II. ASSESSMENT AREA HISTORY AND CHARACTERIZATION OF CURRENT CONDITIONS

A. HISTORIC AND CURRENT LAND USES

Additional information regarding historic and current land uses within the assessment area is available in the Social Assessment of the Northern Coast Range AMA (Wong-Leonard 1997).

1. Settlement Patterns

Before the first European explorations into the Pacific Northwest in the 1700s, American Indians occupied the coastal and interior valleys of western Oregon. The Kalapuya established a subsistence pattern extending westward from the Willamette Valley up to Mt. Hebo (Honey, et al. 1981). They were adept at using fire on a large scale for maintaining hunting and gathering areas in the Willamette Valley (Beckham, et al. 1982, Boyd 1986, and Zyback 1988). Along the coast, the Tillamooks used the coastal lowlands and river valleys of the Coast Range. They set small fires, usually one half to one acre in size (rarely over about three acres), to maintain hunting and gathering areas (personal conversation with C. Adams, Tribal Forester, and M. D. Mason, Tribal Attorney, 1994). The Kalapuya and Tillamooks traveled long, established trails through the Coast Range to trade with each other (Beckham 1975; Honey, et al. 1981). Some descendants of the Kalapuya and the Tillamooks are now members of the Confederated Tribes of Siletz Indians of Oregon and the Confederated Tribes of the Grand Ronde Community of Oregon.

In 1842, the first large group of immigrants (more than 100 people) arrived in Oregon. By 1843 over 1,000 settlers had arrived, and many of them settled in Yamhill County. The Donation Land Act of 1850 and the Homestead Act of 1862 provided enough incentives that the coastal lowlands and river valleys of the Coast Range were quickly settled by immigrants. More than 90 percent of the farms were established within the grasslands of the Willamette Valley and the Coast Range river valleys. Others settled in oak openings and other sparsely timbered areas which were easily cleared for cultivation. The remainder of the claims were associated with logging operations or water driven mills located on the river banks. As immigrants continued to pour into Northwestern Oregon between 1870 and 1900, the lower forested areas were claimed for farms and cleared to increase pasture and control brush. At that time, fire was one of the most effective means utilized by the settlers to clear the land (see fire disturbance discussion later in this chapter).

As the demand for lumber increased, many settlers in the more heavily forested areas of the Coast Range relinquished their homesteads to timber companies. Large tracts of land that were too remote for logging or homesteading and homesteads that never "proved-up" were incorporated into the National Forest System. Around the turn of the century, much of the land within twenty miles of the coast had been burned repeatedly and early surveyor's notes identified it as "brushfields." Tracts which were not being homesteaded became what we now know as the Hebo Ranger District of the Siuslaw National Forest.

In 1866, Congress granted all odd numbered sections of land thirty miles on each side of the railroad right-of-way to the Oregon and California Railroad Company. When the stipulations of the grant were violated, Congress litigated to have the lands revested to the United States government. Currently, these lands are predominately managed by the Bureau of Land Management, with some smaller tracts managed by the Forest Service.

2. Logging

As the homesteaders and settlers began clearing the land, the lower valleys were the first areas impacted by timber harvest and transportation routes. Splash dams were commonly used to transport logs down waterways to mills. In the late 1800s, railroads became an important means of transporting both people and logs. After damages inflicted by the 1933 Tillamook Burn to the railroad infrastructure, some of the major railroads operating on the fringes of the Coast Range went out of business. By the 1950s, previously inaccessible areas were accessible by an increased network of roads, and the use of steel spars for yarding enabled loggers to reach farther into the forest to harvest timber. In the 1970s, the timber industry and associated manufacturing industry reached its peak in the assessment area.

As existing stands of old-growth timber were depleted, large sawmills and plywood mills, which were major employers in the area, started to close. Today, logs are chipped or sawed in highly automated mills designed to process smaller diameter logs efficiently. More recently, the Northwest Forest Plan (USDA and USDI 1994b) established a new management direction for BLM and National Forest System lands, resulting in harvest at a much lower level than those during the 1970s and 1980s.

Today, in each of the four major counties (except Yamhill County) of this assessment area, employment in manufacturing has decreased. The phenomena is typified by the decline in forest industry employment, the major component of the region's manufacturing sector.

3. Agriculture

The narrow confines of the valleys and coastal plains naturally limited the degree of agricultural development in the assessment area. Agriculture, along with logging and fishing, provided the foundation for economic development. Today agriculture has not developed much beyond the original lands cleared by the first settlers. A significant dairy industry is located in and around the Tillamook area. Orchards, grass-seed fields, Christmas tree farms, and vineyards occupy the agricultural lands near the Willamette Valley. Small farms occupy the interior valleys. Residential areas are located in association with the agricultural lands.

4. Minerals

Rock quarries are scattered throughout the assessment area. They provide rock used in road surfacing and bank stabilization, and fill material for developing home and commercial lots. In the early 1980's, seismic oil and gas exploration was conducted throughout the area and large areas were leased through the oil and gas leasing program. Current records indicate that no further activity is planned. Based on geological formations it is believed that the assessment area has low potential for leasable minerals.

5. Recreation

Recreational uses include, but are not limited to, water play activities, canoeing, kayaking, drift boating, fishing, watching wildlife, hunting, horse-back and off-highway vehicle (OHV) riding, driving for pleasure, sightseeing, mountain biking, and hiking. As recreation demand increases groups are volunteering to develop and maintain additional trails. Current proposals include a horse-back riding trail on Mt. Hebo and OHV trails in the vicinity of the Upper Nestucca. The 1990 OHV proposal includes approximately 50 miles of trail, of which 23 miles have been approved and developed to date, and an additional 15 miles are currently being addressed in the Upper Nestucca Morotcycle Trails Environmental Assessment (BLM EA #OR-086-97-05, dated 6/25/97). This area's mild climate attracts tourist throughout most of the year, with heaviest visitation focused primarily on the coastal strip. Some recreational uses (i.e. hunting, berry picking) are strictly seasonal. Refer to the Salem District Resource Management Plan (USDI 1995) and the Siuslaw National Forest Land and Resource Management Plan (Siuslaw 1990) for additional details on proposed and existing recreation in the assessment area.

Scenery objectives tend to be compatible with LSR objectives. Large blocks of old growth, small patches of old growth, and even individual large, old trees are valuable for scenery. There are remnant old-growth trees in some developed recreation sites within the assessment area.

LSR and recreation objectives often conflict when road closures and obliterations restrict vehicle access.

6. Economic Values

Due to the highly productive forest which covers much of the assessment area, timber and a wide variety of other forest products are major contributors to the local economy. Other valuable forest products found in this assessment area include firewood, decorative ferns, grasses and boughs, Christmas trees, mushrooms, mosses, seedling transplants, bark, and burls. The economic stability of communities in the assessment area is also dependent on the agricultural industry, the commercial and sport fishing industry (supported by anadromous fish spawning and rearing habitat in the assessment area), and the recreation industry (supported by facilities such as campgrounds, visitor centers, and hiking trails).

B. PHYSICAL CHARACTERIZATION

1. Physiographic Province

The Oregon Coast Range is characterized by highly dissected low elevation mountains that were shaped by earthflows and debris slide processes. Incised valleys are distributed throughout the area. Dunes and wetlands occur along the coast, with numerous headlands made of more resistant rock.

