700 ROAD FOREST HABITAT RESTORATION PROJECT
SITE MANAGEMENT PLAN
CEDAR RIVER MUNICIPAL WATERSHED

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EXECUTIVE SUMMARY

The 700 Road Forest Habitat Restoration Project Area (the Project Area) is located in the center of the Cedar River Municipal Watershed, one mile south of Chester Morse Lake and seven miles southeast of the Cedar Falls headquarters complex. The Project Area is approximately one mile north of a patch of high quality old-growth forest. Its location is designed to provide future habitat connectivity for species dependent on late-successional forest (LSF) conditions, as well as habitat connectivity from the riparian area along the Rex River to the ridge top encompassed in the Project Area. The Project Area currently consists of a dense forest (generally greater than 370 trees per acre) dominated by 61-67 year-old western hemlock, Douglas-fir, and western red cedar, with minor components of Pacific silver fir, noble fir, red alder, and black cottonwood. Vertical and horizontal structural complexity is minimal, understory vegetation is limited, and a low level of biodiversity is present. The Project Area consists of 477 acres, of which 358 acres will be ecologically thinned, 14 acres will be restoration thinned, and 105 acres will be retained untreated in leave units. Of the areas to be ecologically thinned, no more than 288 acres (up to 80% of the thinned area) will have trees removed from the site, while the remaining area (20%) will have all cut trees left on the forest floor as down wood. The size of the project is designed to provide restoration of a forest habitat patch that is ecologically significant to species with medium home ranges (e.g., hairy woodpecker), while contributing to habitat for LSF-dependent species with large home ranges (e.g., northern spotted owl). An extremely compacted 70-year old logging road that runs through the several of the thinning units will be decommissioned and replanted to native vegetation as part of this project. A cultural resources survey on the units designated for ecological thinning determined that no areas of cultural significance were present on the site.

Goals from the Cedar River Watershed Habitat Conservation Plan that apply to this Project Area are to accelerate the development of LSF characteristics, provide wildlife habitat for targeted species, and enhance natural biological diversity. Specific restoration objectives are: 1) maintain or increase the growth rate of trees, 2) increase plant species diversity and facilitate understory development, 3) increase forest structural complexity, 4) create and facilitate maintenance and recruitment of large-diameter snags and down wood (DW), and 5) protect special habitats and water quality. We will initially use ecological thinning and restoration thinning to achieve these objectives, including canopy gap creation, retention of small unthinned patches, snag creation, and DW augmentation. Planting selected understory species may follow this restoration intervention, if needed.

The Project Area is divided into fifteen management units, including nine ecological thinning units each with a different restoration treatment, one restoration thinning unit, and five leave units, collectively designed to create a mosaic of habitats at the forest patch scale. The specific treatment for each thinning unit is based on the current tree density, size, and species composition, combined with site-specific objectives. Ecological thinning will use a variable density method in which trees in all size classes will be retained, with variable (rather than uniform) spacing between remaining trees. This method will create structural complexity and habitat heterogeneity by simulating natural processes such as tree death from competition, windthrow, and other small-scale disturbances characteristic of late-successional forests. Biodiversity will be fostered not only by enhancing structural complexity, but also by retaining

unusual habitat features such as trees with physical damage and all deciduous trees. Restoration thinning will thin only the most prevalent species and retain all the largest trees, while creating variable spacing between the remaining trees. Untreated leave units will not only provide heterogeneity at the local forest scale, but will also serve as comparison areas for long-term effectiveness monitoring.

The different restoration treatments will result in a range of 165-365 trees per acre being retained in the ecological thinning units. In order to achieve the overall restoration objectives and desired post-treatment tree density, 59-243 trees per acre or 25-35 percent of the existing basal area, will be thinned from the ecological thinning units. This level of thinning is conservative compared with other Pacific Northwest thinning projects designed for ecological restoration because this forest has not previously been thinned and strong winds in the area can cause an increased risk of windthrow.

Only the most prevalent tree species (western hemlock, Douglas-fir, and western red cedar) will be cut in order to maintain existing tree species diversity and increase the relative proportion of less frequent species, resulting in higher diversity indices. There will be an upper diameter limit above which no trees will be thinned, ensuring that all larger trees are retained. The upper diameter limit of trees to be thinned varies by ecological thinning unit (19 inches in one unit, 18 inches in one unit, 16 inches in five units, 15 inches in one unit, and 13 inches in the final unit). These diameter limits are based on current scientific literature and expert silvicultural opinion. These limits are designed to achieve restoration objectives 1-4 by: 1) providing retained trees with sufficient space and reduced competition to increase their growth rate (thereby facilitating development not only of large living trees, but also future recruitment of large snags and DW); 2) increasing light to the forest floor to foster understory shrub, herb, and tree seedling development (for species diversity and increased vertical structure); and 3) introducing heterogeneity into the currently homogenous upper canopy to increase horizontal structural complexity. Up to 3.5 million board feet will be removed from the Project Area and sold to cover the costs of the project. This project is expected to be within the city's budget, but will generate less revenue than the costs for the project, including those associated with planning, data collection, cultural resources surveys, log removal, snag creation, and monitoring.

Small canopy gaps will be scattered throughout each ecological thinning unit, covering approximately five percent of the area. Additionally, five percent of each thinning unit will be left untreated in small leave patches (skips). Most gaps and skips will be small (ca 0.04 acre), but 10 larger canopy gaps (four ¼ and ½ acre, and two ¾ acre) will be created, with 10 associated skips of the same sizes. All of these gaps and skips will create structural and habitat complexity and foster species diversity. In the larger gaps, selected dominant live trees will be retained and snags and DW created. Snags will also be created throughout the Project Area (four snags per acre in eight ecological thinning units and 11 snags per acre in one unit) to provide habitat for cavity nesting species. Some larger diameter trees (up to 20 inches) will be used when creating the higher density patch of 11 snags per acre. The conversion of large trees to snags will fulfill the dual objectives of significantly affecting the upper canopy, thereby increasing light to the forest floor, and providing larger diameter snags for those species such as pileated woodpecker that require large snags for nesting. A variety of snag creation techniques will be used, both to investigate the relative success of the methods and to provide a variety of

habitat types over time. The tops of all created snags will be left on site as DW. In addition to these tree tops, large volumes of DW will be created in three units (E7, RT, and the eastern portion of E6), in which all thinned trees will be left on site.

There are three streams located in the Project Area (one permanent and two ephemeral) that will be protected during the thinning (e.g., no equipment will enter into the riparian zone, no trees will be yarded through the streams, all deciduous trees will be retained). Surveys in these streams indicated that no fish or amphibian species were present and that a significant natural barrier downstream prevents future colonization by fish. Stream habitat will be enhanced for benthic invertebrates and other stream biota through felling of large woody debris into the channel. The only wetlands and seeps on the site are associated with these streams, and will receive the same protection as the streams. There are no other special habitats such as springs, rock outcrops, or talus slopes located in the Project Area.

This project will benefit wildlife species dependent on LSF conditions on a scale that is relevant to species with larger home ranges by providing essential habitat much sooner than if no restoration were conducted. In addition, many wildlife species should benefit immediately from the increased habitat complexity and plant species diversity, including forest bats, small mammals, birds, and amphibians.

Uncertainties exist about the amount of overstory tree growth response and the magnitude of effect on understory plants that will be derived from the different ecological thinning treatments. There is also uncertainty about the number of snags and methods of snag creation that will provide the amount of habitat for cavity-nesting species, the ecological effect of leaving down wood in large quantities on the forest floor, and the number and sizes of gaps and skips that are needed to create optimal habitat heterogeneity and structural complexity. To address these uncertainties, three types of monitoring will be conducted. Compliance monitoring will ensure that contract specifications are met during implementation of restoration treatments. Effectiveness of the ecological thinning in achieving the objectives will be evaluated using a series of 14 vegetation plots within the ecological thinning and untreated leave units, a series of plots within created gaps, and monitoring a sample of created snags. Validation monitoring will determine use of the thinned areas and the created gaps by forest dwelling bats, an indicator wildlife species representative of late-successional forest conditions. All results will be compared with the untreated leave areas, to document the magnitude of responses under the different treatments.

1.0 INTRODUCTION

1.1 Background

The Cedar River Municipal Watershed (CRMW) is the larger of two municipal watersheds that serve the City of Seattle. This watershed supplies 67 percent of the high quality drinking water provided to approximately 595,000 homes and businesses in Seattle and roughly 30 neighboring cities, towns, and water districts. The City owns virtually the entire 91,346-acre CRMW upstream of the Landsburg Diversion Dam, where drinking water is diverted from the Cedar River into the municipal water supply system. To protect water quality, unsupervised access is not allowed within the CRMW. The watershed is 95 percent forested and is currently managed under the 50-year multi-species Cedar River Watershed Habitat Conservation Plan (CRW-HCP), which was implemented in April, 2000 (City of Seattle 2000). "The overall goal of the HCP is to implement conservation strategies designed to protect and restore habitats of all species of concern that may be affected by the facilities and operations of the City of Seattle on the Cedar River, while allowing the City to continue to provide high quality drinking water and reasonably priced electricity to the region." (CRW-HCP: 2.4-43). The watershed is being managed as an ecological reserve using an ecosystem approach, with the goals (among others) of protecting and restoring aquatic, riparian, late-successional, and old-growth forest habitats. No harvest for commercial purposes will be conducted under the CRW-HCP, but silvicultural manipulations, including thinning and planting, will be employed to achieve a range of ecological objectives.

This document is the management plan for the 700 Road Forest Habitat Restoration Project. It includes a site description, desired future conditions, ecological objectives, key ecological processes, hypotheses, planned and potential future prescribed silvicultural restoration treatments (e.g., restoration planting), a description of the harvest system, road plans, cost-benefit analysis, and monitoring plans. Section 6.0 includes detailed descriptions of the silvicultural treatments. A glossary is included as Appendix I. The authority for forest restoration projects is provided by the Final Cedar River Watershed Habitat Conservation Plan, signed by the City of Seattle, the United States Fish and Wildlife Service, and the National Marine Fisheries Service (City of Seattle 2000).

Selling excess trees removed during this project will require an ordinance from the Seattle City Council. Public input is available through a formal review process for city council ordinances, as well as an HCP oversight committee. Other public input may also be solicited. A State Environmental Policy Act (SEPA) review is not required for this project. As a fundamental component of completing and adopting the CRW-HCP, a National Environmental Policy Act (NEPA) Environmental Assessment (EA) and a SEPA Environmental Impact Statement (EIS) was successfully completed and adopted. This adoption took place on May 27, 1999, as made record by a letter from then-director Diana Gale to interested parties. As a result, any work undertaken as the direct implementation of a project or program within the CRW-HCP is already compliant with SEPA regulatory requirements. In addition, the 700 Road Forest Habitat Restoration Project would be classified as Class II under the Forest Practice Rules and therefore subject to a categorical exemption from SEPA review.

1.2 General CRW-HCP Goals and Objectives

The CRW-HCP identifies some of the watershed management goals and objectives that apply to upland forest:

> "The mitigation and conservation strategies for watershed management are designed to avoid, minimize, or mitigate for the impacts of any taking of listed species, including the spotted owl and marbled murrelet, and for the equivalent of taking of unlisted species addressed by the HCP. These strategies are also designed to provide a net benefit for the species addressed by the plan, contribute to recovery of these species, and contribute to the maintenance of natural biodiversity [see glossary] in the watershed and region. The strategies will also benefit many other fish and wildlife species inhabiting the biological communities and ecosystems of the watershed that are not specifically addressed by this HCP. Because this HCP focuses on species dependent on late-successional and old-growth forest, riparian and aquatic habitats, those species that depend primarily on the earliest seral forest habitat, such as the grass-forb-shrub stage of succession, will receive less benefit from the HCP or will lose habitat under the HCP, as these habitats will be less common than they are today." (CRW-HCP: 4.2-10)

"The general conservation objectives for watershed management are to:

- Develop strategies for watershed management, consistent with water supply functions, that protect and improve water quality, as well as aquatic and riparian habitats;
- Develop scientifically sound conservation strategies for the watershed that combine mitigation, protection, restoration, research, monitoring, and adaptive management to achieve the conservation objectives of the HCP;
- Develop strategies to restore and sustain the natural processes that create and maintain key habitats for species addressed by the HCP and that foster natural biological diversity of native species and their communities;
- Protect existing old-growth forest in the municipal watershed and promote development of additional mature and late-successional forest that will better support the native organisms characteristic of late-successional and old-growth forest communities;
- Develop an integrated, landscape approach that addresses the spatial relationship of habitats within the watershed and with regard to nearby areas to improve the ability of the watershed, over time, to support the species addressed by the HCP;
- Pursue land management approaches that, as practicable, help avoid catastrophic events such as forest fires that would jeopardize drinking water or habitats for species addressed by the HCP;
- Protect special habitats in the municipal watershed; and
- Commit not to harvest timber for commercial purposes, effectively establishing the forests in the watershed as an ecological reserve that will protect existing old-growth forest, recruit a significant amount of mature and late-successional forest, and make a significant contribution to the support of regional populations of species that depend on late-successional and old-growth forests and/or aquatic and riparian ecosystems." (CRW-HCP: 4.2-10-11)

The CRW-HCP divided the undeveloped habitat in the CRMW into three major components and developed conservation measures for each. The components are 1) late-successional and old-growth forest communities, 2) aquatic and riparian ecosystems (e.g., streams, wetlands, forested riparian corridors), and 3) special habitats (e.g., talus/felsenmeer slopes, upland meadows, cliffs, etc.). Of the 91,346 acres in the CRMW, 85,277 acres are forested, 2,914 acres are in the aquatic and riparian component, 1,809 acres are in the special habitats component, with the remainder developed. Of the forested acres, 13,980 acres are already in late-successional or old-growth conditions (>120 years old). The remaining 71,297 acres are available for recruitment into the late-successional forest habitat component (CRW-HCP: 4.2-15).

1.3 CRW-HCP Upland Forest Goals

The overriding goal of the CRW-HCP is to protect water quality for the municipal drinking water supply. In addition, numerous other goals are delineated in the CRW-HCP. Four general management goals that apply to the 71,297 acres of upland forest are to 1) accelerate the development of late-successional forest characteristics, 2) provide wildlife habitat for targeted species, 3) enhance natural biological diversity, and 4) help avoid catastrophic events. The goals of accelerating the development of late-successional forest characteristics, enhancing biological diversity, and providing habitat for late-successional forest dependent wildlife species are intertwined. Restoration treatments are designed to accelerate development of late-successional forest characteristics, including large trees, structural complexity, species diversity, habitat heterogeneity, and large standing dead and down wood. The treatments will both create and maintain mosaics of habitats over a range of spatial and temporal scales, providing wildlife habitat for a variety of native wildlife species and facilitating biodiversity. While disturbances on many spatial and temporal scales are natural components of forest ecosystems in the Pacific Northwest (e.g., windthrow, forest fire, disease, and insect infestations), large-scale catastrophic disturbances may negatively impact water quality and wildlife habitat for species of concern in the CRW-HCP. As a result, if these catastrophic risks are considered to be significant, then restoration treatments may be designed to reduce that risk.

1.4 CRW-HCP Upland Forest Management Activities

The CRW-HCP identifies three primary management activities to achieve the upland forest restoration goals. “Ecological Thinning” consists of thinning forests older than 30 years, with a primary goal of accelerating the development of late-successional forest characteristics. Examples of how thinning may be used to achieve this goal include creating canopy gaps, encouraging understory development, and promoting the growth of large trees. Snags, downed logs, and tree cavities may be created where it is determined that these attributes are deficient. “Restoration Thinning” is the thinning of dense forests generally less than 30 years of age that have a relatively low level of biological diversity. The goals are to reduce competition, increase light penetration, stimulate tree growth, reduce fire hazard, and accelerate forest development to a more biologically diverse stage. Lastly, “Restoration Planting” will be conducted to develop a diversity of tree, shrub, forb, bryophyte, and lichen species characteristic of naturally regenerated forests that should support a wide range of native wildlife species.

1.5 Site Selection

The 700 Road Forest Habitat Restoration Project Area was initially selected using the professional judgement of Watershed Management Division (WMD) staff who have intimate

knowledge of the CRMW (over 25 years of experience in the CRMW), because the Upland Forest Restoration Interdisciplinary Team (UFRIDT) was still developing the site selection and prioritization process. The primary criteria that were used included the current condition of the forest (a high density of overstory trees with little structural complexity and a depauperate understory) and the Project Area's location relative to existing old-growth forest, the Rex River, and the Chester Morse Reservoir. The overstory trees are in the competitive exclusion stage of forest succession, competing for limited water, nutrients, and light (see Section 4.1). This competition is substantially slowing the growth rate of the trees, thereby limiting the development of large live trees and the eventual recruitment of large snags and down wood (DW). In addition, the dense overstory canopy restricts light to the forest floor, and thus the establishment of a diversity of species of trees, understory shrubs, and herbs, which subsequently impedes structural development on the site.

Other considerations in selecting this site included:

- a growing site that will foster the eventual development of very large trees;
- the potential to create habitat connectivity for animals dependent on late-successional forest conditions;
- a habitat patch linking riparian habitat along the Rex to the ridge top, providing an elevational link between adjacent subbasins;
- good existing tree species diversity that provides a strong basis from which to enhance biodiversity;
- a relatively young forest (62-67 years) in which most trees still have sufficient crown depth to allow a relatively rapid response to decreased competition;
- the opportunity to implement a range of restoration treatments and use a variety of harvest systems, allowing the comparison of methods for use in future restoration efforts.

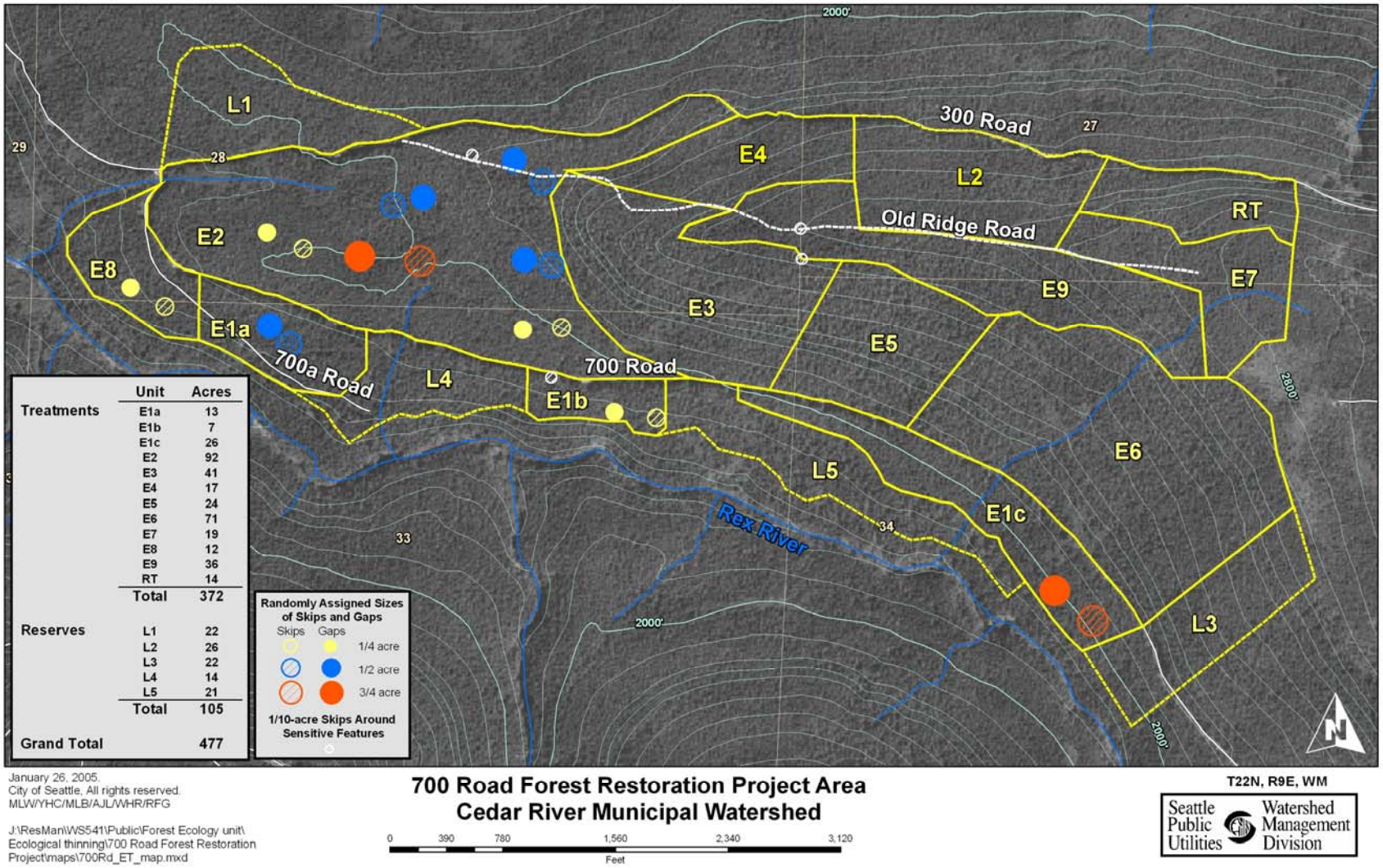
The methodology for site selection and prioritization designated in the draft of the Upland Forest Restoration Strategic Plan (Richards et al. 2004) has subsequently identified the Project Area as having forest characteristics that would benefit from ecological and restoration thinning. Finally, the Project Area, when viewed in concert with other forest restoration activities proposed in the Upland Forest Restoration Strategic Plan, provides habitat connectivity between the old-growth forests patches in the upper CRMW with the maturing forests and 45 Road Forest Habitat Restoration Project in the lower CRMW.

