APPENDIX D
DISTURBANCE ECOLOGY

THE EFFECTS OF CLIMATE

CLIMATE AND HIGH INTENSITY (STAND REPLACING) FIRES

Major stand replacement fires in the Hemlock Zone may be the result of regional or even continental scale climate conditions. In regions characterized by infrequent high-intensity fires, the vast forests can be traced back to a few major fire years (Heinselman 1983). Historic weather information supports a correlation between major fire years and periods of severe drought.

The 500 year-old stands found in the Cascades and Olympics, and the 400-460 year-old stands found in the East Fork may be a result of fires during a drought period or short term climate change (Franklin and Hemstrom 1981). The prevailing weather pattern responsible for major fires in the Rockies and Lake States from 1755-1759 (Heinselman 1983) may have been a factor in the 1738-1790 fires on the Coos Bay District, or the 250-year age class found in the Oregon and Washington Cascades. Agee (1991) identified 14 fire events in the Oregon Cave National Monument. Nine of these correspond to fire scar dates or regeneration pulses observed just north of the East Fork Coquille watershed. Coos Bay District fire histories document major fires between 1845 and 1855. The fire history coincides with pioneer and early newspaper accounts of coastal Oregon fires from 1845 to 1849 (Morris 1934).

CLIMATE AND TREE GROWTH

The climate also affects growth patterns. Douglas-fir trees regenerated between 1738 and 1790 have growth ring patterns significantly different from those of trees regenerated before 1700. The ring pattern of trees regenerated between 1735 and 1780 shows rapid growth for the first 80-100 years (three to four rings/inch, tapering to six or eight over time.) Then growth slows so abruptly that a magnifying glass may be necessary to get an accurate ring count. Trees regenerated before 1700 also show rapid initial growth that declines quickly, and continues to decline steadily for the life of the tree. These patterns were observed while looking at hundreds of tree stumps from Roman Nose Mountain to the East Fork Coquille River.

THE EFFECTS OF FIRE

INTERACTION OF DISTURBANCE AND BIOLOGICAL PROCESSES

There are several factors, other than the type of disturbance, that affect the course of succession and stand development. They are; disturbance intensity, disturbance frequency, seed source availability, and local environmental conditions (Hemstrom and Logan 1986). Another factor is the species' ability to sucker or stump sprout after the aerial portion of the plant has been killed.

THE EFFECTS OF TOPOGRAPHY ON FIRE PATTERNS

The few great Coast Range fires were so enormous that we overlook the part that patchy light to moderate severity fires' play in shaping stand structure and distribution. Large catastrophic fire events are rare. An analysis by Strauss *et al.* (1989) showed one percent of the fires resulted in 80% of the area burned in Fire Climate Region 12 (coastal Washington and Oregon). Morrison and Swanson (1990) studied effects of topography on fire patterns, and found that gentle topography might further extensive stand replacement fires under favorable weather conditions. Complex topography favors patchy fires. The Coast Range exemplifies complex topography rich in natural fire breaks. High stream densities result in many sharp ridges, narrow draws and creek bottoms, aspect changes, and diverse plant communities over short slope distances. These natural firebreaks act to steal a wild fire's momentum resulting in a mosaic of fire intensities, and in turn, a mosaic of stand structures across the landscape.

Coos Bay District aerial photos, especially 1943-1952, support this finding locally. A good example is the north facing slopes in the Park Creek drainage. Fire patterns with sharp contrasts occur over short distances. The distances are so short and the areas of uniform fire severity so small that the variations are best viewed as within-stand diversity. The boundaries of this complex burn pattern correlate directly to topography, allowing trees to survive in small moist sites protected from all but the most intense fires. These protected pockets are only a few hundred feet from exposed ridges that burn over during most fire events. Scattered large trees on unstable north facing head-walls survived previous fires because of discontinuous fuels, moist soils throughout the year, and/or a cool humid microclimate. Other stands with trees dating from 1540-1622 occupy the east end of the drainage, and protected sites next to the main stem of Park Creek, north facing lower slopes, and benches. Early twentieth century fire created or maintained open ground and young reproduction on ridge tops, and on exposed steep south to west facing aspects.

Less complex topography exhibits a less complex fire pattern where fire severity, as a function of aspect and slope position, is obvious. Large areas of uniform fire severity occurred in homogenous stands. Topographic breaks and changes in aspect results in pronounced boundaries. Species diversity is exhibited between stands over larger landscapes.

STAND STRUCTURAL DEVELOPMENT FOLLOWING HIGH INTENSITY FIRE

Stands regenerated following high intensity fires are even-age and predominantly Douglas-fir. Old growth stands with no subsequent underburning were studied in the North Coquille sub-watershed. Transects[1] were run in T26S, R10W, Sections 19 & 21, next to the Little North Fork

[1] The surveyors mapped tree bole and shrub locations along the transects. They also recorded, DBH, relative tree heights, total crown depth, length of boles with epicormic branching, crown diameter, and shrub heights.