2. Climate Description

The Coast Range has a maritime climate influenced by its proximity to the Pacific Ocean. Cool, wet winters and relatively warm, dry summers are characteristic of the area. The mean temperature of the coldest month (January) averages fifteen to twenty degrees Fahrenheit lower than that of July, the hottest month. Normal annual precipitation in the north Oregon Coast ranges from 50 inches to more than 175 inches. Most of the precipitation (generally 60 to 75 percent) falls as rain from November through March, with some intense winter storms. Occasionally, Arctic air meets an onshore flow, producing snowfall. In general, snow persists for only a few days except for the tops of the highest peaks. Strong winds (70 to 100 miles per hour), often associated with rainstorms, may occur during the fall and winter. The "Pineapple Connection (or Express)" pumps tropical heat and moisture from the central Pacific northward resulting in low pressure ystems that may drop several inches of rain over a period of a few days. El Nino and La Nina (ocean temperatures in the Pacific) conditions oscillate over a period of several years. We are currently experiencing a moderate La Nina, resulting in average to below normal temperatures and above average levels of precipitation in the assessment area. During El Nino, the assessment area is generally warmer and drier. There is also evidence of larger scale 20 to 30 year wet and dry climatic cycles, with indications that we are currently entering a wet cycle (George Taylor, Oregon State Climatologist).

The mountains of the Coast Range have a pronounced effect on local climate. Elevations range from sea level at the western edge of the assessment area and 50 to 200 feet in the Willamette Valley to over 3,000 feet in the highest peaks of the Coast Range. From north to south, the highest peaks in the assessment area are Mt. Hebo at 3,176 feet, Laurel Mountain at 3,589 feet, and Sugarloaf Mountain at 3,415 feet. Most other mountain tops are below 2,000 feet. Major ridges receive substantially more precipitation than do nearby lowlands. Coastal areas average 80 inches of precipitation annually and interior areas west of the crest receive an average of about 120 inches. Normal annual precipitation for some of the highest peaks range from 125 inches at Mt. Hebo to 175 inches at Laurel Mountain. In calendar year 1996, Laurel Mountain received 204 inches, the most precipitation for any station in the state of Oregon since rainfall records have been kept. The eastern slopes of the Coast Range average about 80 inches annually, decreasing to about 50 inches in the valley margin.

The prevalent annual streamflow cycle has flashy, high streamflows during the winter months followed by low baseflows during the dry summer months, when most of the flow in channels is derived from emerging groundwater. In coastal drainages notable flood years have been 1861,1890, 1909, 1927, 1953, 1955, 1964, 1974, 1982, 1983 and 1996.

High potential evapotranspiration and low precipitation during warm, sunny summers may produce moisture deficits where soil and bedrock have low water holding capacities. Moisture deficits are more pronounced in the dissected volcanic uplands and Tillamook volcanic uplands geomorphic types (Table 1) because soils are generally thinner, higher in rock fragments and bedrock tends to be slightly permeable to impermeable. In other areas, stands on ridges and exposed south facing slopes with thin, rocky soils can develop plant moisture stress in late summer.

3. General Geology of the Northern Coast Range

The northern Coast Range is underlain by basalts that were originally part of the ocean floor. The Siletz and Tillamook Volcanics are the oldest rocks in the Coast Range, ranging in age from 53 to 56 million years old. The volcanic units include basalt flows, which are relatively resistant, and basaltic ashes, breccias and pillow basalts that are more erodable. Layers of sand, silt, clay and volcanic debris were deposited in shallow seas over the basalt forming the following sedimentary formations. A small percentage of the assessment area is the Tyee Formation, which is a thickly bedded sandstone. It grades northward into the finer grained, more thinly bedded Yamhill Formation. Along the coast, the Yamhill Formation is interlayered with basalt and is covered by the Nestucca and related sedimentary formations which are over 5,000 feet thick. The Nestucca Formation is a deep-water deposit mixed with ash from the Cascade volcanoes. Both the Yamhill and Nestucca Formations are very fine grained and highly erodable (Baldwin, 1964; Orr, et al. 1992). In general, the sedimentary rocks tend to be more erodable than the volcanics. Therefore, even though the volcanic units may cover less area in places, they resist rapid erosion of the higher elevations, exerting a controlling influence on landforms by maintaining the high topographic relief of the Coast Range.

Between 29 and 38 million years ago, igneous rocks were intruded into the sediments, and formed dikes and sills that are resistant to erosion. The highest peaks in the Coast Range are underlain by these resistant intrusions, such as Mt. Hebo near the Oregon Coast. Approximately 15 million years ago, the Columbia River basalts were erupted in eastern Washington and Oregon. They flowed westward and the heavier, fluid lavas were forced under the soft, water-saturated sediments. These lavas form "rootless" dikes and sills in the central and northern Coast Range. (Orr 1992).

The continuing tectonic uplift of the Coast Range began approximately 10 million years ago, when the Pacific ocean floor began to subduct beneath the North American continent. This uplift continues to build the Coast Range.

4. Landtype Association Units

Landtype associations were classified and mapped by delineating areas with similar geology and topography at a scale of 1:250,000. These areas were then categorized and described by comparing the attributes of stream gradient, stream density, and slope. Stream density was also used as a surrogate for landscape texture and dissection. Most of this information was produced using a digital elevation model (DEM) in a Geographic Information System (GIS). More information on Landtype Associations can be found in "A Hierarchical Approach to Classifying Landforms and Stream Systems in the Oregon Coast Range" (USDA 1997, in progress).

To delineate geomorphic zones for the entire assessment area (Map 4), landtype associations with similar geology were grouped into larger blocks or "geomorphic zones". It is assumed that the bedrock geology is the main determination for attributes such as stream gradient, confinement, and density; type of sediment that will be produced; and steepness of the slopes. The general characteristics of these large geomorphic zones have been summarized in Table 1.

TABLE 1. GEOMORPHIC ZONES

Geomorphic Zones	Geologic Features	Soil Characteristics	Stream Characteristics	Management Concerns
Interbedded volcanic and sedimentary rock. Includes the Nestucca Formation. Moderate to subdued relief. LTAs: 2S, 2C, 2T, 2K, 2N, 2Q	Siltstone, shale and sandstone of the Nestucca and Yamhill Formation interbedded with volcanic rock that was often intruded through the sediments at a later date. Sedimentary bedrock is generally very soft, and highly fractured and forms areas of low to moderate relief. Higher elevations are often dominated by volcanic rock on ridge systems. Large, ancient earthflows are common and often originated at the contact between sedimentary and volcanic rock.	Soft grained sedimentary rock is easily weathered and produces deep soils with high water holding capacities. Surface layers are rich in organic matter and amorphous clays which make them very productive. Soils developed on volcanic rock are not as easily weathered and may be steeper and more erosive. Soils are deep to very deep on hummocky, incised ancient earthflows. Water holding capacities are high and presence of alder is common.	Stream gradient: a moderate to high percentage (13-47%) of stream miles are in the 1-4% gradient class. Stream density: variable, but in the moderate range. Average of 7.1 miles/square mile. Substrate: because of the variable bedrock, sediment produced is a mixture of everything from silt to boulders. Springs are often found at the contact between sedimentary and volcanic rock and in landslide deposits.	Alder is very common on, ancient earthflow deposits and in floodplains. Earthflow deposits have deeper soils with higher water holding capacities and may explain the high occurrence of alder. Channel and bank stability is likely to be lower in landslide deposits because of their unconsolidated nature. Road slumping is common. Debris torrent risk is low to moderate.
Steep, dissected volcanic uplands. Includes the Tillamook and Siletz River Volcanics and interbedded sediments. LTAs: 2PSR1, 2PSR2, 2PSR3, 2P2, 3S	Pillow basalt, breccias and marine sediments of the Siletz River volcanics dominate geologic groups. The Siletz River volcanics are the oldest rocks found in the coast range and formed in a marine environment. Bedrock is hard and less permeable and forms steep valley sideslopes. This geomorphic unit is generally found on areas of high relief because it is more resistant to erosive forces.	Volcanic rocks are more resistant to erosive forces and weather into soils of variable depth depending on topographic position. Pillow basalts weather to clay. Soils are high in amorphous clays and organic matter. Incised valleys are more prone to erosive processes such as landslides because of oversteepened slopes. In general, soil depth on sideslopes is moderately deep and rock fragment content is higher. Soils on southerly slopes are more prone to moisture stress.	Stream gradient: over 75% of streams have greater than 4% gradient class. Stream density: variable, but in the mod rate range(average of 6.6 miles/square mile). Substrate: basaltic clay, silt, gravels, cobbles and boulders. These LTAs are likely to have a higher number of confined, high gradient streams.	Debris torrents originating from headwalls are very common. However, debris torrent risk is highly variable in these LTAs. Midslope road failures are more likely to occur because of high gradient streams. Intense burning on south facing slopes reduces productivity.
Tillamook volcanic uplands. Steep, highly dissected terrain. LTA: 2P	Geology consists of Tillamook Volcanics, interbedded fine grained sedimentary rocks and scattered volcanic dikes and sills. This area is a transition zone between the Tillamook Volcanic uplands and the coastal lowlands. As a result, this area is highly dissected, with steep V-shaped valleys.	Soils are similar to those developed in the Tillamook and Siletz River volcanics. Steep slopes with shallow gravely soils are more common. Rock outcrops are common. Erosion potential is high on oversteepened slopes. Soils on southerly slops are more prone to moisture stress.	Stream gradient a low number (less than 9%) of stream miles in the 0-4%-gradient class. Stream density: moderate to high. Substrate: a mixture of everything from silts and clays to durable gravels and boulders.	Debris torr nt potential is extremely high. Of all the LTAs in the Coast Range, this area has the highest percentage of slopes greater than 60%. Road failures are more likely to occur because of instability of bedrock and stream gradient. Road maintenance or stabilization is critical in reducing road failures. Removal of vegetation in head-walls also increases occurrence of landslide. Intense burning on steep, south facing slopes reduces productivity.