2.0 SITE DESCRIPTION

2.1 Location

The Project Area encompasses 477 acres, of which 358 acres are in nine ecological thinning units (designated as E1-E9), 14 acres are in a restoration thinning unit (RT), and 105 acres are in five untreated leave units (L1-L5) (Figure 1). The Project Area is located in Sections 27, 28, 33, and 34 of T22N, R9E, W.M, and is bounded on the north by the 300 Road and a flagged

Figure 1. **700 Road Forest Habitat Restoration Project Area, Thinning and Leave Units**



	Unit	Acres
Treatments	E1a	13
	E1b	7
	E1c	26
	E2	92
	E3	41
	E4	17
	E5	24
	E6	71
	E7	19
	E8	12
	E9	36
	RT	14
	Total	372
Reserves	L1	22
	L2	26
	L3	22
	L4	14
	L5	21
	Total	105
Grand Total		477

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J:\ResMan\WS541\Public\Forest Ecology unit\Ecological thinning\700 Road Forest Restoration Project\maps\700Rd_ET_map.mxd

700 Road Forest Restoration Project Area
Cedar River Municipal Watershed

0 390 780 1,560 2,340 3,120
Feet

T22N, R9E, WM

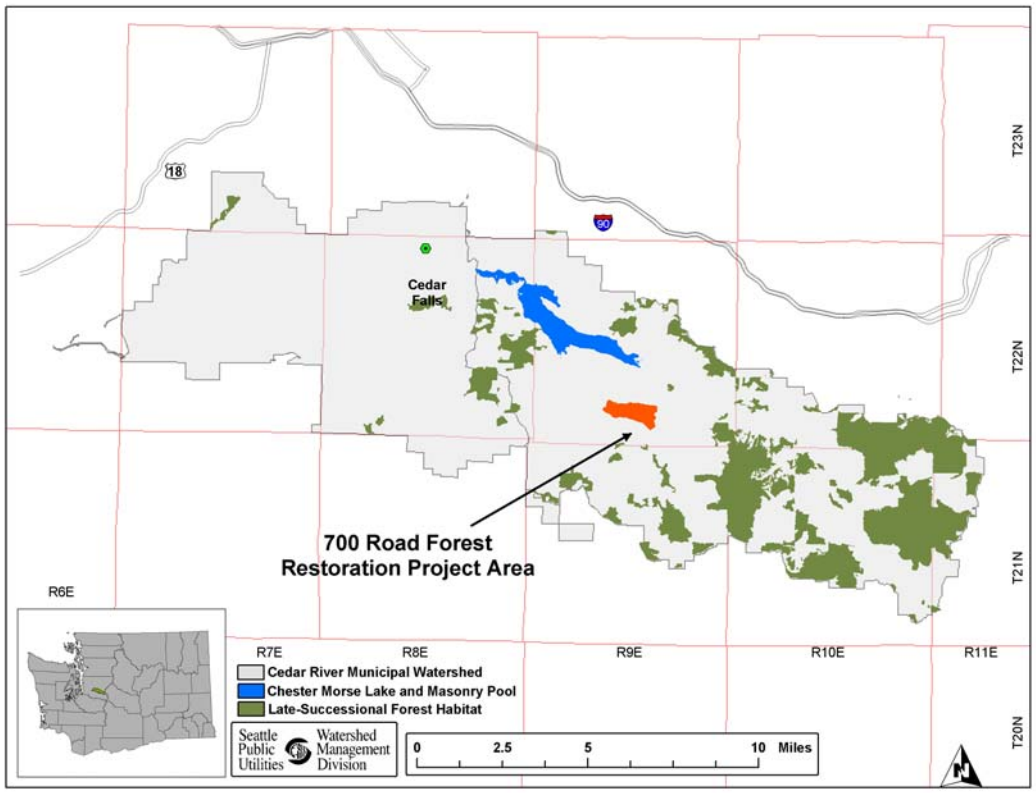
Seattle Public Utilities — Watershed Management Division

boundary line, and on the east and south by a flagged boundary line. The junction of the 300 and 700 roads lies at the western end of the area, and the 700 road bisects the Project Area. In addition, there is a 70-year old road running from the 300 road along the ridge line and ridge top. The site is located roughly 1.0 mile south of Chester Morse Lake, 7.0 miles southeast of the WMD headquarters at Cedar Falls, and 10.9 miles southeast of downtown North Bend, Washington.

2.2 Landscape Context

The Project Area lies within the lower Rex River sub-basin near the geographic center of the CRMW. While forest within the CRMW will not be commercially harvested during the 50-year term of the CRW-HCP, forested land outside and adjacent to the CRMW may be subject to continued rotation harvest or conversion to other landcover types. The CRMW property boundaries lie approximately 3.0 miles to the north and south of the Project Area, 10.3 miles to the east, and 14.3 miles to the west. The major landowner adjacent to the CRMW and north of the Project Area in the South Fork Snoqualmie River watershed is the USDA Forest Service (USFS). Plum Creek Timber Company owns land adjacent to the CRMW south of the area in the Green River watershed. The nearest late-successional or old-growth forest in the CRMW is approximately 1.0 mile south of the Project Area (Figure 2). The Rex River sub-basin has 1,740 acres of old-growth forest that represents 12 percent of the sub-basin. Puget Sound is approximately 31.0 miles to the west of the Project Area.

Figure 2. Late-successional forest in the vicinity of the 700 Road Forest Habitat Restoration Project Area



Although 372 acres is a small proportion of the CRMW (<0.4 percent), it is of sufficient size to provide habitat for species with medium home range sizes, such as the hairy woodpecker (*Picoides villosus*). It will also substantially contribute to habitat restoration for old-growth forest dependant species on a metapopulation scale, including those species that have home ranges in the thousands of acres, such as northern spotted owl (*Strix occidentalis)*, northern goshawk (*Accipiter gentilis*), pileated woodpecker (*Dryocopus pileatus*), fisher *(Martes pennanti*), and American marten (*Martes americana)* (Morrison et al 1998, Smallwood 2001). Forest restoration projects in the 300-500 acre range allow for diverse treatments at appropriate habitat patch scales, creating a mosaic that will provide habitat for a multitude of species. This would not be possible if only small isolated patches of habitat were restored. This patch size also can provide habitat connectivity on a spatial scale that is relevant to species listed in the HCP.

2.3 History and Cultural Resources

Historic Native American use in the CRMW has been well documented, although no historic villages or camps have been identified on the Project Area itself and are considered unlikely, given the location (Schalk and Schwartzmiller 2004). An historic trail has been identified along the ridge that runs east-west through the Project Area, and may have been used in prehistoric times. The area may have been used for hunting and/or gathering of resources, activities that can leave little or no permanent record, although culturally modified trees may still be present (none were found in the cultural resource survey). American settlers moved into the vicinity in the late 1800s, largely to exploit the timber and mineral resources, and remnants of an old logging camp is located in the southeastern portion of the Project Area, just north of the Rex River. A two-phase cultural resources survey was implemented in 2003 (Schalk and Schwartzmiller 2004). Phase I included a pedestrian survey of the acres to be ecologically thinned. Phase II involved subsurface surveys of locations of interest with high probability to contain cultural debris. No areas of cultural significance were located, and thinning is not expected to have an adverse effect on cultural resources.

The Project Area was clearcut logged from 1929-1934, which was probably followed by burning to remove logging debris (there is evidence of fire, including charred stumps and DW). The area was likely naturally reseeded, although no documentation of burning or reseeding is available for this site. The existing forest ranges from 61 to 67 years old, with the older trees at the lower elevations in E1 and E2, and the younger trees on the ridge top in E7 and RT. The Project Area has not been previously thinned.

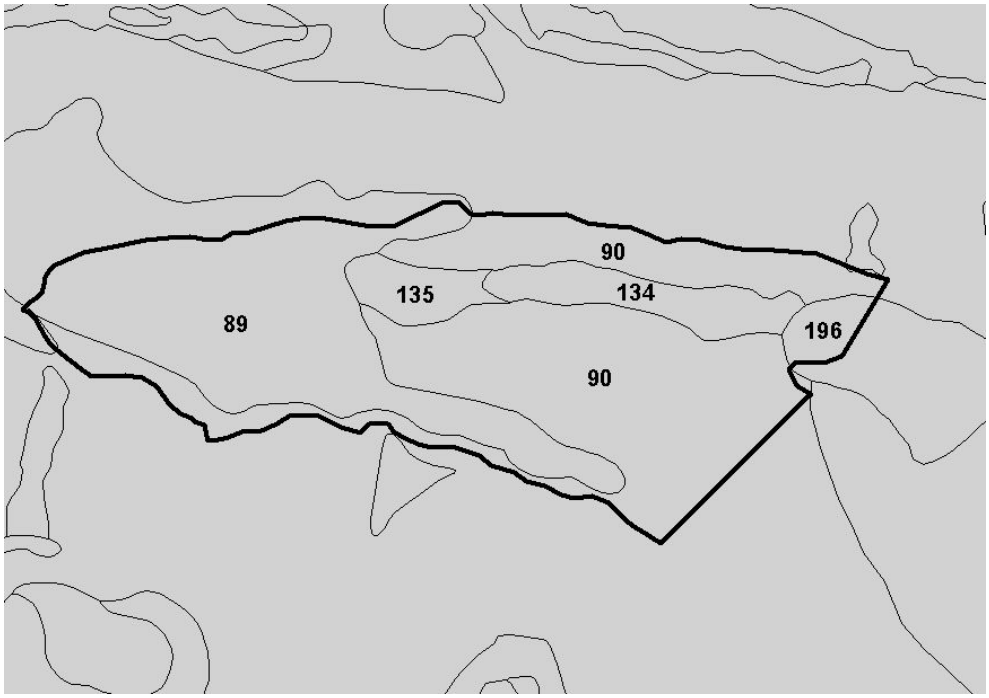
2.4 Soils

There are five types of soil on the Project Area (Table 1 and Figure 3), all formed in a mixture of volcanic ash and pumice derived from andesite (USDA-SCS 1992). Under bare soil conditions, these soil types provide a slight to moderate erosion hazard that generally increases with slope. These soils typically support overstory vegetation of Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*), while Pacific silver fir (*Abies amabilis*), noble fir (*Abies procera*), red alder (*Alnus rubra*), and black cottonwood (*Populus balsamifera*) can also be present. Understory vegetation may include Oregon-grape (*Berberis aquifolium*), salal (*Gaultheria shallon*), western sword fern (*Polystichum munitum*), red huckleberry (*Vaccinium parvifolium*), and Pacific trillium (*Trillium ovatum*).

Table 1. Description of soil types found in the 700 Road Forest Habitat Restoration Project Area.

Soil Name	Slope (%)	Map ID #	Source	Elevation (ft)	Permiability	Water Capacity	Runoff	Erosion Hazard	Associated Tree Species	50-Yr Site Curve	100-Yr Site Curve	Site Class	Associated Understory Species
Kaleetan sandy loam	8-30	**89**	volcanic ash and pumice over colluvium derived from andesite and glacial till	1,600-2,800	moderate	moderate	slow	slight	Douglas-fir, western hemlock, western red cedar, red alder	DF 113	DF 145	III	Oregongrape, salal, western swordfern, red huckleberry, Pacific trillium, vine maple, deer fern, longtube twinflower, western brackenfern
Kaleetan sandy loam	30-65	**90**	volcanic ash and pumice over colluvium derived from andesite and glacial till	1,600-2,800	moderate	moderate	medium	moderate	Douglas-fir, western hemlock, western red cedar, red alder	DF 113	DF 145	III	Oregongrape, salal, western swordfern, red huckleberry, Pacific trillium, vine maple, deer fern, longtube twinflower, western brackenfern
Melakwa sandy loam	8-30	**134**	volcanic ash and pumice over colluvium derived from andesite	1,600-2,800	moderate	moderate	slow	slight	Douglas-fir, western hemlock, western red cedar, red alder	DF 104	DF 128	III	western swordfern, Oregongrape, salal, vine maple, red huckleberry, Pacific trillium, deer fern, longtube twinflower, western brackenfern
Melakwa sandy loam	30-65	**135**	volcanic ash and pumice over colluvium derived from andesite	1,600-2,800	moderate	moderate	medium	moderate	Douglas-fir, western hemlock, western red cedar, red alder	DF 104	DF 128	III	western swordfern, Oregongrape, salal, vine maple, red huckleberry, Pacific trillium, deer fern, longtube twinflower, western brackenfern
Playco loamy sand	8-30	**196**	volcanic ash and pumice mixed with colluvium derived from andesite	2,500-3,600	moderate	high	slow	slight	western hemlock, Pacific silver fir, noble fir, Douglas-fir	WH 89	WH 127	IV	montia, trillium, devilsclub, huckleberry, Oregongrape, Pacific yew, salal, western swordfern

Figure 3. Map of soil types in the 700 Road Forest Habitat Restoration Project Area. See Table 1 for description of types.



The majority of the Project Area has a tree growth potential of site class III, on a scale of I to V where the lower the site class number, the better the tree growth potential. Douglas-fir trees will typically grow to 104 to 113 feet in height over 50 years on these soil types, and 128 to 145 feet in 100 years. The soils on a small portion of the area toward the top of the ridge are site class IV, where western hemlock trees will typically grow 89 and 127 feet tall, in 50 and 100 years respectively.

2.5 Elevation and Topography

The elevation of the Project Area ranges from 1,760 to 2,840 feet above sea level (asl), with slope varying from 0 to 50 percent (Figure 1). A ridge runs downhill from east to west through the middle of the area, creating south, west, and north facing aspects. Gently sloped areas are primarily on the west and south sides of the Project Area, as well as along the apex of the ridge. Relatively steeply sloped areas occur on the north and south sides of the ridge.

2.6 Climate

The climate of the Project Area is typical of weather on the west slope of the Cascade Mountain Range in Washington, where conditions are highly variable and dependent upon elevation, topography, aspect, and latitude. The nearest weather station is located at Chester Morse Lake (previously known as Cedar Lake) near the Masonry Dam, which is 1,560 feet asl (data available at: http://www.wrcc.dri.edu). Temperatures at the station range from an average monthly maximum of 72°F in August, to an average monthly minimum of 30°F in January. Annual

average precipitation is 102 inches, falling primarily as rain from October to March. Annual snowfall averages 68 inches. The Project Area receives strong southeasterly fall winds, and occasional strong northeasterly spring winds.

2.7 Aquatic Resources

The southern sections of the Project Area drain directly into the Rex River, while most of the northern portion drains into the Rex River via Morse Creek. Units L1, E4, L2, RT, E7 and portions of E2 drain into the upper Cedar River via Eagle Ridge Creek. Both the Rex and Cedar rivers flow into Chester Morse Lake, which when taken with the Masonry Pool, provides a 1,690-acre reservoir that is controlled by the Masonry Dam. From the Masonry Dam, the Cedar River flows approximately 14 river miles downstream to the water supply intake at the Landsburg Diversion Dam, and ultimately into Lake Washington approximately 22 river miles downstream of Landsburg.

2.7.1 Streams

Three unnamed surface streams (one permanent and two ephemeral) have been identified within the Project Area (Figure 1). The permanent stream is located at the west end of the Project Area in E2. It flows in a westerly direction from its point of origin, located about 1,200 feet east of the 700-300 road junction. Immediately above the 700 road the channel is moderately entrenched into alpine till. Boulders (from the till) as well as scant in-channel large woody debris (LWD) currently form steps within this 4-6% gradient step-pool channel. Approximately 500 feet upstream, the channel becomes an unentrenched 2-4% gradient channel dominated by root and LWD-formed steps. Within this upper reach, roots and small LWD seem sufficient to maintain natural channel processes. Overall stream power through this reach is low, reflecting the small drainage area and gentle gradient. No secondary or overflow channels were observed along this stream.

At the point of origin, the stream flows through conifer-dominated forest. At about 500 feet from the origin the riparian area becomes dominated by deciduous trees that persist until the 700-300 road junction, at which point the stream passes through a culvert and out of the Project Area. It then continues its westerly flow to the Rex River. The stream is not passable by bull trout (*Salvelinus confluentus*) or rainbow trout (*Oncorhynchus mykiss*) from the Rex River because of a seven-foot drop at the Rex River and a 30 percent bedrock cascade for almost 400 feet below the 700 road. No fish or amphibians were found in this stream during surveys conducted by WMD staff in the spring of 2003.

The western ephemeral stream has a southerly course through the E2 and L4. This un-entrenched, 1-4% gradient step-pool channel has a very small drainage area and low stream power. Large woody debris and roots function to form steps and stabilize banks. Small, adjacent wetlands dominated by cedar and deciduous trees are present near the head of the channel. Within this upper reach, roots and small LWD seem sufficient to maintain natural channel processes in this tributary. Below the 700 road in L4 the channel becomes very weakly defined and eventually goes subsurface.

The eastern ephemeral stream flows in a southwesterly direction through E7, E9, E6, and the eastern portion of E1. It is a steep (generally >20% gradient) cascade channel that is mostly

ephemeral with no chronic bank erosion or obvious slope stability issues. In-channel LWD levels are low throughout the extent of the channel and existing wood is generally highly decayed. Primary wood functions include step formation and sediment storage. Within Unit E7 the channel becomes unconfined, is significantly more gentle (<10% gradient), less distinct, and is flanked by numerous seeps. Below the 700 road (in E1) the channel splits, with an approximate 125-foot wide island of conifer trees between them.

No amphibians were detected in either of these ephemeral streams during surveys in the spring of 2003.

2.7.2 Wetlands

There are no wetlands or seeps in the Project Area that are not closely associated with the streams described above.

2.7.3 Special aquatic areas

No special aquatic areas, such as springs, occur in the Project Area.

2.8 Vegetative Resources

The Project Area lies in the transition between the Western Hemlock and Pacific Silver Fir Zones in the western foothills of the Cascade Mountains (Franklin and Dyrness 1988). The natural disturbance regimes in these forest types range from small scale insect and pathogen infestations to windthrow and catastrophic forest fires. Typical fire-return intervals in this area of the western Cascades range from one hundred to several hundred years (Agee 1993).