Coquille and North Fork Coquille respectively. Douglas-fir regenerated between 1760 and 1780 are the dominant and co-dominant trees. Regeneration of western hemlocks and western redcedars occurred between 1779 and 1840 with the peak between 1811 and 1831, after Douglas-fir regeneration tapers off. These species have full crowns (covering up to 70% of the bole) and occupy an intermediate crown position, reaching the lower live limbs of the Douglas-fir.

The study found stand structure to be dependant on aspect. Variations are due to fire intensity, shrub and hardwood competition, and animal damage, all dependent on aspect.

Fire intensity is higher on south aspects. This exposes a more uniform expanse of mineral soil and kills or severely retards stump-sprouting hardwoods and shrubs. Evergreen huckleberry, rhododendron, salal, and Oregon grape, commonly found on south facing slopes, have a slow growth rate. Myrtle, also found on the south aspects, re-sprouts vigorously but usually is held in check by big game browsing during the grass/shrub seral stages.

Mountain beaver clipping and red alder competition following disturbance is more common in moist north aspects. Vine maple and salmonberry re-sprout vigorously, competing for growing space on north aspects. On moist protected areas in north facing draws and head walls these shrubs may even escape fire damage. Re-sprouting vine maple can be held in check by big game browsing. However, deer and elk prefer south aspects and will exert greater browse pressure on re sprouting shrubs on those sites. Mountain beaver, red alder, and shrubs can exclude conifers from moist areas, resulting in gaps in the forest canopy characteristic of stands on north aspects.

A more detailed description of the differences in stand structure between north and south aspects is provided below and shown in Figures D.1 and D.2.

South facing slopes

Douglas-fir predominates the overstory occupying the co-dominant position. A few western redcedar and western hemlock occupy the intermediate position. The stands are often single-story. Some stands are two-story with a Douglas-fir overstory and a myrtle understory. The canopy is uniform and the stands well stocked. The uniformity and density on south slopes cause crown size to be 15-20% less than on north aspects, based on aerial photo measurements. Large openings are associated with disturbances (such as salvage logging, root rot pockets, fire slop-overs, and road construction) or non forest ground. Any understory western hemlocks and western redcedars are found next to gaps in the overstory or are confined to disturbance areas.

Open space between the crowns is the result of the crown abrasion during high winds. That space allows enough light to reach the forest floor to support a moderate to a dense shrub layer on most sites. Shrub competition often prevents conifer regeneration in the understory. The shrub layer is usually dominated by salal and evergreen huckleberry; vine maple and hazel may also be present and locally abundant. Patches of vine maple on upland south facing slopes are associated with moist areas like draws and head walls or shallow soils. In the later case, the underlying bedrock is holding water close to the surface.

Branching patterns of the Douglas-fir suggest a past with very high crown competition. The upper 30-40% of the branches exhibit a normal pattern. The middle third often exhibits fan-shaped epicormic branching. Epicormic buds on tree boles are stimulated as light levels increase following mortality of less vigorous trees. The fan-shaped branching provides nesting platforms and substrate for epiphytes.

North Facing Slopes

Viewed from the air, the forest canopy has a rough texture including many gaps occupied by brush (typically vine maple or salmonberry). Canopy closure is in 40-70% range. Douglas-fir has a more pronounced differentiation into crown classes, and a greater variation in crown lengths. Western redcedar and western hemlock are more common and become progressively more abundant closer to riparian zones. They are typically found in the intermediate crown position, along the margins of gaps with occasional bigleaf maples.

Head walls and steep ground next to the first order draws often have vine maple and/or salmonberry brush layers and low conifer stocking. Often conifer stocking is absent when these sites exceed 95% slope. As on the south facing slopes, little conifer regeneration exists in the understory except in disturbed areas.

Openings are occasionally occupied by swordfern on steep north facing head walls. Douglas-fir adjacent to these gaps exhibit a characteristic crown and branch size, and an epicormic branching pattern suggesting the gaps supported red alder during the first 70-100 years.

Shrubs

Shrub development following disturbances locally is similar to that for the Hemlock Zone. Hemstrom and Logan (1986) observed that herb and shrub species which were dominant in mature and old-growth stands will reestablish dominance by the third year. By that time most shrubs would be as abundant as they were in the pre-disturbance stand. They also found that salmonberry and thimbleberry were more abundant five years after disturbance than they were before. They noted that salal and vine maple increased following harvest, and that Bracken fern was the most common early seral stage species in salal-dominated associations.

Of all the shrub species, salmonberry, vine maple, and blue blossom ceanothus, are most likely to cause conifer seedling mortality. Salmonberry is found on moist, north-facing, lower slopes, head walls, and riparian zones. Close to oceanic influence, salmonberry can occupy the entire slope from the creek to the ridge. Vine maple is found where water is abundant at least part of the year and soils are well drained. Gravelly soils found on steep slopes meet vine maple's requirement for well-drained soil. Seasonally high rainfall, an impermeable soil layer that holds water near the surface, and/or lower slope positions where ground water is concentrated by gravity provide needed water. Blue blossom ceanothus is commonly found on south to west facing slopes near broad valleys. The presence of blue blossom ceanothus (typically in association with poison oak and grand fir) suggests a landscape with a history of frequent fire.

