	2·8	·	·
Erigeron peregrinus callianthemus	+·2	·	·
Goodyera oblongifolia	+·+	·	+·+
Hieracewm albiflorum	+·4	+·+	·
Osmorhiza chilense	+·8	·	·
Pedicularis racemosa	+·2	·	·
Thallictrum occidentale	+	·	·
Tiarella unifoliata	·	·	+·+
Trifolium eriocephalum piperi	1·22	·	·
Valeriana sitchensis	1·12	·	·
Veratrum viride	+·2	·	·
Viola adunca	+·2	·	·
Viola orbiculata	2·30	3·8	·
ANNUALS			
Microsteris gracile	+·6	·	·
INDIGENOUS SPECIES IN MACROPLOT	27	6	8

APPENDIX C. SMALL MAMMAL COMPONENTS

Results of trapping small mammals in stands of climax forests located in eastern Washington and northern Idaho. Data compiled from Rickard (74) are designated R in table and those from Hoffman (44) are designated H. Nomenclature of associations has been changed as needed to conform with that of this bulletin.

Association	Trap-days	Source	Stand number[a]	Numbers of animals captured: Microtus longicaudus	Sorex vagrans	Peromyscus maniculatus	Eutamias amoenus	Clethrionomys gapperi	Sorex obscurus	Sorex cinereus	Phenacomys intermedius
Pinus ponderosa-Festuca	405	H	2			9					
Pinus ponderosa-Symphoricarpos	540	R	—	9	3	20	5				
" "	675	R	—	1		9	5				
Pinus ponderosa-Physocarpus	675	R	—	2	1	6	6				
Pseudotsuga-Physocarpus	675	R	—	1		8	8				
" "	675	R	—		5	3	3	2			
Pseudotsuga-Calamagrostis	405	H	—		1						
Abies grandis-Pachistima	630	R	34		1	5	[b]	2	3	2	
Thuja plicata-Pachistima	675	H	3			15	4	11		5	1
Tsuga heterophylla-Pachistima	405	H	27		2	3				2	
" " [c]	405	H	27		2	3	1		1	1	1
Thuja plicata-Oplopanax	405	H	82		1	1	1	2			
Abies lasiocarpa-Pachistima	630	R	—		2	12	4	5		6	
" "	450	R	—		1	18	[b]	1			
Abies lasiocarpa-Xerophyllum[d]	630	R	—			9	3	4		2	
" "	360	R	—			6	[b]	2		1	

[a] Numbering of stands as in this publication.

[b] Observed, but not trapped.

[c] Duplicate trapping pattern, 200 m distant in same stand, established to evaluate consistency of results.

[d] Abies lasiocarpa-Xerophyllum and Tsuga mertensiana-Xerophyllum associations not distinguished. Data may refer to either or both.

APPENDIX D. SOIL CHEMISTRY

Results of analyses of the upper decimeter of the mineral soil. Means and 95% fiducial limits are indicated.