2.8.1 Overstory

The tree stratum is dominated by 61-67 year-old western hemlock and Douglas-fir trees that originated in the late 1930s following clearcut logging in the late 1920s and early 1930s. There are also significant numbers of western red cedar and Pacific silver fir trees, with some red alder, noble fir, black cottonwood, and Pacific yew (*Taxus brevifolia*). The trees on the lower slopes have generally exhibited greater growth (E1, E2, and E8), but all of the ecological thinning units have some larger trees. Douglas-fir trees typically comprise the dominant canopy class with shade-tolerant western hemlock comprising co-dominant and subdominant canopy classes.

A forest inventory was conducted on 429 acres of the Project Area (L1 and L3 were omitted) in September 2001. A variable radius plot method was used to quantify certain tree characteristics roughly every two acres, which resulted in 216 plots. Based on this inventory information and field reconnaissance, nine units with relatively unique characteristics were identified for ecological thinning (E1-E9), one unit for restoration thinning (RT), and three units to be left untreated (L2, L4, L5). A summary of this information is included in Appendix II. Areas L1 and L3 were chosen because of their similarity to E1, E2, and E6, and will have comparable data collected in 2005 to document baseline conditions.

In the units designated for ecological thinning, the density of live trees ≥6 inches in diameter at breast height (dbh) ranges from 298 to 471 trees per acre (E5 and E6, respectively). Average tree diameters range from 8.8 to 14.7 inches quadratic mean dbh (E7 and E1, respectively), with a maximum tree diameter of 33 inch dbh in E2. Maximum tree height ranges from 104 to 139

feet (E4 and E1, respectively). Tree species abundance is dominated by western hemlock in all of the units (ranging from 43 to 81 percent of the trees per acre in E3 and E6, respectively). Douglas-fir is the second most abundant species in all units except E1 and E4. Western red cedar provides significant species abundance (≥5 percent) in all units except E6. Pacific silver fir is present in five of the nine ecological thinning units, but is only significantly abundant in E1(8 percent). Deciduous trees (red alder and black cottonwood) were detected in Units E1, E2, and E6. See Section 6 and Appendix II for a complete description of current overstory tree data by thinning unit, as well as the projected leave tree data after thinning.

The forest inventory of the restoration thinning unit (RT) provides limited data because it ignores trees less then 6 inches dbh, which make up a significant portion of the trees. There are 373 trees per acre that are ≥6 inches dbh, with the largest tree being 14 inches dbh. Western hemlock and Douglas-fir (both over 40 percent) are most abundant, but there is also a significant number of western red cedar (12 percent). No deciduous trees were identified.

The forest inventory data for L2 indicates that there are 407 trees per acre ≥6 inches dbh, with an average diameter of 9.1 inches quadratic dbh. The largest diameter tree in L2 is 22 inches dbh, and the species abundance is dominated by western hemlock (55 percent). Western redcedar, Douglas-fir, and Pacific silver fir are also significantly abundant in this untreated leave unit.

2.8.2 Understory

No understory data were collected with the 2001 forest inventory. Some understory data were collected in 1992, however, as a supplement to a forest inventory conducted in a portion of the Project Area (E5, E6, E7, E9, L2, RT, L3, and a small portion of the eastern end of E1) (Mason, Bruce, and Girard 1992). Seventeen herb and shrub species were identified, with Oregon grape, sword fern, salal, red huckleberry, and vine maple predominating (Table 2). Forty of the 43 plots contained some understory vegetation, although only 14 plots had ≥50% cover, with most plots having less than 25% cover. This is consistent with general field observations made in 2003 of a generally depauperate understory vegetation with little tree regeneration.

2.8.3 Biological Legacies, Snags, Stumps, and Down Wood

The 2001 forest inventory of the Project Area identified snags (all western hemlock) in only three of the ecological thinning units (E1, E2, and E3). The largest snag (20 inches dbh) was sampled in E1, with no other snags larger than 14 inches dbh sampled. In the 1992 survey, a portion of the Project Area (E5, E6, E7, E9, L2, RT, L3, and a small portion of the eastern end of E1) was sampled for snags as a supplement to a forest inventory (Mason, Bruce, and Girard 1992). This survey also found large snags to be scarce (Table 3). On 43 plots, 28 snags were sampled, with the largest 18 inches dbh. The average diameter was 8.1 inches dbh, with 17 of the sampled snags ≤8 inches dbh. All were decay class I (i.e., little decay, indicating recent mortality). Species composition consisted of two Douglas-fir, four red alder, eight Pacific silver fir, eight western hemlock, and six unknown. Prior to the 1980s, snags were routinely removed from logging areas as a safety precaution.

Table 2. Understory species occurrence, with number and percent of plots by cover class[a] in the 700 Road Forest Habitat Restoration Project Area[b], 1992 study.

Species	Species Occurrence		≥50% cover		25-49% cover		<25% cover	
	# Plots	% Plots	# Plots	% Plots	# Plots	% Plots	# Plots	% Plots
Alaska blueberry	6	14	0	0	0	0	6	14
Bunchberry dogwood	2	5	0	0	0	0	2	5
Beargrass	1	2	0	0	0	0	1	2
Pacific blackberry	3	7	0	0	1	2	2	5
Foamflower	5	12	0	0	0	0	5	12
Devil's club	3	7	0	0	0	0	3	7
Deer fern	8	19	0	0	0	0	8	19
False lily-of-the-valley	1	2	0	0	0	0	1	2
Lady fern	6	14	0	0	1	2	5	12
Oregongrape	30	70	5	12	5	12	20	47
Queen's cup	1	2	0	0	0	0	1	2
Red huckleberry	15	35	0	0	1	2	14	33
Rosy twistedstalk	3	7	0	0	0	0	3	7
Salal	25	58	5	12	4	9	16	37
Sword fern	21	49	2	5	1	2	18	42
Vanilla leaf	1	2	0	0	0	0	1	2
Vine maple	14	33	2	5	2	5	10	23

[a]Because cover by understory species can overlap, and not all species occurred on all plots, percentages do not add to 100.
[b]43 plots = 2.15ac total sampled

Table 3. Snag and stump data from plots sampled in the 700 Forest Habitat Restoration Project Area[a], 1992 study.

Habitat Element	Diameter Class	# Sampled	Average diameter	Range of diameters	Estimated #/acre
Snags	≥16" dbh	1			0.5
	9-15" dbh	10			4.7
	≤8"dbh	17			7.9
Total		28	8.1	4-18	13.1
Stumps	>30"dbh	29			13.5
	20-29"dbh	48			22.3
	10-19"dbh	42			19.5
	<9"dbh	2			0.9
Total		121	24.8	9-80	56.2

[a]43 plots = 2.15ac total sampled

Residual stumps of the forest that stood on the site prior to being clearcut harvested in the early 1930s were also sampled in the 1992 survey (Table 3) (Mason, Bruce, and Girard 1992). Of the 121 stumps sampled on the 43 plots, 24 percent were >30 inches dbh. Estimated dominant tree density (those greater than 20 inches dbh) was 36 trees per acre. These data are consistent with

data collected on residual stumps from two one-third acre plots in E5 and E6 in 2002. The first plot contained 19 stumps, with an average diameter of 36.7 inches (range 20 to 54). The second plot had 12 residual stumps with an average diameter of 41 inches (range 24 to 60). The samples indicate a dominant tree density in the original forest of 36 to 57 trees per acre with a basal area of 350 to 460 ft^2 per acre. It was not possible to determine the species of the stumps because of the amount of decay. Application of these data towards current treatments is problematic due to the varying decay rates of different tree species and sizes. The data do indicate the site potential, may portend future conditions, and begin to establish a reference condition approximation.

Down wood was sampled from thirty-seven 66-foot transects in 1992 from the same areas described for understory vegetation, snags and stumps (Mason, Bruce, and Girard 1992). They measured 113 pieces of DW, ranging from five to 50 inches and averaging 15.8 inches diameter where the transect crossed the piece. Estimated volume of DW from this sample was 5,352 ft^3/ac. Although DW was not sampled in 2001, field observations indicated the amount varied throughout the Project Area, attributable to the differing levels of competitive mortality. A large amount of large diameter DW is present in L2, possibly a result of cutting snags that were generated from an escaped burn started to control logging slash. This untreated leave unit was designed in part to protect this important habitat element.

2.9 Wildlife Habitat

The second-growth forest in the Project Area potentially provides habitat for a suite of wildlife species, including bats, small and large mammals, amphibians, and birds (Appendix III). Wildlife respond not to forest age, but rather to ecological characteristics such as structural complexity, plant community composition, species diversity, and dead wood elements (snags and DW), that together provide food, shelter, and moisture requirements. As described above, most of the thinning units currently consist of relatively small-diameter western hemlock and Douglas-fir trees with limited understory, providing adequate wildlife habitat for few species and individuals (Aubry et al. 1997).

This forest lacks characteristics typical of late-successional forest, such as large trees, snags, DW, a variety of berry-producing shrubs, mast-producing trees or shrubs, canopy layering, plant species diversity, and variable tree spacing and densities. Because 28 of the 83 species listed in the CRW-HCP are associated with late-successional forest habitat (the others requiring riparian or other "special" habitats), actions facilitating the development of these characteristics are a primary management goal. Native species not listed in the CRW-HCP are also considered during management planning as long as there are no conflicts with the overall goals of the CRW-HCP. A list of wildlife species that potentially could use the Project Area, either now or in the future, along with key habitat elements the area might provide, is included in Appendix III.

Accelerating this area toward late-successional forest conditions should provide valuable wildlife habitat for species dependent on LSF conditions and foster increased biological diversity, which is especially important in the local and regional landscape context. In addition, because ecological thinning will facilitate short-term responses by understory plants, it should provide immediate habitat benefits for numerous species, including several species of forest bats, small mammals, amphibians, and birds (Aubry et al. 1997, Hagar et al. 1996, Haveri and Carey 2000, Humes et al. 1999, Muir et al. 2002, Suzuki and Hayes 2003, Wilson and Carey 2000).

2.10 Special Habitats

No special habitats (e.g., talus slopes, rock outcrops, meadows) occur in the Project Area.

3.0 DESIRED FUTURE CONDITIONS

The desired long-term future condition of the Project Area includes characteristics consistent with late-successional conifer forests of the region that are subject to similar environmental constraints. These characteristics include large trees (stumps indicate that trees >60 inches dbh have grown on the site); a greater diversity of tree, shrub, forb, and bryophyte species; a greater variety of tree sizes, spacing, and densities incorporating both horizontal and vertical structural complexity; more small canopy gaps; and a greater abundance of large snags and DW occurring in patches across the Project Area.

Late-successional forest conditions in the Pacific Northwest vary with different environmental conditions (elevation, soil productivity), the site's ecological history (type and frequency of disturbance), and long-term climate. In addition, a key characteristic of old-growth forest is its inherent variability and spatial heterogeneity (characteristics we are simulating with restoration treatments). These variable conditions make establishing specific numeric targets for desired future forest characteristics and restoration objectives difficult, if not impossible. However, we have developed hypotheses about the response of the forest to the restoration treatments (see section 4.3 for specific hypotheses as related to ecological objectives and processes). Generally, in the short and intermediate terms we anticipate the restoration treatments will increase the growth of co-dominant trees, result in crown elongation through epicormic branching, increase seedling initiation, and increase the cover of shrubs and forbs as compared with the untreated leave areas. Structural complexity (both vertical and horizontal) should be increased in the treatment areas relative to the leave areas as a result of the understory plant response. These conditions should support a variety of native wildlife species over the short, intermediate, and long-term that will not occur in the untreated leave areas or much of the surrounding area because of their lack of habitat diversity and available niches. Species utilizing the site should eventually include many of the 28 LSF dependent species listed in the CRW-HCP (Appendix III). Species requiring extremely shady areas (e.g., certain saprophytes) will be provided for in the leave areas and small untreated skip patches within treatment units. In addition the majority of the CRMW will not be thinned, and will continue to provide dense overstory with little light to the forest floor. Monitoring the success of forest habitat restoration on this site will concentrate on documenting measurable key forest attributes that are targeted by our restoration treatments, and comparing them to similar leave areas where no restoration activity is implemented (see section 9).

4.0 FOREST PROCESSES AND ECOLOGICAL THINNING

4.1 Overview of Forest Development

Numerous models have been developed that classify Pacific Northwest forest development into stages. These range from the simple four-stage model of Oliver and Larson (1996) that focuses on live trees in dense, even-aged stands to the recent eight-stage model of Franklin et al. (2002). Oliver and Larson's (1996) stages include: 1) stand initiation or early-successional, 2) stem

exclusion or mid-successional, 3) understory reinitiation or late-successional forest, and 4) old-growth or shifting mosaic. The stand initiation stage occurs as tree seedlings become established throughout the forest stand, either naturally or by planting, following a stand replacement event (e.g., clearcut harvest, forest fire). This stage can last for several decades. The stem exclusion stage occurs when the trees have grown to a size such that they are competing with one another for resources (e.g., sunlight, nutrients, and water). This stage generally occurs when the stand is 20 to 100 years old and results in decreased growth rate and significant tree mortality. The understory reinitiation stage occurs after tree densities have decreased, either through competition mortality or thinning, and the tree canopy opens to allow greater light penetration to the forest floor. Understory plants and a new cohort of trees are then able to establish under the overstory trees. This stage generally occurs from 60 to 200 years old. The old-growth stage occurs when the dominant trees become very large and the understory is developed enough to have several layers (e.g., subdominant trees, saplings, seedlings, shrubs, and herbs). Shifting mosaic refers to the dynamics of the old-growth stage where dominant trees periodically fall to create canopy gaps (Franklin and Waring 1980). Tree growth and competition occurs within these gaps until dominance is reestablished, but usually by shade tolerant species as opposed to the shade intolerant pioneers. The old-growth stage generally occurs when a stand is greater than 180 years old.

The stages in the Franklin et al. (2002) model are more structurally based and cover a much broader range of time (up to 1,200 years). Their disturbance and legacy creation stage occurs prior to stand initiation. The next two stages, cohort establishment and canopy closure, correspond roughly to Oliver and Larson's (1996) stand initiation and early stem exclusion stages. The fourth stage, biomass accumulation/competitive exclusion, corresponds to the stem exclusion phase and beginning of understory reinitiation. The maturation stage covers the remainder of the understory re-initiation and early old-growth stages. Then older forest is split into three further stages: vertical diversification, horizontal diversification, and pioneer cohort loss.

4.2 Ecological Thinning

The best emerging science indicates that thinning younger forests can accelerate development of LSF conditions (Tappeiner et al. 1997, Carey et al. 1999, Carey et al. 1999b, Garman et al. 2003). There is also evidence that older forests (>100 years) can respond favorably to thinning (Williamson 1982, Latham and Tappeiner 2002). Ecological thinning in the CRMW seeks to reduce inter-tree competition, increase residual tree growth, and increase the structural heterogeneity and biological diversity of the forest using the most current techniques and best available science. The goals are to shorten the competitive exclusion phase, prevent stagnation in forest development, and accelerate the forest from the competitive exclusion stage that provides little wildlife habitat to the more biologically diverse understory reinitiation or maturation phase that will provide habitat for a broader range of wildlife species. Thinning allows remaining trees to maintain or increase their growth rates, while simultaneously providing more sunlight for understory growth and seedling regeneration. Ecological thinning seeks to mimic the structural heterogeneity found in late-successional forests by leaving a variety of tree sizes (diameter and height), spacing, and densities throughout the forest, including creating numerous small gaps and leaving small patches unthinned.

Removing only trees in subdominant and intermediate canopy positions (i.e., thinning from below), the technique often used in standard commercial thinning, may not significantly affect the light regime on the forest floor. In addition it would eliminate some structural elements such as slower-growing shade tolerant plants that contribute to plant and wildlife habitat diversity (Lindenmayer and Franklin 2002). Consequently, the goals of increasing forest vertical structural complexity and increasing the understory species diversity would not be achieved. While thinning from below is considered better than no thinning for forest habitat restoration, studies suggest that customized thinnings designed to achieve variable densities within stands and augmenting snags, understory species, and down wood are ecologically preferable (Anonymous 2003, Carey et al. 1999, Lindenmayer and Franklin 2002, Muir et al. 2002).

Because maximizing stand yield is not the goal as it might be in commercial thinning, we will balance the objectives for increasing individual tree growth with the other objectives to facilitate development of habitat complexity and diversity. Consequently, a variable density thinning method will be used, which leaves trees across smaller size classes as well as larger diameter trees, creates variable (rather than uniform) spacing between trees, and creates numerous canopy gaps and denser unthinned skip patches (Carey et al. 1999). This treatment is designed to simulate natural processes such as tree death from competition, windthrow, lightning, disease, or insects, and other small-scale disturbances that combine to create the structural complexity and biological diversity observed in late-successional forests. Trees with unusual features or physical damage (e.g., forked tops, broken tops, mistletoe brooms) are important components of biodiversity, and will be retained during the thinning treatment. Additionally, the few existing large snags and DW will be retained and new snags and logs will be created, thereby furthering the structural complexity of the Project Area.

Lindenmayer and Franklin (2002) recommend using multiple techniques to create structural complexity and compositional diversity in previously harvested forests, including:

- thinning to grow large diameter trees;
- variable density thinning (creating canopy gaps, leaving untreated skip areas, as well as varying spacing between trees);
- thinning from “above” by selectively removing some dominant trees or branch pruning to sustain or release shade-tolerant understory trees and understory shrubs and herbs;
- conservation of tree or other plant species that fulfill different structural and functional roles (i.e., deciduous trees, and species with edible fruits, distinctive bark or branching, or high capacity to host epiphytes);
- conserving and creating decadence (snags, logs, cavities); and
- planting desired tree or understory species.

The 700 Road Forest Habitat Restoration Project will utilize all these recommendations to retain and increase elements of biodiversity, including the selective removal of some co-dominant tree canopy by means of snag creation. The trees remaining after thinning will be able to maintain, and in many cases, accelerate growth. This continued growth will lead to larger live trees that will provide greater structural complexity (e.g., bark, branches, crown, roots), increased wildlife habitat value, and more biological diversity in the future. Ultimately, some of these large trees

will be naturally recruited as large snags and DW. Opening the canopy through ecological thinning and gap creation will encourage understory development and tree regeneration. Retaining various sized areas in denser patches (not thinned) will help create within-site variability, simulating a natural forest pattern. In addition, the snag creation will supplement this critical habitat element for numerous wildlife species while the forest matures to a stage when it begins naturally producing larger snags. It is well documented that commercial thinning results in greater numbers of wildlife species and more individuals using the forest (Aubry et al. 1997, Hagar et al. 1996, Hayes et al. 1997, Humes et al. 1999, Suzuki and Hayes 2003). Ecological thinning should at a minimum mimic these results, although because it is simulating natural disturbances, creating increased structural complexity and species diversity, and creating snags and DW, it should result in even greater wildlife response.

Because forest habitat restoration techniques are relatively new, the efficacy of these silvicultural treatments will not be completely known for many years or decades. We are using the most current literature and expert opinion in designing treatments to maximize the probability of the achieving an ecological outcome that will most benefit species dependent on LSF in the long term, while at the same time benefiting numerous other species in the near term.

4.3 Hypotheses About the Effects of Ecological Thinning on Key Forest Processes

Several key forest processes, including soil formation, primary productivity, food webs, and nutrient cycling will be influenced by the restoration treatments. Forest successional development, however, is the primary process that we expect to influence with ecological thinning. The numerous processes associated with successional development can be divided into four categories: individual tree, canopy, dead wood, and understory processes (Figure 4). All of these processes are complex and interrelated, and lead to forest structural development.

