Vegetation Of The Douglas-Fir Region

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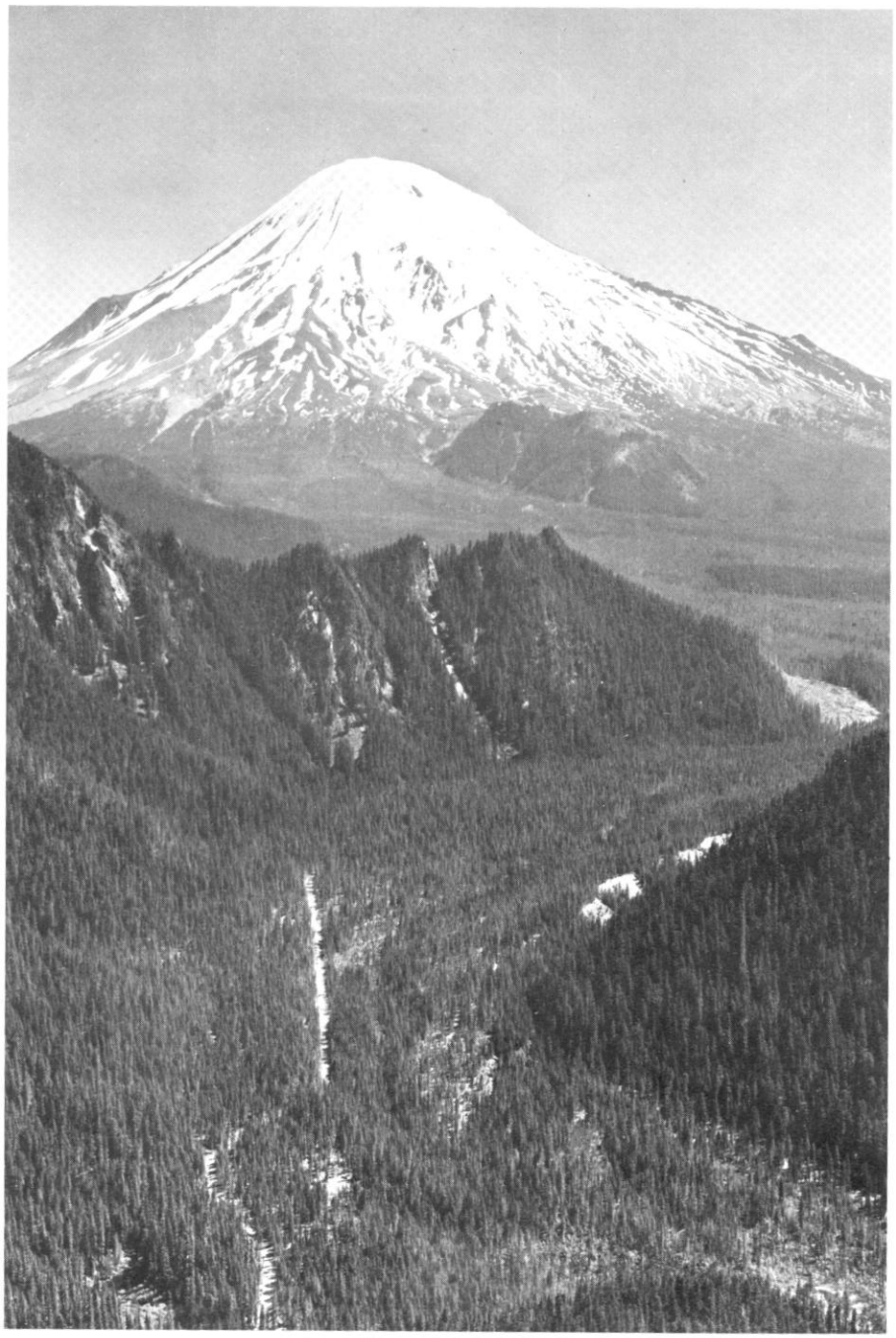

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CHAPTER IV

VEGETATION OF THE DOUGLAS-FIR REGION

Jerry F. Franklin

The Douglas-fir region of western Washington and Oregon and northwestern California is one of the most densely forested areas of the world. It represents maximal development of the temperate coniferous forest. The region is well known for the extensive areas dominated by Douglas-fir, with climax forests of western hemlock and western redcedar, and coastal "rain forests" of coast redwood and Sitka spruce. In this chapter I will attempt to outline major compositional, structural, and successional features of these varied and productive forests. More thorough accounts of the forest zones and communities that make up the Douglas-fir region are found in Franklin and Dyrness (1973). Little space is devoted here to a review of the autecology (physiology, life history, etc.) of the tree species; extensive summaries are available in Fowells (1965), Krajina (1969), and U.S. Department of Agriculture, Forest Service (1974).

SOME GENERAL AND DISTINCTIVE FEATURES

The forests of the Douglas-fir region are nearly without rival in the world. Their uniqueness and features which sharply contrast them with other temperate forests of the world are, however, rarely fully appreciated. Such features include coniferous dominance, massive organic matter accumulations, and productivity and growth patterns.

The dominance of evergreen conifers over hardwoods is conspicuous. One early estimate put the ratio of hardwoods to conifers at 1:1000 (Kuchler 1946). Most temperate forest regions in the world (Asia, Europe, and eastern North America) have natural forests in which deciduous hardwoods dominate, with conifers concentrated on sites with harsh environments or occurring mainly as pioneer species. In the Douglas-fir region roles are reversed with hardwoods often concentrating on stressful sites (e.g., oaks on dry habitats) or functioning as pioneer species (e.g., red alder).

The large number of dominant coniferous species which achieve large sizes and long lives is a second important feature (Table 1). Nowhere is there a group of dominant tree species which are the match of these; every single coniferous genus represented finds its largest (and often longest-lived) representative here—and sometimes its second and third largest as well: true fir (*Abies*), spruce (*Picea*), pine (*Pinus*), white-cedar (*Chamaecyparis*), redcedar (*Thuja*), redwood (*Sequoia*), incense-cedar (*Libocedrus*), hemlock (*Tsuga*), and of course, Douglas-fir (*Pseudotsuga*). Foresters in the region occasionally forget their good fortune in having such a large array of potentially productive tree species as alternatives or associates to Douglas-fir.

These large, long-lived species dominate dense forests rather than occurring as isolated individuals. Consequently, old-growth ecosystems in this region have the greatest biomass accumulations of any plant formations in the temperate zone and, probably, the world. Coast redwood stands are, of course, the star of the show with biomass accumulations of up to 4,500 t/ha. Forests in which basal area, live aboveground biomass, and cubic wood volume exceed 100 m^2, 800 t/ha, and 2,000 m^3, respectively, are not uncommon (Waring and Franklin 1977).[1] These values are far in excess of maxima reported for temperate deciduous forests, although some of the evergreen *Eucalyptus* forests of Australia may prove comparable.

When the Douglas-fir region is compared with other temperate forest regions, contrasts in productivity are not as great as in maximum biomass. It can be extremely high in favorable coastal environments; Fujimori (1971) reported, for example, an annual net production of 36.2 t/ha in a young western hemlock stand. Figures of this type and the board- and cubic-foot productivity levels indicated for Site I coast redwood, western hemlock, Douglas-fir, and western hemlock-Sitka spruce stands in yield tables are among the world's reported maxima. Tropical forests may have greater gross productivities, but have greater losses to respiration and other factors. Typically, however, forests in this region grow more slowly initially than, for example, in the Eastern United States. This is exemplified by Worthington's (1954) comparison of Douglas-fir and loblolly pine (Fig. 1). The sustained height and diameter growth of coniferous stands in this region is clearly one key factor in the record biomass accumulations.

The dominance of evergreen conifers and high productivities are believed to be largely a consequence of the relatively dry cool summers and warm winters that characterize the Douglas-fir region (Waring and Franklin 1977). Native conifers carry on substantial amounts of photosynthesis during fall, winter, and spring—outside of the so-called growing season (Fig. 2). Deciduous hardwoods are placed at a further disadvantage by the dry summers which reduce the amount of assimilation possible during that period. There are also advantages to the coniferous habitat in meeting nutritional needs (lessened annual requirements for mineral up-

[1] For footnote, see end of Reference section.

