V. STRUCTURE AND COMPOSITION OF FOREST STANDS

It is important that management activities within Late-Successional Reserves maintain the compositional and structural elements necessary to the development of late-successional forest characteristics. Chapter IV characterized the landscape, set coarse scale goals, and prioritized areas for treatment. This section of the assessment describes some of the key late-successional habitat characteristics at various seral stages, focusing on the mature and old-growth condition.

A. SUCCESSIONAL PATHWAYS

Successional pathways describe the typical, dominant compositional and structural stages that can be expected under natural conditions as plant communities develop following a disturbance. The successional pathway that a plant community follows is a major determinant of how late-successional habitat characteristics develop in a given stand. They are described by the dominant tree species and relative density of the overstory (the upper reaches of the forest canopy, where most light is intercepted), regeneration of tree species in the understory, and the composition and density of the shrubs, herbs and grasses which make up the ground cover over time. The composition and density of stands at any seral stage are dependent on the type and intensity of disturbance, available seed sources and environmental conditions (Franklin, et al. 1988).

Sub-series environments (Table 4 and Map 5) were described within the western hemlock and Sitka spruce series. Although the concept of sub-series environments is likely to apply to the grand fir and the noble fir/Pacific silver fir series, information and experience with these plant series was not available, so sub-series successional pathways were not described. The plant communities of these sub-series environments vary in their successional pathways, both in the variety of species supported and the number of individual plants of a given species present. Conceptual models of succession were developed for each environment based on general successional sequences described by Franklin and Dyrness (1973), information derived from the Siuslaw Plant Association Guide (Hemstrom and Logan 1986) and resource inventories (Siuslaw Vegetation Resource Survey data, USDA 1987, and 1984 Siuslaw Ecoplot Intensive Survey data, Hemstrom and Logan 1986), and field observation. Although seral-stage development can follow a myriad of successional pathways, only the most commonly observed paths are described. The following is a working hypothesis of successional pathways that would occur for the four common climax vegetation series found in this assessment area and their sub-series environments.

1. Western Hemlock Series

Wet Environment

The western hemlock wet environments occur most often on lower slopes and in riparian areas. Soils have a high water table. Moving from the Coastal Fog Zone to the Coast Range Foothills along the edge of the Willamette Valley, the wet environment becomes more restricted to narrow bands in the valley bottoms. After disturbance, tree regeneration (especially regeneration of conifers) is sporadic, due to intense vegetation competition. Salmonberry is the predominant understory shrub species. Large down logs play an important role in this environment where they serve as "nurse logs", allowing seedling to become established above the surrounding shrubs. Red alder often has a larger presence than conifer in early-seral stages and remains a large component in young and mature stages.

The two dominant tree communities which occur in this environment (Table 7) are simply different mixes of red alder, Douglas-fir and western hemlock, depending on micro-site conditions. All three species re-establish quickly following a disturbance. Generally, either Douglas-fir or red alder dominate the site through the early and mid-seral stages. After the initial tree and shrub cover is established, competition for light is so intense that shade tolerant tree species dominate the regeneration layer; western hemlock is most common, but western redcedar is a significant component of this environment. If no major disturbance occurs, red alder will decline in both of these communities, losing its vigor and decaying beginning at about 80 years of age (Newton and Cole 1994). As the alder dies out, it is often replaced by shade tolerant conifers (western hemlock and western redcedar), which become a major component of late-seral overstory canopies (see Tables 38 and 39, illustrating the late-successional structure of stands in these environments). This sub-series environment has the lowest number of total trees per acre of the western hemlock environments and the highest percentage of red alder of all the sub-series environments.

Another common successional pathway in the wet environment begins with pure alder, usually found in areas too wet for Douglas-fir, and in areas in which a significant amount of bare soil following a disturbance has created a desirable seedbed for alder. If undisturbed, the alder areas will begin to lose vigor and decay after 80 to 100 years of age. Shade tolerant species such as western hemlock and western redcedar will become established on a variable basis, depending on seed source. These conifers will begin to occupy the overstory as the alder deteriorates. In frequently disturbed areas such as floodplains and landslides, alder will constantly be regenerated, dominating the site.

On some sites, pure stands of western hemlock or salmonberry "brushfields" become established following the initial disturbance. However, these sites are considered to be less common and minor in distribution, so they are not identified in Table 7.

Table 7. Conceptual successional pathways[1] for dominant stand types in *all* disturbance regimes[2] in the western hemlock wet[3] environment.

Stand characteristic	Seral stage (age since major dis urbance in years) -- **western hemlock wet environment**					
	pioneer (0 to 10)	very early (11 to 24)	early (25 to 49)	mid (50 to 79)	late (80 to 149)	old-growth (≥150)
Dominant overstory stand type and ranking[4]	a (1) PSME/TSHE/ALRU	PSME/TSHE/ALRU	PSME/TSHE/ALRU	PSME/TSHE/ALRU	PSME/TSHE/ALRU[5]	PSME/TSHE
	b (1) ALRU/PSME/TSHE	ALRU/PSME/TSHE	ALRU/PSME/TSHE	ALRU/PSME/TSHE	ALRU/PSME/TSHE[5]	PSME/TSHE
	c (2) ALRU	ALRU	ALRU	ALRU	ALRU/TSHE[5]	TSHE/THPL
Total overstory (conifer and hardwood) canopy cover[6]	a Low to moderate	Moderate	High	High	Moderate to high[5]	Moderate
	b Moderate	High	High	High	Moderate[5]	Moderate
	c Moderate to high	High	High	High	Moderate to low[5]	Moderate to low
Dominant understory composition[7] and canopy cover	a RUSP, ACCI- high	RUSP, ACCI-mod	RUSP, ACCI-mod	RUSP, ACCI-mod	RUSP, ACCI-mod	RUSP, ACCI-mod
	b RUSP, ACCI- high	RUSP, ACCI-mod	RUSP, ACCI-mod	RUSP, ACCI-mod	RUSP, ACCI-high	RUSP, ACCI-mod
	c RUSP, ACCI- high	RUSP, ACCI-high	RUSP, ACCI-high	RUSP, ACCI-high	RUSP, ACCI-high	RUSP, ACCI-high

[1]Conceptual pathways developed from projections based on inventory data (USDA 1987 Vegetation Resource Survey and 1984 Ecoplot Intensive Survey, Hemstrom and Logan 1986 - Siuslaw National Forest) for stands in the late-seral stage, and field observations. For each stand characteristic, information within a row preceded by the same letter corresponds to the same successional sequence.

[2]Disturbance regimes are described in Chapter II (see *Disturbance Regime Blocks*).

[3]Includes the western hemlock/salmonberry, salmonberry-vine maple, and devil's club plant associations (Hemstrom and Logan 1986).

[4]Dominant overstory species codes: PSME = Douglas-fir, ALRU = red alder, TSHE = western hemlock, and THPL = western redcedar. Ranking codes indicate the relative probability of a particular successional sequence occurring: (1) = most commonly occurring sequence, and (2) = less commonly occurring sequence.

[5]The majority of the red alder (ALRU) would likely have fallen out of the stand by age 100.

[6]Canopy cover classes: high = more than 70%, moderate (mod) = 30 to 70%, and low = less than 30%.

[7]Dominant understory species codes: RUSP = salmonberry and ACCI = vine maple. Other common associated species include devil's club (western hemlock/devil's club plant association), red huckleberry, and swordfern (Hemstrom and Logan 1986).

Moist Environment (Western Hemlock Series)

The western hemlock moist environments occur on deep, well drained soils, usually mid slope. After disturbance, regeneration of conifers is predominant, with initial densities dependent on exposure of organic/mineral soil, density of competing vegetation and seed source.

Two dominant tree communities are most common in this sub-series environment (Table 8, conceptual pathways "a" and "b"). The first is a pure conifer stand type, usually found in areas following a disturbance which has created exposed mineral soil, a seed bed preferred by Douglas-fir. Varying amounts of shade tolerant species, especially western hemlock may be present, depending on how much litter and duff exist in the newly disturbed stands. In these areas, usually dominated by Douglas-fir, stands will develop at a variety of densities. Herbs and shrubs will occupy most of the growing space the first ten years after a stand replacing disturbance. From age 11 to 79, Douglas-fir will dominate the growing space, in dense areas, going through intense inter-tree competition. By age 80, portions of these areas could be occupied by dense stands with relatively slim tree boles, and live crown ratios less than 25 percent. Portions of stands with initial stocking levels of less than 100 trees per acre would have significantly larger diameters and crowns. Ground vegetation will begin to appear as these stands become more open. From age 80 to 149 mortality by inter-tree competition will continue, and tree density will be reduced. As the stand opens, shade tolerant conifer species will become established or will be released. The number of trees in the regeneration layer varies greatly depending on seed source, overstory shade, and competing shrubs.