We developed specific hypotheses about the effect of ecological thinning (including thinning, and creation of canopy gaps, snags, and DW) on each of these processes (Figure 5). The primary influence that we expect to have on individual tree growth processes is either a maintenance or increase in all aspects of tree growth (diameter, crown dimensions, and height to a lesser degree) and an increase in shade tolerant tree regeneration. Because most trees on the Project Area currently average 40% live crown, we predict that it will take at least ten years to measure an overstory diameter growth response resulting from the decreased competition and increased light availability. We may, however, be able to measure a crown response in as little as five years. Understory tree regeneration will most likely be measurable within five years.

We expect a significant increase in canopy elaboration over time, including development of multi-layered or continuous vertical canopy through growth of shade-tolerant species and establishment of epicormic branching on shade intolerant dominants as a result of the thinning and gap creation. The created gaps will provide this forest successional element in the short term as the forest is maturing to a point where gaps will begin to be created naturally. We expect the canopy gaps to decrease in size within 15-20 years due to branch elongation, and some gaps may close within several decades due to tree regeneration. We believe the dominant trees retained in the larger gaps (see Section 6) will greatly benefit from the increased light, and develop into large trees with sufficient branch structure to provide an important habitat component in the

long-term (e.g., nesting platforms for northern goshawk). These residual trees will also serve as shelterwood protection for initiation of various understory vegetation communities.

Dead wood processes will be enhanced in the short term by snag creation throughout the Project Area (both throughout the forest matrix and in the larger canopy gaps), and DW creation in the gaps (entire trees) and in the matrix (from tree tops from the created snags throughout the Project Area), and all thinned trees left on ground in E7, RT, and the eastern portion of E6. We predict that dead wood will be provided in the medium term by retaining deciduous and true fir species. These species have a shorter life span and will be unlikely to successfully compete with longer lived trees, such as Douglas-fir and western redcedar. Dead wood will also be provided by the continued competition mortality in the untreated leave and small skip areas. In the long-term, natural mortality processes such as windthrow, disease, and insect damage will continue to provide dead wood. Soil formation processes will be enhanced by the variety of sizes of dead wood provided to the forest floor (e.g., the wide range of sizes of existing DW, the small diameter branches from the thinned trees, the intermediate sizes of DW from snag creation, and the larger diameter tree boles left on the ground in E6 and E7).

We expect that the greatest short-term effect of thinning and gap creation will be on understory development, an ecological element that is generally lacking throughout the Project Area. The understory plants are expected to persist in the gaps and also in the forest matrix because we expect that the canopy will not completely close with the existing cohort. This should provide long-term habitat for numerous small mammals and bird species.

Figure 4. Summary of Processes Included in Forest Successional Development Predicted to be Influenced by Silvicultural Interventions.

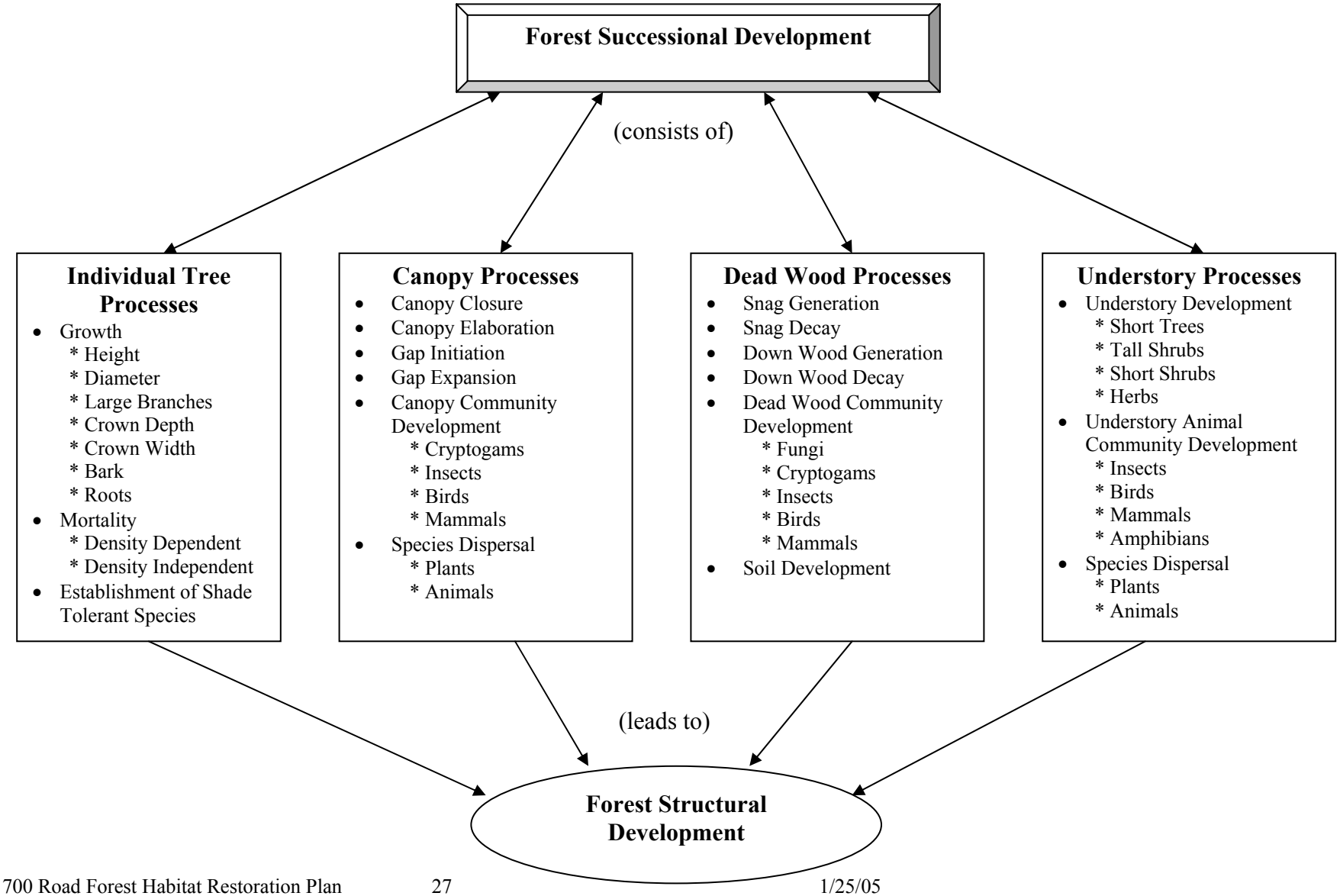


Figure 5. Basic conceptual diagram of the predicted effects on ecological processes by silvicultural interventions, 700 Road Forest Habitat Restoration Project Area.

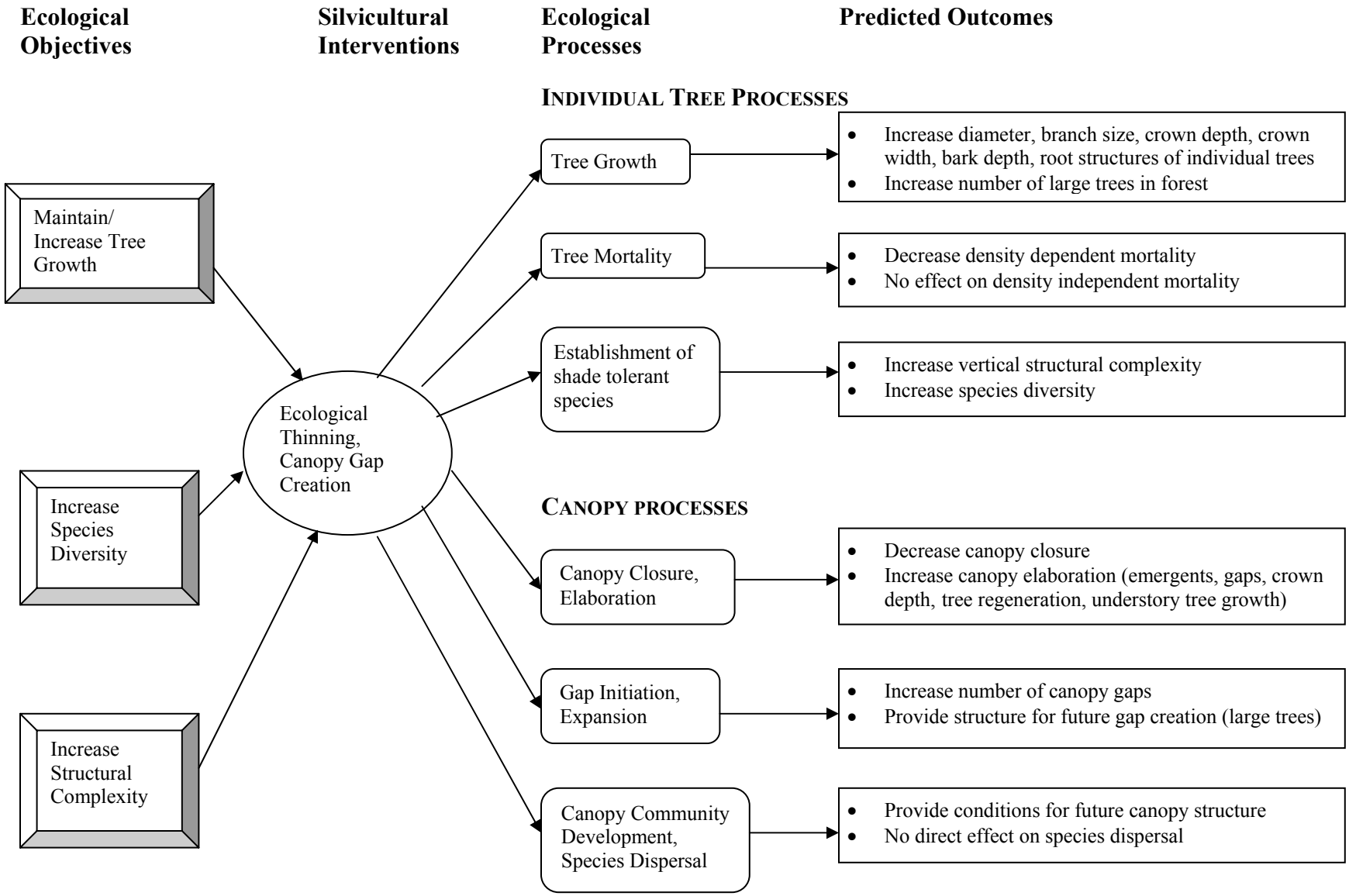
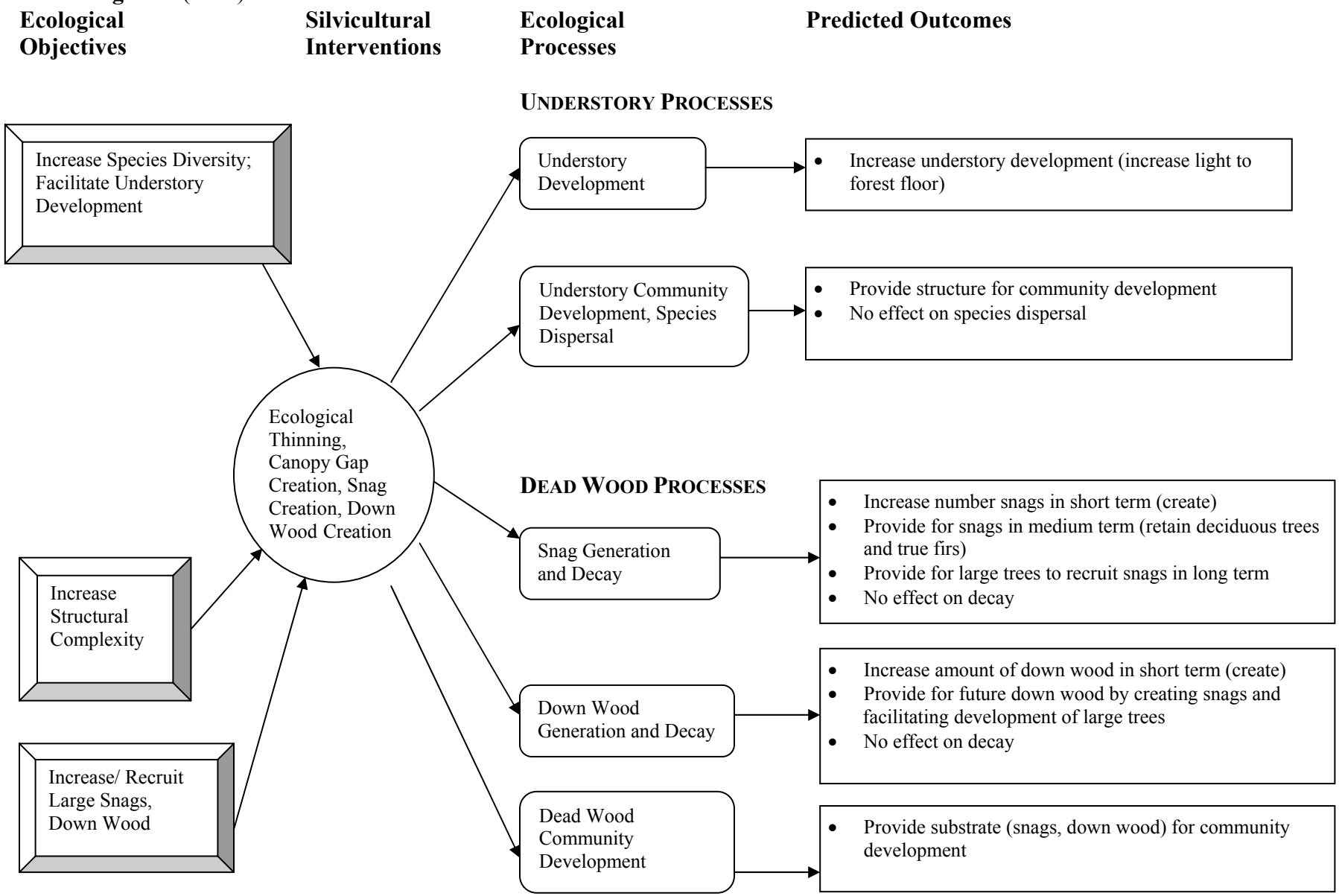


Figure 5 (cont.)



5.0 OBJECTIVES AND PRESCRIBED SILVICULTURAL TREATMENTS

5.1 Broad CRW-HCP Goals

Three of the forest management goals specified in the CRW-HCP apply to this Project Area: 1) accelerating the development of late-successional forest characteristics, 2) providing wildlife habitat and 3) fostering natural biological diversity. Because much of the Project Area currently is covered with small diameter, densely stocked trees, has relatively low vertical and horizontal structural complexity with little or no understory development, and relatively low wildlife habitat value, prescribed silvicultural treatments will be used to achieve the site-specific ecological objectives described in Section 5.2. Not all objectives will be achieved on all portions of the Project Area, but the treatments are expected to create and enhance structural heterogeneity, habitat value, and biological diversity.

5.2 Specific Ecological Objectives and Treatments

There are five management objectives for the Project Area. Associated with each objective is a number of silvicultural methods we will use to achieve the management objective (Table 4). Much of the Rex River basin was clearcut harvested by the 1970-80s, though one high quality patch of old-growth forest does remain at a higher elevation within the basin (Figure 2). Because of the proximity to an existing old-growth habitat patch and the scarcity of older forest in the remainder of the basin, the primary goal for this project is to accelerate forest development over most of the Project Area in order to provide future late-successional forest habitat for old-growth dependent species. A secondary goal is to provide habitat in the near term for the numerous wildlife species that use the maturation stage but not the competitive exclusion stage.

Objective #1: Maintain or Increase Growth Rate of Trees.

Competition for light, water, and nutrients has limited the growth rate and diameter of overstory trees on large portions of the Project Area, slowing the development of this habitat element. By reducing the density of overstory trees, the growth rate can maintain or increase rather than decrease, thereby accelerating the development of larger diameter trees (Smith et al. 1997). Ecological thinning will reduce the current average density of $\geq$370 live trees/acre to 165-365 live trees per acre, depending on the Ecological Thinning Unit (see Section 6.2). This treatment will reduce competition and maintain or increase the growth rate of the remaining trees. Based on the diameter of legacy trees and stumps, we expect that a range of 30 to >60 inch dbh trees will eventually develop on the Project Area, depending on the site-specific conditions.

Extensive data exist on tree densities and growth rates in Douglas-fir forests in the western Cascades (U.S. Forest Service 1974). Relative density (RD) is an index of tree growth potential based on tree density, quadratic mean diameter (used in preference to the arithmetic mean because it has a stronger correlation to the actual volume occupied by trees), and a theoretical maximum tree density used primarily in even-aged Douglas-fir forests (Reineke 1933). Several RD measures exist that express the level of competition affecting tree growth. The two RD measures most commonly used in this region are Reineke SDI (Reineke 1933) and Curtis RD (Curtis 1982). These can be readily expressed in the form of stand management diagrams. We use the diagram given by Hayes et al. (1997), which is derived from Reineke (1933) and Long (1985). The RD values shown on the diagram (calculated from number of trees and quadratic

Table 4. Proposed methods to achieve ecological objectives on 700 Road Forest Habitat Restoration Project Area.

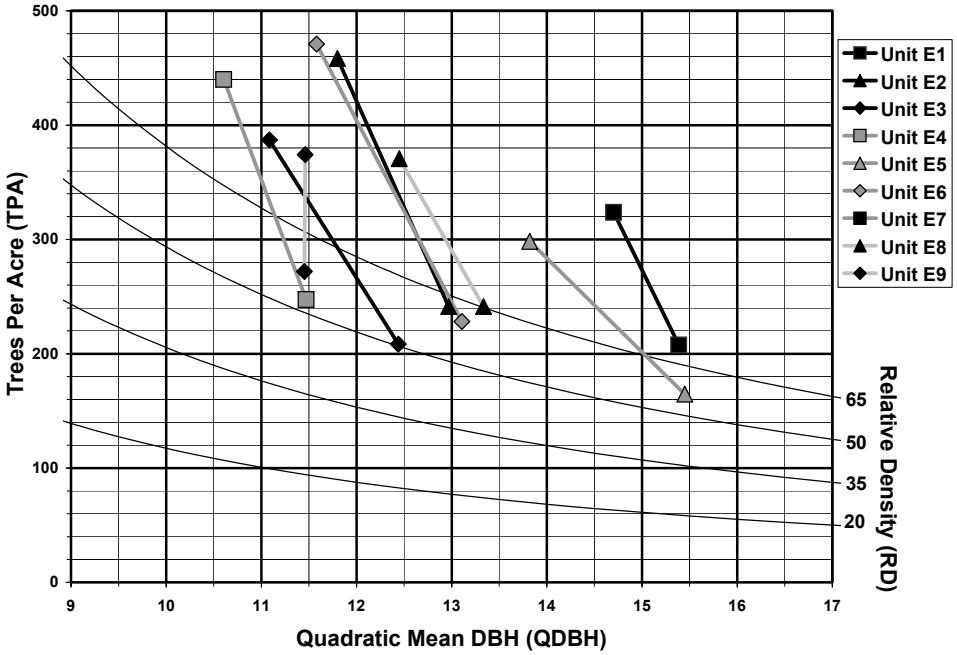
Ecological Objective	Methods to Achieve Objectives
Maintain/Increase Tree Growth Rate	Thin to decrease competition
	Thin to increase light to individual tree crowns
	Create gaps to increase light to tree crowns at gap edge
	Leave trees in larger gaps to facilitate the growth of very large trees with large branch structure
Increase Species Diversity/Facilitate Understory Development	Thin to increase proportion of less frequent tree species
	Thin to increase light to forest floor, including removing some co-dominant tree canopy through snag creation
	Create canopy gaps
Increase Structural Complexity (Vertical and Horizontal)	Retain subdominant and understory trees (especially shade tolerant species)
	Retain shrubs to extent possible
	Thin to increase light to forest floor (increase tree regeneration, shrub, herb initiation and growth), including removing some co-dominant tree canopy through snag creation
	Create canopy gaps/Leave small patches untreated to provide heterogeneity at the forest stand scale.
	Create different leave tree densities in the various ecological thinning units, to provide heterogeneity and mosaics of habitat patches at the forest stand scale
	Leave trees in gaps to facilitate development of large trees (faster diameter and crown growth, creating canopy roughness)
	Thin to accelerate tree growth (encourage development of emergent trees, creating canopy roughness)
Increase Number Snags/Facilitate Maintenance/Recruitment of Large Diameter Snags and Down Wood	Retain existing snags
	Retain existing DW
	Create snags in forest matrix (supplement for cavity nesting species in near term)
	Create snags in gaps (supplement for cavity nesting species in near term)
	Create DW in gaps, leave tops from snag creation, leave all tree boles in E7,RT, and a portion of E6 (supplement for DW dependent species in near term)
	Leave all deciduous trees/true firs (become snags/DW in medium term)
	Create leave units and small untreated skip areas within thinning units to provide continued small snag recruitment through competition mortality
	Thin to accelerate tree growth (large diameter snags and DW in long term)
	Leave dominant trees in gaps (create large trees/large diameter snags and DW in long term)
Protect/ Enhance Special Habitats/Water Quality	No thinning/entry within 200 feet of Rex River, on inner gorge slopes, wet areas along the inner gorge slope break, or potential unstable areas
	No ground-based equipment within 30 feet of streams
	Place large woody debris within stream channels

mean diameter) are essentially interchangeable with Curtis RD (calculated from basal area and quadratic mean diameter). Competition mortality is expected above RD 65, with some

beginning between 55 and 65. Regeneration of shade tolerant conifers (western hemlock, red cedar, pacific silver fir) can be expected at RD values less than about 45. We used RD based on Curtis (1982) as a convenient aid in calculating the tree retention density required to achieve the ecological objective of maintaining or increasing tree growth because the Project Area is even aged, although it is dominated by western hemlock rather than Douglas-fir.