Table 1. Typical and maximum ages and dimensions attained by selected species of forest trees on better sites in the Pacific Northwest.[1]

Species	Typical			Maximum	
	Age	Diameter	Height	Age	Diameter
	Years	—Cm—	—M—	Years	—Cm—
Abies amabilis	400+	90-110	44-55	590	206
Abies procera	400+	100-150	45-70	450	270
Chamaecyparis lawsoniana	500+	120-180	60	—	359
Chamaecyparis nootkatensis	1,000+	100-150	30-40	3,500	297
Larix occidentalis	700+	140	50	915	233
Libocedrus decurrens	500+	90-120	45	>542	368
Picea engelmanni	400+	100+	45-50	>500	231
Picea sitchensis	500	180-230	70-75	>750	525
Pinus lambertiana	400	100-125	45-55	—	306
Pinus monticola	400+	110	60	615	197
Pinus ponderosa	600+	75-125	30-50	726	267
Pseudotsuga menziesii	750+	150-220	70-80	1,200	434
Sequoia sempervirens	1,250+	150-380	75-100	2,200	501
Thuja plicata	1,000+	150-300	60+	>1,200	631
Tsuga heterophylla	400+	90-120	50-65	>500	260
Tsuga mertensiana	400+	75-100	35+	>800	221

[1]Typical values mainly from Franklin and Dyrness, 1973; maximum diameters from American Forestry Association 1973; maximum ages from Fowells (1965) or personal observation.

take in a region where growing season decomposition is reduced by moisture deficiencies) and in dealing with moisture stress during the dry summers.

MAJOR SUBDIVISIONS

Although the dense, evergreen habit gives them a common appearance, forests in the Douglas-fir region are, in fact,

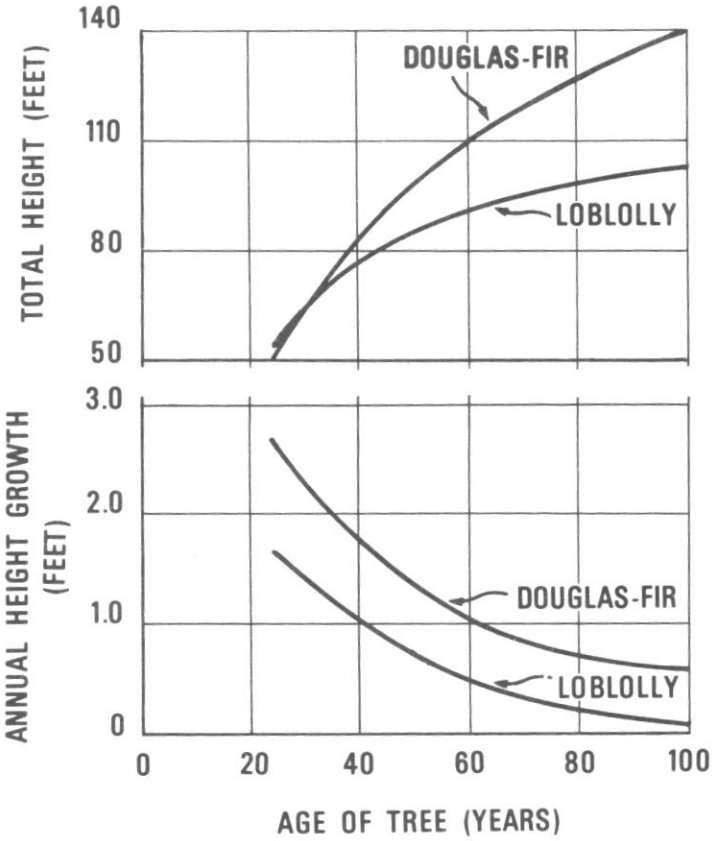

Figure 1. Contrasting patterns of height growth in relation to age between average loblolly pine and Douglas-fir (after Worthington 1954).

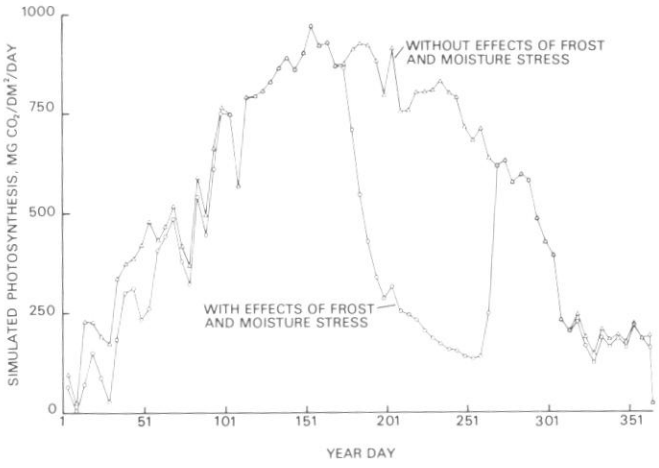

Figure 2. Simulated patterns of net photosynthesis on an average Douglas-fir site (central western Cascades of Oregon) based on temperature with and without effects of frost and moisture stress); note the high proportion of photosynthesis taking place outside of the growing season. (Courtesy of William Emmingham.)

highly variable in composition, structure, and productivity depending upon environmental conditions and successional stage (time since the origin of a stand). The occurrence of Douglas-fir as a component of the forests is perhaps the major common element. There are, however, a number of forest types in the region from which Douglas-fir is absent as a result of unsuitable environment, loss through successional processes, or chance.

The greatest proportion of the biological variability is accounted for by environmental conditions or patterns so the following account of the forests will be structured by environment. There is within the Douglas-fir region a broad range of environments—dry, rainshadow valleys in the lee of coastal ranges, particularly wet areas along the coast, etc. Major environmental gradients are also present—decreasing temperatures and increasing precipitation with increasing latitude and elevation.

We can more clearly see broad patterns in geographic and elevational variability by recognizing subregions or zones which are relatively homogenous environmentally (Fig. 3, Table 2). These zones can be divided into three major groups relative to the modal Western Hemlock Zone: (1) coastal strips (Sitka Spruce and Coast Redwood Zones) which are wetter and milder than the rest of the region; (2) drier and warmer areas in the southern mountains and in rainshadow valleys (Mixed Conifer, Mixed Evergreen and Interior Valley Zones); and (3) subalpine areas with cool, snowy environments (Pacific Silver Fir, Mountain Hemlock, White Fir and Shasta Red Fir Zones). The zones are based largely on the forest associates—particularly climax trees—of Douglas-fir (Table 3).

There is substantial local variability in the vegetation of the Douglas-fir region which still must be dealt with. We can often handle this best by recognizing a series of community types or habitats arrayed along local moisture or other environmental gradients. Some typical habitat or community "spectra" will be presented under some of the zonal descriptions which follow. These habitats and communities are generally best recognized by the understory vegetation, including tree reproduction, shrubs, and herbs. A forester must learn to recognize and interpret understory vegetation if full use is to be made of the potential it offers for appraising forest land potential and problems.

Western Hemlock Zone

The Western Hemlock Zone is the most extensive in the Douglas-fir region (Fig. 3) and the most important for timber production. Environmentally, it also provides the modal or "average" condition with regard to temperature and moisture. Elevational ranges are from 0 to 700 m (49° north latitude) and 150 to 1,000 m (lat. 45° N.) in the