Unique role of Oregon Myrtle

Oregon myrtle is found on south aspects below 1,800 ft. elevation and on flood plains. Presence of myrtle on drought-prone aspects and flood plains where periodic flooding causes anaerobic conditions in the soil, suggests myrtle tolerates climatic and physiological drought stress. Myrtle is shade tolerant and its' thick canopy shades out understory plants.

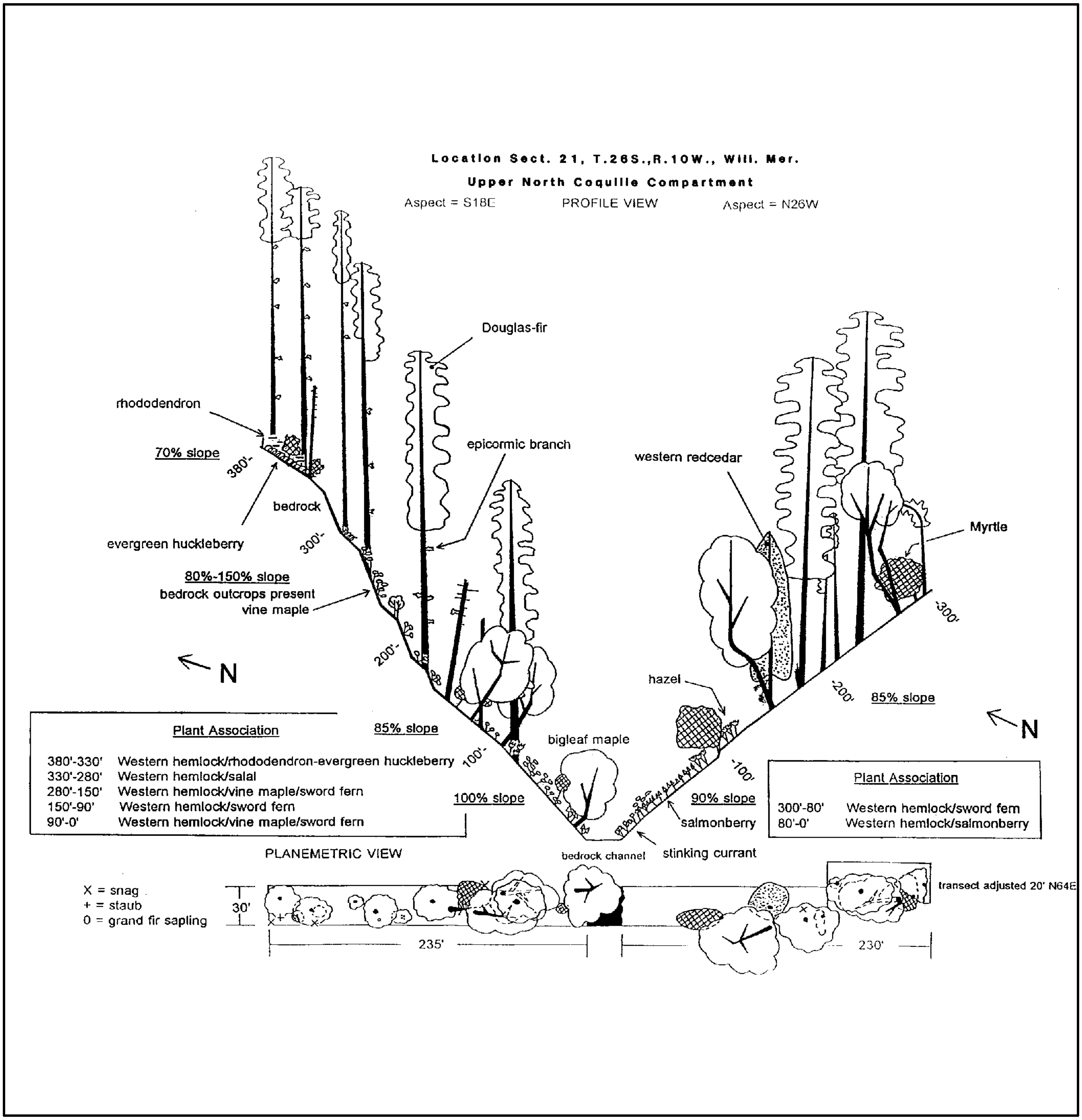

Figure D.1. Typical vegetation transect in the Upper North Coquille Compartment.