In areas which are relatively wet or are near a good alder seed source, alder can become a major component of this environment. Most commonly, these stands develop as Douglas-fir dominated stands with scattered pockets of red alder. They follow a successional pathway similar to that of the pure conifer stands. However, understory shrub and herb cover is generally higher under the red alder canopy. The increased competition can reduce the success of shade intolerant tree seedling establishment in the understory, shifting the composition of the regeneration layer in favor of shade tolerant western hemlock and western redcedar, which replace alder in the late-seral stage.

A less common tree community develops when conifer seed sources are not available following the disturbance. In this assessment area, these communities occur where large scale fires reburned two or more times (e.g., Mt. Hebo and the areas which reburned in the Tillamook Fire) in the same area between the mid 1800s and 1910. These stands are predominately red alder, with only widely scattered Douglas-fir or western hemlock. Without disturbance, the alder will begin to lose vigor and decay after about 80 years of age, leaving more of an open Douglas-fir stand or allowing establishment of shade tolerant conifer species, depending on seed source. Some areas with frequent small disturbances, such as landslides, will be maintained as pure alder.

In all stands, after age 150, wind, root rot, inter-tree competition and insects will continue to lower the overall density of Douglas-fir, creating more variation in stocking and species composition. Varying densities and ages of alder, shade tolerant conifer species and Douglas-fir will be found in the understory. Intermediate disturbances, especially prevalent in the Valley Margin Zone and the eastern fringes of the Interior Zone may serve to produce these characteristics sooner than those stands developing after a single disturbance. Table 14 illustrates the mature condition in the late-seral stage. It averages 109 total trees per acre, 53 percent of which are Douglas-fir, 34 percent are western hemlock, and red alder accounts for eight percent of the stand density.

Table 8. Conceptual successional pathways[1] for dominant stand types in *all* disturbance regimes[2] in the western hemlock moist[3] environment.

Stand characteristic	Seral stage (age since major disturbance in years) -- **western hemlock moist environment**					
	pioneer (0 to 10)	very early (11 to 24)	early (25 to 49)	mid (50 to 79)	late (80 to 149)	old-growth (≥150)
Dominant overstory stand type and ranking[4]	a (1) PSME	PSME	PSME	PSME	PSME	PSME/TSHE
	b (1) PSME/ALRU	PSME/ALRU	PSME/ALRU	PSME/ALRU	PSME/ALRU[5]	PSME/TSHE
	c (2) ALRU/PSME	ALRU/PSME	ALRU/PSME	ALRU/PSME	ALRU/PSME[5]	TSHE/TSHE
Total overstory (conifer and hardwood) canopy cover[6]	a Low to moderate	Moderate	High	High	High	Moderate to high
	b Low to moderate	Moderate	High	High	High[5]	Moderate to high
	c Moderate to high	High	High	High	Moderate[5]	Moderate
Dominant understory composition[7] and canopy cover	a POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-low	POMU, ACCI-low	POMU, ACCI-mod	POMU, ACCI-mod
	b POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod
	c POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod	POMU, ACCI-mod

[1]Conceptual pathways developed from projections based on inventory data (USDA 1987 Vegetation Resource Survey and 1984 Ecoplot Intensive Survey, Hemstrom and Logan 1986 - Siuslaw National Forest) for stands in the late-seral stage, and field observations. For each stand characteristic, information within a row preceded by the same letter corresponds to the same successional sequence.

[2]Disturbance regimes are described in Chapter II (see *D sturbance Regime Blocks*).

[3]Includes the western hemlock/swordfern, Oregon oxalis, vine maple/swordfern, and vine maple-salal plant associations (He strom and Logan 1986).

[4]Dominant overstory species codes: PSME = Douglas-fir, ALRU = red alder and TSHE = western hemlock. Ranking codes indicate the relative probability of a particular successional sequence occurring: (1) = most commonly occurring sequence, and (2) = less commonly occurring sequence.

[5]The majority of the red alder (ALRU) would likely have fallen out of the s and by age 100.

[6]Canopy cover classes: high = more than 70%, moderate (mod) = 30 to 70%, and low = less than 30%.

[7]Dominant understory species codes: POMU = swordfern and ACCI = vine maple. Other common associated species include Oregon oxalis, (western hemlock/Oregon oxalis plant association), salal (western hemlock/vine maple-salal plant association), and red huckleberry (Hemstrom and Logan 1986).

Dry Environment (Western Hemlock series)

The western hemlock dry environments occur on upper slope positions which are exposed to year round wind disturbance and experience droughty conditions in the summer. Due to the dryness of this area, fires usually burn hotter, removing competing vegetation and providing a good seed bed for Douglas-fir, so it dominates the pioneer through late-seral stages in almost pure stands. In the mature condition, the species mix in this environment has the highest percentage of Douglas-fir and the lowest percentage of red alder, of any western hemlock or Sitka spruce environment (Table 14).

Shrubs such as salal, Oregon grape and Pacific rhododendron (common on Valley Margin Zone sites) will occupy most of the growing space the first ten years after a stand replacing disturbance. Like the moist environment, from age 11 to 79, Douglas-fir will dominate the growing space and in dense areas will be going through intense inter-tree competition. By age 80, as in the moist areas, portions of these areas could be occupied by dense stands. From age 80 to 149 mortality will continue, and overall tree density would be reduced. As the stand opens up, shade tolerant conifer species (primarily western hemlock) will become established on a random basis depending on seed source. After age 150, wind, root rot, inter-tree competition and insects will continue to lower the overall density of Douglas-fir, allowing western hemlock to become a significant component of the overstory canopy (Table 9).

The primary differences between the moist and dry environments are that the dry environment has more intense, initial shrub competition with establishing seedlings; more frequent small scale wind disturbance; and lower site productivity due to its relatively thin and droughty soil conditions, and lower available nutrients. These things combine, often resulting in smaller individual tree sizes and lower tree stocking levels than stands in the moist environment. This slows the development of some late-successional characteristics such as large trees, snags and logs. However, the high frequency of wind disturbance blowing down small patches on ridgetops and upper slopes may also accelerate late-successional structural characteristics, if it occurs in mid and late-seral stages, by removing overstory Douglas-fir and releasing shade tolerant western hemlock to create a multi-layered canopy, and increasing snags and large down wood. The infection levels of laminated root rot also tend to be higher on these upper slope positions (and throughout the dry environment in general), which contributes to the susceptibility of Douglas-fir trees to windthrow. Additionally, fire may do the same thing in the Valley Margin Zone and the eastern fringe of the Interior Zone. These frequent, low to moderate intensity fires can kill small pockets of trees and expose mineral soil which encourages seedling establishment, resulting in a two or more layered overstory canopy with numerous snags and large logs on the ground.

Table 9. Conceptual successional pathways[1] for dominant stand types in *all* disturbance regimes[2] in the western hemlock dry[3] environment.

Stand characteristic	Seral stage (age since major disturbance in years) -- **western hemlock dry environment**					
	pioneer (0 to 10)	very early (11 to 24)	early (25 to 49)	mid (50 to 79)	late (80 to 149)	old-growth (≥150)
Dominant overstory stand type[4]	PSME	PSME	PSME	PSME	PSME	PSME/TSHE
Total overstory canopy cover[5]	Low to moderate	Moderate	High	High	High	Moderate to high
Dominant understory composition[6] and canopy cover	POMU, GASH-mod	POMU, GASH-mod	POMU, GASH-low	POMU, GASH-low	POMU, GASH-mod	POMU, GASH-mod

[1]Conceptual pathways developed from projections based on inventory data (USDA 1987 Vegetation Resource Survey and 1984 Ecoplot Intensive Survey, Hemstrom and Logan 1986 - Siuslaw National Forest) for stands in the late-seral stage, and field observations.
[2]Disturbance regimes are described in Chapter II (see *Disturbance Regime Blocks*).
[3]Includes the western hemlock/evergreen huckleberry, salal, dwarf Oregon grape, dwarf Oregon grape-salal, salmonberry-salal, and all rhododendron plant associations (Hemstrom and Logan 1986).
[4]Dominant overstory species codes: PSME = Douglas-fir and TSHE = western hemlock.
[5]Canopy cover classes: high = more than 70%, moderate (mod) = 30 to 70%, and low = less than 30%.
[6]Dominant understory species codes: POMU = swordfern and GASH = salal. Other common associated species include dwarf Oregon grape, (western hemlock/dwarf Oregon grape and dwarf Oregon grape-salal plant associations), rhododendron (all western hemlock/rhododendron plant associations), evergreen huckleberry (western hemlock/evergreen huckleberry plant association), salmonberry (western hemlock/salmonberry-salal plant association), red huckleberry, and vine maple (Hemstrom and Logan 1986).