The ecological thinning treatment is designed to be conservative, decreasing the density to a level allowing vigorous tree growth for a considerable period of years, while still providing a sufficient number of trees to support future forest processes (Figure 6) and avoiding unacceptable windthrow risks. In contrast, unthinned areas will exhibit decreasing growth rates from continued competition. To ensure that larger diameter trees are retained on the Project Area, an upper diameter limit will be established, ranging from 13 to 19 inches dbh depending on the species and ecological thinning unit, above which no trees will be thinned. In unit E3, however, some 20-inch dbh trees will be used for snag and DW creation (see Section 6.2 for complete explanation). This upper diameter limit will allow us to significantly influence forest processes (e.g., increasing light to the forest floor, decreasing competition with neighboring trees) while still maintaining sufficient numbers of larger trees for future large live tree, snag, and DW recruitment (100% of trees ≥17 inches dbh will be retained in five units, >90% in two units, and >75% in two units). The two units with >75% of all trees ≥17 inches dbh retained (E1 and E3) have more larger diameter trees initially present and the thinning will remove a portion of the center of the diameter distribution in order to significantly affect the light regime and increase structural complexity.

Figure 6. Trees per acre, quadratic mean diameter, and relative density for ecological thinning units E1-E9 before and after thinning.



Large-diameter trees are characteristic of late-successional and old-growth forests. Cavities in large-diameter trees are required for nesting habitat by spotted owl. Marbled murrelet (*Brachyramphus marmoratus*) require large branches for nesting, habitat characteristics that generally develop only on large-diameter trees. The vertical structure provided by large emergent trees is important to certain bird species, such as the olive-sided flycatcher (*Contopus cooperi*) and several raptors. The deeply fissured bark that develops in older trees supports invertebrate communities, is used by bark-foraging birds such as brown creepers (*Certhia americana*), and is used as roosting sites for many species of bats. In addition, larger trees support a variety of lichens and fungi that are important food sources for many small mammals, including the northern flying squirrel (*Glaucomys sabrinus*), a major prey species for northern spotted owls (Johnson and O'Neil 2001).

Objective #2: Increase Plant Species Diversity/Facilitate Understory Development.
Tree species diversity is already relatively high on the Project Area, with the presence of seven tree species. Most of the Project Area, however, is dominated by western hemlock and Douglas-fir. By thinning only the most abundant species, we will increase the relative proportion of less frequent species throughout the Project Area, resulting in higher diversity indices (Table 5). A variety of tree species with different timing of seed production provides a more stable and diverse food source for birds and small mammals than would a single species. In addition, different conifer and deciduous species provide a range of growth rates and bark surfaces that contribute to the complexity of the forest and biodiversity (Johnson and O'Neil 2001). Deciduous trees in particular host a high diversity of macrolichens and moth species, and are critical habitat elements for many bird species (Muir et al. 2002, Starkey and Hagar 2001). An array of both conifer and deciduous leaves on the forest floor provides litter important to many invertebrates, insectivores, small mammals, and amphibians, as well as contributes to nutrient and carbon cycling and soil development.

Understory development on the Project Area is extremely limited by the high canopy closure and resultant low light levels at the forest floor. Reducing the density of trees through thinning and removal of some selected co-dominant tree canopy through snag creation will allow more light to reach the forest floor, which should enhance initiation and growth of understory trees, shrubs, and herbs. Creating canopy gaps will also contribute to understory development by allowing shrubs and herbs with greater light requirements to colonize the Project Area. A diversity of tree, shrub, and herbaceous species is characteristic of late-successional forests, and provides a wide range of habitat elements for native wildlife species. Berry and flower producing shrubs are essential habitat elements for several wildlife species, including rufous hummingbird (*Selasphorus rufus*), red fox (*Vulpes fulva*), and band-tailed pigeon (*Columba fasciata*). Deciduous foliage provides substrate for foliar insects that are a food resource for many bird and bat species. In addition, the presence of deciduous trees appears to be a key habitat element for several species of birds, including olive-sided flycatcher, Pacific slope flycatcher (*Empidonax difficilis*), and downy woodpecker (*Picoides pubescens*).

Table 5. Change in percent tree species composition (number of trees) and diversity indices before and after ecological thinning, 700 Forest Habitat Restoration Project Area.

	Percent Composition by Tree Species[1]								
Unit	WH	DF	RC	PSF	NF	RA	BC	Shannon-Weiner Diversity Index	Simpson Diversity Index
E1 (thin 30% BA[2])									
Before	64	8	19	8	0	1	0	1.05	2.18
After	51	13	26	11	0	2	0	1.26	2.99
E2 (thin 35% BA)									
Before	58	19	16	2	0.2	5	0	1.15	2.49
After	41	25	24	3	0.3	9	0	1.39	3.56
E3[3] (thin 30% BA)									
Before	43	38	12	7	0	0	0	1.17	2.89
After	29	41	23	13	0	0	0	1.31	3.52
E4 (thin 30% BA)									
Before	60	18	22	0	0	0	0	0.95	2.27
After	45	23	34	0	0	0	0	1.07	2.84
E5 (thin 30% BA)									
Before	63	29	8	0	0	0	0	0.85	2.06
After	52	36	14	0	0	0	0	0.98	2.50
E6 (thin 35% BA)									
Before	81	11	3	3	0	3	0	0.70	1.49
After	65	20	6	5	0	5	0	1.07	2.18
E7 (thin with gaps only)									
Before	59	33	8	0	0	0	0	0.88	2.16
After	59	33	9	0	0	0	0	0.90	2.21
E8 (thin 25%BA)									
Before	80	15	5	0	0	0	0	0.62	1.52
After	74	20	8	0	0	0	0	0.75	1.75
E9 (thin 30% BA)									
Before	70	26	5	0	0	0	0	0.74	1.82
After	64	31	6	1	0	0	0	0.83	2.05

[1]WH = Western Hemlock, DF = Douglas-fir, RC = Western Red Cedar, PSF = Pacific Silver Fir, NF = Noble Fir, RA = Red Alder, BC = Black Cottonwood
[2]BA = Basal Area; See Appendix II for data on basal area for each tree species. Note: basal area is used as an easily measured surrogate for the amount of light reaching the forest floor, and therefore the available growing space.
[3]Removing canopy from all diameters, so no effect on percent composition

Objective #3: Increase Forest Structural Complexity.

A continuous forest canopy containing large emergent trees and layers of dominant, co-dominant, intermediate, and suppressed trees, tall shrubs, short shrubs, and herbaceous vegetation provides vertical structural complexity that has not yet developed in the Project Area. Ecological thinning will reduce the tree density, create variable spacing, and create patches of tree density varying from 165-365 trees per acre in the ecological thinning units to ≥400 trees per acre in the five untreated leave units and the small untreated patches within the thinning units.

The juxtaposition of denser areas in the leave units, with the varied leave tree spacing and densities and various sized gaps created in the ecological thinning units simulates the variability seen in a natural forest, and will contribute to both biodiversity and heterogeneity at the local forest scale. Ecological thinning and selective removal of some co-dominant tree canopy through snag creation will increase the light level to the forest floor, which should facilitate tree, shrub, and herb establishment in the understory, leading to development of intermediate canopy layers and increasing vertical structural heterogeneity. Retaining emergent trees, trees with physical damage, existing snags, deciduous trees, and shade-tolerant conifers in the ecological thinning units will also contribute to spatial variability, structural complexity, and resultant biodiversity. Leaving unthinned patches will provide structural complexity and provide for plants that require dense shade (e.g., western coralroot).

Horizontal structural complexity in late-successional forests is provided, in part, by canopy gaps created by natural small-scale disturbances and individual tree death. Spies et al. (1990) found that canopy gaps occupied 18.2 percent of mature Douglas-fir forests (80-200 years old) and 13.1 percent of old-growth forests in western Oregon and Washington. Many of these gaps were greater than 25 years old and were occupied by understory vegetation. They hypothesized that small gaps in younger developing forests are likely filled from horizontal branch growth of the dominant trees. Gaps in older forests are frequently created from large trees dying and falling. We will simulate these processes by creating a variety of sizes (0.04 – 0.75 ac) of small gaps over a total of 5 percent of the area in each ecological thinning unit, with the goals of increasing forest structure and light penetration from the gap into the adjacent thinned forest. The larger gaps should persist for prolonged periods and allow for shade intolerant tree regeneration. A gap study in southern Washington found that Douglas-fir can regenerate in gaps as small as 1/3 acre (Anonymous 2002). In addition, small skip areas in which no thinning will take place will be created near the gaps over an additional 5 percent of the area in each ecological thinning unit. The goal is to create small-scale heterogeneity and mosaics of habitat within the Project Area, including open areas in canopy gaps, various densities of open forest in the different ecological thinning units, and denser forest in untreated skip areas and leave units.

Structural complexity develops as the forest matures and is important for many species of wildlife, with different species utilizing different canopy layers. Ground foragers such as winter wren (*Troglodytes troglodytes*), spotted towhee (*Pipilo erythrophthalmus*), and most insectivores and rodents primarily use litter, DW, and herbaceous plants on the forest floor. Species such as Wilson's warbler (*Wilsonia pusilla*) and Douglas squirrel (*Tamiasciurus douglasii*) use low and intermediate shrub and overstory tree canopy layers for foraging and nesting, and species such as golden crowned kinglet (*Regulus satrapa*) and forest deer mouse (*Peromyscus keeni*) primarily utilize the upper canopy. Spatial heterogeneity, including both areas of high vertical diversity of vegetation and areas of sparse understory, provides the variety needed for species such as spotted owl to locate, track, and capture prey, as well as perches from which they can pounce (Carey et al. 1999).

Objective #4: Increase Number of Snags and amount of Down Wood in Short-term; Facilitate Recruitment of Large-diameter Snags and Down Wood in Medium- and Long-term.
Large volumes of large-diameter standing and down dead wood are key characteristics of old-growth forests. In a study of naturally regenerated forests, Spies and Franklin (1991) found that

mature forests (80-195 years) average six large diameter (>19.5 inches dbh) snags per acre, with a total of 40 snags of all sizes per acre. Snags and DW are generally not evenly distributed across old-growth forests, but often occur in patches. There are few snags in the Project Area, and no cutting of larger diameter snags will occur. It is possible during the thinning operation that an occasional small snag may need to be cut in order to protect worker safety and to comply with Washington State Department of Labor and Industry safety requirements. If this occurs, the wood will be retained on site as DW. In addition, we will create larger snags in the forest matrix in all ecological thinning units, as well as in the gaps (see Section 6.2).

Maintaining the five leave units, the10 untreated larger skips, and the numerous smaller skips as no-cut zones during the ecological thinning will allow continued small snag and DW recruitment through competition mortality. Once the snags fall, they will function as DW on the forest floor, providing wildlife habitat and enhancing soil formation. Ecological thinning should facilitate more rapid development of large-diameter trees, and therefore recruitment of large-diameter snags over the long-term, as trees die through natural processes such as windthrow, lightning, and insects. Retention of short-lived deciduous and true fir species and trees with physical damage will also contribute to snag recruitment in the intermediate term. It is expected that snags will continue to occur in patches across the Project Area, a pattern that is seen in naturally functioning forest ecosystems.

All existing DW will be retained on the forest floor during ecological thinning. There is a wide range of sizes of existing DW that will decay at varying rates, providing soil enhancement throughout long time frames. All trees thinned from E7 and the eastern portion of E6 will be retained on site, providing a large volume of large diameter DW in these units. For example, in addition to already existing DW, 1,018 ft^3/ac of DW covering over 11% of the forest floor would be created in the eastern portion of E6 by leaving all thinned trees on the forest floor. Additionally, we will create large diameter DW in the larger gaps, simulating a natural functioning forest where small gaps are created by single or a few trees falling, leaving DW in the gap. We will also leave a few dominant trees in the larger gaps, where growth conditions should be favorable for creating a large tree, and eventually a large diameter snag. In addition, smaller diameter DW will be enhanced throughout the Project Area by retaining the tops of all created snags, as well as the branches and tops from thinned trees, and in RT by leaving all trees thinned on the forest floor.

Additional large diameter DW within the remaining forest will not be created at this time because the volume of DW from the 1992 data was much higher than the range of DW found from 19 old-growth plots in the CRMW. The 1992 plots from portions of the 700 road site had an average DW volume of 5,352 ft^3/ac, compared with a range of 62-1,460 ft^3/ac in the old-growth plots (Mason, Bruce, and Girard 1992, unpublished data 2003). Although the 1992 plots were limited, they do indicate that high-density patches of DW occur on the site, which is consistent with the pattern observed throughout the Project Area in 2002. In addition, Spies and Franklin (1991) found that naturally regenerated forests <80 years of age in western Washington and Oregon averaged 3,177 ft^3/ac DW, with a 95% confidence interval of 2,330-4,342 ft^3/ac. We are concerned that leaving volumes of DW throughout the Project Area much higher than found in naturally regenerated forests could inhibit understory growth and movement by large

mammals. Consequently, the remaining thinned trees will be removed from the site and sold to help cover a portion of the costs of the project.

Snags are a vital habitat component for many wildlife species, ranging from cavity excavating species such as woodpeckers, to secondary cavity users, including several owl species (Thomas et al. 1979). Numerous bat species use large-diameter snags, especially at more advanced stages of decay (Christy and West 1993). Loose bark provides both day and night bat roosting sites, and cavities provide a stable microclimate for maternity colonies. Down wood, especially large-diameter logs, is used by numerous wildlife species, including amphibians, many small carnivores, and a myriad of insect species (Spies and Cline 1988). A large log is a primary growth substrate for many species of fungi and plant species (e.g., the "nurse log" phenomenon) (Cowling and Merrill 1966, Maser et al. 1988). Down wood is also crucial for carbon and nutrient cycling and water retention (Harmon et al. 1986). Although large-diameter snags and DW (>30 inches dbh) are more persistent and can be used by a greater variety of wildlife species, smaller wood is still used by many species.

Objective #5: Protect/Enhance Special Habitats and Water Quality.
Many species of fish, amphibians, and invertebrates are sensitive to increased sedimentation and temperature. Our objective is to protect both the in-stream habitat, as well as municipal water quality. Environmental impacts to the Rex River were avoided by placing the Project Area boundary upslope of the inner gorge slope break, wet areas along the inner gorge slope break, and potential unstable areas. This resulted in the Project Area being ≥200 feet from the Rex River.

The three small streams and their associated wetland and seep areas will have no deciduous trees cut from within the riparian zone. In addition, all conifer trees will be left that have any part of their canopy projecting over the maximum bankfull width of the main or any secondary channel or associated wetland or seep. No ground-based equipment will be brought within 50 feet of the bankfull width of the channel, and there will be no yarding over stream channels unless there is no ground or canopy disturbance (i.e., no logs will be dragged through a stream channel). Some conifers will be thinned from within the riparian zone to accelerate forest development near the stream, particularly the growth of conifers to eventually provide large DW. The trees within the riparian area that will be thinned will be felled directionally away from the channels. In addition, some trees will be felled across and left within the stream channels to enhance current in-channel habitat.

6.0 SPECIFIC THINNING TREATMENTS

To achieve the management objectives (Section 5.1), the Project Area (477 acres) was divided into 15 units based on ecological variables such as current tree density, tree diameter, and hill slope (Figure 1). In order to create diversity and a mosaic of habitats across the Project Area, nine of the units (E1-9, 358 acres) were designated as likely to benefit ecologically from thinning. One unit will be restoration thinned (14 acres), while five units (105 acres) were designated as untreated leave units, which will not be thinned. The leave units were designed to include denser patches within the management area to achieve heterogeneity on the local forest scale. Although these units are not technically controls (i.e., they were not randomly selected), they are very similar to the thinning units and will serve as areas with which the results of the

ecological thinning can be compared. The untreated leave units are expected to maintain slow growth rates of overstory trees, support limited understory development, support plants requiring dense shade, and recruit small snags as a result of competition mortality. The units designated for ecological thinning required customized thinning treatments based on existing forest composition and the goal to increase forest structural complexity at multiple spatial scales.

6.1 Data and Scenarios Considered

During development of the final thinning treatments, we evaluated a range of data and potential scenarios. In order to predict tree growth response, we calculated RD (defined in Section 5.2), basal area, and height to diameter ratios (see the following paragraphs for explanation). We used a forest growth model to evaluate tree growth response given the potential scenarios. Finally, we considered distribution and amount of canopy gaps and diverse methods for snag creation.

Basal area, which sums the cross-sectional area of all trees at dbh by species over a given area, is a calculation that has been used extensively in tree growth and growth response to thinning research (Curtis and Marshall 1989). It is a good surrogate for the amount of growing space occupied by overstory trees, and thus the amount of resources (light, water, nutrients) available for understory plants (shrubs, herbs, trees). Based on extensive professional experience thinning similar forests, we considered 25, 30, and 35 percent basal area removals as the range of reasonable targets that would most appropriately affect the ecological processes in the forest, but would not entail significant risk of windthrow in this area that can experience strong winds. Removing more than 35 percent of the basal area could potentially increase the risk of windthrow in portions of the Project Area (U.S. Forest Service Silvicultural Institute, pers. comm.). The project team calculated the number of trees per acre that would be retained under each basal area removal scenario using a variety of tree species in the thinning pool. We evaluated a wide range of potential thinning pools (using different tree species and diameters), with various maximum diameter limits. We also considered removing a limited amount of canopy from larger diameter trees through snag creation.