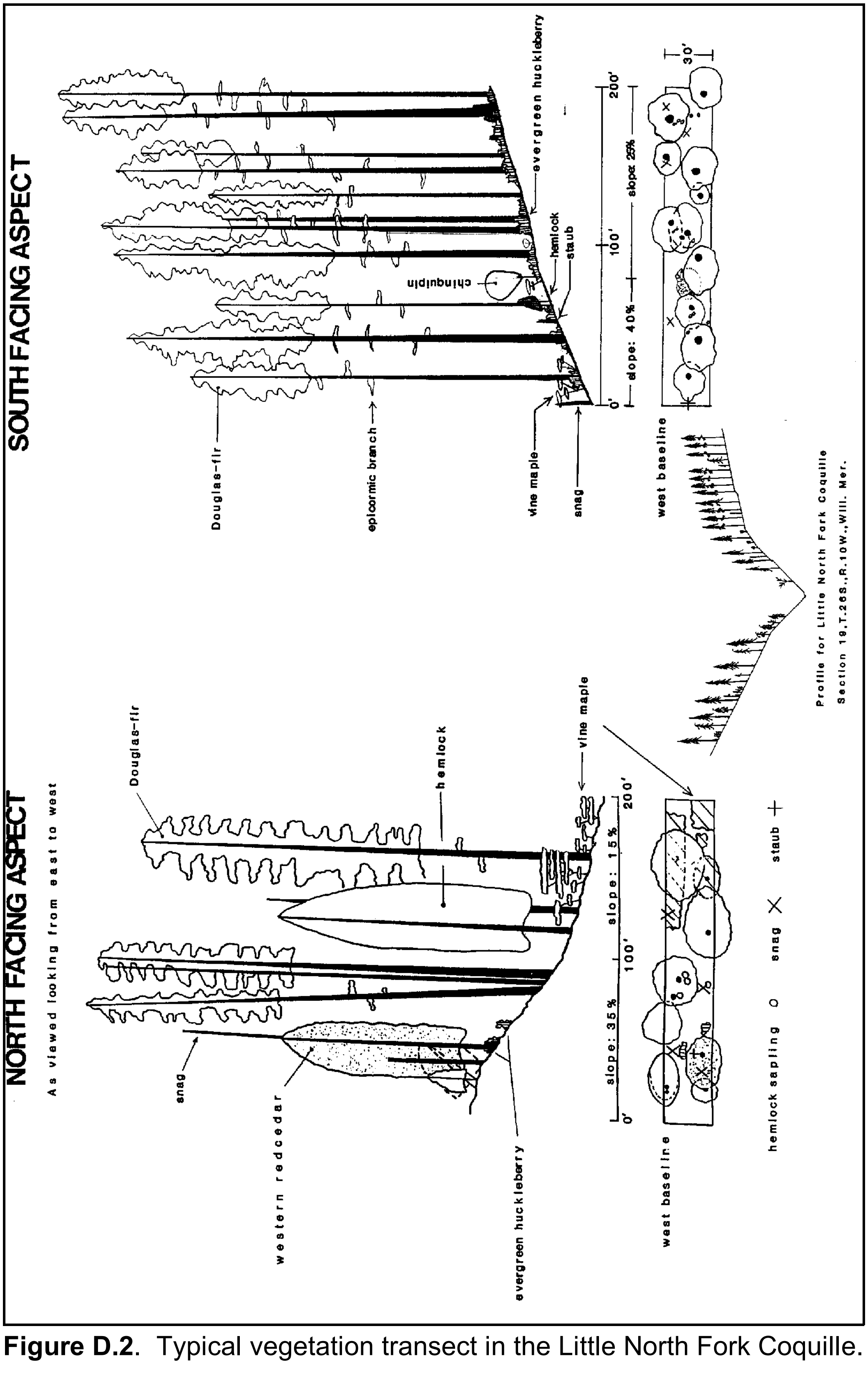

Figure D.2. Typical vegetation transect in the Little North Fork Coquille.

Myrtle-occupied flood plains are a unique Western Oregon riparian plant community found south of the Umpqua River. Myrtle-dominated flood plains may have a grand fir component, and occasionally Port-Orford-cedars or western red cedars are present. When Douglas-fir is found in a myrtle-dominated flood plain, it is usually confined to the tops of mounds. Bigleaf maple is found on stream banks in the myrtle riparian community. When bigleaf maple is found away from the stream bank, examination of the site may reveal that the bigleaf maple is located next to an old silted-in channel. This suggests bigleaf maple cannot regenerate in the shade of established myrtle, but needs a disturbance or a gap in the canopy like that found above streams[2].

Myrtle also occurs as a shrub in California chaparral. Like other chaparral species, myrtle leaves contains flammable oils that explode into flame when ignited. Myrtle’s flammability and ability to vigorously re-sprout give it a competitive advantage. The explosively burning foliage may destroy nearby vegetation, while the re-sprouting ability enables myrtle to rapidly capture the site following the fire. Myrtle's habit of explosive ignition may enable it to compete with the taller conifers by transferring fire from the ground to the crowns of the conifer. This has management implications. Periodic underburns keep myrtle in a short shrubby growth form. Extended fire exclusion allows the myrtle to grow closer to the lower portion of the overstory conifer crowns. The myrtle could serve as fuel ladder, possibly causing a stand replacement event. In terms of ecological function where fire is a major disturbance, myrtle acts more like highly-flammable, understory conifers than other hardwoods, which tend to slow fire.