TABLE 1 (continued). GEOMORPHIC ZONES

Geomorphic Zones	Geologic Features	Soil Characteristics	Stream Characteristics	Management Concerns
Coastal volcanic headlands LTA: 2M	Geology is a mixture of erosion resistant volcanics and fine grained, erodable sediments. Moderate to steep relief.	Soils are highly productive compared to other zones. High year round soil moisture does not limit plant grow h or survival. Surface layers are rich in organic matter and amorphous clays.	Stream gradient: less than 9% have a 0-4% gradient. Stream density: moderate (6.4 miles/square mile) Substrate: basalt gravel, cobbles and boulders, s me clay	Numerous scenic areas and state parks. High potential for blowdown. Moderate risk of debris torrents.
High relief Tyee sandstone intruded by volcanic dikes LTA: 3R	Dikes form areas of higher relief and are more resistant to erosive forces. Coarse grained sedimentary rock intruded by volcanic dikes found in the southern portion of the assessment area.	Soils are moderately deep on spur ridges to very deep on broad backbone ridges. Soils are moderately productive to productive and have moderate water holding capacities. Soil moisture stress may limit plant growth or survival on steep slopes.	Stream gradient: over 85% of streams with high gradient. Stream density: 6.9 miles per square mile Substrate: basalt gravel with sandstone pebbles.	Transition zone from Coast Range to the valley, includes Kings Valley, may result in some unique habitats for plant and animal species. Moderate risk of debris torrents.
Low relief Tyee sandstone LTAs: 3D, 3W	Coarse grained sedimentary rock of the Tyee sandstone form areas of low relief. Occurs near the southern boundary of the assessment area and includes part of the Yaquina River drainage, areas south of the Siletz River and the lower portion of Drift Creek.	Soils are moderately deep on ridge systems to deep on lower side slopes. Soils range from gravely loams on steep slopes to clay loams where deep soils occur.	Stream gradient: low to moderate (19-32%) percentage of low gradient streams 0-4%. Stream density: 6-7 stream miles per square mile. Substrate: sandstone pebbles and cobbles, sand and silt.	Moderate risk of debris torrents.
Coastal lowlands LTAs: 2Z and 3Z	Areas of low relief that include the floodplains, estuaries, and coastal plains around Tillamook, Lincoln City, the Salmon River estuary and the dunes around Cape Kiwanda. High percentage of the area is underlain by alluvium and river terrace deposits (37%). Most of the remaining area is underlain by erodable, fine grained sediments.	Soils on low relief alluvial deposits are generally deep with moderate to poor drainage and have a higher frequency of flooding. Fine grained sediments are easily weathered and produce deep soils. Soils are typically andic intergrades rather than andisols.	Stream gradient: a high number (52-71%) of low gradient streams. Most of the low gradient streams are unconfined. Stream density: high with greater than eight stream miles/square mile. Substrate: mostly fine grained sediment, silts, clays and sand.	High occurrence of flooding and wet-lands. More human use and activity is increasing potential for water pollutants. Historically provided highest quality fish habitat. High potential for providing quality fish habitat due to large numbers of low gradient, unconfined streams. Low risk of debris torrents.
Willamette and Yamhill Valley lowlands LTAs: 2Y, 2H	Much of the area (51%) is underlain by Pleistocene lake deposits, primarily silt. A quarter of the area is underlain by alluvium and river terrace deposits. Gentle to flat lowlands, broad river valleys.	Soil/climate changes on the east side of the coast range. Dark surface layers become thinner and more red. Soils developed in deep lake deposits are used for agriculture and very productive.	Stream gradient: a high number (46%) of low gradient streams. Most low gradient s reams are unconfined. Stream density: no data. Substrate: mostly silts, clay and sand.	Population density is high and pressure on water resources is increasing. More water quality concerns and limitations. High probability of pollutants from agricultural run-off and non-point source pollution. Low risk of debris torrents.

5. General Soil and Soil/Climate Descriptions

Soils have generally developed from marine volcanics and sediments. A description of soils by geomorphic zone can be found in Table 1. Most soils are very productive for growing vegetation because of the climate, rapid decomposition rates and high biological activity. Typical forest soils are shallow (on ridges) to deep (on lower slopes) and have dark, humus-rich surface horizons high in amorphous clays. Dominate soil orders west of the Coast Range summit are andisols and inceptisols. They are wet for approximately three quarters of the year and mean annual soil temperatures range from zero to fifteen degrees Celsius. East of the Coast Range summit the climate becomes drier and soil order changes to ultisols and mollisols.

This assessment area has been categorized by climate and soil types into soil/climate zones. The Oregon Coast Province portion of the assessment area includes three soil/climate zones which are distinguished mainly by climate and landform (USDA, 1995):

Coastal Fog Zone

Climate within the coastal fog zone is typified by very high winter rainfall accompanied by high winds, with fog and low clouds common. This zone usually extends ten to fifteen miles inland from the coast. The eastern edge of this zone is generally determined by the extent to which fog hangs in the valley bottoms. Soil temperatures are relatively uniform from summer to winter (isomesic). Fog and low clouds increase effective soil moisture during the summer months and fog drip is common. Soil temperature rarely falls below freezing, ideal for growing Sitka spruce, western redcedar and western hemlock. The coniferous forest stands of this zone are typically dense, tall, and among the most productive in the world (Fujimori 1971).

Interior Zone

This zone has the highest mountain peaks, and therefore, the greatest variability in climate. In general, soil moisture remains high in the winter due to heavy rainfall or snowfall and moist in the summer months. Summer soil moisture levels on upper slopes south of the Salmon River are somewhat drier than those found north of the Salmon River. Soil temperature varies as elevation increases. Above 1,800 feet, soil temperature starts to decline and chance of snow increases. Snow rarely stays for more than a few days. Above 3,000 feet, temperature drops even more as soil temperatures change to frigid or cryic conditions. Throughout this zone, biological activity is high and accompanied by high decomposition rates and moderate accumulations of organic matter. Douglas-fir, red alder and western hemlock compose the majority of forest communities in the Interior Zone.

Valley Margin Zone

Frequent storms that move in from the Pacific Ocean, and cooling of the marine air as it is lifted over the Coast Range combine to produce considerable cloudiness from mid October to mid March. Most rainfall occurs during this period, with less than 10 percent of precipitation

occurring during the summer months. Soils are significantly drier and warmer during summer months, limiting plant growth. Oregon white oak, grand fir, and Douglas-fir compose the majority of forest communities in this zone.