Ecological thinning will move all nine ecological thinning units away from competition mortality (e.g., the maximum tree size/density relationship of RD 65) to a tree density that will facilitate a higher rate of growth (Figure 6). We calculated the relative density that would be achieved with the various basal area removals and different maximum diameter limits. Our goal was to reduce the relative density below 60-65. The relative density for optimal tree growth ranges from 35 to 55, a range in which the trees are far enough apart that they have sufficient growing spacing for crown development (U.S. Forest Service Silvicultural Institute, pers. comm.). This range should also provide sufficient light to the forest floor to promote understory development and shade-tolerant tree regeneration. Due to high initial stand densities, we plan to reduce stand density to below RD 55 only in units E3 and E4. In other units relative density will be reduced to RD 65 or lower. Greater basal area removal at the current developmental stage could potentially result in large-scale windthrow. The relative density of E7 will not change because the planned treatment will cut groups of trees without thinning of the matrix.

The average tree height to diameter ratio can indicate the amount of wind firmness of the forest. Tall trees with small diameters have much less root structure than shorter trees with larger

diameters. Trees that grow in close proximity to each other are unable to develop the crown and root structure that enable them to resist strong winds. Trees that grow in more open environments develop large crown and root structures, and have a smaller height to diameter ratio. Wonn and O'Hara (2001) found that trees in western Montana with a height to diameter ratio of more than 80 were more susceptible to windthrow than those with lower ratios. We had no equivalent data for the western Cascades, so used a conservative ratio of 70 as our target to reduce the risk of windthrow (R. Curtis, emeritus silviculturist, USFS, pers. comm.). We calculated two height to diameter ratios for each ecological thinning unit: 1) using all trees within the unit, and 2) using only the most dominant trees (the largest 80 trees in each unit). Combining information on the height to diameter ratio, the quadratic mean diameter, and the relative density, allowed us to evaluate the risk of windthrow under each basal area removal scenario.

Forest growth models are useful for projecting current overstory tree growth in an even-aged forest stand. Because of the high level of uncertainty in applying these models to development of LSF characteristics, however, we have only used them for short-term overstory growth responses. We used the Forest Vegetation Simulator (FVS) and the Stand Visualization System (SVS) models, to help visualize the effect on the forest under various thinning scenarios. An example of the SVS results is presented in Figure 7, which compares current conditions (from the 2001 forest inventory data) with those projected seven years after thinning (year 2011, assuming thinning occurred in 2004) for each ecological thinning unit using the basal area removal described in Section 6.2. The models predict that the thinning treatments will accelerate development of larger trees (QDBH >30 inches) 40 to 70 years faster compared with no thinning, depending on the initial conditions. The SVS results portray the increase in spatial variability after the thinning treatments. The models do not, however, include other important components of LSF development, such as understory response, tree regeneration, snags, and DW. Unfortunately, none of these models will predict development of vertical structure from understory tree, shrub, and herb regeneration.

Potential number and placement of canopy gaps and untreated skip areas were evaluated by considering slope and aspect while concurrently assessing the risk of windthrow. We propose creating numerous gaps and leaving small untreated patches throughout the Project Area (gaps will comprise 5 percent of the area in each thinning unit, and unthinned skips will comprise another 5 percent). Gaps and unthinned skips will range from 0.04 - 0.75 acres each. The larger gaps were designed to be large enough to influence key forest processes, to provide horizontal structural complexity, and to allow some shade intolerant tree regeneration. We will monitor the effects of the ¼, ½, and ¾ acre gaps on understory plant and tree initiation and use the data to guide planning of future ecological thinning projects.

We considered a range of snag creation techniques, including girdling at breast height, crown girdling, top blasting, saw topping, limbing, and fungal inoculation (see Appendix IV for a complete description of the techniques considered and their associated costs). Snags will created after the thinning is complete and decisions on techniques will be made at that time based on safety, logistics, reported success, and cost. A number of different techniques will be utilized, however, to provide a staggered entry of snags into the ecosystem.

Figure 7. Results of Stand Visualization System forest growth model for units E1-E9, before thinning and seven years post-thinning. Note: the inventory data are from the 2001 forest cruise and the anticipated thinning will occur in 2005. The term 'beginning of cycle' refers to the beginning of the growing season in 2011.

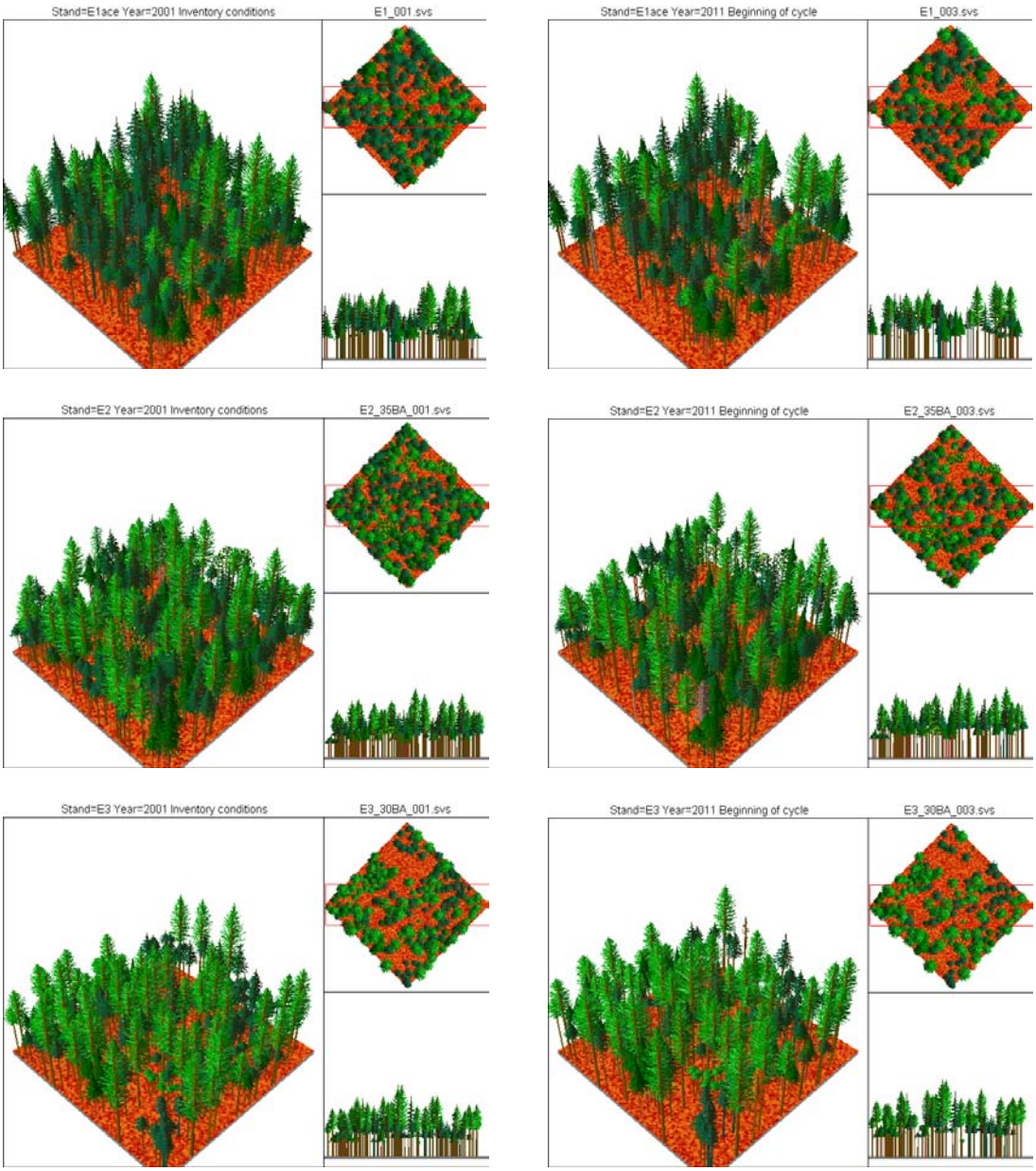
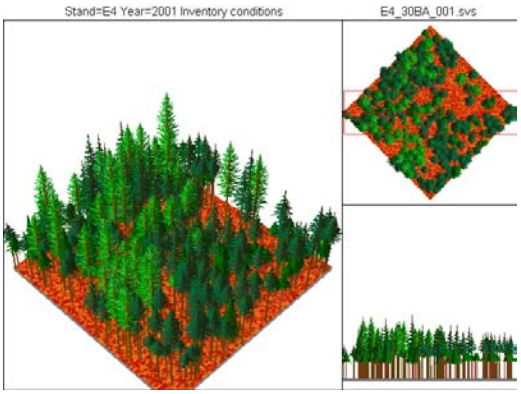
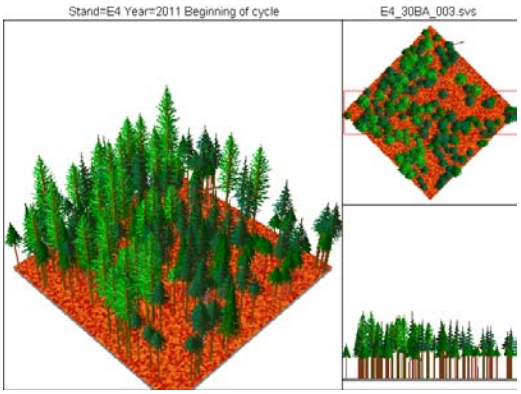
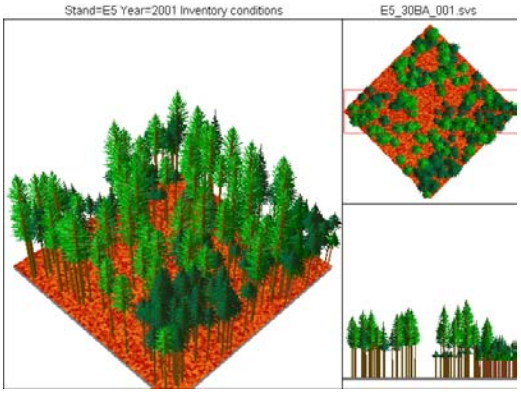
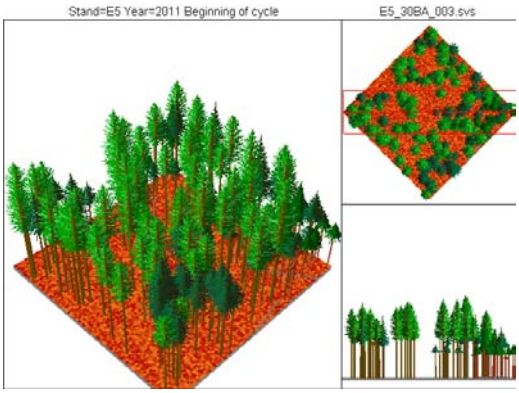


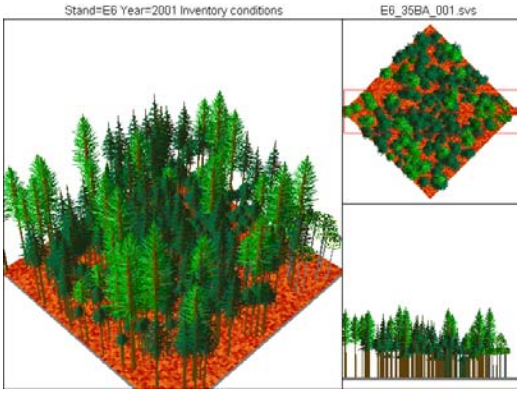
Figure 7 (cont.)











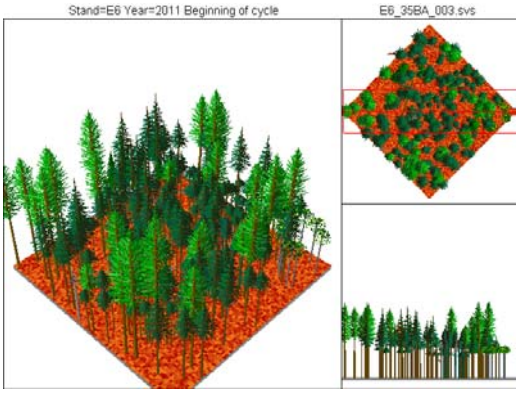
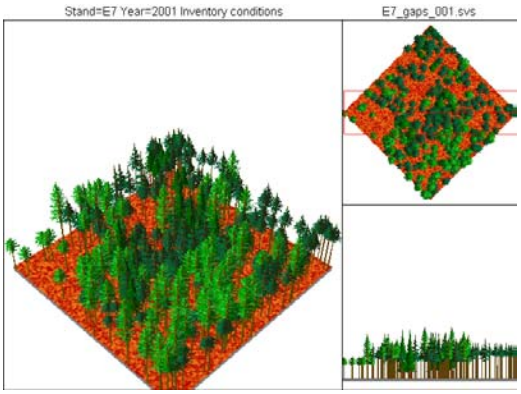
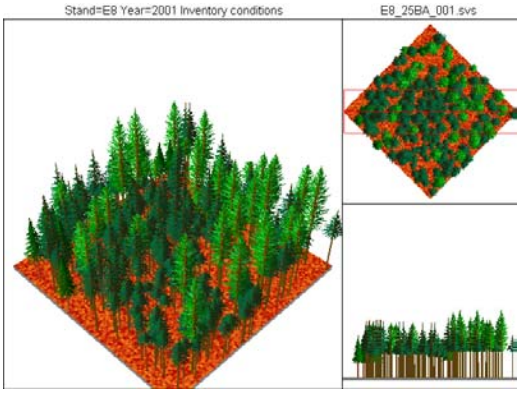
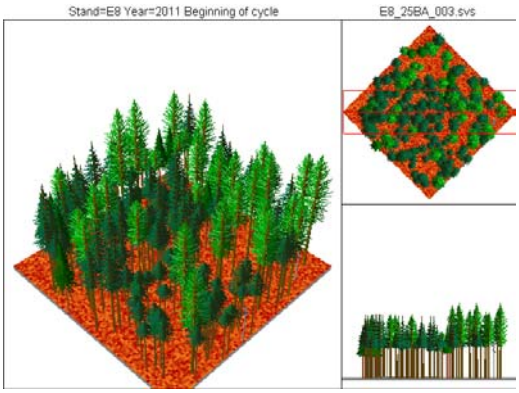


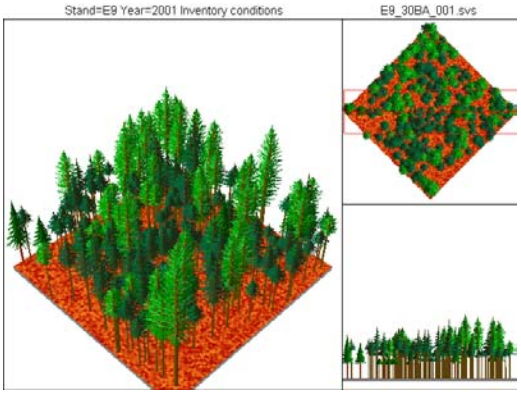
Figure 7 (cont.)

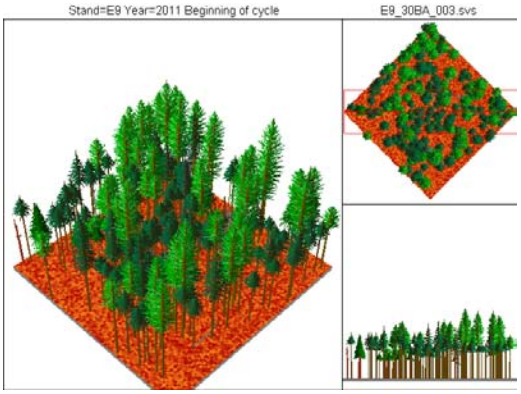


The FVS/SVS tree growth model does not effectively illustrate canopy gap treatments, so the picture of post-treatment conditions in unit E7 could not be simulated.









In addition, different tree species and sizes will be used for snag creation (see Appendix II for the pool of trees to be used for snag creation by ecological thinning unit), to provide a variety of habitat for different wildlife species.

6.2 Thinning Treatments

The primary data we used in developing the final treatments and determining the final target thinning pools were number of trees per acre, dbh, basal area, relative density, quadratic mean diameter, height to diameter ratio, and tree species (Tables 6 and 7). Examining relative density, height to diameter ratio, and quadratic mean diameter, combined with years of professional

experience allowed us to evaluate the risk of windthrow for each unit. We varied the basal area removal and leave tree density among the units to achieve both stability from windthrow and to create a diversity of patch types at the local forest scale.

The thinning pool includes only the most prevalent species to make the tree species composition more diverse, retaining all deciduous and other minor conifer tree species. In addition, upper diameter limits for thinning were created in all ecological thinning units, to ensure that sufficient numbers of larger diameter trees would be retained (see sections 6.2.1 – 6.2.9 for specific limits for each unit).

Some trees of all diameters within the thinning pool will be cut, with all trees outside the thinning pool retained (Appendix II). The marking/selection guide (delineating which trees within the thinning pool will be cut) will be applied as if the leave (non-target) trees did not exist, to ensure there will be variable spacing between trees and a large variety of tree diameters and heights retained within the unit. Application of this treatment will create greater heterogeneity of inter-tree spacing. If cable yarding occurs in any unit, the cables will not be run through the live crowns of the dominant or co-dominant overstory, to avoid damage to these trees. The number of residual trees and residual square feet of basal area per acre are the key variables for measuring operator compliance. A detailed marking and harvest guide was developed for each ecological thinning unit to enable contractors to accurately follow the prescription without the necessity of marking trees prior to thinning (Appendix V). The guide was reviewed by several experts, all of whom agreed that it achieves that goal. However, CRMW staff will mark both trees to be retained and trees for snag creation in unit E2 (and potentially more units, if needed), in small training areas of approximately three-acres each. These training areas will be used by potential contractors as an aid in interpreting the marking and harvest guide.

Although the ecological thinning is not designed as a formal research experiment, we are using the site as part of adaptive management learning. This site will help us learn about the effects of different thinning techniques (leave tree density, size of trees thinned, species composition of leave trees, removal of only small trees versus removal of some dominant tree canopy through snag creation, leaving down wood on the forest floor), how different sizes of canopy gaps contribute to forest structural complexity and affect forest processes, and the effect of different harvest systems and snag creation techniques. This type of information will help us to design more effective habitat restoration projects using silvicultural treatments in the future.

We determined that the risk of windthrow could be too high if we created larger gaps on units with steep slopes. Consequently, only those units with the gentlest slope will have the larger gaps created within them (E1, E2, and E8). We will create 10 larger gaps (four each of ¼-acre and ½-acre, and two ¾-acre) that were randomly assigned within these units. Associated with each canopy gap will be an untreated skip area of the same size, to provide structural complexity and within-patch heterogeneity. Untreated areas will be placed, whenever possible, around existing large diameter snags, DW, or streams. See Section 6.2.2 for a complete discussion of the gaps and untreated skip areas.