2. Sitka Spruce Series

Wet Environment

Found in the Coastal Fog Zone and the coolest, wettest sites of the Interior Zone, the Sitka spruce wet environment occurs on lower slopes, in riparian areas, and in poorly drained soils on steeper slopes. Soils have a high water table. Salmonberry and devil's club dominate the understory shrub species and respond rapidly to any disturbance of the overstory canopy. This vegetation competition results in sporadic regeneration of conifers following a disturbance. Large down logs play an important role, serving as "nurse logs" and allowing seedling to become established above the surrounding shrubs. Additionally, since these sites are close to the coast, they are commonly subjected to high winds during times when the normally wet soils are saturated; making windthrow a common intermediate disturbance. Windthrow and intense vegetation competition result in generally low stocking, averaging only 64 trees per acre which are nine inches or larger in diameter (Table 14), for stands in the late-seral stage.

The overstory canopies range from mixed western hemlock, Douglas-fir, and Sitka spruce to nearly pure stands of red alder. These sites are resilient to fire (Barnett 1984). The most common communities to develop over long periods of time are conifer dominated. Western hemlock and Douglas-fir are most commonly found in the overstory during the pioneer through late-seral stages, along with Sitka spruce and red alder (Table 10). Wind is a frequent intermediate disturbance, often creating large enough openings to allow establishment of shade intolerant Douglas-fir along with shade tolerant Sitka spruce, western hemlock and western redcedar. Thus, old-growth stands generally have a relatively even mix of Douglas-fir, Sitka spruce and western hemlock in the overstory.

The timing and amount of disturbance on a site, as well as available seed sources, can result in the establishment of a second, slightly less common, community dominated by alder. These stands typically include scattered western hemlock and Sitka spruce which survive in the shade of red alder and eventually make their way into the overstory. The pathway for alder dominated sites is similar to that of conifer dominated sites, but Douglas-fir generally plays far less of a role. As the alder begins to lose vigor and decay after 80 to 100 years of age, western hemlock, Sitka spruce and western redcedar often become established in the regeneration layer and eventually become the dominant species in the overstory. Salmonberry is usually well established under alder canopies, inhibiting seedling establishment. These sites are generally thought to have even lower stocking, 100 to 150 years after a major disturbance than the conifer dominated sites.

Pure alder stands are only maintained on sites which are continually disturbed by flooding or landslides. Outside of these areas, the alder will begin to lose vigor and decay after 80 to 100 years of age. In stands where Sitka spruce and western hemlock are not found in the overstory canopy or regeneration layer, successional development after the alder canopy falls apart is unclear (Hemstrom and Logan 1986). These stands may simply become brushfields, dominated by salmonberry for long periods of time. As these sites are only a minor component of the Sitka spruce wet environment and their successional pathway is relatively unpredictable, they are not projected in Table 10.

Table 10. Conceptual successional pathways[1] for dominant stand types in *all* disturbance regimes[2] in the Sitka spruce wet[3] environment.

Stand characteristic	Seral stage (age since major disturbance in years) -- **Sitka spruce wet environment**					
	pioneer (0 to 10)	very early (11 to 24)	early (25 to 49)	mid (50 to 79)	late (80 to 149)	old-growth (≥150)
Dominant overstory stand type and ranking[4]	a (1) PSME/TSHE/ PISI/ALRU	PSME/TSHE/ PISI/ALRU	PSME/TSHE/ PISI/ALRU	PSME/TSHE/ PISI/ALRU	PSME/TSHE/PISI/ ALRU[5]	PSME/PISI/TSHE/ THPL
	b (2) ALRU/TSHE/ PISI	ALRU/TSHE/PISI	ALRU/TSHE/PISI	ALRU/TSHE/PISI	ALRU[5]/TSHE/PISI	TSHE/PISI/THPL
Total overstory (conifer and hardwood) canopy cover[6]	a Low to moderate	Moderate	Moderate	High	Moderate to high[5]	Moderate to high
	b Moderate to high	High	High	High	Moderate to low[5]	Moderate
Dominant understory composition[7] and canopy cover	a RUSP, OPHO, POMU - high	RUSP, OPHO, POMU - high	RUSP, OPHO, POMU - moderate	RUSP, OPHO, POMU - moderate	RUSP, OPHO, POMU - moderate	RUSP, OPHO, POMU - moderate
	b RUSP, OPHO, POMU - high	RUSP, OPHO, POMU - high	RUSP, OPHO, POMU - high	RUSP, OPHO, POMU - high	RUSP, OPHO, POMU - high	RUSP, OPHO, POMU - high

[1]Conceptual pathways developed from projections based on inventory data (USDA 1987 Vegetation Resource Survey and 1984 Ecoplot Intensive Survey, Hemstrom and Logan 1986 - Siuslaw National Forest) for stands in the late-seral stage, and field observations. For each stand characteristic, information within a row preceded by the same letter corresponds to the same successional sequence.

[2]Disturbance regimes are described in Chapter II (see *Disturbance Regime Blocks*).

[3]Includes the Sitka spruce/salmonberry and devil's club plant associations (Hemstrom and Logan 1986).

[4]Dominant overstory species codes: PSME = Douglas-fir, PISI = Sitka spruce, ALRU = red alder, TSHE = western hemlock, and THPL = western redcedar. Ranking codes indicate the relative probability of a particular successional sequence occurring: (1) = most commonly occurring sequence, and (2) = less commonly occurring sequence.

[5]The majority of the red alder (ALRU) would likely have fallen out of the stand by age 100.

[6]Canopy cover classes: high = more than 70%, moderate = 30 to 70%, and low = less than 30%.

[7]Dominant understory species codes: RUSP = salmonberry, OPHO = devil's club, and POMU = swordfern. Other common associated species include vine maple, Oregon oxalis, and red huckleberry (Hemstrom and Logan 1986).

Moist Environment (Sitka Spruce Series)

The Sitka spruce moist environments occur on deep, wet and well drained soils; usually on benches, alluvial deposits, and mid to lower slopes in the Coastal Fog Zone and valleys of the Interior Zone. After disturbance, regeneration of conifers is predominant, with initial densities dependent on exposure of organic/mineral soil, availability of seed sources, and density of competing vegetation. Two tree communities predominate in this sub-series environment.

The most common community is a relatively dense, pure conifer stand of western hemlock and Sitka spruce, which appear to be in their optimum environment, dominating most natural stands from early through old-growth seral stages (Table 11). Douglas-fir and red alder rapidly establish anywhere that disturbance exposes a seedbed of mineral soil. Although vine maple, swordfern and red huckleberry grow extremely well, shrub and herb competition is not as intense as it is in the wet and dry environments. However, shrubs and herbs will still occupy most of the growing space the first ten years after a stand replacing disturbance. From ages 11 through 79, a mixture of conifers will dominate the growing space, going through intense inter-tree competition. By age 80, portions of these areas are likely to be occupied by dense stands with relatively slim tree boles and live crown ratios less than 25 percent. From age 80 to 149 mortality by inter-tree competition will continue, and tree density will be reduced. Portions of stands with initial stocking levels of less than 100 trees per acre have significantly larger bole diameters and crowns. As small opening are crea ed in the overstory canopy by blowdown, insects, disease or inter-tree competition; western hemlock, Sitka spruce, western redcedar and Pacific yew will establish, or are released, at varying densities depending on seed source and the degree to which the overstory has been opened. Intermediate disturbances which are especially prevalent in the Valley Margin Zone and the eastern fringe of the Interior Zone, may produce these characteristics sooner than those stands developing after a single large scale fire. Inventories of late-seral stands in the mature condition indicate an average stand density of 102 total trees per acre, comprised of 52 percent western hemlock and 29 percent Sitka spruce (Table 14). Douglas-fir accounts for only eleven percent of the stand density.

The second type of tree community occurs in areas wet enough and with adequate seed source to favor alder establishment. A substantial red alder canopy can develop and is the main competitor with conifers on many sites (Hemstrom and Logan 1986). This pathway is very similar to the pure conifer pathway, except that red alder can dominate the site for the first 80 to 100 years, when it begins to lose vigor and decay. Depending on seed source, the alder overstory is generally replaced quickly by shade tolerant species in the late-seral stage (see Table 11, conceptual pathway "b").

As with other wet and moist environments in the western hemlock and Sitka spruce series, wind, disease, inter-tree competition and insects will continue to lower the overall stand density after age 150, creating more variation in stocking. Varying densities and ages of alder, shade tolerant conifer species, and Douglas-fir will be found in the understory depending on the type and size of the disturbance. Additionally, areas with frequent disturbances, such as landslides, will be dominated by red alder. Since this is a minor portion of the landscape it is not shown as a pathway in Table 11.