C. VEGETATIVE CHARACTERIZATION

Vegetation can be characterized by plant series and plant associations, or plant communities. **Plant series** describe forest vegetation by the *dominant or climax tree species* that would be maintained over time without disturbance, e.g., western hemlock series (Franklin and Dyrness 1973). **Plant associations** (Hemstrom and Logan 1986) describe the *dominant tree and shrub and/or herb layers* that develop on a site over long periods of time, after coming into balance with the physical and biological environment of the site. **Plant community** (USDI 1995) describes the current *dominant tree, shrub and/or herb layers*.

Climate, geology and soils influence the occurrence of a plant series on a coarse scale. The Sitka spruce series dominates the maritime, Coastal Fog Zone and occurs in the wetter portions (especially north facing slopes on the west side of the Coast Range) of the Interior Zone in the western portion of the assessment area (Map 5). The western hemlock series occupies the majority of the landscape, dominating the Interior and Valley Margin Soil/Climate Zones. It is associated with the widest range of environments. The noble/Pacific silver fir series is limited to highest peaks of the Coast Range in the Interior Soil/Climate Zone. The grand fir series appears to be associated with the Valley Margin Zone and the floor of the Willamette Valley. The noble/Pacific silver fir and the grand fir series are found in small, isolated patches within the assessment area and the actual extent of these series is currently being studied.

Plant associations with similar species composition and productivity have been categorized into "*sub-series environments*". The sub-series environments within the Sitka spruce and western hemlock series are described as **wet**, **moist**, or **dry**. These are relative terms and are based on the moisture gradient in which they are found. In wet environments, soils are moist throughout much of the year. Plant growth in the dry environments is limited during the summer months by soil moisture stress. Soil moisture stress may be a limiting factor in the moist environments during the driest parts of the year.

Table 2 characterizes the relationship between plant series, sub-series environments, plant associations and plant communities found within the assessment area.

Table 2. Relationship Between Series, Sub-Series Environments, Plant Associations[1] & Plant Communities[2]

SERIES	SUB-SERIES ENVIRONMENTS	PLANT ASSOCIATIONS[1]
Sitka Spruce[1]	WET	[1]Sitka spruce/devil's club & salmonberry
Sitka Spruce[1]	MOIST	[1]Sitka spruce/Oregon oxalis, swordfern, & fool's huckleberry-red huckleberry
Sitka Spruce[1]	DRY	[1]Sitka spruce/salal, & salmonberry-salal
Western Hemlock[1] (Douglas-fir-red alder)[2]	WET	[1]western hemlock/devil's club, salmonberry, & salmonberry-vine maple
Western Hemlock[1] (Douglas-fir-red alder)[2] (Western hemlock-Douglas-fir-red alder) (Western hemlock-Douglas-fir)	MOIST	[1]western hemlock/Oregon oxalis, swordfern, vine maple/swordfern, & vine maple-salal
Western Hemlock[1] (Douglas-fir)[2] (Douglas-fir - Western hemlock) (Douglas-fir -Oregon white oak)	DRY	[1]western hemlock/dwarf Oregon grape, dwarf Oregon grape-salal, evergreen huckleberry, salal, salmonberry-salal, & all rhododendron plant associations
Noble/Pacific Silver Fir		[2](vine maple-rhododendron & big huckleberry)
Grand Fir		[2](snowberry/swordfern & salal-snowberry/swordfern)

1. Plant Association and Management Guide (Hemstrom and Logan 1986).
2. Current tree and understory species, Salem District Resource Management Plan (USDI 1995).

D. DISTURBANCE PROCESSES

1. Human Impacts

Human uses of the land have changed vegetation patterns through fire, land clearing, logging, planting with inappropriate species (or seedlings of the appropriate species from inappropriate seed zones) which are not adapted to local site conditions, mineral extraction, agriculture, fishing, manufacturing, road building and establishment of residential communities. Additionally, human settlement, road building, grazing, fire, farming and timber harvest have all dramatically affected fish habitat within the assessment area. Large woody debris has been removed from stream channels for harvest, flood control and navigation. Riparian areas have been cleared or converted from conifers to alder and brush. Stream channels have been constrained by road construction. These activities have increased landslides and erosion, increasing the amount of fine sediments carried and stored in streams, rivers and estuaries. Recreational activities can have major impacts on water quality, soils, vegetation and wildlife. The types of recreational impacts which could adversely affect attainment of LSR objectives are generally related to harassment of wildlife species and changes in vegetation, resulting in impacts to wildlife and plant habitats. For example, as hiking, horseback, and off-highway vehicle (OHV) use increases or expands into new, relatively undisturbed areas, disturbance could discourage use of the area by late-successional wildlife species such as the marbled murrelet. These activities could also negatively impact amphibians and "survey and manage" (ROD Table C-3) plant and invertebrate species.

Roads are an important issue for late-successional habitat because the human use associated with them can have negative impacts on attainment of LSR objectives. Impacts range from introduction of noxious and invasive plant species to illegal removal of live trees, snags, and large down wood, and dumping of garbage.

Administrative sites (i.e. campgrounds and picnic areas, radio towers and other facilities, parking lots, utility and road right-of-ways) reduce the amount of late-successional habitat locally. However, a number of these administrative sites are located either in developed areas or on mountain tops that are currently in an early-seral stage of development. Maintaining these early-seral conditions is thought to have little impact on the overall condition of LSRs (ROD, C-15, 17, and 18).

2. Physical Disturbance Processes

Understanding the geographic variability of soil, climate, and disturbance effects can help us interpret spatial landscape patterns and structural landscape components. Since plant and animal populations have adapted to the range of historic landscape patterns, an understanding of these patterns is important in managing late-successional habitat. Fire and wind are the two dominant natural disturbance processes affecting the large scale vegetation pattern in this assessment area. The frequency, severity and size of these disturbances have greatly influenced the composition and structure of habitats across the landscape.

Wind

Although wind is a common intermediate disturbance throughout the assessment area, it is especially significant in the Coastal Fog Zone, where yearly winter windstorms are responsible for creating small patches of blowdown scattered throughout this zone. Most patches are less than one half acre in size and few exceed ten acres in size. Infrequent severe windstorms cause blowdown of large tracts (100 to 1,000 acres) of forest. The most recent severe windstorms were the 1962 Columbus Day storm and the Friday the Thirteenth blowdown, November, 1981. Efforts to predict the location and size of these events have not been successful in the past. Effective guidelines have been developed and are being used to reduce the risk of blowdown associated with management activities such as timber harvesting and road building (USDA 1953, USDA 1964, Doubek 1982).

Fire

Both physical and biological elements of the landscape affect fire disturbance patterns. Physical features such as landform type (relief and drainage density patterns), soil and geologic substrates influence fire behavior patterns. Climatic features, such as precipitation, fog and wind patterns, control fire spread and effects on vegetation composition and pattern. The distribution of sub-series environments, seral stages, and the arrangement, composition, and structure of vegetation all influence the amount and arrangement of fuel, and thus, fire behavior patterns. The Tillamook Burn illustrates the effects of topography and fuels on fire behavior. The fire generally stopped at the ridgetop between the Nestucca and Tillamook River basins due to changes in the vegetation cover which resulted from previous fires in the Nestucca River basin and due to the effects of local topography on east wind conditions.