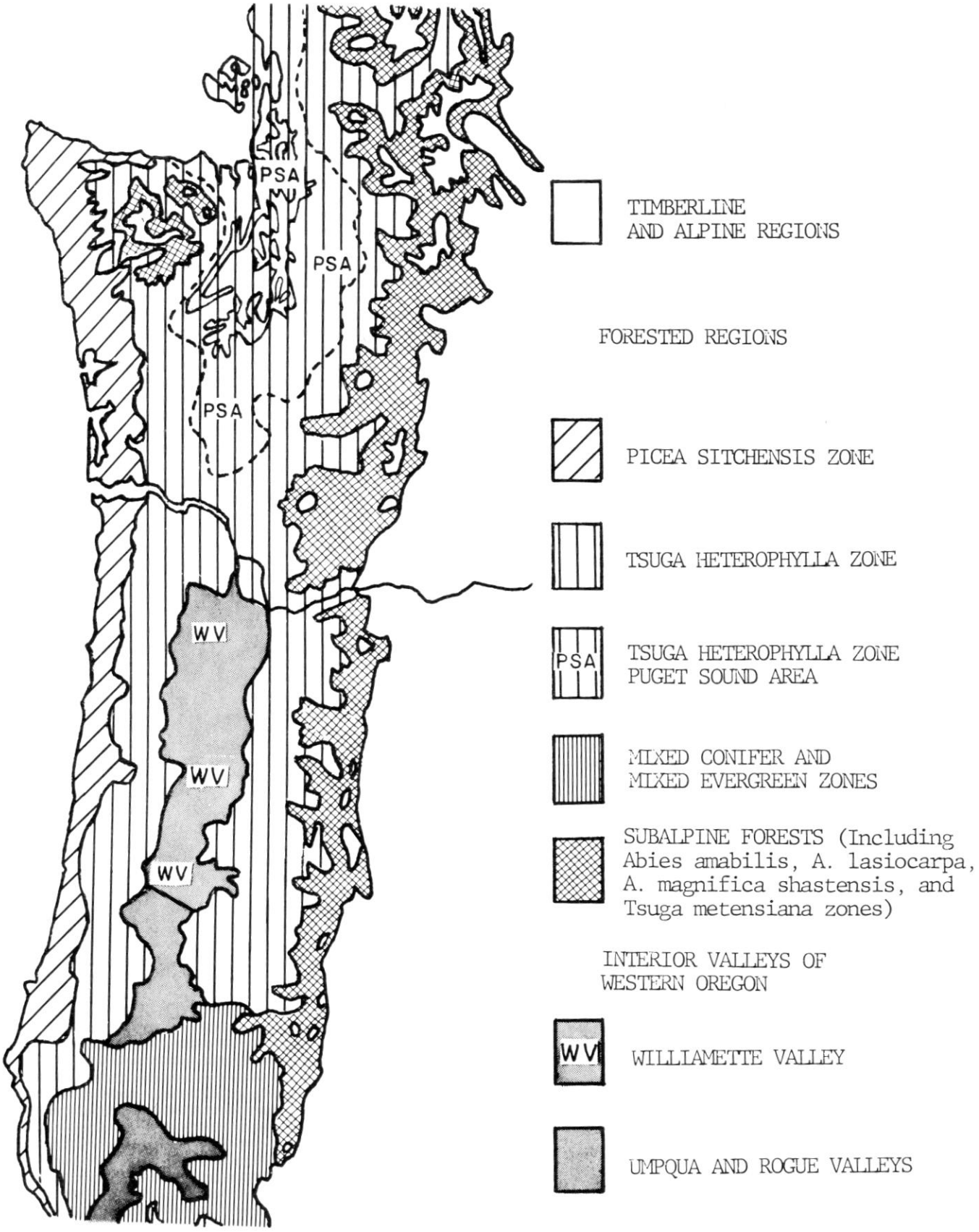

Figure 3. Vegetation zones the Douglas-fir region in Washington and Oregon.

Table 2. Vegetation zones within the Douglas-fir region.

Zone	Location	Environment[1]
Western Hemlock	Cascade and Coast Ranges	Mesic and moderate
Sitka Spruce	Coastal strip (northern 3/4)	Wet and moderate
Coast Redwood	Coastal strip (southern 1/4)	Wet and warm
Mixed Conifer	S. Cascades and E. Klamath Mountains	Dry and moderate
Mixed Evergreen	Klamath Mountains	Dry and moderate
Interior Valley	Lee of Coast Ranges, N. Oregon	Dry and warm
Pacific Silver Fir	Wash. and N. Oregon mountains	Wet and cold
Mountain Hemlock	Cascade Range and Olympic Mountains	Wet and cold
White Fir	S. Cascade and Klamath Mountains	Mesic and cool
Shasta Red Fir	S. Cascade and Klamath Mountains	Mesic and cool

[1] Relative to Western Hemlock Zone.

Cascade Range and 150 to 550 and 0 to 1,125 m on the western and eastern slopes, respectively, of the Olympic Mountains.

Major forest trees in the zone are Douglas-fir, western hemlock and western redcedar (Table 3). Note that, although it is called the Western Hemlock Zone after the major climax species, large areas are dominated by forests of Douglas-fir. Much of the zone has been logged, or burned, or both during the last 150 years; and Douglas-fir is often an exclusive dominant in the seral stands that have developed. Even old-growth stands (400+ years old) often retain a major Douglas-fir component.

Minor tree species include Sitka spruce near the coast, grand fir, and western white pine. Both western white and lodgepole pine are common on glacial drift in the Puget Sound area. Near the southern limits of the zone in Oregon, small amounts of sugar pine, incense-cedar, or even ponderosa pine may be present. Hardwood associates are most commonly red alder, bigleaf maple, and, in Oregon, golden chinkapin.

Community Types

There have been numerous detailed studies of the forest communities found in the Western Hemlock Zone (see, e.g., Spilsbury and Smith 1947, Becking 1954, Bailey 1966, McMinn 1960, Krajina 1965, and Dyrness *et al.* 1974). Similar patterns are indicated with a major association between moisture regime and composition and productivity (Fig. 4) (Zoebel *et al.* 1976). A typical pattern (combining the work of several authors) is as follows:

Table 3. Major (M) and minor (m) tree species in the various zones of the Douglas-fir region; major climax species are underlined.

Species	Western Hemlock	Sitka Spruce	Coast Redwood	Mixed Conifer	Mixed Evergreen	Interior Valley	Pacific Silver Fir	Mountain Hemlock	White Fir	Shasta Red Fir
Douglas-fir	M	M	M	M	M	M	M	m	M	m
Western hemlock	M	M	M	m	m		M	m		
Western redcedar	M	M		m			m			
Sitka spruce	m	M	m							
Coast redwood		m	M		m					
Port-orford-cedar	m	m	m		m					
Grand or white fir	m	m	M	M	m	M	m		M	m
Incense-cedar	m			M	m	m			m	
Sugar pine	m			M	m				m	
Western white pine	m			m	m		m	m	m	m
Ponderosa pine				M	m	M				
Lodgepole pine	m	m	m		m		m	M		M
Pacific silver fir	m						M	M		
Noble or Shasta red fir							M	M	m	M
Subalpine fir								M		m
Mountain hemlock								M		M
Alaska-cedar							m	m		
Red alder	M	M	M				m			
Black cottonwood	m	m				m				
Bigleaf maple	m	m	m	m	m	M				
Golden chinkapin	m			m	m	m				
Pacific madrone	m	m	m	m	M	M				
Tanoak			M	m	M	m				
Oregon white oak				m	m	M				

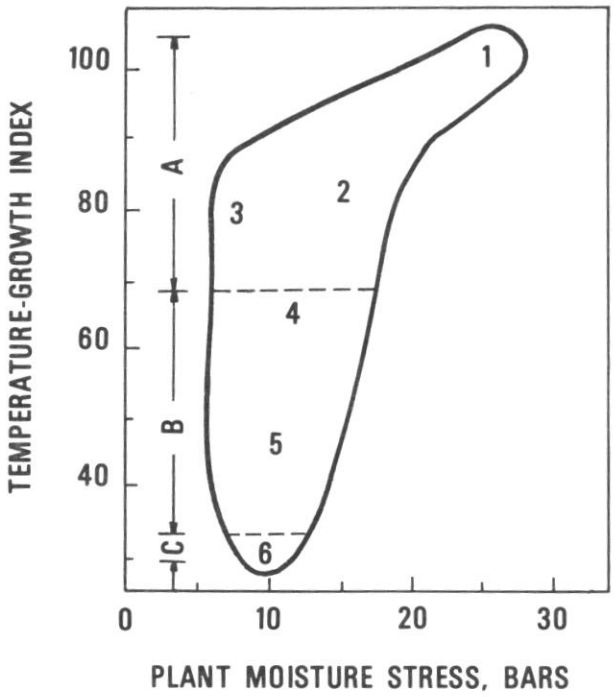

Figure 4. Associations between forest communities and temperature and moisture regimes in the central western Cascades of Oregon (after Zobel, *et al.* 1976); the moisture gradient most important within the Western Hemlock Zone, temperature is most important in separating the temperature and subalpine regions. Zones shown by letters: A = Western Hemlock Zone, B = Pacific Silver Fir Zone and C = Mountain Hemlock Zone; Numbers are plots representing habitat types: 1 = Douglas-fir/Oceanspray, 2 = Western Hemlock/Pacific Rhododendron/Oregongrape, 3 = Western Hemlock/Swordfern-Oregon Oxalis, 4 = Western Hemlock-Pacific Silver Fir/Pacific Rhododendron/Twinflower, 5 = Pacific Silver Fir/Alaska Huckleberry/Bunchberry Dogwood, and 6 = Pacific Silver Fir-Mountain Hemlock/Beargrass.

Moisture Regime	Plant Association and Habitat Type[2]
Dry	Douglas-fir/Oceanspray
	Western Hemlock/Salal or/Pacific Rhododendron-Salal
	Western Hemlock/Oregongrape or/Pacific Rhododendron–Oregongrape
	Western Hemlock/Swordfern
	Western Hemlock/ Swordfern-Oregon Oxalis
	Western Redcedar/Devil's Club/Ladyfern
Wet	Western Redcedar/Skunk Cabbage

Most of the forests in the zone can be related to this basic array of habitats which are here named after a major climax tree species and distinctive understory species. Not all of the array will occur in a local area and the forests are often dominated by other than the climax tree species (most particularly by Douglas-fir and, to a lesser extent, red alder on the Western Hemlock habitat types).