THE EFFECTS OF LOW TO MODERATE BURNS ON ESTABLISHED STANDS

If established stands experience subsequent low to moderate severity fires, additional age classes often are the result. In multi-cohort[3] stands, Douglas-fir is the predominant species in the oldest age class. Western hemlocks and western redcedars are less fire-tolerant than Douglas-fir (due to their thin bark and shallow roots) and only survive very cool fires or in unburned patches left by fires that burn in a mosaic pattern. On sites where subsequent fire killed most of the older trees, the younger age class is dominated by Douglas-fir. Where a subsequent fire kills only a few older trees, the resulting partial shade favors establishment of an even-age understory of western hemlock (Hofmann 1924).

Competition and suppression mortality

In wild stands, a tree's risk of mortality increases with the proximity and size of neighboring trees (Peet and Christensen 1987). Big trees out-compete smaller trees for light and nutrients, suppressing and eventually killing them. In plantations with uniform spacing, few trees have a growing space advantage over neighboring trees, resulting in greater uniformity and a lower rate of suppression mortality. As growing space in plantations is occupied, crown diameter (or depth) decreases at about the same rate for all trees. The uniform growth and lower mortality

[2] If this observation is true, down cutting by a stream and it’s subsequent long-term confinement to a single channel may result in a decline of bigleaf maple in the myrtle dominated riparian zone.

[3] A cohort is a group of trees regenerating after a single disturbance. A multi-cohort stand is a stand that arose after two or more disturbances. All but the first disturbance would be less than stand replacing in severity (Oliver and Larson 1990).

rate results in a more efficient use of the site and higher yields in plantations compared to same-aged natural stands on similar sites. Plantations lack the size diversity, variations in crown depth, and variations in health and vigor of trees associated with wild stands[4]. In wild stands, competition mortality occurs between crown closure and the time when gaps created by tree mortality can no longer be filled by lateral growth of adjacent trees (Peet and Christensen 1987). Snags produced through competition mortality in young stands are from lower crown classes and/or areas of dense stocking. These snags are small diameter with short crown depth. Snags recruited toward the end of the stem exclusion phase may be large enough to serve as roosting and nesting habitat for the small to medium size cavity dwellers. Large snags are recruited by factors other than suppression mortality. During the self-thinning phase, stands acquire a relatively uniform spacing pattern (though not as uniform as in recent plantations laid out in a grid pattern). After the self-thinning phase, most mortality is due to factors other than growing space, like windthrow, lightening, disease, and fire (Peet and Christensen 1987).

Local Fire History

Fire histories prepared for the Coos Bay District show most old growth stands experienced subsequent burns of sufficient severity to eliminate fire intolerant species in the overstory and kill or set back the herb and shrub layer. This created gaps, partial shade conditions, and reduced vegetative competition creating a suitable environment for western hemlock and western redcedar regeneration. Resulting overstory and the understory stands now differ in canopy strata, age, and species.

Extreme age differences occur on the upper slopes above the East Fork Coquille River where the overstory regenerated between 1534 and 1622 and the understory regenerated after underburn(s) between 1912 and 1923. The underburns were of sufficient severity to kill all western hemlock and western redcedar existing on those sites before 1912 except isolated individuals growing in moist protected draws.

Most even-aged understory hemlock stands found throughout the watershed regenerated during the 15-20-year period immediately following underburns in 1850, 1868, 1891, 1912, 1917, 1922, 1932, 1936 and 1944. These stands go through successional stages just like stands regenerated after a stand replacement event (Oliver and Lawson 1990). Many understory hemlock stands, dating from the 1920s - 1940s, are now in, or starting to emerge from, the stem exclusion stage. In this stage, the understory intercepts most of the sunlight before it reaches the forest floor, severely limiting shrub and herb development.

The most complex stands regenerated after the 1534-1622 fire years. They were altered by moderate severity fire(s) between 1738 and 1790 and further altered by low to moderate

[4] This discussion applies to recent plantations where: site prep was uniform and effective at reducing microsite variation, nearly all crop trees were planted, maintenance treatments were timely, and contract stipulations were strictly enforced. Older plantations can have high within-stand variation where: site prep was less uniform, crop trees are a mix of planted trees and naturals, maintenance was not timely, and where the precommercial contract stipulations (or the contract inspector) allowed the contractor to leave “whips” and tall seedlings untreated. Those untreated whips and tall seedlings for a time benefit from the increased day light reaching the forest floor after thinning. This adds to the species and size diversity in the young stand until such time that the overstory (crop trees) closes canopy.

severity fires occurring between 1845-1855 and/or 1881-1944. These stands differ by slope position and aspect as follows:

- Southwest facing ridges burned most recently and burn more frequently than the rest of the landscape. Resulting stands are often a single age and single story. They are the youngest wild stands on the landscape.

- South to west facing slopes, and upper ridges on other aspects, support multi-cohort stands (two to three groups) with two distinct canopies. The upper canopy is composed of Douglas-fir usually less than 300 years old. Younger even-aged hemlock with an occasional Douglas-fir form the lower canopy.