The long term history of fire in the entire area has not been systematically documented. Fire disturbances in Pacific Northwest coastal zones are described as low frequency (more than 200 years between disturbances), high severity regimes (Agee 1993). Ongoing and recently completed projects in the central Coast Range, approximately twenty miles south of this assessment area, have refined this general description. Analysis of charcoal distribution in a sediment core from Little Lake (located adjacent to Triangle Lake in LSR R0268) , revealed a mean fire return interval of 160 to 190 years from 2000 years ago to the present (Long 1995). Preliminary results from a large scale dendrological fire history project covering approximately 340,000 acres, spanning from the coast (Rock and Cummins Creek) to the valley margin (east of Triangle Lake) , indicate that there is spatial variability in historic fire patterns over the last 500 years. Coastal and Interior Zones in the study area appear to have been dominated by single or two age class stands, with fire return interval ranging from 200 to 300 years. Valley Margin Zone sites had a much higher proportion of two to four age classes, with fire return intervals ranging from 100 to 200 years (Impara, personal communication). This information suggests that there is large scale geographic variability in fire regimes across the landscape. The Fire Management Plan for the assessment area (Appendix C), proposes a control strategy for wildfire management and identifies that prescribed burning is appropriate on some sites.

American Indian and Euro-american settlement of the area since the latter half of the 1800s was responsible for many large and small scale fires. The Nestucca Fire of the 1840s and the 1933 Tillamook Fire each burned approximately 300,000 acres in, and adjacent to, this assessment area. Mt. Hebo and some of the surrounding areas (all of which, burned as part of the Nestucca Fire) reburned in 1902 and again in 1910 (Teensma, et al. 1991). Portions of the Tillamook Fire area reburned in 1939, 1945 and 1951 (Munger 1944, Kemp 1967). Since these fires occurred, many small scale fires have reburned portions of the larger fire's area. Small scale fires have also burned some mature forest stands.

Teensma, et al. (1991) mapped age class distributions (inferred from various sources) for four different years: 1850, 1890, 1920, and 1940. Several human caused fires between 1850 and 1940 have changed landscape patterns. The total number of patches in each age class almost doubled from 1850 to 1940 as a result of small human caused fires and suppression efforts on potentially large scale events. Approximately half of the entire assessment area (regardless of ownership) burned once since 1840. At least ten percent of the entire assessment area reburned once or twice between 1840 and 1950. These fires and reburns have had significant effects on landscape pattern, and on the composition and structure of vegetation.

Disturbance Regime Blocks Fire history information suggests there is spatial variability in fire effects across the assessment area. An attempt was made to map, at a landscape scale, the general geographic distribution of fire regimes in the Provincial Assessment Report (USDA 1995). The concept that fire regimes are stable temporally and spatially, and can be discreet geographic entities are working hypotheses that will be revisited and refined as more information becomes available.

Distribution of physical and biological environments were used to map disturbance regimes across the Northern Coast Province. Landform types (USDA 1981) and plant series distribution were used to group geographic areas into blocks predicted to have similar fire frequency, severity, and size patterns (Map 6). Relief patterns and climatic influences (fog, east wind events) were considered in the groupings.

These working boundaries were overlaid on the age class distribution maps (Teensma et. al, 1991) to validate assumptions about the effects of physical and biological elements on disturbance processes and resultant vegetation patterns. Geographic variability in patch sizes and types was closely approximated in overlaying the working boundaries on the age class distribution maps. This supported the hypothesis that landform/topography, climate and vegetation distribution influence fire disturbance processes and landscape pattern.

Five of the eight disturbance regime blocks described in the Provincial Assessment Report (USDA 1995) are located within this assessment area. Table 3 displays the disturbance regime characteristics and the resultant vegetation pattern for each of the disturbance regime blocks.

Table 3. Disturbance Regime Blocks

DISTURBANCE BLOCK	LAND-FORM	SUB-SERIES ENVIRONMENT	DISTURBANCE TYPE; REGIME DESCRIPTION[1]	LANDSCAPE PATTERN
COASTAL FOG	Low relief, scattered headlands and hummocks same area as soil/ climate zone	Wet and moist *Sitka* spruce environments dominate area.	Wind dominant process; operates at two scales - (1 high to mod. frequency storms, small to medium size, and high severity. (2 low frequency storms occur at large to giant size with high severity. Fire is uncommon; low frequency, large to giant size, and high severity. American Indians and European settlers have influenced fire pattern.	Heterogeneous mix of patch sizes and seral stages; earlier seral patches most frequently small to medium, resulting from small scale wind events; large and giant patches created infrequently and move from early to late-seral conditions.
NORTH INTERIOR-TILLAMOOK	Steep, h ghly dissected relief	Western hemlock moist and dry environments dominate the area, with wet and moist Sitka spruce environments represented in western part of the block and in local fog pockets and river bottoms.	Low frequency, high severity, large to giant size fire regime. European settlement may have affected fire patterns.	Large to g ant patches moving from early through to late condition.
NORTH INTERIOR-HEBO	Low, hummocky relief with scattered peaks	All western hemlock environments present, with the moist environment dominating.	Low frequency, mod. to high severity, medium to large fire regime. American Indian and European settlement activities have severely affected fire and vegetation patterns.	Medium to giant patches, with variable remnant tree retention. Alder plays a major role in successional development from early through late-seral conditions.
CENTRAL INTERIOR-LINCOLN COUNTY	Low relief, heavily influenced by wide coastal zone and adjacent valley margin	Moist env ronments of the western hemlock series dominate; with wet and dry environments represented as well.	Fire occurs at low frequency, variable severity and medium to giant sizes. American Indian and European settlement activities have greatly influenced fire activity in this block.	Medium to giant sized patches, with high variability of remnant trees within that move from early to late-seral conditions.
VALLEY MARGIN	Valley foothills of low relief, low to mod dissection	Dry western hemlock and grand fir environments	Fire occurs at shortest intervals - mod. to high frequency; variable sizes and severities.	Variable pattern

1. **Disturbance Frequency (years)**
   Low >300
   Moderate 100-300
   High <100

***Severity (% mortality)**
Low <30%
Moderate 30-70%
High >70%

***Size (acres)**
Small <100
Medium 100 - 1,000
Large 1,000 - 10,000
Giant >10,000

Landslides, Floods and Earthquakes

Landslides, earthquakes, and floods are integral to the development of landforms, soils, and streams in this assessment area. These earth forming processes have shaped mountains and valleys over a long period of time.

Large earthflows are common in the upland areas and most abundant in the fine grained rock types of the Nestucca and Yamhill formations. These large landslides may have covered thousands of acres. The resultant surrounding topography is lower relief and hummocky.

Springs are common and drainage patterns in the hummocky topography follow an irregular pattern. Recent studies have shown that the North Oregon Coast has experienced strong earthquakes in the past (Minor and Grant 1996) and is vulnerable to earthquakes, and tsunami flooding from off-shore earthquakes; an earthquake of magnitude eight to nine on the Richter scale has been predicted from studying historic earthquakes (Priest 1995). Such an earthquake could act as a trigger for these large earthflows, especially if the ground is saturated at the time.

Debris torrents commonly originate from headwalls in the incised drainage patterns on harder bedrock like the Siletz and Tillamook volcanics. They are confined to stream channels. Alder dominates those areas which are disturbed on a regular basis. Human activities such as logging and road construction, have destabilized steep slopes throughout the assessment area, increasing the occurrence of debris slides and torrents. Instead of a single sho t period of intense landsliding, which would have normally occurred following large scale fires, repeated sliding resulted from moderately severe storms. The number of large trees available to fall into stream channels has been greatly reduced (even eliminated in some areas) making the stream network less efficient at trapping and holding sediment. Although no systematic studies of this effect have been conducted across the landscape, these activities are thought to have changed channel shape and function. Streams lack the quality fish habitat in pools and complex side channels produced by logjams. As a result, during flood events, fish lack calm water holding areas and may get swept into the lower channels or out to sea where they may not be able to survive.