Douglas-fir/Oceanspray habitats (Fig. 5) are generally the hottest and driest forested sites in the Western Hemlock Zone–too dry, in fact, for growth of western hemlock. Most often these are on shallow stony soils and steep southerly slopes. Patchy, all-sized stands of Douglas-fir are characteristic with incense-cedar, Pacific madrone, Oregon white oak, and bigleaf maple as minor associates. Douglas-fir stands may be allaged; and, in any case, this is an environment where it is expected to be a climax species. Understory species may contrast sharply with those on adjacent, more mesic sites including the shrubs oceanspray, California hazel, snowberry, and salal. Grasses, iris, modest whipplea, and snow queen are characteristic herbs. Communities belonging to this general type are most common in southern parts of the Western Hemlock Zone but do occur as far north as Vancouver Island.

Figure 5. Forest exemplifying the hot, dry Douglas-fir/Oceanspray community; all size classes of Douglas-fir are typically present.

[2]For footnote, see end of Reference section.

Moderately dry and/or nutrient deficient sites are characterized by Western Hemlock/Salal or/Pacific Rhododendron/Salal plant associations (Fig. 6).[3] Douglas-fir

Figure 6. The Douglas-fir/Salal community is a common early successional stage on Western Hemlock/Salal habitat type; understories are depauperate.

is the major pioneer and western hemlock the major climax species. Extensive Douglas-fir/salal forests found in the Puget Trough have lodgepole and western white pines as occasional associates. Salal and, when present, Pacific rhododendron dominate the species-poor understory and may be nearly all that the casual viewer sees. Other species commonly present are rose, snowberry, Oregongrape, huckleberries, and a variety of low herbs such as prince's pine and deerfoot vanillaleaf.

Western Hemlock/Oregongrape and/Pacific Rhododendron/Oregongrape habitats are considered modal, i.e., they occupy central portions of the moisture and temperature gradients (see e.g., Zobel *et al.* 1976). Communities on these sites generally have shrub layers in which Oregongrape, red huckleberry, trailing blackberry, vine maple, and, in Oregon, Pacific rhododendron are characteristic (Fig. 7). An inconspicuous herb layer of species such as evergreen violet, twinflower, goldthread, and rattlesnake plantain is common. Swordfern and salal are common but not as understory dominants.

Figure 7. Old growth forest stand on Western Hemlock Pacific Rhododendron/Oregongrape habitat type showing typical understory components.

It is in the moist Western Hemlock/Swordfern and/Swordfern-Oregon Oxalis habitats that lush herbaceous understories are encountered (Fig. 8). These sites are the most favorable for forest growth, and impressive stands of Douglas-fir, western hemlock and western redcedar are often present. Shrub layers are typically not well developed although vine maple and/or Oregongrape can be understory dominants. The herb layer is well developed with swordfern, coolworts, and twinflower most common. Oregon oxalis, deerfern, ladyfern, and several Liliaceae are among the numerous succulent herbs which cover the forest floor on the particularly rich Western Hemlock/Swordfern-Oregon Oxalis habitats.

The Western Redcedar/Devil's Club/Ladyfern communities occupy valley bottom habitats and have herbaceous understories which are even more luxurious and rich in species than those just described (Fig. 9). Devil's club is an unpleasant but characteristic shrub species. Vine maple is a common dominant species. The herb layer consists of ladyfern, mountain woodfern, oakfern, deerfern, wood violet, false bugbane, twisted stalk, coolworts, and threeleaf anemone. Douglas-fir, grand fir, bigleaf maple, and other tree species are often present in these communities; but western hemlock and western redcedar dominate. Tree reproduction is often sparse, perhaps due to competition from the dense understories, but it does appear that western redcedar is as

[3]For footnote, see end of Reference section.

Figure 8. Lush herbaceous understories, in which swordfern and many other herbs are abundant, characterize the Western Hemlock/Swordfern-Oregon Oxalis habitat type.

capable of perpetuating itself on these sites as the hemlock, thereby achieving climax status.

Swamp habitats and communities are characteristic of the wet end of the moisture gradient; the Western Redcedar/Skunk Cabbage type is representative of this group. Due to excessive moisture, poor aeration, etc., tree densities and overall productivity are generally low. Western redcedar, lodgepole and western white pines, red alder, and Oregon ash are common tree species; others may be present (e.g., Douglas-fir and western hemlock) but are typically confined to upland microsites or hummocks. Many understory species can be present in these semi-aquatic habitats; but willow, skunk cabbage, and sedges (especially slough sedge) are among the most common.

Many communities and habitat types have been (and will continue to be) described from the Western Hemlock Zone. Nevertheless, the majority can be identified as variants or relatives of the basic community spectrum just presented.

Successional Relations

Secondary succession following destruction of a forest stand by wildfire or logging is highly variable in detail depending on local site conditions and the intensity of the disturbance. Nevertheless, a generalized sequence is recognized (Fig. 10) (Isaac 1940, Dyrness 1973). The sequence begins with an herbaceous or weed stage that

Figure 9. Representative valley bottom Western Redcedar/Devil's Club/Ladyfern habitat; these are typically well watered habitats with rich alluvial soils.

typically lasts 4 or 5 years. Major dominants are invading annual and perennial herbs such as woodland groundsel, fireweeds, and bracken fern. Residual herbs, such as swordfern, may also contribute significant cover. A shrub stage follows in the classical successional sequence. Residual species such as vine maple, Pacific rhododendron, trailing blackberry, and salal develop well in newly opened environments and are joined by invaders such as willows and snowbrush ceanothus. The shrub stage continues until the shrubs are overtopped by tree saplings, which may be from 10 to 25 years depending upon the site.

Composition and density of the young forest stands is very dependent on type and extent of disturbance, available seed source, planting or seeding programs, and environmental conditions. Development of dense, nearly pure, essentially even-aged Douglas-fir stands is typical, a tendency encouraged by most artificial regeneration programs. Stands often go through a dense pole stage in which the understory is drastically depleted; understories of salal, vine maple,

Figure 10. Shrubby stage of vegetation development following logging and slash burning on an area in the central western Cascade Range; shrub dominants are mainly residual Pacific rhododendron and vine maple in this area.

swordfern, and similar species which are common in more open stands may also persist.

Other common types of young stands include those where: (1) western hemlock or other shade tolerant species dominate (i.e., Douglas-fir is absent or nearly so) and (2) red alder is the major or sole dominant. Both situations are most likely to be encountered in wetter parts of the Western Hemlock Zone such as the northern Washington Cascade Range and west side of the Coast Ranges and Olympic Mountains.

Red alder forests are worthy of particular note because of red alder's recognized roles as conifer competitor and nitrogen fixer. They are particularly common on the moist, productive sites (e.g., swordfern habitats) in the coastal regions. Red alder reproduces abundantly on mineral seedbeds on such sites and grows extremely fast (Zavitkovski and Stevens 1972). It typically overtops conifers resulting in pure or nearly pure alder stands in which it is only very slowly replaced by other trees. This slow replacement is partially caused by the dense shrubby understories of salmonberry and other species which develop under increasingly open canopies of the relatively short-lived alder (Fig. 11). The successional replacements for Red Alder/Salmonberry communities are, incidentally, not well understood. They probably range from semipermanent brushfields to conifer forests developed from shade-tolerant species (e.g., Sitka spruce, western hemlock and western redcedar) persisting from the initial disturbance or subsequently invading the alder stand. Red alder is also noted for its soil improving qualities, particularly fixation of large amounts of nitrogen (Tarrant and Trappe 1971).