Table 11. Conceptual successional pathways[1] for dominant stand types in *all* disturbance regimes[2] in the Sitka spruce moist[3] environment.

Stand characteristic	Seral stage (age since major disturbance in years) -- **Sitka spruce moist environment**					
	pioneer (0 to 10)	very early (11 to 24)	early (25 to 49)	mid (50 to 79)	late (80 to 149)	old-growth (≥150)
Dominant overstory stand type and ranking[4]	a (1) TSHE/PISI/ PSME	TSHE/PISI/ PSME	TSHE/PISI/ PSME	TSHE/PISI/ PSME	TSHE/PISI/ PSME	TSHE/PISI/ PSME/THPL
	b (2) ALRU/TSHE/ PISI	ALRU/TSHE/ PISI	ALRU/TSHE/ PISI	ALRU/TSHE/ PISI	ALRU[5]/TSHE/ PISI	TSHE/PISI/ THPL
Total overstory (conifer and hardwood) canopy cover[6]	a Low to moderate	Moderate	High	High	High	Moderate to high
	b Moderate to high	High	High	High	Moderate[5] to low	Moderate
Dominant understory composition[7] and canopy cover	a ACCI, POMU, VAPA - moderate	ACCI, POMU, VAPA - moderate	ACCI, VAPA, POMU - low	ACCI, VAPA, POMU - low	ACCI, POMU, VAPA - moderate	ACCI, POMU, VAPA - moderate
	b ACCI, POMU, VAPA - moderate	ACCI, POMU, VAPA - moderate	ACCI, POMU, VAPA - moderate	ACCI, POMU, VAPA - moderate	ACCI, POMU, VAPA - moderate	ACCI, POMU, VAPA - moderate

[1]Conceptual pathways developed from projections based on inventory data (USDA 1987 Vegetation Resource Survey and 1984 Ecoplot Intensive Survey, Hemstrom and Logan 1986 - Siuslaw National Forest) for stands in the late-seral stage, and field observations. For each stand characteristic, information within a row preceded by the same letter corresponds to the same successional sequence.

[2]Disturbance regimes are described in Chapter II (see *Disturbance Regime Blocks*).

[3]Includes the Sitka spruce/swordfern, Oregon oxalis, and fool's huckleberry-red huckleberry plant associations (Hemstrom and Logan 1986).

[4]Dominant overstory species codes: PSME = Douglas-fir, ALRU = red alder, TSHE = western hemlock, PISI = Sitka spruce, and THPL = western redcedar. Ranking codes indicate the relative probability of a particular successional sequence occurring: (1) = most commonly occurring sequence, and (2) = less commonly occurring sequence.

[5]The majority of the red alder (ALRU) would likely have fallen out of the stand by age 100.

[6]Canopy cover classes: high = more than 70%, moderate = 30 to 70%, and low = less than 30%.

[7]Dominant understory species codes: ACCI = vine maple, POMU = swordfern, and VAPA = red huckleberry. Other common associated species include Oregon oxalis and fool's huckleberry (Hemstrom and Logan 1986).

Dry Environment (Sitka Spruce Series)

The Sitka spruce dry environments occur on ridgetops and upper slope positions on relatively shallow and well drained soils in the Coastal Fog Zone. This environment also occurs on recently stabilized sand dunes in the salt-spray zone, where shore pine is often the pioneer species. Moisture is a limiting factor in the dry environments, especially for Sitka spruce which experiences droughty conditions during the late summer. Except for shallow soils on steeper slopes, soils in this environment are relatively resilient to the effects of fire.

Salal and salmonberry will occupy most of the growing space the first ten years after a stand replacing disturbance (Table 12) and can be tough competitors if conifer seedlings do not become rapidly established on the site. However, Douglas-fir, western hemlock and Sitka spruce all tend to become rapidly established on these sites following any disturbance (depending on seed source availability). By eleven years after the disturbance, these three conifer species generally begin to dominate the growing space. Red alder is also common on these sites, frequently occurring in small amounts, but rarely becoming a major component of the stand. Between 25 and 49 years after the disturbance, denser conifer pockets will be experiencing intense inter-tree competition. Although stocking densities in this environment are lower than stocking densities in the moist environment, by age 80 portions of these sites could be occupied by dense stands. Inter-tree competition, insects and disease will begin to cause mortality. Such mortality will continue throughout the late and old-growth seral stages.

Intense shrub competition is likely to be the primary factor for low stocking in the Sitka spruce dry environment during the pioneer seral stage. However, wind may be the primary factor for maintaining those low stocking levels during the later seral stages. Wind is a frequent intermediate disturbance factor in this environment, creating patches of blowdown throughout dry environment stands. Blowdown patches vary greatly in size. Smaller patches allow shade tolerant western hemlock, Sitka spruce and, to a lesser extent, western redcedar and Pacific yew regeneration to be released or become established. Larger patches allow the establishment of Douglas-fir and red alder in the regeneration layer. Thus, it appears to accelerate the development of multi-layered overstory canopies when it occurs in mid and late-seral stands. Table 14 illustrates that late-seral stands in the mature condition average 89 trees per acre, with Douglas-fir as the dominant overstory species.

Table 12. Conceptual successional pathways[1] for dominant stand types in *all* disturbance regimes[2] in the Sitka spruce dry[3] environment.

Stand characteristic	Seral stage (age since major disturbance in years) -- **Sitka spruce dry environment**					
	pioneer (0 to 10)	very early (11 to 24)	early (25 to 49)	mid (50 to 79)	late (80 to 149)	old-growth (≥150)
Dominant overstory stand type[4]	PSME/PISI/ TSHE/ALRU	PSME/PISI/ TSHE/ALRU	PSME/PISI/ TSHE/ALRU	PSME/PIS / TSHE/ALRU	PSME/PISI/ TSHE/ALRU[5]	PSME/PISI/ TSHE/THPL
Total overstory canopy cover[6]	Low to moderate	Moderate	High	High	High[5]	Moderate to high
Dominant understory composition[7] and canopy cover	GASH, POMU, VAPA - moderate	GASH, POMU, VAPA - moderate	GASH, POMU, VAPA - moderate	GASH, POMU, VAPA - moderate	GASH, POMU, VAPA - high	GASH, POMU, VAPA - moderate to high

[1]Conceptual pathways developed from projections based on inventory data (USDA 1987 Vegetation Resource Survey and 1984 Ecoplot Intensive Survey, Hemstrom and Logan 1986 - Siuslaw National Forest) for stands in the late-seral stage, and field observations.
[2]Disturbance regimes are described in Chapter II (see *Disturbance Regime Blocks*).
[3]Includes the Sitka spruce/salal and salmonberry-salal plant associations (Hemstrom and Logan 1986).
[4]Dominant overstory species codes: PSME = Douglas-fir, PISI = Sitka spruce, TSHE = western hemlock, ALRU = red alder, and THPL = western redcedar.
[5]The majority of the red alder (ALRU) would likely have fallen out of the stand by age 100.
[6]Canopy cover classes: high = more than 70%, moderate = 30 to 70%, and low = less than 30%.
[7]Dominant understory species codes: GASH = salal, POMU = swordfern, and VAPA = red huckleberry. Other common associated species include vine maple and salmonberry (Sitka spruce/salmonberry-salal plant association), and fool's huckleberry (Hemstrom and Logan 1986).

3. Grand Fir Series

The grand fir series within this assessment area has not been extensively studied. A joint BLM (Steve Garza and Nancy Wogen) and Forest Service (Cindy McCain and Barb Raible) study will provide us with additional information regarding the occurrence of this series and its successional pathways. Grand fir can occur from sea level to 6,000 feet on a variety of landforms and soils. It can grow in many plant communities, on fair to very good forest sites, and in association with nearly all tree species found in the Pacific Northwest. Within the assessment area, the grand fir environment typically occurs at elevations at or below 1,000 feet along the eastern slopes of the Coast Range in or near the Valley Margin Zone (Map 5), and at higher elevations on drier sites. Annual precipitation is approximately 50 inches, decreasing eastward as one nears the Willamette Valley floor. Grand fir can act as both a climax and early-seral species, ranging from a late colonizer of dry forest sites to a pioneer on recently burned sites. In places where low intensity ground fires have been excluded, grand fir was found to invade rapidly, indicating it is the destined climax species (Antos and Shearer 1980).