Floods are the result of various combinations of heavy rainfall, melting snow, high tides, steep topography, soil conditions, vegetation cover, and landslides. Flood occurrence is expected to increase over the next twenty-year period as the climate goes from a drier cycle to a wetter cycle (George Taylor, Oregon State Climatologist). Activities that increase runoff (e.g. road development and activities which remove the vegetation, duff, or litter layer from the forest floor) may increase landslides, which may change historic conditions and further increase flooding and the occurrence of landslides. Road closures or obliterations, road improvements or maintenance to correct drainage problems, and restoration of deteriorated sites can reduce runoff and reduce the risk of floods and landslides.

3. Biological Disturbance Processes

The insects and diseases discussed in this section commonly exist at endemic levels throughout the assessment area. Insect and/or disease caused tree mortality in small pockets cattered across the landscape can significantly improve habitat diversity for many vertebrate and invertebrate species which depend upon snags and down wood. Conversely, epidemic outbreaks over large areas can severely damage high value late-successional habitat, recreation sites, and plantations and young timber stands (a significant concern of local landowners adjacent to federally managed lands).

Insects

Because large blocks of old growth (10,000 to 100,00 acres in size) no longer exist in the Coast Range Province, knowledge regarding landscape scale disturbances resulting from insect outbreaks is limited. As the amount of late-seral forest increases, several species of insects have the potential for killing large numbers of trees over areas 100 acres or more in size. Increased numbers of dead or dying trees (either snags or down logs, resulting from disturbances) will favor several species of bark beetles (*Dendroctonus spp.*). Multi-layered western hemlock canopies increase the chance of western hemlock looper (*Lambdina fiscellaria lugubrosa*) outbreaks. However, old-growth stands are also better able to withstand insect attacks, having relatively larger and more diverse populations of insect predators and more diverse tree species mixes.

Several types of insects which defoliate or kill trees are common in the assessment area, but the insect which seems to be most commonly associated with individual tree mortality or small pockets of dead trees is the Douglas-fir beetle (*Dendroctonus pseudotsugae*). The spruce beetle (*Dendroctonus rufipennis*) is also common, especially in the Coastal Fog Zone, but tree mortality caused by this bark beetle has been rare over the past ten years. However, during outbreaks the spruce beetle usually outruns natural controls until most of the mature spruce is killed. From the mid 1960s through 1990, bark beetle caused tree mortality steadily declined throughout this assessment area as a result of land managers promptly removing pockets of blowdown.

The Sitka spruce weevil (*Pissodes strobi*) causes considerable damage to the terminal leaders of Sitka spruce trees in the assessment area. The weevil is generally thought to attack trees between about eight and 30 years old and up to 50 feet in height (Furniss and Carolin 1977). Growing Sitka spruce in small dense patches appears to minimize damage in plantations in this assessment area.

Douglas-fir beetle The Douglas-fir beetle is indigenous to the Coast Range of Oregon and is extremely common. This beetle maintains its normal low level populations by infesting Douglas-fir trees which have blown down or are weakened by root diseases or other stress-causing factors. At endemic levels, small populations of Douglas-fir beetles increase by breeding and reproducing in down, injured or diseased trees which have been dead for less than one year (Furniss and Carolin 1977). After a significant disturbance event, populations will increase in down and weakened Douglas-firs to levels at which beetles, in subsequent years,

will attack and kill healthy standing trees. If significant amounts of windthrow do not occur in following years, these outbreaks typically will last three more years, with the beetles attacking and killing successively fewer trees each year (Hostetler and Ross 1996).

The general pattern of Douglas-fir beetle outbreaks is predictable. When the number of infested trees and/or fresh down logs reaches or exceeds three trees larger than 12 inches in diameter per acre, it is likely that one standing, live Douglas-fir will be killed during the following spring for every two trees which were infested during the first year. For every four trees infested and killed during the second year, it is likely that one tree will be infested and killed in the third year; and for every 25 trees infested and killed in the third year, one tree will be successfully attacked and killed in the spring of the fourth year. The actual impacts will vary due to climate, general tree and stand vigor, etc. (Hostetler and Ross 1996).

This pattern of Douglas-fir beetle outbreaks has been identified based on relatively small pockets of blowdown or standing tree mortality, so caution is being exercised in applying this experience to larger areas and numbers of recently dead trees. Since much of the assessment area is deficient in snags and down wood, projects to create large numbers of snags and down wood have been proposed. Guidelines have been developed and are being implemented to limit risk of bark beetle outbreaks during these projects. They will be closely monitored to further refine these guidelines, if necessary.

Since 1990, the number of patches of dead/dying trees on federally managed lands in the assessment area has been increasing as windthrow and resulting tree mortality is being retained to increase snag and down woody debris levels. Concerned with the increases being reported by field crews, the BLM's Tillamook Resource Area used aerial photographs taken in 1993 to examine 318 randomly selected, quarter section sized samples in thirteen sub-watersheds in the upper portions of the Nestucca River Basin. This analysis identified an average of 2.6 patches of dead trees per square mile, with a median patch size of eight dead trees per patch and a range of two to 21 dead trees per patch. Field investigations of several patches revealed that bark beetles were generally attacking and killing trees in and adjacent to root disease centers. It is quite likely that bark beetles were attracted to these patches of stressed trees and could more easily overcome them. In addition, some apparently healthy trees along the edge of the root disease infection center were attacked and killed. Survey information regarding patches of dead trees in the Upper Nestucca prior to 1990 was not available. However, insect and disease detection flights for the Siuslaw National Forest from 1985 through 1989 identified 0.3 patches of dead trees per square mile in the Middle Nestucca sub-watershed, with an average of four dead trees per patch and a range of two to eleven dead trees per patch.

Disease

Laminated root rot Laminated root rot, caused by the fungus *Phellinus weirii*, is the most widespread and damaging disease in the assessment area. It is most abundant outside of the Coastal Fog Zone, and is especially prevalent in Douglas-fir stands on the eastern slopes of the Coast Range. *P. weirii* is a native root pathogen, and therefore, is a natural part of many forest ecosystems (Thies and Sturrock 1995). Tree species differ in their susceptibility to this disease. Douglas-fir and grand fir are highly susceptible (readily attacked and killed), western hemlock and noble fir are intermediately susceptible (often infected, but seldom killed), pines

and cedars are tolerant or resistant (rarely attacked or killed), and all hardwoods are immune (Hadfield, et al. 1986).

P. weirii survives in stumps and large roots of host trees up to 50 years after the trees have been cut or killed (Hadfield, et al. 1986). Infected stumps and roots are the inoculum sources for initiation of disease in the next stand of susceptible species established on the site (Tkacz and Hansen 1982; and Lawson, et al. 1983). Susceptible trees become infected as their roots contact inoculum in the soil (Thies 1984 and Hadfield, et al. 1986). This allows the disease to continue into the subsequent stand. On infested sites regenerated with susceptible species, substantial root contact with buried inoculum from the previous stand does not often occur for ten to fifteen years (Hadfield, et al. 1986). At this time, mortality in the new stand becomes apparent. When the stand is fifteen to twenty years old, the infection may begin to spread from the initial infection source. Disease centers are believed to expand radially at the rate of about one foot per year (Nelson and Hartman 1975). Field surveys conducted by Walt Kastner and Don Goheen (1994) in 25 to 45 year old stands in the Nestucca River Basin and the Scappoose block (in the vicinity of LSR RO271, northeast of the assessment area) indicate that approximately five to eleven percent of the area within Douglas-fir stands is infested with this disease, and Douglas-fir basal area in disease centers is less than half of that in healthy portions of the stand.

P. weirii has a major influence on the character of many Douglas-fir stands in the assessment area. Tree mortality creates snags and openings in the canopy. Shrubs, hardwoods, or shade tolerant, disease resistant conifer species quickly occupy these various sized gaps (Thies and Sturrock 1995). In addition, infection predisposes trees to windthrow. Live infected trees are susceptible to attack and killing by bark beetles. Therefore, this disease can be a major source of coarse woody debris. Disease centers range in size from less than one acre to several acres (Thies 1984).