	pH	Organic matter	P as lb/acre	K as meq/100g	Ca as meq/100g	Mg as meq/100g	Cation ex. cap.	% base saturation
Pinus-Stipa	6.32±0.16	1.57±0.62	7.03± 1.64	0.59±0.61	4.2± 1.76	0.93±0.29	7.3± 3.13	76.2±10.2
Pinus-Festuca	6.12±0.13	2.62±1.18	11.50± 6.10	0.75±0.58	7.4± 3.74	1.93±1.20	12.8± 5.57	82.2± 6.3
Pinus-Symphoricarpos	5.97±0.50	6.30±1.07	47.00±17.35	1.54±0.74	14.5± 4.25	3.28±1.67	24.6± 5.76	77.4±11.1
Pinus-Physocarpus	6.26±0.25	[a]		2.14±1.53	18.4±11.44	4.32±2.50	34.1±17.73	78.7±16.2
Pseudotsuga-Symphoricarpos	6.23±0.26			1.24±0.33	13.4± 2.47	2.48±2.06	19.7± 2.70	87.1±10.9
Pseudotsuga-Physocarpus	6.25±0.17			1.34±0.34	17.3± 3.25	2.33±1.09	24.4± 4.01	85.1± 5.1
Pseudotsuga-Calamagrostis	5.90±0.17			1.13±0.36	13.6± 4.66	1.14±0.32	21.7± 5.17	71.1± 8.5
Abies grandis-Pachistima	6.08±0.21			0.85±0.28	13.5± 2.31	1.27±0.29	23.9± 2.42	66.4±12.0
Thuja plicata-Pachistima	6.01±0.15			0.50±0.44	17.1± 4.70	0.80±0.40	27.4± 3.00	67.2±17.1
Tsuga heterophylla-Pachistima	5.00±0.39			0.28±0.10	4.1± 5.17	0.50±0.82	20.5± 4.71	24.4±30.3
Abies lasiocarpa-Pachistima	5.19±0.22			0.55±0.12	5.5± 2.41	0.97±1.15	28.5± 3.39	25.5± 9.8
Abies- & Tsuga-Xerophyllum	4.48±0.05			0.40±0.04	2.8± 1.63	0.25±0.17	27.4± 2.93	13.1± 4.9
Abies- & Tsuga-Menziesia	4.38±0.02			0.41±0.67	1.8± 0.69	0.48±0.15	29.5± 3.21	9.2± 2.1
Abies lasiocarpa-Vaccinium	5.10±0.21			0.45±0.24	4.7±11.50	0.50±2.14	23.1± 7.83	24.0±51.6

[a] Only minimal values reported in some analyses, so means are not significant.

APPENDIX E. SPECIES DIVERSITY

Habitat type	Median no. of herb & shrub Spp. per stand	Total list of tree species per h.t.
Pinus ponderosa-Agropyron	15	1
Pinus ponderosa-Stipa comata	17	1
Pinus ponderosa-Stipa thurberiana	20	1
Pinus ponderosa-Festuca	20	1
Pinus ponderosa-Purshia	—	1
Pinus ponderosa-Symphoricarpos	22	1
Pinus ponderosa-Physocarpus	33	1
Pseudotsuga menziesii-Symphoricarpos	22	4
Pseudotsuga menziesii-Physocarpus	28	3
Pseudotsuga menziesii-Calamagrostis	19	4
Abies grandis-Pachistima	28	6
Thuja plicata-Pachistima	23	5
Tsuga heterophylla-Pachistima	18	6
Thuja plicata-Oplopanax	22	5
Thuja plicata-Athyrium	28	4
Abies lasiocarpa-Pachistima	17	6
Abies lasiocarpa-Xerophyllum	12	8
Tsuga mertensiana-Xerophyllum	7	7
Abies lasiocarpa-Menziesia	10	7
Tsuga mertensiana-Menziesia	7	4
Abies lasiocarpa-Vaccinium	5	4

APPENDIX F. CLIMATIC DATA

Some climatic parameters of weather stations representative of major categories of forest vegetation in the core area. Precipitation (P), potential evapotranspiration (PET) and actual evapotranspiration (Ea) are given in inches. Ea is calculated based on assumptions of both 2 inches and 6 inches of growth-water storage capacity of the soil profile. Water surplus (WS) is the difference between P and Ea assuming 6 inches of water storage.