Fire is a common disturbance in the grand fir zone. Fires have a variable severity ranging from low intensity ground fires to high intensity crown fires. After a disturbance such as a ground fire, the successional pathway would start with the establishment of grasses, small herbs, swordfern, salal, common snowberry, and vine maple as the ground cover in the pioneer through early-seral stages. Douglas-fir and co-dominant hardwoods such as big leaf maple, Oregon ash, hazelnut, and Oregon white oak will reproduce and comprise most of the understory tree component. As the canopy begins to close, scattered amounts of shade tolerant grand fir regeneration begins to emerge in increasing density. The ground cover will become less dense as the canopy begins to close due to less light reaching the forest floor. In a major disturbance such as a crown fire, the successional pathway would be similar. Initially, conifer and hardwood regeneration will be scattered due to a higher competition from ground cover and fewer live residual trees as a seed source. As the same conifer and hardwood species regenerate and become established over time, and the canopy begins to close, the shade tolerant grand fir would become established in the understory. In both scenarios, as the forest matures, the canopy would be co-dominated by Douglas fir, Oregon white oak, and bigleaf maple. As the forest reaches its climax stage, grand fir or possibly grand fir in combination with Douglas-fir would become the dominant overstory. Eventually, deteriorating Douglas-fir and hardwoods will occupy various strata within the stand and coarse woody debris would become scattered throughout the forest in the late-seral stage.

4. Noble Fir/Pacific Silver Fir Series

The noble fir/Pacific silver fir environment occurs at elevations greater than 2,500 feet in the Northern Coast Range AMA. Communities in which noble fir/Pacific silver fir are major climax components occur sporadically in high rainfall areas (greater than 80 inches), typically on mountain tops and north to northeast slopes in the northern Oregon Coast Range. Noble fir is classified as shade intolerant and is incapable of establishing itself under a closed forest canopy. In natural stands, noble fir is subject to replacement by its very shade tolerant

associates, Pacific silver fir and western hemlock. An anomaly in this area is a frequent occurrence of stands of noble fir at the highest elevations of the Oregon Coast Range from which Pacific silver fir is absent (Packee, et al. 1981). Primary locations in which these species are found include Saddleback Mountain, Fanno Ridge, Bald Mountain, Trask Mountain, and Mt. Hebo.

The typical successional pathway after a major disturbance, would start with the immediate establishment of a variety of herbaceous vegetation. Vine maple and Pacific rhododendron would soon follow. Shortly after establishment of ground cover, Douglas-fir and noble fir seedlings would become established. Western hemlock may be established simultaneously or develop later under a forest canopy. Pacific silver fir usually is last to invade the site, coming in under the mixed canopy of Douglas-fir, noble fir and western hemlock. Once the Pacific silver fir reaches the upper canopy, it often outgrows the western hemlock and becomes taller after 100 years. Noble fir usually maintains a height advantage over Pacific silver fir wherever they occur together (Packee, et al. 1981). The understory can be characterized as mostly open, with the dominant shrub species consisting of vine maple and Pacific rhododendron. Conifer seedlings generally experience little competition from hardwoods and shrubs in these plant communities. Due to the locations in which these stands occur, they are often subject to small scale disturbances such as wind, and snow and ice storms. At each occurrence of these small scale disturbances course woody debris would become common and scattered throughout the stand. As the stand matures, so will its complexity. Deteriorating conifers will occupy various strata within the stand, with shade tolerant Pacific silver fir and western hemlock seedlings continually establishing themselves in the disturbed areas.

5. Management Implications Of Successional Pathways

Use of successional pathways in evaluating proposed management activities requires knowledge of the physical environment (soil/climate zone, landform and slope position), the biological environment (series and sub-series environments), and where the stand is in its successional development. This information should be used in conjunction with other information and concerns (Aquatic Conservation Strategy concerns, LSR management objectives, wildlife habitat distribution, etc.) to determine the appropriateness of a proposed management activity or the outcome of a recently implemented management activity. There may be instances when the dominant vegetation development pathways are by-passed to create conditions desired for specific purposes. For example, a wet environment in the western hemlock series densely stocked with conifer would be an uncommon site condition for mature stands in that environment. However, many planted stands in that environment are densely stocked with conifers and, due to a severe deficit of large woody structure in the streams in this assessment area, it is often desirable to grow large trees which can be placed in the stream, enhancing fish habitat.

Specific prescriptions for management activities should consider which structure and compositional elements are possible and appropriate for a given site, as specific management objectives may be more easily accomplished in one environment than in another. Table 13 highlights some of the key components of late-successional forest habitat and evaluates the

potential for a given environment to be able to support that component (or management objective). Comparison of these potentials will assist managers in determining which activities will best meet their objectives. These conditions are not absolutes, but occur over a continuum throughout the various environments because of microsite conditions.

Table 13. Potential for Sub-Series Environments to Meet Key Structural Components When Considering Dominant Natural Successional Pathways.

Management Objectives	Western Hemlock Sub-Series Environments		
	Wet	Moist	Dry
Grow large trees	H	H	M
Establish multi-layered canopy of conifer	M	H	M-L
Establish multi-layered canopy of conifer & hardwoods	H	M	L
Recruit large diameter snags & large woody debris	H	H	M-L
Maintain high stocking (high stand density)	L	H	M
Provide coarse woody debris for aquatic structures	H	H	L
Provide variable spacing (gaps, clumpiness)	H	H	M
Develop/maintain wind firmness	M	H	M

Management Objectives	Sitka Spruce Sub-Series Environments		
	Wet	Moist	Dry
Grow large trees	H	H	M
Establish multi-layered canopy of conifer	M	H	M
Establish multi-layered canopy of conifer & hardwoods	H	H	L
Recruit large diameter snags & large woody debris	H	H	M
Maintain high stocking (high stand density)	L	H	M
Provide coarse woody debris for aquatic structures	H	H	M-L
Provide variable spacing (gaps, clumpiness)	H	H	M
Develop/maintain wind firmness	M-L	M	M-L

H=High probability M=Moderate probability L=Low probability

In the **Western Hemlock Zone:**

The "wet" environment has the highest potential for:

- supporting a low to moderate density of conifers with high spacing variability (due to competitive nature of shrubs).
- developing a canopy composed of a variety of species in each layer, with a large component of hardwood species and shade tolerant conifers (western hemlock and western redcedar).
- being a place to grow the largest trees (but not many of them), with some trees having large, heavy limbs on the lower bole of the tree ("wolfy" trees).
- being a good place to recruit those few large trees for future aquatic structure.

The "moist" environment has the potential for:

- developing an overstory which will have a high density of conifers and variable spacing.
- developing a multiple species, conifer canopy, with some hardwood component mixed in.
- being a place to grow and recruit a quantity of large diameter snags and coarse woody debris both on site and for aquatic structure.

The "dry" environment would support different structural characteristics. It has the potential for:

- developing an overstory with moderate densities. Spacing could be less variable, however, harsh sites with shallow soils and fine scale disturbances may result in variably spaced trees with gaps.
- developing wolfy limbed trees, due to either fine scale disturbances (wind or disease) or harsh site conditions.
- supporting a mix of shade tolerant (western hemlock and western redcedar) and shade intolerant (Douglas-fir) species in lower canopy layers. There would be few hardwoods in the canopy.

In the **Sitka Spruce Zone**:

The "wet" environment has the highest potential for:

- supporting the lowest density of conifers with highly variable spacing (due to competitive nature of shrubs).
- developing a canopy composed of a variety of species in each layer, with a large component of hardwood species and a relatively even mix of shade tolerant (western hemlock and Sitka spruce) and intolerant (Douglas-fir) species in the lower canopy layers, becoming established in openings and on nurse logs.
- being a place to grow the largest trees (but not many of them). Many would be wolfy.
- being a good place to recruit those few large trees for future aquatic structure.

The "moist" environment has the potential for:

- developing an overstory with a relatively high density of conifers at variable spacings.
- developing a multiple species overstory canopy composed mainly of conifers (western hemlock and Sitka spruce) with some hardwood component.
- being a place to grow and recruit a quantity of large diameter snags and coarse woody debris both on site and for aquatic structure.

The "dry" environment has the potential for:

- developing an overstory with moderate densities. Spacing could be less variable, however, harsh sites with shallow soils and fine scale disturbances may result in variably spaced trees with gaps.
- developing trees with wolfy limbs, due to either fine scale disturbances (wind or disease) or harsh site conditions.
- supporting a mix of shade tolerant (western hemlock and western redcedar) and shade intolerant (Douglas-fir) species in lower canopy layers. There would likely be a hardwood component in the overstory canopy.

In ALL environments in ALL vegetation zones management activities should strive to:

- maintain health and vigor of the plant communities.
- encourage natural diversity of plant species in all layers.
- maintain existing late-successional structural components (e.g., large trees, wolfy limbs, large logs on the ground, snags).
- recruit snags and large, down logs.
- encourage development of in-stand vertical and horizontal diversity.