Before human activities became the dominant disturbance agents on the landscape, the distribution and spread of the fungus was probably influenced strongly by fire history and pattern. Fire determined the location, spread, and longevity of the host trees, and thus the fungus. West of the summit of the Coast Range in the Nestucca River drainage, a significant association was found between *P. weirii* and slope position in 70 to 100 year old Douglas-fir stands (Kastner, et al. 1994). The percentage of plots containing *P. weirii* infected Douglas-fir trees was highest on ridges and decreased downslope. No relationships were found, however, between the incidence of disease and plant community type or aspect. The lower incidence of disease occurrence associated with lower slope positions seems most likely related to lower trees stocking levels (especially for Douglas-fir), resulting from competing vegetation and animal damage inhibiting successful regeneration.

In an unmanaged forest, trees infected with laminated root rot often blow down, pulling a substantial portion of infected material out of the soil. In managed stands, however, timber harvesting of infested sites generally leaves infected stumps and root systems in the soil (Thies and Sturrock 1995). Prompt reforestation of these sites with highly susceptible species, such as Douglas-fir, increases the occurrence and intensity of the disease. If highly susceptible species are favored in infection centers during thinning, the effects of the disease are likely to become more severe. In stands of highly susceptible species the traditionally recommended

commercial thinning prescriptions to maximize timber production have been found to increase the spread of laminated root rot and are generally not recommended when disease is present in 20 percent or more of the stand (Thies and Sturrock 1995). During planting and thinning, favoring less susceptible or non-host species in disease centers helps reduce the spread of this disease and increases stand diversity.

Swiss needle cast Swiss needle cast has been a source of increasing concern over the last ten years in stands of Douglas-fir in the Coastal Fog Zone. The following information on Swiss needle cast is provided by Oregon Department of Forestry (ODF 1996). The disease is caused by the native fungus, *Phaeocryptopus gaeumannii*, and only affects Douglas-fir trees. Wind-borne spores infect newly produced needles in spring. Symptoms include chlorosis, premature loss of needles, reduced height and diameter growth, and occasional mortality. Diseased trees commonly retain little more than current year needles. Affected stands typically have very dense shrub layers because of increased l ght coming through the rather sparse overstory canopy. There seems to be a considerable amount of variation in the severity of symptoms exhibited by individual Douglas-fir trees in a given stand, suggesting a genetic tolerance exists within the species. Symptoms are most obvious in late winter until bud break in spring. Also, the disease appears to be more severe on southerly exposures. Although the disease is most apparent in ten to twenty year old Douglas-fir plantations, mature stands are affected as well. An aerial survey of Oregon coastal forests conducted by the Oregon Department of Forestry in April 1996 revealed that most of the obviously symptomatic stands covered approximately 130,000 acres within fifteen miles of the coast. However, a few occurrences of the disease were noted further inland.

Until recently, the disease was mainly a problem where Douglas-fir was planted outside of its natural range. The disease was apparently first discovered in Switzerland in the early 1900's. Subsequently, the disease has been reported from other European countries (Boyce 1940, Peace 1961), New Zealand (Hood and Kershaw 1975), the eastern United States (Boyce 1940), and in Christmas tree plantations in the Lake states (Morton and Patton 1970). Swiss needle cast was found on Douglas-fir in the western United States and Canada in 1938 and 1939, but no significant disease related damage was reported (Meinicke 1939).

There is considerable speculation as to why the disease has recently become so damaging within the natural range of Douglas-fir. The following are some possible explanations offered by Oregon Department of Forestry (1996): Douglas-fir may be poorly adapted to many sites in the Coastal Fog Zone. Douglas-fir planted in this zone may lack the genetic tolerance to the disease because the seed source may have been from outside of the Coastal Fog Zone, even though it may have been from the appropriate seed zone. More Douglas-fir is now in this zone than historically, thus greatly increasing the inoculum load. Changes in climate and weather patterns may have favored the disease. The pathogen may have become more virulent. Finally, soil and plant nutrient relationships may have influenced susceptibility to the disease or severity of damage.

Based on current knowledge of this disease, Federal and State land managers are developing management strategies in the Coastal Fog Zone (ODF 1996 recommendations). In establishing new plantations on high risk sites in the Coastal Fog Zone, these guidelines recommend that species other than Douglas-fir should be planted. On other sites in the Coastal Fog Zone, the

proportion of Douglas-fir planted should be small and from a very local seed source. Disease tolerant seed sources are being investigated. In managing stands on high hazard sites, species other than Douglas-fir should be favored during thinning and sites which are predominately Douglas-fir should be interplanted with non-host species.

Annosus root disease Annosus root disease, caused by *Heterobasidion annosum*, is common at endemic levels in many Coast Range stands. It may become a concern when managing stands of western hemlock in the assessment area through repeated entries over long periods. The disease can cause substantial butt decay in western hemlock that is over 150 years old, as well as mortality resulting from stem breakage (Buckland, et al. 1949 and Foster, et al. 1954). Spores of the fungus colonize freshly exposed wood on stump surfaces and stem wounds; the disease spreads to adjacent healthy trees most commonly by root contacts (Hadfield, et al. 1986). Although the rate of disease infection was nearly twice as high in commercially thinned 40 to 120 year old western hemlock stands in western Oregon and Washington compared to unthinned stands, losses due to decay were very low (Goheen, et al. 1980). Minimizing wounding during thinning operations in western hemlock stands and retention of other species to produce a mixed species stand have been successful in reducing losses from this disease (Hadfield, et al. 1986).

Armillaria root disease Armillaria root disease occurs throughout the assessment area. It can be a primary killer of healthy trees, a secondary pathogen attacking stressed trees, and a saprophytic decay fungus of dead trees (Wargo and Shaw 1985). The causal fungus is *Armillaria obscura* (Hadfield, et al 1986). Mortality is the most serious form of damage (Morrison 1981). Armillaria root disease can also cause butt rot and reduced growth (Hadfield, et al. 1986 and Morrison 1981). All conifers in Oregon and Washington can be affected by this disease, but west of the Cascades, it is usually associated with conditions that stress trees (Hadfield, et al. 1986). Mortality in Douglas-fir plantations occurs most frequently when the trees are between 10 and 25 years old. Bark beetle attacks may hasten mortality of infected trees.

As trees increase in age, they appear to increase in resistance to the disease (Morrison 1981). In mature stands in the assessment area, most infection centers are rather small, usually involving a dozen trees or less. Trees generally die standing, producing snags. Often shade tolerant conifer reproduction will be released as a result of overstory mortality, adding to the structural diversity of the stand. The causal fungus infects nearby trees primarily by mycelial growth across root contacts, with some infection occurring by rhizomorphs growing several feet through soil and contacting susceptible roots (Hadfield, et al. 1986).

Establishing and maintaining trees in a vigorous condition will help to reduce damage from this disease (Shaw and Roth 1978). Specific management recommendations include, avoiding conditions that stress trees, such as poor quality planting, reforesting sites with low quality or off-site planting stock (Hadfield, et al. 1986), injury (Wargo and Shaw 1985), and establishing plantations on sites with a high hazard of disease (Shaw and Roth 1978).

Black-stain root disease Black-stain root disease, caused by *Leptographium wageneri*, appears to have the potential to cause higher levels of mortality in Douglas-fir than any other

native pathogen (Hansen, et al. 1988). It only attacks Douglas-fir and various species of pine, *Pinus sp*. The disease appears to be increasing in both frequency and severity in Oregon and Washington. The level of infection in the assessment area, however, is relatively low at the present time. West of the Cascades and into British Columbia, the disease occurs essentially over the entire range of Douglas-fir, with the most frequent and widespread infections occurring in southwest Oregon. Increasing disease occurrence may be related to increased levels of stand disturbance (Cobb 1988).

This root disease is unusual because it appears to cause the only true wilt disease of conifers (Cobb 1988). Hyphae of *L. wageneri* block the tracheids of host trees (Hadfield, et al. 1986). Mortality can occur within a few months after infection in seedlings and saplings (Cobb 1988). Large trees may die within 2 years after infection, but some may live for 10 years or longer.