Table 6. Summary of current and post-thinning conditions for the nine Ecological Thinning Units[1]

Characteristic		Ecological Thinning Unit								
		E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**
Number of Acres		46	92	41	17	24	71	19	12	36
Thinning pool[2]		WH≤19", RC 13-16", PSF 8-12"	WH ≤16", DF ≤16", RC≤15"	WH≤15", DF≤16"	WH&DF ≤13", RC≤9"	WH≤14", DF≤18"	WH≤16", DF≤16"	WH≤16", DF≤15"	WH≤15", DF 10"	WH9-16", DF9-16"
Basal Area (ft^2/ac)	Percent thinned, entire unit	30	35	30	30	30	35	Gaps	25	30
	Current live trees	382	348	259	270	311	344	183	313	268
	Leave live trees	268	221	176	178	214	214	157	234	194
Trees Per Acre	Current live trees	324	458	387	440	298	471	428	371	374
	Leave live trees[3]	208	241	208	248	165	228	365	241	272
Relative Density	Current live trees	100	101	78	83	84	101	62	89	79
	Leave live trees	68	61	50	52	55	59	na	64	57
Quadratic Mean Diameter (inches)	Current live trees	14.7	11.8	11.1	10.6	13.8	11.6	8.8	12.4	11.5
	Leave live trees, entire unit	15.4	13.0	12.5	11.5	15.4	13.1	8.9	13.3	11.5
Height/ Diameter Ratio	Current live trees, entire unit	73.4	76.6	71.8	86.7	72.0	86.7	84.2	71.6	78.0
	Current live trees, largest dominants	60.4	64.5	65.9	71.2	63.0	64.2	62.5	69.9	65.5
	Leave live trees, entire unit	70.4	74.2	70.6	83.9	68.6	82.9	82.3	70.9	78.3
	Leave live trees, largest dominants	60.7	64.9	66.6	71.0	63.7	64.8	63.2	69.1	65.2
Snags	Current snag/acre	1	2	8	0	0	0	0	0	0
	Number snags/acre to be created	4	4	11	4	4	4	4	4	4
	Snag creation pool	WH 15-19"	WH&DF 14-16", RC 14-15"	WH&DF 17-20"	WH&DF 11-13"	DF 13-18"	WH&DF 14-16"	WH&DF 10-13"	WH 15-16"	WH&DF 15-19"

[1] Data are for all trees ≥ 6 inches dbh, from 2001 forest inventory
[2]WH = Western Hemlock, DF = Douglas-fir, RC = Western Red Cedar, PSF = Pacific Silver Fir
[3]Numbers are estimates and may not agree exactly with numbers in Table 7 due to rounding

Table 7. Density of trees (per acre) by species before and after ecological thinning.[1,2]

Thinning Unit	Current Tree Species	Number Before Thinning	Projected Number Thinned	Projected Number After Thinning
E1	Western Hemlock	208	103	105
	Douglas-fir	26	0	26
	Western Red Cedar	60	6	54
	Pacific Silver fir	27	3	24
	Red Alder	3	0	3
	Total Live	363	112	228
E2	Western Hemlock	267	168	99
	Douglas-fir	87	28	59
	Western Red Cedar	75	18	57
	Pacific Silver fir	8	0	8
	Noble fir	1	0	1
	Red Alder	21	0	21
	Total Live	458	217	241
E3	Western Hemlock	165	102	60
	Douglas-fir	148	63	85
	Western Red Cedar	48	0	48
	Pacific Silver fir	26	0	26
	Total Live	387	179	208
E4	Western Hemlock	264	154	110
	Douglas-fir	79	21	58
	Western Red Cedar	97	14	83
	Total Live	440	193	247
E5	Western Hemlock	188	102	86
	Douglas-fir	87	28	59
	Western Red Cedar	23	0	23
	Total Live	298	133	165
E6	Western Hemlock	381	232	149
	Douglas-fir	52	7	45
	Western Red Cedar	13	0	13
	Pacific Silver fir	12	0	12
	Red Alder	12	0	12
	Total Live	471	243	228
E7	Western Hemlock	253	38	215
	Douglas-fir	141	21	120
	Western Red Cedar	34	0	34
	Total Live	428	59	365
E8	Western Hemlock	295	81	178
	Douglas-fir	56	8	48
	Western Red Cedar	19	0	19
	Total Live	371	130	241
E9	Western Hemlock	260	87	173
	Douglas-fir	95	10	85
	Western Red Cedar	17	0	17
	Pacific Silver fir	1	0	1
	Total Live	374	102	272

[1] Data are for all trees ≥ 6 inches dbh
[2] Basal area for each species by each diameter can be found in Appendix II.

If possible, all existing snags will be left in place. If any snags need to be cut for safety purposes, however, they will either be topped as high as possible with the top left on site, or cut and left in place as DW. The safety decision is at the sole discretion of the operator. If, during the operation, a large snag (>30 inches dbh and 30 feet tall) is discovered, it will be reported to the compliance officer. SPU staff will then evaluate the snag and its relative ecological significance, make a decision on whether or not to retain it or use it for DW, and if retained,

determine an appropriate means to protect the snag and ensure operator safety. The Contract Administrator will work with the Contractor to modify the contract to find supplemental trees elsewhere in the Project Area or to compensate for any additional costs to the operator if additional trees are left to protect the snag.

In addition to retaining existing snags, four snags per acre will be created throughout the Project Area, with a higher density of 11 snags per acre created in E3. The trees for snag creation will be selected from the larger trees within the thinning pool and marked during the thinning (Table 6). A range of sizes within the snag creation pool was used to both provide different snag decay rates and to allow flexibility in selecting the trees. Multiple tree species will be used for snag creation within each unit, to provide a variety of decay rates. If possible, created snags will be clumped within each unit, rather than evenly distributed, to simulate natural patterns. For safety reasons, no snags will be created within 1.5 times the snag height from an active road. Snag creation will occur after ecological thinning is complete, and will use a variety of the techniques discussed in Section 6.1. Different techniques will cause different rates of tree mortality and different expected snag longevity, providing a variety of wildlife habitat over the short term. The trees for snag creation will be marked during the thinning operation (Appendix V). A separate contract will be developed for the actual snag creation.

No existing DW will be removed from the Project Area. Logs up to 30 inches diameter may be bucked only if they significantly interfere with the thinning operation. If large diameter logs (>30 inches diameter) are discovered and must be maneuvered around, the operator will report it to the compliance officer. WMD staff will then assess the ecological significance of the log and evaluate alternatives for maintaining the integrity and functionality of the piece.

6.2.1 Ecological Thinning Unit 1 (E1)

Ecological Thinning Unit 1 (46 acres) is located between the 700 road and the Rex River and is split into three disconnected parts, separated by leave areas L4 and L5, areas with lower tree density (Figure 1). It is located on a southerly aspect, oriented generally northeast to southwest, with an elevation range of approximately 1,800 to 1,960 feet asl. This unit contains portions of the two ephemeral streams that flow into the Rex River, both of which are surface dry for much of the year. In general, the ephemeral channels in Unit E1 (that extend into Units E6 and E7) tend to be steep (generally >20%) boulder-dominated cascade channels within which riparian vegetation plays a limited role in overall morphology. Although in-channel LWD levels are low throughout these units and existing wood is generally highly decayed, the potential for LWD to promote significant sediment storage is limited by tight channel confinement and high transport capacities. In addition, no chronic bank erosion or slope stability issues were observed in any of these streams, reflecting the relative insensitivity of key aquatic processes to past timber harvest practices.

Although these channels have not exhibited dramatic changes following past management, the following thinning prescriptions have been developed to ensure protection and promote restoration of key processes:

- Leave all trees that have any portion of their canopy extending over the bankfull channel width of the main or any secondary channel or associated wetland or seep.
- Ground-based equipment will be excluded within 50 feet of the channel.

- No yarding corridors will cross the stream, and any logs that might need to be yarded through the riparian area will be fully suspended, ensuring no ground disturbance.
- No deciduous trees will be thinned.
- One source tree (14 to 17-inch diameter conifer) will be directionally felled toward the channel approximately every 100 feet. Felled trees (using tree species and sizes from the snag creation pool, see Table 6) will be from within 50 feet of the channel.
- Any part of the tree falling within ten feet of the bankfull edge will be left in place, although portions of the tree falling in the upland may be removed.

The intent of felling one 14 to 17-inch diameter conifer every 100 lineal feet into these streams is to improve short-term sediment storage processes over the period it will take to restore natural stand mortality processes and rates adjacent to these streams. Additionally, the LWD will improve the aquatic habitat for invertebrates and other stream biota. With respect to the maintenance of bed and bank stability, the retention of all trees within the drip-line of the stream, and hence with roots likely reaching the stream banks, should ensure short-term bank stability. The thinning of adjacent trees should result in long-term improvements in bank stability triggered by more vigorous root networks from larger trees and enhanced LWD recruitment.

Because of its slope position, flat gradient, and adjacency to the Rex River, E1 has a deeper soil profile, and therefore higher growth potential, than the rest of the Project Area. Because of the higher site quality, trees in this unit are taller than in the rest of the project area and have the greatest quadratic mean diameter.

Absolute tree density in E1 is 324 trees per acre (TPA) with a basal area (BA) of 382 square feet per acre, resulting in a relative density of 100 (Table 6). Removing 30 percent (114 ft^2) of the basal area will reduce the relative density to 68, which is higher than ideal to promote maximum tree growth response. A relative density of 35 to 55 would result in optimal growth rates of the residual trees and provide better conditions for understory initiation and seedling establishment. A conservative prescription is justified, however, because this will be the first entry into the forest and there will be a significant risk of windthrow. A relative density of 68 will allow the forest to develop structural stability by allowing the crown and root structure to expand, therefore creating more stability against wind. The current average height to diameter ratio of all live trees is 73, which demonstrates the high degree of interdependence the smaller trees have for wind firmness. The largest trees in the forest (80 trees greater than 15 inches dbh) have an average height to diameter ratio of 60, suggesting that these dominant trees are already relatively wind firm (i.e., the ratio is less than 70).

The project team used the current tree density and distribution (Tables 6 and 7; Appendix II) to establish a thinning pool (pool of trees from which some trees can be harvested) of western hemlock 6-19 inches dbh, and western red cedar 13-16 inches, and Pacific silver fir 8-12 inches dbh. Six to twelve inch diameter western red cedar will be retained to provide both species diversity and vertical structural complexity. All larger trees will be retained. The range of the thinning pool was chosen to have a positive effect on the light regime below the canopy and to affect understory development. In order to promote within unit tree species diversity western hemlock will be preferentially cut over western red cedar and Pacific silver fir, with the cedar and silver fir only thinned when they occur in dense clumps. All other tree species, including

Douglas-fir, noble fir, red alder, and black cottonwood, will be retained. The current 324 live trees per acre will be reduced to 208 live trees per acre by removing approximately 103 western hemlock, and 6 western red cedar per acre, thinning across all diameters within the thinning pool. Pacific silver fir will only be cut in those areas where the species shows a clumped distribution. Leaving the larger diameter trees and thinning across all diameters of the target pool will result in a variable distribution of residual tree sizes and spacing.

The retained Douglas-fir, Pacific silver fir, noble fir, red alder and black cottonwood will provide species diversity, habitat variety, and vertical canopy structure. Pacific silver fir, a very shade tolerant species, can live for extended periods under the dominant canopy, providing intermediate layers of green canopy, and snags and DW over the long-term. We predict that the noble fir will not survive the competition beyond the short term because of its shade intolerance, providing snags and DW in the short and intermediate terms. The large red alder and black cottonwoods are short-lived, and are expected to die and provide snags and DW in the intermediate term, while providing current substrate for macro-lichens. Once these species have died, they may create small canopy gaps, providing an opportunity for understory plant and seedling initiation, while increasing horizontal structural complexity.

Throughout the unit we will create an average of one small gap (0.04 acre) per 1.3 acre and leave a matching number of small skips of the same size per acre. Small skips and gaps will provide for more spatial variability and will create heterogeneous resource environments that promote species diversity. Additionally, we will create three larger gaps and leave three larger untreated skip areas in E1 to provide structural complexity and within-patch heterogeneity (Figure 1). See Section 6.2.2 for a complete discussion of the larger gaps created and untreated skip areas left in E1, E2, and E8. The total area in gaps will be 5% of the treatment unit with a matching area in untreated skips.

6.2.2 Ecological Thinning Unit 2 (E2)

Ecological Thinning Unit 2 (92 acres) is located at the western end of the Project Area, and is bounded on the west by the junction of the 700 and 300 roads. This unit represents the toe of the ridge dividing the 300 and 700 road systems, with the old ridge road running through the northern portion of the unit. The unit is generally flat, but does contain some north and south facing slopes on either side of the ridge, with a small amount of 20-25 percent slope along the ridge. The elevation ranges from approximately 1,880 to 2,160 feet above sea level.

This unit contains the only permanent stream in the Project Area, and the headwaters of one of the ephemeral streams (see Section 2.7). The perennial channel is moderately entrenched into consolidated alpine till. Boulders (from the till) as well as scant LWD currently form steps within this 4-6% gradient step-pool channel. Approximately 500 feet upstream of the 700 road, the channel is unentrenched and slopes decrease to a gradient of 2-4%. In the upper reach, roots and small LWD seem sufficient to maintain natural channel processes. Overall stream power throughout this reach is low, reflecting the small drainage area and gentle gradient. No secondary or overflow channels were observed along this tributary. The presence of till in these gently sloping depressions result in relatively shallow groundwater and riparian vegetation dominated by cedar and deciduous trees.

In light of the above, thinning treatments within this riparian corridor will include all the measures described in E1 (above), in order to meet aquatic restoration objectives consistent with the CRMW Aquatic Restoration Strategic Plan (Bohle et al. 2004). In particular, within this perennial step-pool channel, our goal is to maintain and restore sediment storage and transport processes associated with wood-formed steps. Our interim objective in these streams is a function of stream gradient, and our goal is to achieve approximately two steps per 100 meters or one step every 150 feet of stream. In order to achieve this objective, a conservative felling strategy of a tree every 100 feet was adopted. With respect to the maintenance of bed and bank stability, the retention of all trees within the drip-line of the stream, and hence with roots likely reaching the stream banks, should ensure short-term bank stability. The thinning of adjacent conifer trees should result in long term improvements in bank stability triggered by more vigorous root networks and enhanced LWD recruitment. The upper portion of the ephemeral stream within this unit has some small headwater wetlands that will be protected using the measures as described in E1.

Thirty-five percent of the current stand basal area (127 ft^2/ac) will be removed (Table 6). Approximately 157 western hemlock, 28 Douglas-fir, and 18 western red cedar per acre will be harvested from the current 458 trees per acre, retaining a tree density of roughly 241 live trees per acre. The ecological thinning will reduce the relative density from 101 to 61. As discussed for E1, this is a higher than optimal relative density, but because this is a first entry into the forest, we believe it is the maximum amount that can be removed while protecting against windthrow. The largest trees in this unit have a height to diameter ratio of 65, suggesting these dominant trees should not be at risk from windthrow as a result of the thinning. The average height to diameter ratio for the entire unit will be reduced from 77 to 74, indicating constant levels of wind firmness for the entire unit as a result of the thinning.

A thinning pool for this unit of 6 to 16 inches dbh for western hemlock and Douglas-fir, and western red cedar 6 to 15 inches dbh best meets the ecological objectives (Table 7). All larger trees, as well as the Pacific silver fir, noble fir, and red alder, will be retained to provide species diversity, canopy structure, and future snag and DW recruitment (as discussed for E1). The target pool includes some trees from the co-dominant canopy, which will allow increased light to reach the residual trees and the forest floor, encouraging understory plant initiation and tree regeneration. The additional light to the dominant canopy will cause the crowns to expand, both in depth and width. This will accelerate annual radial growth (increasing the diameter and expanding the root structure) which will help establish more stability against windthrow, as well as providing larger habitat trees in a shorter time frame. As with E1, leaving the larger diameter trees and thinning across all diameters of the thinning pool will result in a variable distribution of tree size and spacing among trees throughout the unit.

Canopy Gaps and Untreated Skip Areas (E1, E2, and E8)

Throughout the unit we will create an average of one small gap (0.04 acre) every two acres and leave a matching number of small skips of the same size per acre. Small skips and gaps will provide for more spatial variability and will create heterogeneous resource environments that promote plant species diversity and provide a variety of wildlife habitats. Additionally, we will create 10 larger paired canopy gaps and untreated skip areas of three different sizes (¼, ½, and ¾ acres) in E1, E2, and E8 to add horizontal structural complexity to the Project Area and to

simulate natural gap creation (Figure 1). Small gaps in mature forest are generally created through single or small numbers of large trees falling, creating a variety of gap sizes. The smaller gap sizes are designed to simulate this process. The larger ¾ acre gaps are designed to create horizontal structural complexity and to provide longer-lasting canopy gaps for understory plant initiation, intolerant tree species recruitment, and future forest complexity. The total area in gaps will be 5% of the treatment area with a matching area in untreated skips.

The larger circular gap/untreated skip area pairs were randomly assigned to the units. E1 will have one pair of each: ¼ acre, ½ acre, and ¾ acre. E2 will have two ¼ acre pairs, three ½ acre pairs and one ¾ acre pair. One additional skip area (0.35 acre) will be marked at the upper end of the stream in E2. E8 will have one ¼ acre pair. The different size gaps will have various numbers of live trees retained and snags and DW created within them (Table 8). The leave trees within the gaps will generally be the largest, healthiest trees available, although if a large live tree with a physical damage (i.e., broken top, multiple stem, visible conk) is available, it will also be considered for retention. Because of the increased light availability, these trees are expected to develop into large diameter trees with large branches, providing future wildlife nesting habitat for species such as marbled murrelet.

The snags within the gaps will be created from the next largest available trees. The DW will consist of approximately 20-inch diameter trees selected from near gap edges, if available, and fallen into the gap. Priority for the largest trees within the gap will first be given to the live trees, next to the snags and finally to the DW creation.

Table 8. **Amount of trees, snags, and DW in larger canopy gaps**

Gap Size	Live Trees Left	Snags Created	Down Wood Created
¼ acre	0	0	0
½ acre	2	2	2
¾ acre	3	3	3

Approximate locations for larger (greater than 0.04 acre) canopy gap and untreated skip areas were randomly assigned (see Appendix V). SPU staff determined the final location for each gap and untreated area by considering tree species composition, density, diameter, presence of large snags or DW, topography, and probable harvest systems in the vicinity of the initial coordinate. Locations could shift up to 150 feet from the original coordinate, depending on local conditions. The untreated areas were located within a range of 150 to 300 feet from the paired gap. Both gaps and skip areas were marked with flagging, and their actual locations recorded with a global positioning system (GPS). The trees in the gaps for live tree retention, and snag and DW creation will be marked prior to the thinning. Other trees will be removed from the gaps. Untreated skip areas will be avoided during the thinning operation.

6.2.3 Ecological Thinning Unit 3 (E3)

Ecological Thinning Unit 3 (41 acres) is located adjacent to and east of E2, on the south side of the ridge that divides the 300 and 700 road systems with the ridge road generally serving as the northern border of the unit. The unit faces primarily south with some westerly aspect. Elevation

in the unit ranges from 2,080 to 2,560 feet above sea level. There are no streams present in this unit. This unit is dominated by western hemlock and Douglas-fir, with small inclusions of western red cedar and Pacific silver fir.

The goal for this Thinning Unit is to investigate the ecological effects on the forest processes of tree growth, understory initiation, and seedling regeneration by removing a portion of the dominant and co-dominant tree canopy through snag creation (a method analogous to thinning across all diameters). Lindenmayer and Franklin (2002) recommend removing some dominant trees in order to adequately influence the light regime on the forest floor. We predict that this prescription will result in a marked increase in light to the forest floor that should greatly facilitate understory development, increase plant species diversity, and facilitate tree regeneration, all of which will contribute to increasing forest structural complexity. We are considering this as an experimental approach, and will monitor results. Because of the small acreage involved, and the number of larger trees retained (738 trees ≥20" dbh will remain in the unit after snag creation) it should entail low risk that insufficient larger diameter trees remain.

Based on a current live tree density of 387 live trees per acre (Table 6 and Appendix II), we will thin approximately 105 western hemlock, and 63 Douglas-fir per acre. We will only remove trees ≤ 16 inches dbh from Unit E3 during the thinning process. The remainder of the canopy removal will be accomplished by creating approximately 11 snags per acre from a portion of trees between 17 and 20 inches dbh, removing the branches to ensure the light regime will be affected in approximately the same manner as if we removed the tree. Using both species to create snags will provide differing decay rates and longevity of the snags. The combination of thinning and snag creation will result in an effective basal area removal of 30 percent (83 ft^2) and a reduction of the relative density from 78 to 50. We are removing less basal area than in E1 and E2, and are not creating gaps larger than 0.04 acre in E3 due to risk of windthrow. The height to diameter ratio of the largest dominant trees in E3 is 66, indicating that this portion of the stand is relatively windfirm. The residual relative density of 50, although higher than optimal, should provide good growing conditions in the near term.