The noble fir and Pacific silver fir series is a unique environment not discussed in depth here. Management objectives in this environment should encourage increasing biodiversity by re-establishing those species at higher elevations.

B. LATE-SUCCESSIONAL STRUCTURAL AND COMPOSITIONAL CHARACTERISTICS

The structure of natural coastal forests is extremely diverse because of numerous processes operating at different spatial and temporal scales. Stand development and succession are important processes that determine forest habitat. Differences in forest structure should be viewed on a continuum rather than in discrete classes (Franklin and Spies 1991). No one condition is appropriate across the landscape. Knowledge of late-successional structural and compositional characteristics is key in identifying the desired future conditions to strive for in management activities. The mature and old-growth conditions descr bed in this section of the document are provided as the best available information for th s assessment are and are recommended as the desired future condition.

1. Differences in Forest Structure Between Stands of Different Ages

Late-successional forest function may be influenced by the changes which occur in vegetation structure and composition at different ages of development (Franklin and Spies 1991). The condition of existing late-seral forests within this assessment area provides a reference point to compare younger stands against when assessing their capability of achieving desired future conditions. Additionally, it is important to recognize that managed stands develop quite differently from natural stands. Since the majority of the late-seral stands currently present in the assessment area are 80 to 120 years old (USDA 1995 and Teensma, et al. 1991), there is sufficient local information available to characterize the mature condition only. There is limited information available for the old-growth condition of late-successional forests in the Coast Range. Recent (1996) photo interpretation of vegetation for the Drift-Siletz watershed analysis shows that approximately four percent of that landscape is in the old-growth condition.

Tree density (trees per acre), mean stand diameter at breast height, and basal area are most important in discriminating among age classes. Tree density is about twice as high in young, natural stands as it is in stands in the mature and old-growth conditions. Basal area increases

with age class, and mean tree diameter is highest in mature stands which lack the smaller diameter shade tolerant trees common in old growth (Franklin and Spies 1991).
Stand condition is influenced by the age of the stand. Percentages of snags with natural cavities, percentage of Douglas-fir boles with resinosis, and percent of tree crowns with broken tops are higher in old growth than in the younger age classes (Franklin and Spies 1991). The understory cover of herbaceous vegetation and deciduous shrubs increases with stand age class. Density of shade tolerant saplings is highest in old growth, lowest in mature stands, and intermediate in young stands (Franklin and Spies 1991).

General character stics of old-growth forests that differ from mature include: co-dominance of shade tolerant species such as western hemlock in the overstory, diverse vertical distribution of vegetation, multi-layered tree canopies, numerous gaps in the overstory canopy, large amounts of CWD, and many large trees, some with broken or deformed tops.

2. Mature Forest Structural Characteristics

The description of stand conditions in Table 14 is expressed in terms of trees, logs or snags per acre by species and size class for live trees, and by size class for snags and down logs. Data is based on plot information from the Siuslaw National Forest Vegetation Resource Survey (USDA 1987) and the 1984 Siuslaw Ecology Intensive Survey (Hemstrom and Logan 1986). These surveys focused on sampling late-seral stands on the Siuslaw National Forest. The information in Table 14 was based solely on plots from the Hebo Ranger District and, given the limited occurrence of old growth on this district, the data this table best represents the mature condition on the western half of the assessment area.

Since the structural and compositional data in Table 14 represents the averages of stands in the mature condition, management activities should not target it as an average stand condition. It does, however, provide a reasonable representation of the differences in species and trees per acre by sub-series environments. This information is appropriate within the Siuslaw National Forest boundaries in the assessment area. On lands in the eastern portion of the assessment area stand structural and compositional components are anticipated to be significantly different. Identification and mapping of sub-series environments on these lands are currently in progress, and data from these inventories should be utilized when it becomes available.

The following statistically significant trends (analysis of variance at the 10% level) have been interpreted from the information in Table 14:

In the Western Hemlock series:

- total live trees per acre increase significantly from wet to moist environments, and from dry to moist environments.
- the number of Douglas-fir trees per acre increases significantly from wet to moist and dry environments.
- the amount of red alder increases significantly going from dry to wet environments.

Western hemlock and western redcedar were found in all western hemlock environments.

In the Sitka Spruce series:

- the total number of live trees per acre decreases significantly from moist to dry environments, and from dry to wet environments.
- the amount of Douglas-fir in the moist environments was significantly lower than the amount of Douglas-fir in the dry and wet environments.

Western hemlock is a common co-dominant component in all Sitka spruce environments, much more common than western redcedar.

The variability in snag and down log components across all environments was not statistically significant at the ten percent level. It is important to note that snags, down logs and many of the trends identified above may be influenced by fine scale differences in disturbances and environments. For example, dry environments may experience more within-stand wind and disease related events than the other environments.

Table 14. Structure and Composition of the Mature Condition of Late-Successional Stands by Sub-Series Environments (information is expressed in numbers of trees, logs or snags per acre; all data was rounded to the nearest whole number)

	Western Hemlock - Dry (18 plots)					Western Hemlock - Moist (21 plots)					Western Hemlock - Wet (36 plots)				
Species	Small	Medium	Large	Giant	Total	Small	Medium	Large	Giant	Total	Small	Medium	Large	Giant	Total
Bigleaf maple											1	<1			1
Douglas-fir	20	25	6	<1	51	28	23	6	<1	58	9	10	6	<1	25
Red alder	2	<1			2	7	1			9	13	2			15
Sitka spruce		<1	<1		<1	1	<1	0	<1	1	2	1	<1	<1	2
Western hemlock	19	10	2.2	<1	31	25	11	2	<1	37	23	11	3	<1	36
Western redcedar	4		<1	<1	4	4	<1	<1	<1	4	5	1	<1	<1	6
Total Live Trees	45	36	8	1	89	64	36	9	1	109	53	24	9	1	86
Hard conifer snags	15	2	1	<1	17	14	2	<1	<1	16	4	1	<1	<1	6
Soft conifer snags	2	2	3	1	8	3	3	2	1	8	1	1	1	1	3
Hard log	23	6	1		30	14	2	1	<1	18	10	2	1	<1	13
Soft log	5	2	2	1	10	7	5	5	1	18	3	6	2	1	11
	Sitka Spruce - Dry (13 plots)					Sitka Spruce - Moist (39 plots)					Sitka Spruce - Wet (33 plots)				
Douglas-fir	8	13	10	<1	31	3	6	3	<1	11	9	5	5	<1	20
Red alder	11	1	<1		13	8	1	<1		8	8	2	<1		10
Sitka spruce	6	7	3	<1	16	8	11	9	2	29	3	3	4	2	11
Western hemlock	19	6	2		27	33	17	4	<1	53	12	7	3	<1	22
Western redcedar	1	1	<1		2	<1				<1	2	<1	<1	<1	3
Total Live Trees	46	28	16	<1	89	51	34	15	2	102	34	16	12	2	64
Hard conifer snags	4	1	<1	<1	5	9	2	1	<1	12	5	1	1	<1	7
Soft conifer snags	1	2	3	1	6	1	1	2	1	5	1	1	2	1	4
Hard log	6	2	<1		9	12	4	2	<1	18	8	3	3	1	16
Soft log	4	2	3	1	9	8	4	5	1	18	3	5	2	1	11

Size classes:
Small = 9.0 to 20.9 inches diameter at breast height (dbh)
Medium = 21.0 to 31.9 inches dbh
Large = 32.0 to 47.9 inches dbh
Giant = 48.0+ inches dbh

Data Sources: 1987 Vegetation Resource Survey - 109 plots
1984 Siuslaw Ecoplot Intensive Survey - 51 plots

Snags= dead standing conifers 10 feet tall or taller, with dbh in the above size classes.
Hard snags = snags in decay classes I, II and III (Cline 1977) Soft snags = snags in decay classes IV and V (Cline 1977)

Logs= pieces greater than 20 feet long, having the large end of the log in the above size classes.
Hard logs = logs in decay classes I, II and III (Fogel, Ogawa and Trappe 1973) Soft logs = logs in decay classes IV and V (Fogel 1973)

3. Old-Growth Forest Structural Characteristics

The following information is based on a study by Franklin and Spies (1991) conducted in the Oregon Coast Range south of Newport. Basal area of shade tolerant tree species is an important characteristic of old-growth forests. In general, moist sites have higher basal areas of shade tolerant species than do moderate or dry sites. Density of large diameter Douglas-fir decreases with increasing moisture in the Coast Range, while density of sub-canopy trees generally decreases with increasing site moisture, probably as a result of increasing basal area of shade tolerant trees in the upper canopy which create low light conditions unfavorable to understory trees. Franklin and Spies data (Table 15) outlines significant structural and compositional characteristics by moisture classes. These moisture classes are similar to the sub-series environments identified earlier in this document.