	Mean mon. Temp. °F		Sums of 12 monthly values				
	July	Jan.	P	PET	Ea 2″	Ea 6″	WS
PINUS PONDEROSA SERIES							
Spokane, Wash	69.0	27.4	14.9	24.4	9.1	12.8	2.1
Potlatch, Idaho	65.2	28.1	24.0	23.7	12.8	16.2	7.8
Kooskia, Idaho	72.3	29.2	24.5	26.7	16.1	19.5	5.0
Gibbs, Idaho	68.4	27.0	23.4	—	—	—	—
PSEUDOTSUGA SERIES							
Anatone, Wash.	65.2	25.9	21.1	22.3	12.4	15.6	4.5
Chewelah, Wash.	66.4	23.6	19.5	23.7	10.8	14.4	5.1
Colville, Wash.	67.4	23.8	17.5	24.4	10.8	14.4	3.1
Deer Park, Wash.	65.9	23.8	21.9	23.0	10.7	14.2	7.7
Republic, Wash.	65.1	21.6	15.1	22.2	10.3	13.7	1.4
TSUGA HETEROPHYLLA SERIES							
Avery, Idaho	67.5	27.3	32.2	24.3	14.6	17.8	14.4
Clark Fork, Idaho	64.4	26.0	34.8	23.0	15.0	17.9	16.9
Murray, Idaho	62.9	25.2	37.7	—	—	—	—
Pierce, Idaho	65.5	24.2	40.2	21.9	14.6	17.3	22.9
Priest R. E. F., Ida.	58.0	23.6	32.4	23.1	14.3	17.3	15.1
Sandpoint, Idaho	65.5	25.5	32.8	23.3	13.5	16.7	16.1
ABIES LASIOCARPA SERIES							
Burke, Idaho	59.8	22.2	48.2	17.9	14.5	16.2	32.0
Mullan Pass, Idaho	—	—	37.0	16.1	11.6	13.7	23.3

APPENDIX G. DYNAMIC STATUS OF TREES

Distribution of tree canopy species through the series of habitat types, showing their dynamic status (C=major climax species; c=minor climax; s=seral) as interpreted mainly from the data in Appendix A. Species considered "accidentals" by virtue of rare occurrence in random size classes are here omitted.

Habitat type \ Species	Pinus ponderosa	Pseudotsuga menziesii	Larix occidentalis	Pinus contorta	Abies grandis	Pinus monticola	Thuja plicata	Tsuga heterophylla	Picea engelmanni	Abies lasiocarpa	Tsuga mertensiana	Pinus albicaulis
Pinus ponderosa-Symphoricarpos	C											
Pinus ponderosa-Physocarpus	C											
Pinus ponderosa-Festuca	C											
Pinus ponderosa-Agropyron	C											
Pinus ponderosa-Stipa	C											
Pinus ponderosa-Purshia	C											
Pseudotsuga-Symphoricarpos	s	C	s	s								
Pseudotsuga-Physocarpus	s	C	s									
Pseudotsuga-Calamagrostis	s	C	s	s								
Abies grandis-Pachistima		s	s	s	C	s			s			
Thuja plicata-Pachistima		s	s		s	s	C		s			
Tsuga heterophylla-Pachistima		s	s		s	s	c	C				
Thuja plicata-Oplopanax			s			**s**	C	c	s			
Thuja plicata-Athyrium		s				s	C		s			
Abies lasiocarpa-Pachistima		s	s	s		s			c	C		
Abies lasiocarpa-Xerophyllum				s		s				C		c
Tsuga mertensiana-Xerophyllum			s			s			s	c	C	s
Abies lasiocarpa-Menziesia				s		s			s	C	c	s
Tsuga mertensiana-Menziesia			s						s	c	C	
Abies lasiocarpa-Vaccinium			s	s					C	C		
Abies lasiocarpa-Pinus alb.										C		C

APPENDIX H. BASAL AREA

Distribution of basal area through the associations.

Basal area range, m^2/ha	Pinus-Festuca	Pinus-Symphoricarpos	Pinus-Physocarpus	Pseudotsuga-Symphoricarpos	Pseudotsuga-Physocarpus	Pseudotsuga-Calamagrostis	Abies grandis-Pachistima	Thuja-Pachistima	Tsuga-Pachistima	Thuja-Oplopanax	Thuja-Athyrium	Abies lasiocarpa-Pachistima	Abies- & Tsuga-Xerophyllum	Abies- & Tsuga-Menziesia	Total, stand without Thuja
501 +										1					
451-500															
401-450															
351-400															
301-350															
251-300										3	1				
201-250								3			1				
151-200						1		4	1						1
101-150								2	6	1					
51-100		3		3	3	6	7	1	9	2		11	5	6	40
1-50	4	5	7	5	10	5	8			2		3	8	8	62