True climax forests are rare, but examples of old-growth forests 400 to 700 years in age are common and allow us to draw some conclusions about climax species. Eventual replacement of Douglas-fir by western hemlock in the absence of disturbance has been frequently described (e.g., by Munger (1940) in general terms and by Bailey (1966), Fonda and Bliss (1969), and Dyrness *et al.* (1974) for specific areas). Whether western hemlock enters stands

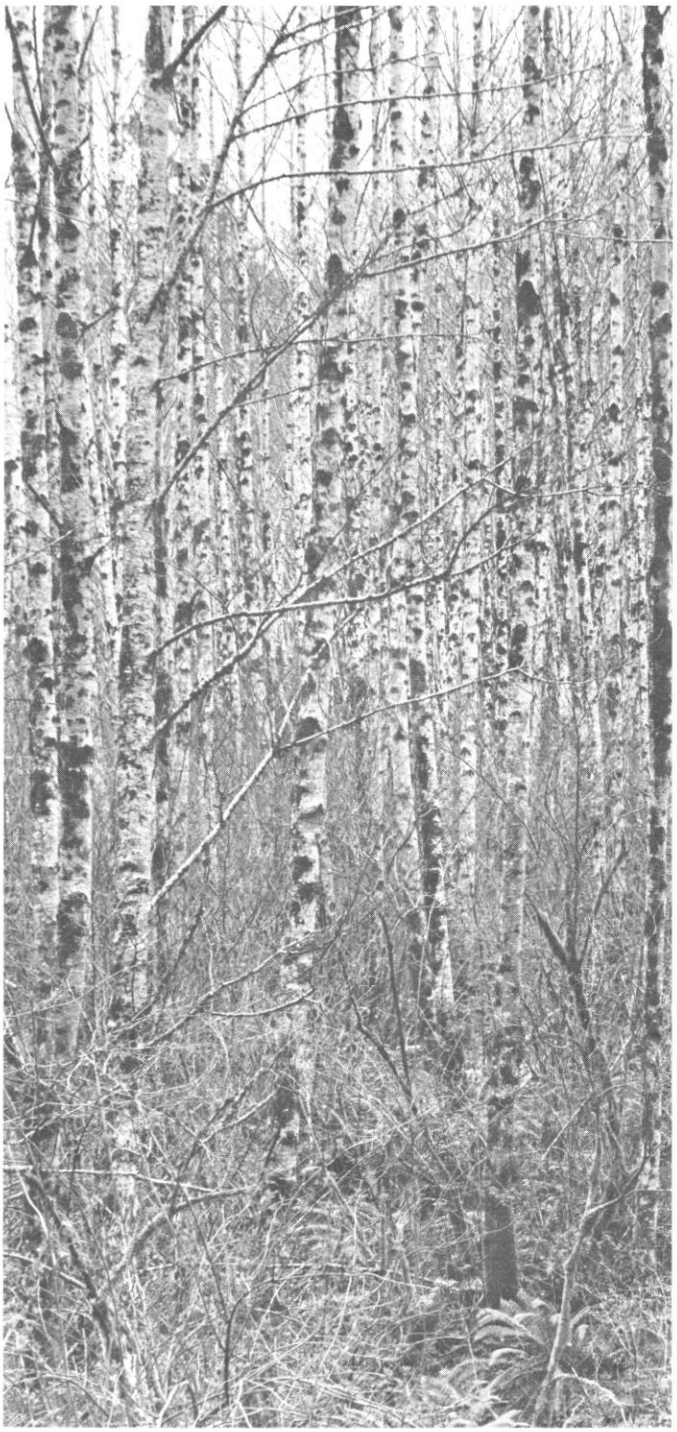

Figure 11. Typical Red Alder/Salmonberry community along the Oregon coast; reproduction of any tree species is retarded by the dense shrubby understory.

early or late in succession is irrelevant because hemlock can reproduce itself under the forest canopy and Douglas-fir cannot, at least on most sites in the zone. On very dry habitats (as described earlier) Douglas-fir can apparently perpetuate itself since stands are much more open and more tolerant associates are absent or severely constrained. On the other hand, on the very wet sites it appears that western redcedar will be a part of any climax stand.

Coastal Zones

The forest vegetation of the Western Hemlock Zone has been described in some detail since it is the most important in the Douglas-fir region and provides a reference point. In the next three sections, the major variations encountered in the nine vegetation zones listed earlier (Table 2) will be considered beginning with the extremely wet and mild coastal Sitka Spruce and Coast Redwood Zones.

Sitka Spruce Zone

This is a long, narrow zone which stretches the length of the Washington and most of the Oregon coast but is rarely more than 5 to 10 miles in width except where it extends up river valleys (Fig. 1). The zone could be recognized simply as a variant of the Western Hemlock Zone characterized by Sitka spruce, frequent summer fog, and ocean proximity.

The coniferous stands in this and the related Coast Redwood Zone are typically dense, tall, and among the most productive in the world. The best timber-growing sites of the Douglas-fir region are found in these zones. Constituent tree species in the Sitka Spruce Zone are Sitka spruce, western hemlock, Douglas-fir, western redcedar, grand fir, and in Washington, Pacific silver fir. Red alder is abundant on logged sites while lodgepole pine is abundant in areas exposed to the ocean and on sandy soils.

Mature forests have lush understories with dense growths of shrubs, herbs, ferns, and cryptogams (mosses, lichens, and liverworts). Average sites have understories comparable to the Swordfern, Swordfern-Oxalis, and Devil's Club/Ladyfern types described for the Western Hemlock Zone (Fig. 12). The major difference consists of the generally greater luxuriance of vegetation in the Sitka Spruce Zone. Forests with dense, shrubby understories are common on less favorable sites such as old sand dunes and steep ocean-facing slopes. Ericads such as salal, Pacific rhododendron, and evergreen huckleberry are typical dominants.

The favorable environmental conditions for growth in the Sitka Spruce Zone are also reflected in the rapidity of typical successional sequences. Dense shrub communities are more common than in the Western Hemlock Zone and develop quickly following logging and other disturbances. Young coniferous stands are as likely to be dominated by western hemlock and Sitka spruce as they are by

Figure 12. Understories in typical Sitka spruce-western hemlock stands are lush; note that the dominant spruces in this picture originated on a nurse log (Neskowin Crest Research Natural Area).

Douglas-fir—barring human intercession and sometimes despite it. Red alder stands are also more common than in the Western Hemlock Zone due to the preponderance of moist to wet sites.

Successional trends in most mature conifer stands are clearly toward a western hemlock climax. Since spruce, cedar, and Douglas-fir are long-lived, they are typically represented in even very old stands; but hemlock dominates the reproduction. Much of the regeneration occurs on rotting "nurse" logs; hundreds of hemlock, spruce, and cedar seedlings may be present, some of which survive, producing lines of mature trees (Fig. 12). On some sites which have relatively open stands, Sitka spruce (e.g., in Olympic "rain forests") and western redcedar (e.g., in swamps) may be major climax species.

Coast Redwood Zone

The Coast Redwood Zone may or may not be a valid vegetative zone, but it is used here to distinguish the coastal and generally fog-affected forest area of extreme southern Oregon (south from about lat. 40°30′ N.) and northern California where coast redwood is a major forest tree species. In fact, the redwood forests probably overlap what could be recognized as Californian extensions of the Western Hemlock and Sitka Spruce Zones.

The superproductive nature of these forests has already been mentioned. Characteristic species are coast redwood, Douglas-fir, grand fir, Sitka spruce, western hemlock, and, as an understory tree, tanoak. Red alder is aggressive here as a pioneer species, and various kinds of "pygmy forests" are associated with special soil conditions (Westman and Whittaker 1975).

In large measure, the communities are similar to those of the Sitka Spruce Zone; lush understories with dense growths of shrubs, herbs, and ferns are characteristic. The swordfern-oxalis understory reaches maximal development here. Other community types are, of course, encountered on drier slopes including some with dense ericaceous understories (Pacific rhododendron, salal, evergreen huckleberry, etc.).

Successional trends in this zone are highly controversial—at least there are a wide variety of opinions on the role of coast redwood. Some scientists feel that fire or flood is essential for perpetuating coast redwood and that other associates (western hemlock, tanoak) are the climax species. Certainly redwood can take advantage of such disturbances, but it appears quite capable of perpetuating itself without them. Viers' (personal communication) data show all-aged stands. Its long-lived habit makes it possible for coast redwood to perpetuate itself with very low replacement rates; these rates are apparently met by occasional sprouts or seedlings which take advantage of small canopy openings.

Dry Zones

As mentioned earlier there are three zones which are drier and generally warmer than the modal Western Hemlock Zone—the Mixed Conifer, Mixed Evergreen, and Interior Valley Zones. These are located mainly in southwestern Oregon and northwestern California. These are zones where moisture stress and heat are more likely to cause the forester problems. Many of the more tolerant associates of Douglas-fir are essentially absent (e.g., western hemlock and western redcedar). A typical distributional pattern for these zones is shown in Fig. 13.