Table 15. Some Structural Components of Stands in the Old-Growth Condition in the Oregon Coast Range by Moisture Classes (Spies and Franklin 1991), shown by mean and range[1] (in parenthesis).

STRUCTURAL COMPONENT	DRY[2]	MODERATE[2]	MOIST[2]
TOTAL basal area of all trees (square feet/acre)	283.1 (200.4 - 405.1)	304.9 (222.2 - 418.2)	313.6 (196.0 - 500.9)
Basal area of shade tolerant species, e.g., hemlock and redcedar (ft^2/acre)	9.6 (0 - 47.5)	69.7 (26.1 - 139.4)	135.0 (43.6 - 274.4)
Number of Douglas-fir trees larger than 40 inches dbh (trees/acre)	12 (4 - 23)	10 (4 - 19)	7 (1 - 10)
Total number of trees larger than 40 inches dbh (trees/acre)	12 (4 - 23)	11 (4 - 21)	10 (2 - 25)
Total number of sub-canopy trees (trees/acre)	17 (0 - 59)	21 (2 - 61)	0

1. The range portrayed here represents the mean, plus or minus one standard deviation (95% confidence limit).
2. 45 plots were sampled in each moisture class.

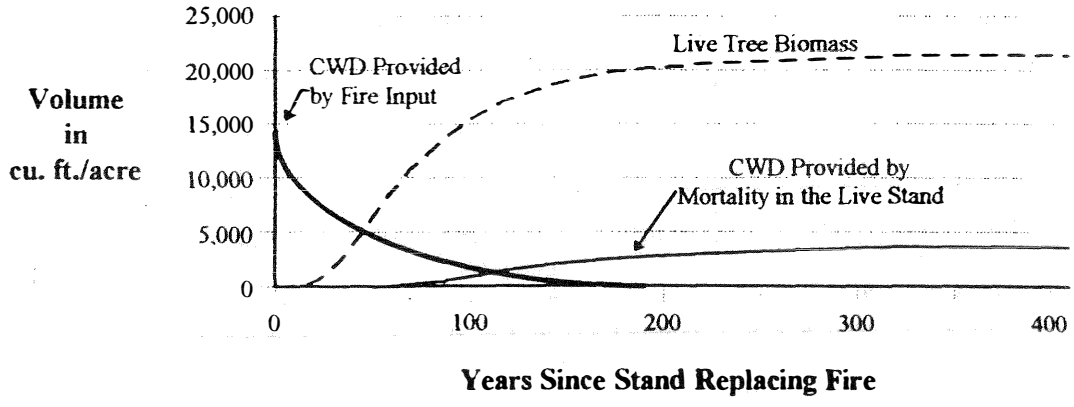
Franklin and Spies (1991) also found that some stand conditions (such as quantity and quality of snags, cavities, and live trees with broken tops) in the Coast Range did not seem to vary by moisture class.

4. Coarse Woody Debris (CWD)

Distribution of CWD through Space and Time

Many late-successional structural and compositional elements develop by the time a stand is 100 to 150 years old. However, large accumulations of Coarse Woody Debris (CWD), including both snags and down logs, take a long time to develop naturally after a stand replacing disturbance. Due to rapid decomposition rates in the Coast Range most of the CWD from the previous stand is not detectable 100 to 150 years after it reaches the forest floor (Wright 1997). Additionally, at 100 to 150 years CWD accumulations are just beginning to increase as large trees begin to die (Spies and Cline 1988). This results in CWD levels operating on a different cycle than live tree biomass. CWD levels are actually highest early in succession and lowest in mid-seral stands. Figure 2 displays the general cycle of CWD over time for a single disturbance event.

Figure 2. Coarse Woody Debris Cycle Following a Stand Replacing Disturbance



Levels of CWD in this assessment area are even lower than the levels depicted in Figure 2 for several reasons:

1) Much of the assessment area has burned in multiple fires within a relatively short period of time (less than 50 years between fires). Subsequent fires generally burned up the logs and snags created by the initial fire and the newly burned, young trees are not large enough to contribute substantial amounts of CWD.
2) In the early 1900s, most of the large logs and snags created by wildfires were salvaged (removed and sold as commercial timber).
3) Many of the natural 80 to 120 year old stands which would have started to contribute large CWD were harvested in the past 50 years. In commercially thinned stands, most of the suppressed trees (which would have provided CWD as they died) have been removed,

snags have been felled for safety concerns, and some of the down wood has been harvested. In clearcuts most of the live trees have been salvaged or removed as firewood. Some of the CWD was removed from the site during harvest and post harvest treatments (i.e., slash burning). Spies and Cline (1988) observed that at least six times more CWD carries over after wildfire in old-growth systems than after logging in old-growth; in addition, the CWD left after logging is smaller and decays faster. Young managed stands will not provide high levels of CWD for at least 150 years after harvest (Wright 1997).

Tables 16 and 17 display the results of two recent surveys of CWD in plantations on the Siuslaw National Forest. Table 16 represents the levels of down wood at the time of final harvest. This information was collected for a fuels inventory by Peterson and Barnes (1987) and compared to previous fuels data inventories. It shows that the majority of material is in the nine inch to over twenty inch size classes. The smaller material is consumed by slash burning at a higher rate than the larger size classes. On the average 2,901 cubic feet per acre remain after harvest and 1,487 cubic feet per acre remain after slash burning.

Table 16. Down Wood Conditions Following Clearcut Harvest 1980 to 1990[1]

Site Condition	CWD Levels by Size Class (in cubic feet/acre)			
	3" to 9"	9" to 20"	Over 20"	Total Over 3"
Before Slash Burning	801	1,082	1,018	2,901
After Slash Burning[2]	81	541	865	1,487

1. Peterson, J.L. and D.A. Barnes (1986-1987). Comparison of biomass characteristics on clearcut units on the Siuslaw National Forest with other western Washington and Oregon sites.
2. Post burn consumption based on professional judgment of worst case scenario. Assumed 3" to 9" material 90 percent consumed, 9" to 20" material 50 percent consumed, and over 20" material 15 percent consumed.

Table 17 displays down log information collected during stand exams for plantations on the Siuslaw National Forest. This information is within the ranges reported by BLM, Salem and Coos Bay Districts, where stand exam information for 40 year old plantations which show down log quantities mostly in the larger diameter classes with an average of 3,085 cubic feet per acre, ranging from 1,831 to 4,083 cubic feet per acre. Values shown in Table 17 indicate the average and one standard deviation in parentheses, which represents the range of the population. The variability is readily apparent. In the early successional plantations, most of the down wood volume is in the soft log class, decay classes III through V. This is consistent with information presented by other researchers (Spies and Cline 1988). Depending on the plantation age, the average down wood volume ranges from 3,010 to 3,409 cubic feet per acre Log lengths were also surveyed. On the average, 51 percent of the down logs inventoried were greater than twenty feet in length, ranging from 29 to 61 percent of the logs being greater than twenty feet in length.

Table 17. Existing Down Log Volumes (Range in Parenthesis) in Plantations on the Hebo Ranger District

Plantation Age	Average Hard Log Volume (in cubic feet/acre)	Average Soft Log Volume (in cubic feet/acre)	TOTAL Log Volume (in cubic feet/acre)
11 to 24 years old	630 (0 to 2,094)	2,423 (0 to 5,049)	3,010 (0 to 6,084)
25 to 49 years old	413 (0 to 1,346)	2,956 (0 to 7,216)	3,409 (0 to 7,787)

1. The range portrayed here represents the mean, plus or minus one standard deviation (95% confidence limit).

The CWD created by a single stand replacing event and then "lost" because of subsequent fire or timber harvest, is referred to as the "**lost legacy**". With most late-seral stands being in the mature condition, CWD in this assessment area is already at the low end of its natural range. Additionally, much of the assessment area has been impacted by repeated burning (Tillamook Burn and Nestucca/Mt. Hebo Fires). Because the levels of CWD are generally low over much of the assessment area, this lost legacy cannot be readily replaced. Since CWD is critical to the development of late-successional habitat, it is recommended that watershed analysis and site specific project plans identify the areas impacted by this lost legacy. Silvicultural treatments in these areas should focus on the development of large trees and the creation of CWD, balancing the need for CWD with the need to accelerate the attainment of other late-successional habitat characteristics and the risks from insects and fire.