- Multi-cohort stands (three to four groups) occupy north facing slopes and lower slopes on other aspects. The upper canopy is composed of older Douglas-fir, established after the 1534-1630 and/or 1738-1790 fire years. Younger even-aged hemlock with an occasional Douglas-fir form the lower canopy.

Stands established as the result of the 1738-1790 fire episodes with subsequent low to moderate severity fires are less complex:

- Multi-cohort stands (two groups) with two distinct canopies occupy south to west facing slopes and the upper ridge locations on other aspects. The upper layer is composed of Douglas-fir dating to 1738-1790. Younger even-aged hemlock with an occasional Douglas-fir form the lower canopy. On some sites stump sprouting, shade tolerant hardwoods dominate the understory. A few south facing ridge tops occupied by young trees date to fires after 1900.

- Single story stands that show little evidence of underburns occupy North facing slopes and the lower slopes of other aspects.

<u>Vegetation response to fine scale disturbance</u>

Gaps opening in the canopy provide new growing space for the plants already on the site. If the understory is fully occupied by shrubs and/or hardwoods when gaps are created, those shrubs and hardwoods will increase in vigor. Conifers will occupy new gaps under one of four conditions:

- where conifer regeneration is already established on the site and is vigorous enough to respond to the new growing space,

- when the gap occurs in a stand that is in the stem exclusion stage. In this case the gap is free of herb, shrub and hardwood competition and is thus suitable for new plants regenerating from seed.

- where the gap creating disturbance is of sufficient severity that it also kills existing herbs, shrubs, and hardwoods, freeing growing space.

- The understory occupants lack the vigor to respond to the new growing space.

Small gaps, and the edges of large gaps, are partially shaded which favors the survival and growth of shade tolerant trees like hemlock and red cedar over Douglas-fir.

Gaps created by landsliding are a special case. The disturbance frees growing space by removing the previous occupants as well as the upper soil layer and organic matter. Exposed subsoils are poor in nutrients and organic matter, favoring red alder. Red alders grows on soils with restricted internal drainage, fixes nitrogen, and has a rapid juvenile growth rate (Johnson *et al.* 1926; Fowells 1965).

THE EFFECTS OF HIGH INTENSITY FIRES AND RE-BURNS ON ESTABLISHED STANDS

Many stand replacement events were a result of multiple burns such as the 1738-1790 and the 1534-1590 episodes. This re-burning pattern affected future stand age and structure of the overstory trees, snag and coarse woody debris (CWD) amounts, and woody debris in streams.

Where re-burns skipped moist areas and/or burned reproduction in a mosaic pattern, resulting stands have a wider range of birth dates than would be expected based on a regeneration lag alone. This process is most clearly observable in the West Fork Smith River where the 1849, 1885, and 1892 fires all burned the same site.

Frequent re-burns resulted in a stand type called “timber scattering” by land surveyors of the last century. The old trees in these stands survived fires due to their thick bark and the distance of their crowns above the fuels on the ground[5]. Surveyors described timber scatterings as having dense brush or young tree regeneration. Timber scatterings are documented in the Middle Creek (Chapman 1875), Tioga Creek (Lackland 1898) and West Fork Smith River (Chandler 1901a, 1901b) subwatersheds. Timber scatterings no longer occur because of fire suppression activities[6].

Coast Range stands have lower levels of CWD compared with similar aged forests in the Cascades (Spies *et al*. 1988). The difference was attributed to a higher incidence of re-burns on the Coast Range.

Size and species of woody debris determine how long it will persist in the stream. Small diameter woody debris and species with low wood densities decompose quickly. The timing and amount of woody debris deposited in streams depends on stocking levels and mortality in adjacent riparian stands. In undisturbed old-growth stands, woody debris is deposited gradually over time. Streams that pass through young forests contain large woody material

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[5] Photographs taken from Coos Mountain Lookout in 1936 show the steep south rim of Park Creek Drainage, in the Middle Creek subwatershed, supporting an open stand (USDI 1995a). That stand has since filled in with a dense conifer understory. Recently cut units on the rim support Columbia tiger lily, fawn lily, and iris. These plants favor light to high shade and well drained soils. Available habitat for these plants has been reduced by the loss of open stands and timber scatterings. In the Umpqua Field Office, Coos Bay District, the columbia tiger lily is largely confined to road cut banks. The fawn lily is uncommon and usually occurs on the edge of rock bands or adjacent to rocky ridges. The iris is more wide spread but is largely confined to exposed ridge top road right of ways and to plantations on oregon grape or salal sites where big game browsing has slowed conifer seedling growth.