Most infections in Douglas-fir stands occur when the trees are 15 to 25 years old, with trees over 30 years old apparently developing a degree of resistance (Hadfield, et al. 1986). Disease centers generally contain dead, symptomatic, and unaffected trees. Most disease centers are less than 0.1 acre, but can be as large as 10 acres.

Long distance disease spread occurs as a result of insect vectors (Hadfield, et al. 1986; and Hunt and Morrison 1980). Two root-feeding weevils (*Pissodes fasciatus* and *Steremnius carinatus*) and a root feeding bark beetle (*Hylastes nigrimus*) are known insect vectors of black-stain root disease in Douglas-fir (Hansen, et al. 1988 and Harrington 1988). Stress appears to be an important factor predisposing Douglas-fir trees to infection via insect vectors. These insects feed and breed in the roots of low vigor trees (Hadfield, et al. 1986). Once the disease has been introduced into a stand by the insect vectors, it spreads to susceptible host trees, regardless of vigor, via root grafts and contacts or by growing a short distance through the soil. The disease has been known to spread at the rate of nearly five feet per year.

To reduce losses from this disease Hadfield, et al. (1986) suggest favoring non-host trees in thinnings, interplanting with non-host trees, and avoiding site disturbance and tree injury. In stands of host trees, thinning between June 1 and September 1 has been successful in reducing the spread of black-stain root disease.

E. VEGETATIVE PATTERNS - REFERENCE AND CURRENT CONDITIONS

Disturbance processes, plant series and sub-series environments, and successional trends influence the range of vegetation patterns on the landscape. Comparisons of the amount and distribution of the various seral stages over time allow us to evaluate landscape changes. Plants and animals have adapted to the range of natural conditions across the landscape. Knowledge of the range of patterns allows us to evaluate and prioritize future management options.

Ideally, comparisons of vegetative patterns should be made at many points in time over a long period (several hundred years) to get a complete picture of the range of natural conditions. Comparisons can provide some insight into historic pattern, and can put current condition in context of the range of natural conditions. It is rarely possible to get specific landscape pattern information for such long time periods. However, we can make assumptions about historic

landscape pattern based on what we know about historical disturbance regimes and management history.

Seral-stage distr bution was only available for two points in time. A mid 1900's seral-stage map (Map 7) covering about 60 percent of the assessment area was derived from a series of county-wide vegetation coverages (described in Appendix A) completed between 1940 and 1956. Although some industrial forest practices were in effect prior to the 1940s, this seral-stage map provides the best information available on the composition of post fire, pre-intensive forest management vegetation patterns. Since logging had been occurring on private lands for more than fifty years and intensive logging on federal lands was just beginning, we are not setting the mid 1900's time period as our desired future condition. Instead, we are using it in conjunction with what we know about disturbance regimes to compare against current vegetation pattern. The scale of the maps developed by Teensma, et al. (1991), was too coarse to be useful for th s exercise.

The current vegetation seral-stage condition (Map 8) of federal lands, including adjacent non-federal lands, were developed by combining BLM and Forest Service vegetation layers. Oregon Department of Forestry provided seral-stage condition data for State lands within the assessment area. For lands not covered by these three datasets, 1988 data from the Coastal Landscape Analysis and Modeling Study (CLAMS) vegetation coverage was used. Appendix A defines each seral stage, as used in this assessment, and describes the process used to delineate seral stages on the maps.

By comparing the mid 1900's and current seral-stage conditions, we can identify some of the effects of past forest practices on vegetation pattern. Because mapping standards between the mid 1900's coverage and the current vegetation coverage are different, care must be taken in interpreting exact vegetation distribution changes. Additionally, since a mid 1900's coverage was not available for the entire assessment area, comparisons are only made across the areas common to both coverages. The following general trends emerged from this analysis of late-seral vegetation patterns across the landscape:

- **Patch Size:**
  Late-seral patch sizes are smaller in the current condition than they were in the mid 1900's reference condition. A shift in dominant patch size from giant (greater than 10,000 acres) to medium (100 to 1000 acres in size) and small (less than 100 acres) has occurred across the assessment area.

- **Number of Patches:**
  The number of patches across the landscape in late-seral condition have more than doubled.

- **Area in Late-seral Condition:**
  The amount of the assessment area in late-seral condition has been reduced. Late-seral stands occupy 50 percent less area in the landscape under current condition than in the mid 1900s.

These trends (decreases in patch sizes, increases in the number of patches, and a significant reduction in the amount of late-successional habitat) have contributed to late-successional

habitat loss and fragmentation across the assessment area. These three trends have also been observed and documented at a larger scale in the recent Provincial Assessment Report (USDA 1995) and at the watershed scale in the Nestucca Watershed Analysis (USDA and USDI 1994c).

In the mid 1900s, the LSR R0807 (Map 2) landscape pattern was largely that of a mid to late-seral-stage forest, with approximately 43 percent of the LSR acres in the late-seral stage, and 34 percent in mid-seral stage. The vegetation pattern was the direct result of the Nestucca fire and scattered numerous settlement burns that occurred throughout the area beginning in the mid 1800s (Teensma, et al. 1991). Late-seral-stage forest occupies about as much area under current conditions (39 percent), but the area occupied by mid-seral-stage forest has been reduced to about eleven percent. Pioneer through early-seral conditions (including the pure hardwood patches) have increased, accounting for 50 percent of the current area of this LSR (Table 4).

The mid 1900's vegetation pattern in LSR R0269 (Map 2) was dominated by late-seral-stage forest, occupying 66 percent of the landscape area. Very little of the LSR was in pioneer through early-seral stages. Current landscape patterns reflect a more variable condition, with significant representation of the pioneer through early-seral stages, and an 84 percent reduction in mid-seral-stage forest (Table 4). Additionally, most of the current late-seral-stage forest is between 110 and 120 years old, and lacking in some late-successional characteristics. Survey notes from the mid 1900s and photographs from that era indicate that the late-seral stands were much older and that down logs, snags, and big trees mixed with smaller trees (some of the characteristics that we associate with old growth) were abundant.

The change from a late-seral-stage dominated forest to a predominately early-seral-stage forest is most evident in LSR RO270 (Map 2). Ninety-two (92) percent of this LSR was dominated by late-seral-stage forest in the mid 1900s. Now 70 percent of it is in pioneer to early-seral-stage stands.

Fifty-eight (58) percent of the AMA which is not designated as LSR (see *AMA* column in Table 4) is mapped in the mid 1900's coverage. Compared to other federally managed lands in the assessment area, this area currently has the lowest proportion of late-seral habitat. Late-seral-stage forest currently covers 14 percent of the landscape, a 36 percent reduction from the mid 1900s conditions. However, it has the highest proportion of mid-seral-stage forest and pure hardwood, currently 21 and 15 percent respectively. Mid-seral-stage forest occupied 24 percent of the mid 1900's landscape. This reflects the recent fire history.

Table 4. Current Seral Stage Distribution

Seral stage[1]	R0807[2]	R0269	R0270	AMA[3]
	Percent of Area			
Pioneer (0 to 10 years)	11	11	0	8
Very Early (11 to 24 years)	14	14	15	13
Early (25 to 49 years)	17	12	53	29
Mid (50 to 79 years)	11	5	1	21
Late (80 + years)	39	55	29	14
Pure Hardwood	8	3	2	15

1. See Appendix A for seral stage definitions.
2. LSR RO807 was originally mapped as LO269 in the Northwest Forest Plan (USDA & USDI 1994b) and in the Provincial Assessment Report (USDA 1995)
3. This AMA is mapped as AO907 in most coverages associated with the Northwest Forest Plan (USDA & USDI 1994b). For the purposes of this table, this column excludes the LSR lands within the AMA.