The July, 1996, Regional Ecosystem Office Review Exemption Criteria (Appendix I) states: "Within the limits dictated by acceptable fire risk, CWD objectives should be based on research that shows optimum levels of habitat for late-successional forest-related species and not be based simply on measurements within natural stands." The optimum levels of snags and down logs needed to sustain late-seral species have not been determined. Most studies have focused on natural stands, identifying the levels of CWD which exist and currently sustain populations of late-seral species. The best available information on late-seral levels of CWD in this assessment area comes from three studies - Spies and Cline (1988), Spies and Franklin (1991), and a Master's thesis in progress by Wright (1997). The Spies and Cline (1988) data and the Spies and Franklin (1991) data were collected from the same plots on sites south of Newport in the Oregon Coast Range. For CWD levels in stands less than 80 years old, the data is extremely variable. This may be because the 1988 and 1991 studies sampled stands which included areas burned two to four times since the mid 1800s, while the Wright data presented in this chapter focuses on natural stands which are likely to have experienced a single disturbance event. However, in all three studies, the CWD levels for late-seral stands are comparable and have been developed into recommendations for this assessment area.

Current CWD Levels

The level of CWD may correlate more closely with disturbance events than with sub-series environments. Because natural disturbances typically do not destroy much of the debris biomass in large pieces of wood, large snags and logs are present in most natural stands of all ages. In addition, CWD is unevenly distributed in the forest; the amount of CWD may vary tenfold between closely adjacent areas and more than half of the CWD may occur on less than one fifth of the total area (Spies and Cline 1988). As shown in Table 18, stand age affects the size and amount of CWD.

Table 18. Current Mean (Range in Parenthesis) Numbers of Snags and Down Logs in the Oregon Coast Range by Stand Age (Spies and Cline 1988)

AGE OF STAND	[1] SNAGS PER ACRE (mean # of snags per acre)			[2] DOWN LOGS PER ACRE (mean # of *logs per acre*)			
	All sizes	>20"	>20" and >16 feet tall	<12" diameter	12" to 24" diameter	>24" diameter	Total #, all sizes
Young (<80 years)	48 (26 to 70)	7 (3 to 11)	2 (0 to 4)	70 (39 to 101)	39 (23 to 55)	7 (3 to 11)	117 (84 to 150)
Mature (80-199 yrs.)	53 (1 to 105)	7 (0 to 14)	3 (0 to 7)	130 (39 to 221)	41 (6 to 76)	10 (0 to 24)	182 (70 to 294)
Old-growth (>199 years)	17 (14 to 20)	7 (4 to 10)	4 (2 to 6)	69 (29 to 109)	45 (39 to 81)	15 (7 to 23)	128 (64 to 192)

1. Includes all decay classes and snags over four inches in diameter and four inches tall
2. Includes all decay classes and no minimum length.

Current Snag Levels Table 19 displays the mean and range (plus or minus one standard deviation) of snag levels found in natural stands in the Oregon Coast Range. At this time, it is the best available information on existing snag levels. The values for "all heights" represent all snags greater than four inches in diameter and greater than four inches tall. The cubic feet/acre values from the Wright Model recently prepared for the Siuslaw National Forest (Wright 1997) are also displayed. Within natural stands at any age, between 40 and 60 percent of the coarse woody debris component is snags (Spies and Cline 1988). Based on this information, the values in Table 19 from the Wright Model represent half of the CWD component. The other half of the CWD component volume is displayed as down logs in Table 20.

Wright's model suggests that the mean range for snags (half of the CWD component from her model) in young natural stands 30 to 50 years old would be 3794 cubic feet/acre. Evaluation of recent Managed Stand Survey data from 50 managed stands on the Siuslaw National Forest showed that plantations seventeen to 50 years of age had an average of six snags per acre, with a range from zero to 40 snags per acre. No snags were found on half of the plots and only three plots recorded a snag greater than twenty inches at dbh. Most snags are less than the average stand diameter, indicating suppression mortality.

Table 19. Current of Number and Volume of Snags in Natural Stands in the Oregon Coast Range, shown by mean and range[1] (in parenthesis).

Stand Age	Spies and Franklin (1991)				[2] Wright (1997)
	Total # of Snags/Acre > or = 20" dbh (all heights)	Total # of Snags/Acre > or = 20" dbh **AND** > 16 feet tall	Total # of Snags/Acre <20" dbh (all heights)	Cubic Feet/Acre of All Snags[3]	Cubic Feet/Acre of All Snags[3]
[4] Young (<80 years)	7 (3 to 11)	2 (0 to 4)	48 (26 to 70)	1230 (615 to 1845)	3794 (2844 to 4839)
Mature (80-199 yrs)	7 (0 to 14)	3 (0 to 7)	53 (1 to 105)	1488 (200 to 2775)	1644 (1603 to 1686)
Old Growth (>199 yrs.)	7 (4 to 10)	4 (2 to 6)	17 (14 to 20)	2117 (229 to 4006)	1906 (1867 to 1946)

1. The range portrayed here represents the mean, plus or min s one standard deviation (95% confidence limit).
2. Wright's (1997) recently developed model suggests that the mean range for CWD in 30 to 50 year old natural stands would be 265 cubic meters/hectar or 3794 cubic feet/acre. These values represent what would be expected following a single fire event in the Central Interior Soil/Climate Zone. Values for the North Interior Zone were not significantly different. Values for the Coastal Fog Zone were higher in the old-growth condition and need further study before applying them. Note: values displayed are half of the act al values modeled, since modeled values included both snags and down logs which are found in approximately equal proportions in Oregon Coast Range stands (Spies and Cline 1988).
3. Snags include all dead standing trees four inches in diameter and larger and four inches tall and taller.
4. Knowledge of the types of stands where Spies' and Franklin's data (1991) was collected suggests that these values and ranges may be on the low end of the range of conditions for the levels of snags found in the Oregon Coast Range. The young, natural stands (less than 80 years of age) which they sampled are likely to have included stands which experienced multiple fires (two to four) since the mid 1800s. Under this type of disturbance, the levels of snags would be much lower than snag levels in stands which experienced only a single stand replacement disturbance.

Current Levels of Down Wood Table 20 displays the mean and range (plus or minus one standard deviation) of down wood that could be expected in the Oregon Coast Range under natural conditions. The amount of down wood found in young natural stands less than 80 years old ranges from 525 to 4839 cubic feet/acre. Mature forests have lower volumes of down wood than are found in old growth. A high proportion of the down wood in stands less than 80 years old is concentrated in decay classes III, IV and V. Mature stands tend to have down wood distributed in decay classes II through V. Down wood in old-growth stands tends to be concentrated in decay classes II and III (Franklin, Spies and Thomas 1988).

Table 20. Current Down Wood Volumes and Percent of Ground Covered in Natural Stands of the Oregon Coast Range (Spies and Cline 1988), shown by mean and range[1] (in parenthesis).

Stand Age	[2]Spies and Cline, 1988		Wright Model, 1997
	[3]Cubic Feet/Acre	[4]Percent of Ground Covered	[5]Cubic Feet/Acre
[6]Young (<80 years)	1102 (525 to 1979)[5]	3.8% (2.5% to 5.1%)	3794 (2844 to 4839)
Mature (80 to 199 years)	1731 (300 to 3162)	5.2% (1.6% to 8.8%)	1644 (1603 to 1686
Old Growth (>199 years)	3262 (1382 to 5141)	6.2% (3.5% to 8.9%)	1906 (1867 to 1946)

1. The range portrayed here represents the mean, plus or minus one standard deviation (95% confidence limit).
2. Spies' and Cline's data (1988) includes all decay classes, to a four inch minimum log diameter.
3. Spies' and Cline's data was reported in cubic meters/hectar; the following conversion formula was used for this table: cubic meters/hectar X 14.306 = cubic feet/acre
4. The Oregon Coast Range had the lowest percent cover of any Pacific Northwest ecosystem assessed. Percent cover is an expression of projected horizontal area covered by down wood. It is calculated from log length and diameter.
5. Wright's (1997) recently completed modeling suggests that the mean range for CWD in 30 to 50 year old natural stands would be 265 cubic meters/hectar or 3794 cubic feet/acre. These values represent what would be expected following a single fire event in the Central Interior Soil/climate Zone. Values for the North Interior and the Coastal Fog Zones were not significantly different. Note: values displayed are half of the actual values modeled, since modeled values included both snags and down logs which are found in approximately equal proportions in Oregon Coast Range stands (Spies and Cline 1988).
6. Knowledge of the types of stands where Spies' and Cline's data (1988) was collected suggests that these values and ranges may be on the low end of the range of conditions for the levels of down wood found in the Oregon Coast Range. The young, natural stands (less than 80 years of age) which they sampled are likely to have included stands which experienced multiple fires (two to four) since the mid 1800s. Under this type of disturbance, the levels of down wood would be much lower than down wood levels in stands which experienced only a single stand replacement disturbance.