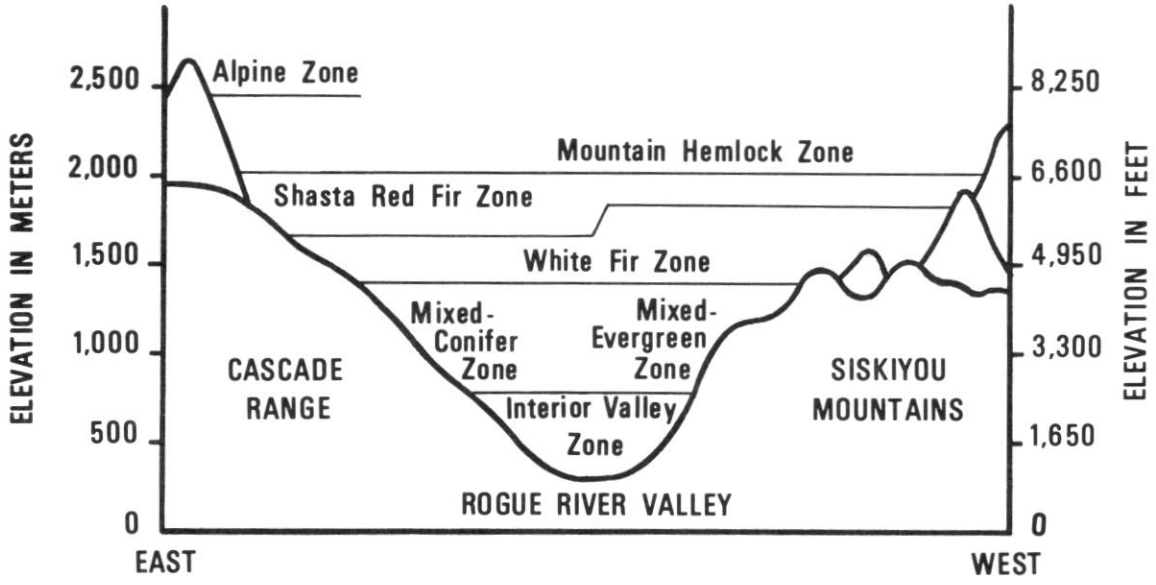

Figure 13. Generalized zonational pattern for vegetation in southwestern oregon.

Interior Valley Zone

The Interior Valley Zone refers to the valley bottoms and lowlands located between the Coast and Cascade Ranges in western Oregon (Fig. 3). These are relatively warm and dry regions because of their position in the lee of the Coast Ranges. The interior valleys are mainly those of the Willamette, Umpqua, and Rogue River. The vegetational mosaic originally included extensive grasslands and oak savannas as well as coniferous forest. Today most of the area is occupied by cities, farms, ranches and other human developments. Nevertheless, we still encounter several natural or semi-natural formations: oak woodlands, conifer forests, grasslands, evergreen shrub, and riparian communities. The first two are probably the only ones relevant to this manual. The Puget Trough occupies an analogous position in western Washington but, for a variety of environmental reasons, has historically had essentially continuous forest cover except in very localized areas (e.g., the prairies in Thurston County).

Forest stands, groves, and savannas dominated by Oregon white oak, California black oak, and Pacific madrone are conspicuous in this zone (Fig. 14). There is a north-south gradient in oak communities; but in the Willamette Valley, an Oregon White Oak/Poison Oak community is most common. Grasses are conspicuous elements. In the Umpqua and Rogue Valleys evergreen shrubs, such as *Ceanothus* spp. and manzanitas, become common.

The conifer forests are heavily dominated by Douglas-fir. Grand fir and bigleaf maple are common associates in the Willamette Valley; ponderosa pine, sugar pine and incense-cedar are common associates in the Umpqua and Rogue Valleys along with hardwoods such as Pacific madrone and California black oak. Douglas-fir is probably a major climax species on many of these dry sites. Regeneration problems can often be severe following cutting.

Successional relationships are varied. Conifers (typically Douglas-fir, ponderosa pine, and grand fir) may be present in oak stands along with bigleaf maple in the Willamette Valley. Depending upon site conditions, oaks, conifers, or even bigleaf maple can apparently be climax. (On severe sites, oaks often provide shelter under which conifers can get established.) Another well documented phenomenon is the development of closed oak woodlands. These have developed since the settlement of the region in the mid-1800's on sites that were originally grassland or oak savanna. Control of wildfires, which originally created and maintained open conditions, is considered largely responsible for expansion of the oak woodlands.

Mixed Conifer Zone

The Mixed Conifer Zone is found in the southern Cascade Range extending north to about the Umpqua-Willamette River divide. This is very clearly the northern

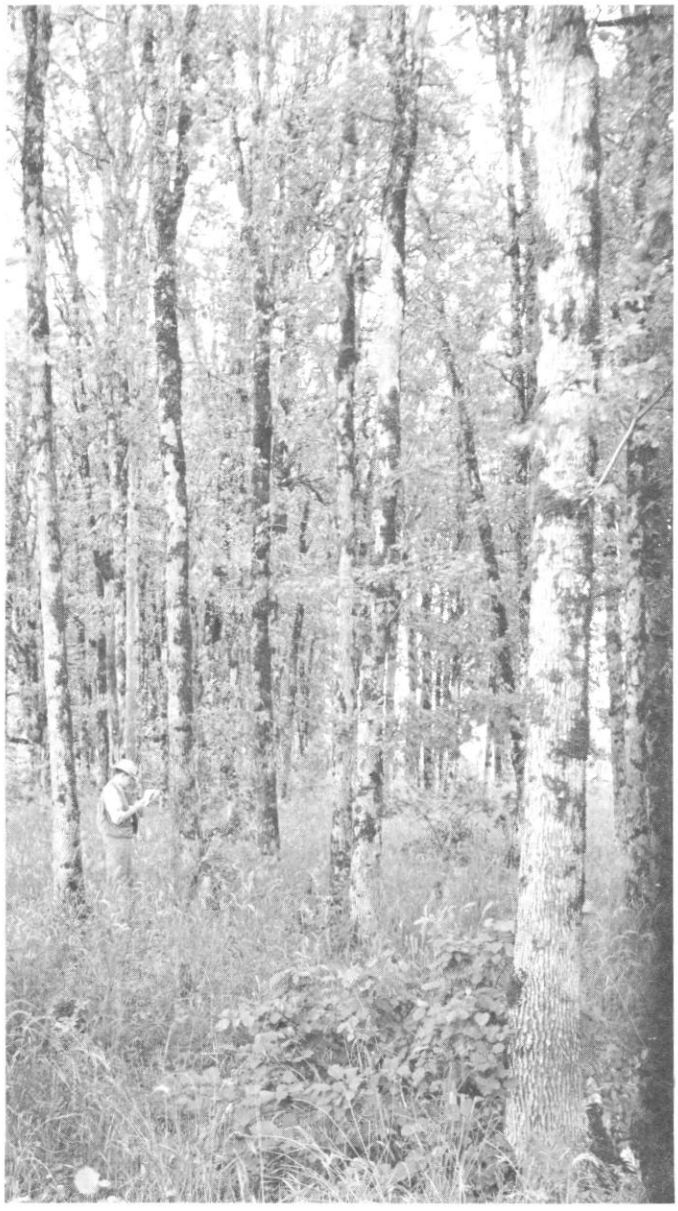

Figure 14. Oregon white oak stand within the Willamette Valley.

extension of Sierran montane or mixed-conifer forests with Douglas-fir, incense-cedar, sugar pine, white fir and ponderosa pine as the characteristic species (Fig. 15). The first two are by far the most important in terms of timber volume, although the pines have very high value and give the forest much of its character.