[6] Timber scatterings were still visible as a distinct type on aerial photos taken over the Tioga Subwatershed in 1943. An oblique view of a timber scattering in the Tioga Subwatershed can be seen in the background of the lower photo of Tioga Camp on page 136 in *Swift Flows the River* by Dow Beckham published 1990 by Arago Books, Coos Bay OR.

from the stand that existed before the last stand replacement fire and small woody debris from the current stand. In old-growth stands swept by high intensity fire, followed by re-burns, woody debris is consumed instead of contributed to the stream. Adjacent streams will be deficient in LWD until young stands can contribute wood to the stream. If the pre fire stand was young and the stream contains only small diameter material, the debris decomposes quickly. Under these circumstances, debris loads will decline appreciably during stand reestablishment (Swanson and Lienkaemper 1978). Riparian zones affected by the 1845-1855 fires, the 1868 fire, or the first fires in the 1891-1944 episode, and subsequently re-burned, are the sites most likely to be deficient in LWD.

THE EFFECT OF SLOPE POSITION/SOIL MOISTURE RELATIONSHIPS

LOWER MODERATE SLOPES

The combination of water draining through the soil profile to this area plus direct precipitation causes them to be moist. Topographic shading may also reduce evapotranspiration demands on soil water here. Erosion processes constantly move soil down- slope, working against the development of deep soil profiles on the mid and upper slope positions. Restricted soil depth and the presence of rock fragments and gravel limit the moisture soils store. Plants adapted to these sites prefer moist well-drained soils and can tolerate some seasonal drought. The accumulation of colluvium on the toe of the slope result in deeper soils there. Growth conditions at the toes of slopes are similar to those found on benches and terraces on lower slopes resulting in similar plant assemblages.

LOWER SLOPE BENCH

The transition from moderate or steep slopes to a bench slows water movement through the soil. Slopes continuing down hill from the outside of the bench allow excess water to drain away. Soils on benches are often deep which gives them considerable capacity to store water compared with sloping ground. Optimum growth for many plants occurs on these sites, and disturbances like fire or blowdown are rare. When there is a disturbance, competition to capture growing space is strong.

On undisturbed north facing sites, a lower slope bench may be dominated by western red cedar, western hemlock, and bigleaf maple. These species grow best on moist well drain soils and tolerate shading enough to grow up through some competition. Scattered large Douglas-fir, dating from a past catastrophic event may be present. The sparseness or absence of Douglas-fir on many lower terraces indicates how rare stand replacement fires are on these moist protected sites.

UPPER FLOOD PLAIN (5-50 YEAR FLOOD FREQUENCY)[7]

This area is characterized by a high water table and occasional flooding limiting tree species to those which can tolerate these conditions. Soils here develop an organic layer, and processes that cause the differentiation of the soil profile into horizons may start between flood events. Alluvial deposition during floods usually covers these soils resulting in buried profiles. Movement of water through the soil is often constricted, favoring plants tolerant of low oxygen levels in the soil. Examples include red alder, myrtle, and grand fir. Western red cedar, and bigleaf maple appear to tolerate short periods of flooding. Douglas-fir is intolerant of virtually any flooding and so may be excluded from these areas except where small rises and hummocks give it the necessary drainage. Trees on these sites perform important hydrologic functions during floods. Those trees adjacent to streams sift out and hold large and small woody debris that serve as habitat and in-stream after the water recedes. Trapping of woody debris on flood plains reduces the loss of this wood from the system and slows flood waters dropping part of the sediment load on the flood plain.

LOWER FLOOD PLAIN (1-5 YEAR FLOOD FREQUENCY)

This area is characterized by a seasonally high water table and frequent flooding. The water table may be high year-round on small creeks where there is little elevation difference between the stream in the summer and the flood plain. Plants must be adapted to saturated soils and many are pioneer species that thrive where there is frequent disturbance by floods. Soils are newly deposited alluvium and are subject to being moved, mixed, and redeposited during high water. Usually plants here either require abundant moisture or are tolerant of low oxygen levels in the soil. Willows and red alders often show scars caused by debris transported in high water, and are often bent over by the force of the flow.

The following is the comparative tolerances of trees found in the Umpqua Field Office to excessive moisture. This information was compiled from several sources by Minore (1979):

most tolerant:	western red cedar, black cottonwood
↓	red alder
↓	Sitka spruce[8], grand fir
↓	western hemlock
least tolerant:	Douglas fir

Plants' tolerance to excessive moisture along with several other factors help explain the variation in vegetation from site to site on the flood plain. These other factors include: season

[7] Distinguishing between a lower slope bench and a 5 to 50 year flood plain may be difficult. If you are uncertain treat the site as a flood plain if it is dominated by myrtle. If the site is covered with alder and salmonberry is responsible for less than 10% canopy closure in the shrub layer than you are likely working with a bench. However, you cannot automatically assume that an alder dominated site with a significant salmonberry component is a flood plain. If the site is dominated by bigleaf maple, the soils are sufficiently well drained to be managed as a bench.

[8] Individual Sitka spruce trees were observed in the lower end of the watershed. However, the watershed is too far inland to actively manage for spruce.

of flooding, depth to the watertable, and whether the groundwater is moving or stagnant. The following is an expanded ranking that considers different types of "excessive moisture" tolerance:

Flood tolerance

Winter

Winter inundation does not significantly affect survival or growth of western hemlock, red alder, Sitka spruce, or western red cedar. Winter inundation as short as one week affects survival and growth of Douglas-fir and has disastrous consequences after four weeks (Minore 1968)

Summer

Relative tolerance of tree seedlings to summer flooding (Minore 1968):

most tolerant:	western red cedar
intermediately tolerant:	red alder, Sitka spruce, western hemlock
extremely intolerant:	Douglas-fir

Both red alder and western red cedar produce adventitious roots which seems to improve their ability to tolerate summer flooding conditions (Minore 1968).