Considering their extent, these forests have had little phytosociological study. Therefore very little can be said about the range of habitat types or communities to be expected. It is known that sites range from very hot and dry

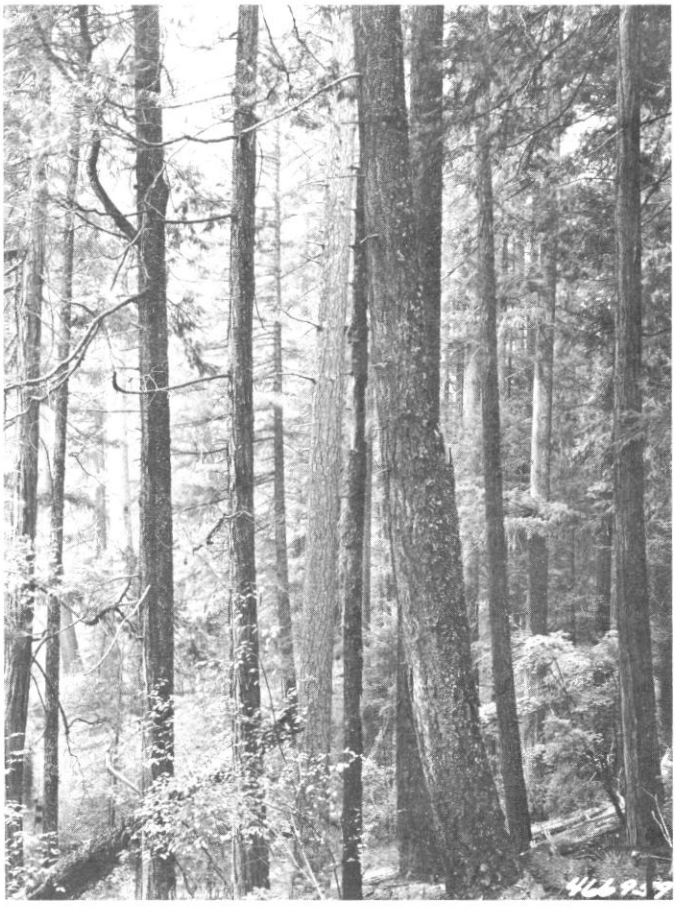

Figure 15. Representative Mixed Conifer Zone forest within which four of the five major forest dominants can be seen Douglas-fir, incense-cedar, sugar pine, and white fir.

where grasslands or oak savannas dominate, through coniferous forests where Douglas-fir and incense-cedar are climax to relatively moist sites where white (or grand) fir[4] is climax. On some very favorable sites outlying populations of western hemlock and western redcedar may be encountered. Community types have been identified in the Abbott Creek Research Natural Area in the upper Rogue River drainage (Mitchell and Moir 1976):

Douglas-fir-Incense-cedar/Pinemat Manzanita,
White Fir-Douglas-fir/Whipple Vine, and
White Fir-Western Hemlock/Vine Maple-Pacific Yew.

Minore (1972) has developed environmental plant indicators for the South Umpqua drainage which provide some additional insights on community composition.

Succession is a slower process in the Mixed Conifer than in the Western Hemlock Zone. Regeneration of trees is

[4]For footnote, see end of Reference section.

generally slowed by the more severe environment. In addition, brushfields dominated by chaparral-like, evergreen shrubs frequently develop. Typical species are varnishleaf ceanothus, mountain whitethorn ceanothus, narrow-leaved buckbrush, golden chinkapin, canyon live oak, and hairy manzanita. Such shrub fields further slow the rate of forest regeneration.

Mixed Evergreen Zone

In the western Siskiyou and Klamath Mountains, average sites are typically occupied by a mixed forest of conifers (upper story of forest canopy) and sclerophyllous broadleaved trees (lower story). This is an extensive forest zone largely unrecognized until recently. Foresters with their emphasis on forest cover types generally overlooked the consistently distinctive nature of this zone's vegetation mosaic.

The most important forest trees are Douglas-fir and tanoak; they are probably major climax species as well. A variety of other trees may also be present, hardwoods being most characteristic: Pacific madrone, golden chinkapin, and canyon live oak. Conifers that may be present include sugar pine, ponderosa pine, incense-cedar, Jeffrey pine on serpentine, Port-Orford-cedar on moist sites, and knobcone pine on recent burns. Understory communities (low shrub and herb layers) are typically not well developed. Poison-oak, Oregon-grape, California honeysuckle, oceanspray, California hazel, and rose are characteristic shrubs in the Illinois River region and indicate a more xeric environment than is typical of the Western Hemlock Zone.

The landscapes of this zone are made up of a complex mosaic of habitat and community types reflecting environmental mosaics and time since last disturbance. The array of vegetation along the moisture and temperature gradients have been described for segments of the zone: the Illinois Valley region by Emmingham (in Franklin and Dyrness 1973), the western Siskiyou Mountains by Whittaker (1960), and most comprehensively by Sawyer, Thornburgh and Griffin (1977).

Serpentine areas are very extensive in this zone. They have very distinctive communities and floras and have been extensively described by vegetation scientists (see e.g., Whittaker 1960 and White 1971). The most relevant aspect of these serpentine studies to the land manager is in making it possible for him to recognize these harsh and unproductive sites which are, incidentally, the locales of a large array of unusual plant species.

Succession is often slow in this zone, at least with regards to development of new conifer forests following disturbance. Sites can easily be lost to evergreen hardwood stands or to dense evergreen chaparral. Brushfields of the latter type are common within the zone and occupy large areas (Gratkowski 1961). Some of the chaparral communities are probably climax–i.e., the sites they occupy are incapable of developing forest cover. Brush species composition, soils, and topography may prove useful in distinguishing climax and seral chaparral sites.

Subalpine Zones

Four subalpine zones were mentioned earlier in this chapter: the Pacific Silver Fir, Mountain Hemlock, White Fir, and Shasta Red Fir Zones. All can be considered elements of a "greater" Douglas-fir region. Because of the abundance of Douglas-fir (presently or potentially) and the extent of the zone, only the Pacific Silver Fir Zone is of major interest. Two of the remaining subalpine zones (Mountain Hemlock and Shasta Red Fir) are cold, very snowy regions from which Douglas-fir is essentially absent. The White Fir Zone is a belt of nearly pure white fir forests which sometimes occurs between the Mixed Conifer or Mixed Evergreen Zones and true subalpine vegetation; it is not an extensive zone in the Douglas-fir region.

Pacific Silver Fir Zone

The Pacific Silver Fir Zone occupies mid-elevations in the Cascade Range of Washington and northern Oregon and extends south to around lat. 43° N. It is also the major zone at mid- to high-elevations in the Olympic Mountains. Typical elevational range is 600 to 1,300 m in northern Washington (where maximal development of the zone occurs) and 1,000 to 1,500 m in northern Oregon. Whether this zone is truly subalpine or only cool temperate is unclear. The zone, however, is clearly wetter, cooler, and snowier than the adjacent Western Hemlock Zone. A permanent winter snowpack of from 1 to 3 m is characteristic.

Major tree species vary considerably depending on geographic location and elevation within the Pacific Silver Fir Zone. Pacific silver fir, western hemlock, Douglas-fir, noble fir, western redcedar, and western white pine are characteristic species. Around Mount Adams and in the Oregon High Cascades, subalpine fir, Engelmann spruce, western larch, and lodgepole pine are also found in the zone. Mountain hemlock and Alaska-cedar are common in cold pockets or near the upper margin of the zone.

The unifying feature of forests within the zone is the occurrence of Pacific silver fir as the major climax species (dominant reproducer in natural stands). Beyond this, patterns in forest composition most commonly encountered by

land managers in this zone will be: (1) Pacific silver fir-western hemlock stands in the northern Washington Cascade Range and western two-thirds of the Olympic Mountains; (2) Douglas-fir, western hemlock, western redcedar, and Pacific silver fir stands in the lower half of southern Washington and northern Oregon's Pacific Silver Fir Zone (Fig. 16); (3) forests in which noble fir is a major dominant in the upper half of the zone in southern Washington and northern Oregon (Fig. 17); and (4) forests of highly varied composition in the High Cascades.