Tolerance to shallow water tables

Observations from the Olympic Peninsula indicate red alder, Sitka spruce, and western hemlock adapt to shallow water tables (water table depth $\geq$15 cm. [centimeters]) and tolerate moderately shallow winter water tables (Minore and Smith 1971). The above species vary in tolerance to shallow water tables when depth to water is $\leq$15 cm. Western hemlock is intolerant of water tables $\leq$15 cm. deep. Sitka spruce tolerates winter water tables of flowing water $\leq$15 cm. deep. Western red cedar tolerates winter water tables of stagnant water $\leq$15 cm. deep. Red alder tolerates water tables $\leq$15 cm. deep.

UNSTABLE LOWER SLOPE

This area includes steep unstable ground extending back from creeks a few to many hundreds of feet. Instability is due to steep slopes where the stream is cutting the toe of the slope. Stream cutting at the toe of the slope usually occurs on the outside curves of streams. The instability is aggravated by ground water acting like a lubricant at the contact between bed rock and the soil. Resulting slope failures expose bare mineral soil, favoring pioneer species like red alder. The readily accessible ground water favors moisture loving plants like salmonberry and vine maple. Their root systems bind the soil into a mat reducing the frequency of mass failure, but not preventing down slope creep. With soil movement, vine maple and/or salmonberry may dominant the site excluding alders and conifers. Available moisture also favors western red cedar and bigleaf maple however their numbers are limited by soil movement, blow down, and brush competition. These sites rarely burn.

The following observations were made on those riparian zones on BLM land that are relatively intact:

- inside the riparian zone there are few trees where unstable slopes exceed 95% and show tension cracks, and salmonberry and/or vine maple dominate the shrub layer. Those trees present are primarily big leaf maple and western red cedar. They usually are found at the margins of the steep ground or on small inclusions of less steep land. Down large wood in these steep riparian zones comes from adjacent upland slopes. Red alder tends to grow in dog hair patches on recent slides, or in scattered small clumps and individuals on stream banks. Douglas-fir and western red cedar can establish and grow on these steep moist sites. However, soil creep causes them to lean precariously or fall. Few if any of these trees are expected to survive to become old growth.

- Where riparian zones have less extreme slopes, or where there is very steep ground without salmonberry, mature stands are stocked with a mix of conifers and hardwoods. Western red cedar and bigleaf maple are universally present on those sites visited. The conifer component is usually greater on the south facing side of a riparian zone than on the north.

STAND LEVEL MANAGEMENT IMPLICATIONS

Ground fires and prescribed underburns may reduce in-stand diversity in the short term. These fires harm few Douglas-fir but kill shade tolerant species. This creates gaps in the overstory and may eliminate the understory. However, this mortality increases snags and coarse woody debris. And over time, regeneration of shade tolerant trees, shrubs, and herbs occur in pulses following underburns. If the management objective is to reintroduce species diversity (such as in the Late-Successional Reserve), then site-specific topography can help determine whether to manage for this diversity within- or between-stands.

Reforestation using a species mix including fire-intolerant species will predispose resulting stands to higher tree mortality in case of low intensity fire or prescribed underburns in the future. Any concern depends on the risk of fire and management objectives. On moist sites or cool exposures fire is infrequent and species tolerance to ground fire may not be an issue. Hot, dry sites and aspects experience a higher risk of wild fire, so managing for fire tolerant species exclusively makes both economic and ecological sense.

Silvicultural prescriptions should address fire-intolerant species where the intent is to mimic effects of a low or moderate intensity fire on a stand. In this scenario, most of the hemlocks and cedars near ridge tops, on south to west aspects, and on droughty sites should be marked for removal. The percentage of the fire intolerant trees marked for cutting should decrease as the marking crew moves around to the north aspect, moves down hill, or onto benches. In the short term, this will result in lower species diversity on some sites but will maintain diversity on a landscape scale and reflect species composition that naturally results with the interaction of fire and topography.

If the management objective is to increase stand complexity, then treatment prescriptions must address the prerequisites for understory tree establishment. This includes providing sufficient light for the establishment of an understory stand, temporary reduction of brush and herb competition, and seed-bed creation. Creating a coniferous understory is least expensive when stands with a dense closed canopy and little understory brush are selected for treatment. These stands need no site preparation to control brush following cutting to open the overstory.

Disturbances that open the overstory include blow down and insect and disease infestations. If seedlings exist that can respond to the increased light levels, the openings will be occupied by trees. Not all understory seedlings are vigorous enough to stand the shock of sudden exposure to increased light levels and air movement. If brush occupies the overstory opening, it will increase in vigor and mass often excluding conifer regeneration from seed.