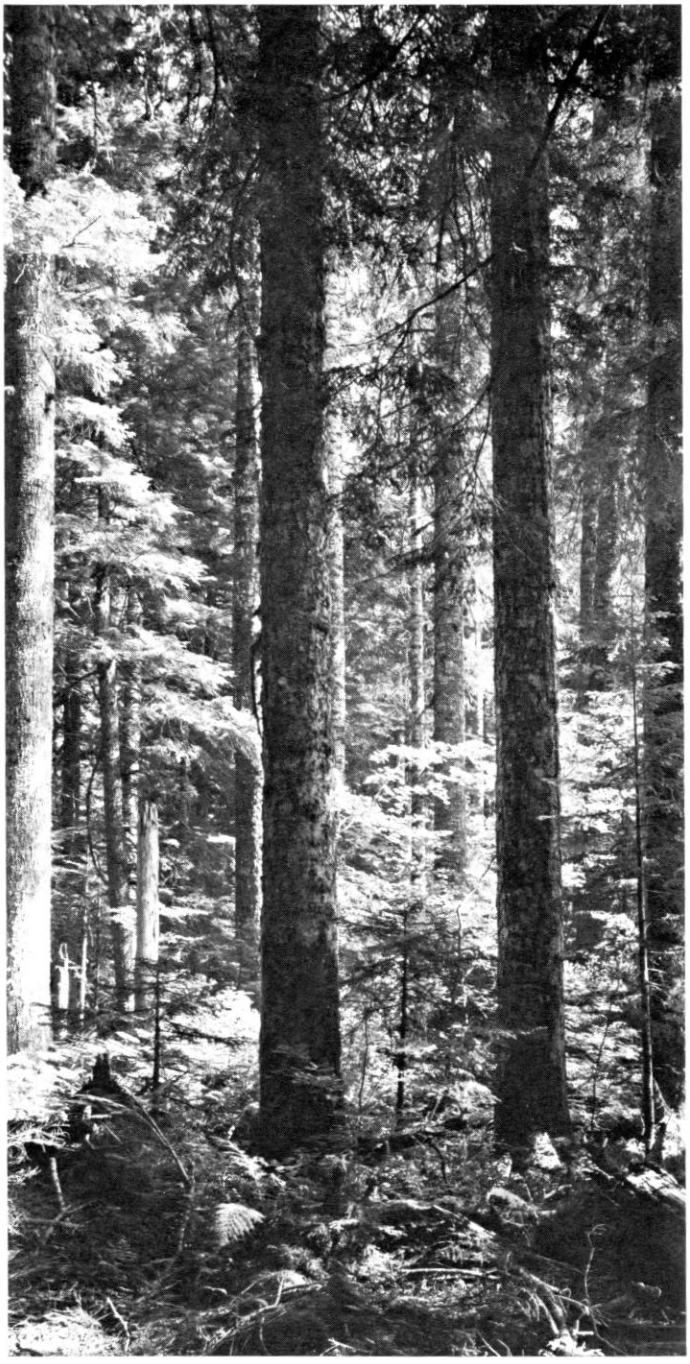

Figure 16. Stands of western hemlock and Pacific silver fir characterize the Pacific Silver Fir Zone.

Figure 17. Noble fir characteristically replaces Douglas-fir as a major pioneer species in the upper half of Pacific Silver Fir Zone.

Community and habitat type patterns have been studied at several locations within the Pacific Silver Fir Zone including western Oregon (Dyrness, *et al.* 1974), southern Washington (Franklin 1966; Thornburgh 1969), Mount Rainier (Moir *et al.* 1977), and Cedar River drainage (Long 1976). Most common are communities with well developed shrub, herb, and moss layers. Characteristic shrubs are ericads such as Alaska, oval-leafed, and big huckleberries and rustyleaf. Typical herbs are bunchberry dogwood, twinflower, and queen cup beadlily. Moister (and generally more productive) habitats in the Pacific Silver Fir Zone are characterized by lush herbaceous understories. Typical constituents are twistedstalks, starry solomon plume, western coolwort, white inside-out-flower, oakfern, and deerfoot vanillaleaf. Many of the severe sites within the zone are characterized by depauperate understories in which beargrass and big huckleberry are the only important species.

Early stages of succession in the Pacific Silver Fir Zone have not been studied in detail. Most of the major dominants are probably species from the predisturbance forest stand such as beargrass, huckleberries, and bunchberry dogwood. Fireweeds and brackenfern are among the more common invaders. Forests may initially be dominated by known

seral species such as Douglas-fir or noble fir. Western hemlock and/or Pacific silver fir can also invade immediately following disturbance particularly in cooler moister portions of the zone such as in the northern Washington Cascade Range. The major climax species, Pacific silver fir, will gradually replace its major shade tolerant associate in the zone, western hemlock.

CONCLUSION

This chapter provides a brief introduction to the varied array of forest communities found in the Douglas-fir region. Much more detailed accounts are available for specific areas. These treatments provide localized information on forest communities or habitat types or both and their relations to environmental gradients (moisture, temperature, and nutrient regimes). Management-oriented interpretations are available in many cases in which productivity (for timber and other resources), regeneration, selection of preferred species, etc., are related to the vegetation or habitat classification. The forester should search out such analyses and learn how to interpret the vegetation for his local area. The understory vegetation (small trees, shrubs, and herbs) can be particularly useful in identification of areas with special problems (e.g., sites that are nutrient deficient, dry, or offering serious potential shrub competition) and special potential. A forester who combines a knowledge of vegetation interpretation with that of soils and their potential has a far more powerful tool than either ability alone provides.

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FOOTNOTES

[1]Waring, R. H., and Jerry F. Franklin. 1977. The evergreen coniferous forest of the Pacific Northwest. (Unpublished).

[2]Note that a habitat type is a land type defined and named on the basis of a plant association, i.e., all the area that is occupied or would come to be occupied through time by a given climax community (plant association).

[3]One major difference between the Western Hemlock Zone in Washington and in Oregon is in the abundance of Pacific rhododendron. It is characteristic of all but the wettest and driest sites in Oregon's Western Hemlock Zone. In Washington, on the other hand, it is nearly absent and is abundant only in the rainshadow of the Olympic Mountains (western half of Puget Trough). Hence, plant communities in Oregon often include rhododendron in their name.

[4]The *Abies* under discussion here is part of the *Abies grandis-A. concolor* complex, widespread in southwestern and eastern Oregon. Some southwestern Oregon populations approach *A. grandis* most closely morphologically; others approach *A. concolor* morphologically and ecologically (Hamrick 1966, Hamrick and Libby 1972, Daniels 1969). For convenience, we will refer to all the morphologically variable populations in the Mixed Conifer and *A. concolor* Zones as *A. concolor.*

APPENDIX I

Scientific Name	Common Name
Abies amabilis	Pacific silver fir
Abies grandis Grand fir	Grand fir
Acer circinatum	Vine maple
Acer macrophyllum	Bigleaf maple
Achlys triphylla	Deerfoot vanillaleaf
Alnus rubra	Red alder
Athyrium filix-femina	Ladyfern
Arbutus menziesii	Pacific madrone
Arctostaphylos canescens	Hairy manzanita
Arctostaphylo spp.	Manzanitas
Berberis nervosa	Oregongrape
Blechnum spicant	Deerfern
Bromus and Festuca spp.	Grasses
Carex spp.	Sedges
Castanopsis chrysophylla	Golden chinkapin
Ceanothus spp.	
Ceanothus cordulatus	Mountain whitethorn ceanothus
Ceanothus cuneatus	Narrow-leaved buckbrush
Ceanothus velutinus	Snowbrush ceanothus
Ceanothus velutinus var. *laevigatus*	Varnishleaf ceanothus
Chimaphila spp.	Prince's pine
Clintonia uniflora	Queencup beadlily
Coptis spp.	Goldthread
Cornus canadensis	Bunchberry dogwood
Corylus cornuta var. *californica*	California hazel
Epilobium spp.	Fireweeds
Fraxinus latifolia	Oregon ash
Gaultheria shallon	Salal
Goodyera oblongifolia	Rattlesnake plantain
Holodiscus discolor	Oceanspray
Iris spp.	Iris
Larix occidentalis	Western larch
Libocedrus decurrens	Incense-cedar
Linnaea borealis	Twinflower
Lonicera hispidula	California honeysuckle
Lysichiton americanum	Skunk cabbage
Menziesia ferruginea	Rustyleaf
Oplopanax horridum	Devil's club
Oxalis oregana	Oregon oxalis

Picea engelmannii	Engelmann spruce
Picea sitchensis	Sitka spruce
Pinus attenuata	Knobcone pine
Pinus jeffreyi	Jeffrey pine
Pinus lambertiana	Sugar pine
Pinus monticola	Western white pine
Pinus ponderosa	Ponderosa pine
Pinus taeda	Loblolly pine
Polystichum munitum	Swordfern
Pteridium aquilinum	Bracken fern
Quercus chrysolepis	Canyon live oak
Quercus garryana	Oregon white oak
Quercus kelloggii	California black oak
Rhododendron macrophyllum	Pacific rhododendron
Rhus diversiloba	Poison oak
Rosa spp.	Rose
Rubus spectabilis	Salmonberry
Rubus ursinus	Trailing blackberry
Salix spp.	Willow
Senecio sylvaticus	Woodland groundsel
Sequoia sempervirens	Coast redwood
Smilacina stellata	Starry solomon plume
Streptopus spp.	Twistedstalks
Symphoricarpos spp.	Snowberry
Synthyris reniformus	Snow queen
Thuja plicata	Western redcedar
Tiarella spp.	Coolworts
Tiarella unifoliata	Western coolwort
Tsuga heterophylla	Western hemlock
Vaccinium spp.	Huckleberries
Vaccinium alaskaense	Alaska huckleberry
Vaccinium membranaceum	Big huckleberry
Vaccinium ovalifolium	Oval-leafed huckleberry
Vaccinium ovatum	Evergreen huckleberry
Vaccinium parvifolium	Red huckleberry
Vancouveria hexandra	White inside-out-flower
Viola sempervirens	Evergreen violet
Whipplea modesta	Modest whipplea
Xerophyllum tenax	Beargrass