Throughout the unit we will create an average of one small gap (0.04 acre) every 0.8 acres and leave a matching number of small skips of the same size per acre. Small skips and gaps will provide for more spatial variability and will create heterogeneous resource environments that promote species diversity. The total are in gaps in this unit will be 2.04 acres or 5% of the unit area.

Due to the steepness of the west-facing slope of the unit, relatively low tree density in this area, and difficult access, 3.5 acres of the total unit area (41 acres) will not be thinned. Slope angle and overstory density already provide increased light at the forest floor level in this patch, however. This unthinned area will be included in the snag creation described below.

We plan to use a variety of snag creation techniques (topping, blasting, girdling), as long as the canopy is removed (Appendix IV). Snags may be clumped or scattered throughout the unit, as the snag pool allows. If creation of all 451 snags is cost prohibitive, we may fell some co-dominant trees and leave them as DW. This prescription will allow us to learn about the relative effect on forest processes of removing some dominant and co-dominant tree canopy, plus having

the additional benefit of creating a dense patch of larger diameter snags within a generally snag-deficient basin. There is currently an estimated density of eight western hemlock snags per acre in this unit, all <15 inches dbh. These snags will be retained to the extent possible during the thinning operation. If any snags need to be felled for safety reasons, they will be retained as DW. The high density of created and retained snags will provide habitat for cavity nesting species as well as future small gap creation and DW recruitment. This should introduce increased structural complexity into the forest as it matures, providing future canopy gaps for understory initiation, seedling recruitment, and increased tree growth for the residual trees.

6.2.4 Ecological Thinning Unit 4 (E4)

Ecological Thinning Unit 4 (17 acres) is located adjacent to and east of E2 and north of E3, on the north side of the main ridge, with the ridge road serving as a portion of the southern border of the unit. The unit faces north, and ranges from 2,200 to 2,560 feet in elevation above sea level. The slope is relatively steep, with gradients up to 40 percent. There are no streams on this unit.

The average tree size in this unit is smaller than in units on the south side of the ridge dividing the project area. The target thinning pool for this unit will be western hemlock and Douglas-fir ≤13 inches dbh, and western red-cedar ≤9 inches dbh. All larger trees and other tree species will be retained to provide species diversity, canopy structure, and future snag recruitment.

Thirty percent of the basal area of the current tree density of 440 live trees per acre (Table 6 and Appendix II) will be removed. Approximately 154 western hemlock, 21 Douglas-fir, and 14 western red cedar per acre will be harvested, retaining a tree density of approximately 248 live trees per acre. The relative density will be reduced from 83 to 52 by the thinning.

The largest 68 trees on this unit have a height to diameter ratio of 70 and a quadratic mean diameter of 15.8. Thinning will lower the height to diameter ratio for all trees from 87 to 84, not lowering the risk of windthrow substantially. The largest dominant trees in this unit, however, have an average height to diameter ration of 71, indicating relative windfirmness. Additional thinning to reduce the relative density to 40-45 and to open the canopy to provide light for understory development could be beneficial on this unit after the trees have increased their crown and root structure.

Throughout the unit we will create an average of one small gap (0.04 acre) every 0.8 acres and leave a matching number of small skips of the same size per acre. Small skips and gaps will provide for more spatial variability and will create heterogeneous resource environments that promote species diversity. The total are in gaps in this unit will be 0.84 acres or 5% of the unit area. No gaps larger than 0.04 acres will be created on this unit due to the elevated risk of windthrow.

6.2.5 Ecological Thinning Unit 5 (E5)

Ecological Thinning Unit 5 (24 acres) is located adjacent to and east of E3, on the south side of the main ridge, extending from the 700 road to the ridge top. The elevation ranges from 1,940 to 2,600 feet above sea level, with slopes up to 45 percent. There are no streams on this site. This unit was logged approximately two years after units E1-E4, so the trees are somewhat younger than in the previous units.

This unit has a tree density of 298 trees per acre and a relative density of 62. It is dominated by western hemlock and Douglas-fir, with a very small component of western red-cedar, and no other tree species found during the 2001 forest inventory. The goal for this unit is to reduce the relative density to provide the best growing environment for the remaining trees and light for understory development. This unit will provide a patch of relatively lower canopy density within the Project Area, creating structural complexity at the local forest scale.

The target thinning pool will be western hemlock 6 to 14 inches dbh and Douglas-fir 6 to 18 inches dbh. All western red cedar will be retained. The height to diameter ratio of the dominant trees (63) and their quadratic mean diameter (19.9 inches) indicate that the dominant trees are already windfirm. As a result, we will remove thirty percent of the basal area or approximately 102 western hemlock and 28 Douglas-fir per acre, retaining a tree density of roughly 165 live trees per acre. Throughout the unit we will create an average of one small gap (0.04 acre) every 0.8 acres and leave a matching number of small skips of the same size per acre. Small skips and gaps will provide for more spatial variability and will create heterogeneous resource environments that promote species diversity. The total are in gaps in this unit will be 1.2 acres or 5% of the unit area. No gaps larger than 0.04 acres will be created due to the steep slope angle and relatively open canopy.

6.2.6 Ecological Thinning Unit 6 (E6)

Ecological Thinning Unit 6 (71 acres) is located adjacent to and east of E5, on the south side of the main ridge, extending from the 700 road to the ridge top. It faces generally south, and contains slopes up to 50 percent, with elevation ranging from 2,160 to 2,760 feet above sea level. One ephemeral stream runs throughout the center of the unit. Protection and LWD enhancement for this stream will be the same as described for the stream segments in E1.

The current tree species composition is 81 percent western hemlock, 11 percent Douglas-fir, 3 percent western red cedar, and 6 percent true firs and deciduous trees. E6 has a high current relative density of 101 which, combined with a low quadratic mean diameter of all trees of 11.6 inches, represents a forest with high competition between the numerous small diameter trees. The current height to diameter ratio is 87 and canopy cover is almost 100 percent. The initial live tree density of 471 trees per acre will be reduced to 228 trees per acre by removing 35 percent of the basal area, or approximately 232 western hemlock, and 7 Douglas-fir per acre. This will reduce the relative density to 59.

The thinning pool will be 6 to 16 inches dbh for western hemlock and Douglas-fir. All larger trees and other tree species (Pacific silver fir and red alder) will be retained to provide species diversity, canopy structure, and future snag recruitment. The height to diameter ratio of the larger trees (64), and the quadratic mean diameter of these larger trees (18.6 inches) indicate that these trees have already expressed dominance and should be relatively wind firm. This means that a 35 percent basal area removal should not incur significant risk of windthrow to the dominant trees. Thinning will reduce the height to diameter ratio for all trees in the unit from 87 to 83. Because of the steep slope and risk of windthrow to the smaller diameter trees, no gaps larger than 0.04 acres will be created on this unit. However, we will create an average of one small gap (0.04 acre) every 0.8 acres and leave a matching number of small skips of the same

size per acre, throughout the unit. Small skips and gaps will provide for more spatial variability and will create heterogeneous resource environments that promote species diversity. The total are in gaps in this unit will be 3.56 acres or 5% of the unit area.

Trees will only be yarded from the western portion of E6 (west of the ephemeral stream). In the eastern portion of the unit (east of the stream) all thinned trees will be left on the forest floor to simulate a large windthrow event. This will increase the amount of down wood (>6" diameter) by 1,018 cubic feet or 3,235 tons per acre. This amount of down wood will cover approximately 11% of the ground, adding to the existing down wood. An input of down wood in this amount is certainly a large pulse as it amounts to 80% of the average volume found in "westside conifer-hardwood forests" of comparable structure (Ohmann and Waddell 2002). The process of soil development is likely to benefit from this treatment considering the substantial extraction of wood from the site during past logging. This treatment will also allow us to evaluate the effects of a large pulse of down wood on understory vegetation response.

6.2.7 Ecological Thinning Unit 7 (E7)

Ecological Thinning Unit 7 (19 acres) is located north of E6, largely on the north side of the main ridge, with the ridge road serving as most of the southern border. This portion of the ridge is broad and represents the highest elevation in the Project Area, with a range of 2,640 to 2,840 feet above sea level. This unit was logged circa 1934, so the trees here are several years younger than in E1 and E2. This elevation is in the transition zone between the western hemlock and Pacific silver fir zones, although the species composition indicates it still lies in the western hemlock zone (Franklin and Dyrness 1988). A small portion of the ephemeral stream that flows through E6 is present. The channel becomes unconfined in E7, is less distinct, and is flanked by numerous seeps. The same stream protection measures described previously apply to this stream segment and the associated seeps.

This unit has the lowest site class designation (Site Class IV) in the Project Area (Table 1). Because of the poorer growing site quality, higher elevation, and younger age, the trees in this unit are smaller than the remaining ecological thinning units, averaging 9.3 inches dbh. The current relative density of 62 is a function of the large number of small diameter trees on the unit.

The proposed treatment in this unit is to cut trees in patches of varying sizes to mimic wind disturbance patterns, rather than thin the entire matrix. No cut trees will be yarded from the unit. Gaps will be created in a range of different sizes, varying from 40 to 120 feet in diameter. The number of gaps created will decrease proportional to gap size, assuming that natural disturbances have a higher likelihood to create smaller canopy gaps. The goal of this treatment is to encourage understory regeneration in gaps while leaving most of the unit in competitive exclusion stage. This situation might cause other groups of trees in the unit to experience wind or snow disturbance and initiate further gap formation in the future. The difference in height to diameter ratio between the unit average (84) and the largest dominant trees (63) indicates, that the main canopy trees have differentiated into canopy classes and that the dominant trees are relatively windfirm.

In order to retain 50 dominant trees per acre a diameter limit of ≤16 inches is placed on the largest trees that can be cut in the gaps. In order to increase relative species diversity, only Douglas-fir and western hemlock will be cut. Total area in gaps will be 2.85 acres and will be distributed among group sizes as follows: Three groups of 120 feet diameter (0.25 acre), eight groups of 75 feet diameter (0.10 acre), fourteen groups of 55 feet diameter (0.05 acre), and twenty groups of 40 feet diameter (0.03 acre).

Four snags per acre will be created from trees of the thinning pool (13-16 inch dbh) to increase the amount of dead standing wood in this unit and provide current snag habitat for snag-dependent species.

6.2.8 Ecological Thinning Unit 8 (E8)

Ecological Thinning Unit 8 is located in the western end of the Project Area, adjacent to E1, south of the 700 Road. It is generally flat and is located on a southwesterly aspect, with an elevation of approximately 1,800 above sea level. In this 12-acre unit only small trees will be thinned to reduce resource competition for the larger trees, while small canopy gaps will provide spatial heterogeneity.

The thinning will remove 25% of the current 313 square feet of basal area per acre and reduce the tree density from 371 to 241 trees per acre. Lowering the relative density from 89 to 64 will reduce tree competition in the near term but will only have a short-term effect on the light environment at the forest floor level, because the overstory trees are expected to quickly recapture the available growing space. Consequently, we expect to see little improvement in understory development and vertical canopy development resulting from this treatment. However overstory crown development will be enhanced.

Throughout the unit we will create 9 small gaps (0.04 acre) or one gap every 1.3 acres and leave a matching number of small skips of the same size per acre. The thinning contractor will determine the location of these skips and gaps. A larger gap of 0.25 acre and an untreated skip are physically marked in the unit. Small skips and gaps will provide for more spatial variability and will create heterogeneous resource environments that promote species diversity. The total acres in gaps in this unit will be 0.61 acres or 5% of the unit area.

This unit, along with Unit E3, will provide information from an array of thinning treatments ranging from this traditional "thin from below" to removing some co-dominant canopy (as recommended by Lindenmayer and Franklin 2002). Results will be monitored for use in future management decisions.

6.2.9 Ecological Thinning Unit 9 (E9)

Thinning unit E9 is located along the top of the ridge bordering units E3 through E7 and L2. The ridge road serves as the northern unit boundary. Elevation in this unit ranges from 2500 feet to 2750 feet. The upper reaches of the ephemeral stream in the eastern part of the project area flow through the unit. This 36-acre unit was created due to its unique location on the ridge top.

The tree stratum in this unit is well differentiated, likely due to a longer establishment period. Dominant trees have a low height to diameter ratio (66) and often have long branches and less

total height than dominant trees in the remaining project area. The goal of the proposed treatment is to reduce competition for the dominant trees to further the development of their crowns and initiate understory development by improving the light environment at the forest floor level. The treatment will reduce the current 268 square feet of basal area per acre by approximately 30%, cutting only trees in the mid-diameter range, western hemlock and Douglas-fir 9 to 16 inches. Leaving small diameter trees will result in dense patches of smaller trees that will provide for shaded areas, while cutting co-dominant trees with larger crowns will create longer lasting canopy gaps and improved light resources for understory development. No additional gaps and skips will be created in this unit.

6.2.10 Restoration Thinning Unit (RT)

The Restoration Thinning Unit (14 acres) is located on a steep slope north of E7 and east of L2, on the north side of the main ridge. During the 2001 forest inventory 373 live trees per acre ≥6 inches dbh were measured, although the actual density is much higher because most of the trees are <6 inches dbh. Only western hemlock ≤11 inches dbh, Douglas-fir ≤ 14 inches dbh, and western red cedar ≤ 14 inches dbh were present. The primary goals for this small unit are to increase residual tree growth by reducing inter-tree competition and to enhance species diversity.

No equipment will be allowed in this unit. We will use hand thinning techniques to an obtain estimated leave tree density of 185 trees per acre, removing 32% of the basal area and reducing the relative density of trees >6 inches from 54 to 34. This treatment should provide optimal growing space for the residual trees. Only the most prevalent species (western hemlock and Douglas-fir) will be thinned, with all western red cedar retained. This will not only enhance species diversity indices on the site, but will also provide spatial variability by retaining some smaller diameter trees. There will be 56 larger diameter Douglas-fir (11-14 inches dbh) per acre retained. The wider spacing of these larger trees will allow them to grow rapidly in both diameter and height, develop large limbs, and deep crown structure, all important wildlife habitat variables. This spacing should also allow the trees to develop large root systems, providing stability against windthrow. Retaining the larger diameter trees and all western red cedar will result in variable spacing between trees, enhancing structural complexity.

To remove 32 percent of the basal area, all western hemlock and Douglas-fir ≤6 inches dbh, plus 60% of the 7 to 10 inch trees will be thinned. All thinned trees will be retained in this unit as DW. Although this will increase the fire risk in the short term, it will also increase the nutrient availability and enhance soil formation processes on this site. To reduce the fire risk, all thinned trees will be cut such that they lay no higher than 20 inches from the ground surface. No snags will be created at this time because of the relatively few larger diameter trees present. No gaps will be created on this site because of the risk of windthrow.

6.3 Future Silvicultural Treatments

The Project Area will be monitored before and after ecological thinning and will be managed adaptively (see section 9). We anticipate planting deciduous trees species such as big leaf maple and black cottonwood in some of the created gaps.

A management decision about whether it would be beneficial to plant a diversity of understory species (shrubs, herbs), especially in the canopy gaps, will be based on the understory

monitoring data. If the expected diversity of native understory species have not occurred within three years after thinning, we will supplement the species diversity by selective planting. Planting treatments will be developed at that time. Because lack of understory response could be due to many factors (e.g., depauperate seed bank, poor dispersal from adjacent forests, inadequate canopy openings), the planting treatments will include varied techniques and follow-up monitoring. We may also experiment with planting non-conventional organisms such as canopy lichens and heart rot fungus. If monitoring demonstrates development of a very dense understory of western hemlock (e.g., 500 trees per acre) in patches larger than one acre, we will hand thin these trees when they reach tree heights of five to six feet (likely in 10-15 years).

The chance of another ecological thin in the Project Area is remote because of the limited number of acres in the CRMW that will be ecologically thinned and the likelihood that many other areas will have much greater ecological need. We will, however, reevaluate the ecological benefits of further ecological thinning in E2, E4, E5, E6, E8, and RT in 15-20 years. If monitoring results show a reduction of understory cover to pre-treatment levels on 50% of the monitoring plots we would consider thinning of overstory trees, leaving all trees on the forest floor, with no further yarding or use of heavy equipment.

7.0 HARVEST/ ENGINEERING SYSTEM

We expect to utilize a combination of harvest engineering systems throughout the Project Area, which may include ground-based equipment, skyline systems, and/or helicopter yarding. Only existing roads will be used, with no road reconstruction or new road construction required. The existing road along the ridge top has not been used since the site was originally logged, but is still extremely compacted, resulting in minimal vegetation growth, even after 65-70 years. This road will be removed as a part of the project, including breaking up the entire surface of the road, recontouring portions of the road to match the original land contour, and replanting with native vegetation. The road currently needs no modifications to be used as a forwarding corridor and a base from which to conduct uphill yarding. Uphill yarding has several advantages over downhill yarding. There is much less ground disturbance, less damage to adjacent trees, narrower yarding corridors, and safer working conditions. In addition, equipment that could be used to decommission the road would already be on site.

All felling and yarding of logs will be implemented with the minimum ground disturbance possible. Other restrictions include:

- no ground-based machinery will be allowed within 50 feet of a stream channel,
- no logs will be dragged through a stream channel,
- if some trees must be moved over a stream channel, there must be no ground or canopy disturbance,
- skyline yarding must not damage live crowns of retained trees,
- live tree tops must not be broken, and
- there must be minimal bark and root damage to the retained trees.

A full explanation of the harvest systems analyzed and recommendations put forth by the silvicultural engineer is included in Appendix VI. We expect to use ground-based systems on the slopes less than 35 percent, skyline systems on steeper slopes with access to existing roads, and/or helicopter yarding on the steeper sections and along the ridge top, if the existing ridge-top

road is not used as a forwarding corridor. Recommendations from the silvicultural engineer by unit are: E1 - a combination of ground-based and skyline systems; E2 - ground-based; E3 and E4 - a combination of skyline and helicopter logging; E5 and E6 - a combination of ground-based, skyline, and helicopter; and E7 - ground-based. Unit E8 was created out of a section of E1, and E9 out of sections of E3, E5 and E6 subsequent to the silvicultural engineering report, so recommendations for these units are not included. Because the terrain in E8 is similar to E1, recommendations will be the same. Other potential site-specific combinations proposed by contractors will be considered by the project planning team if they can accomplish the goals of no road construction and minimal ground disturbance, while adhering to all other restrictions. The harvest engineering report (Appendix VI) will provide insight that staff will use to judge the service contract proposals.

Ground-based equipment will likely include a tracked, cut-to-length processor and full suspension forwarder to minimize soil disturbance and damage to the remaining trees. Cut-to-length processors cut the trees, strip the branches on site, and move forward on paths cushioned by the branches, thereby minimizing soil disturbance and compaction. The processor piles logs that are then picked up by and loaded onto the forwarder that carries, but does not drag, the logs to a nearby road or landing. Forwarders are agile machines that minimize damage to soil and remaining trees because logs are not dragged along the ground or against trees. All yarding corridors and skid trails will be flagged by the contractor and approved by watershed staff before installation and use. Logs will be moved to established roads to provide log trucks easy access and minimal turn-around needs.

8.0 RISKS, BENEFITS, AND COSTS

8.1 Risks

The competitive exclusion stage of forest development (the stage of the forest in the Project Area) is structurally simple, with little or no understory development, little structural complexity, and low plant diversity (Oliver et al. 1985). This stage provides habitat for a limited number of wildlife species (Erickson 1997, Manuwal 1997, West 1997). Maturation is a much more biologically diverse stage, supporting a wider array of wildlife species, including many that are listed in the CRW-HCP (Aubry et al. 1997). If the Project Area is not ecologically thinned, it will likely remain in the competitive exclusion stage for many decades. Because of the high density of trees there is a risk some parts of the Project Area will approach stagnation, where little or no growth occurs for many decades and the forest is dominated by small dense trees with sparse understory (Oliver and Larson 1996, Spies 1997).

The 62-67 year-old trees in the Project Area currently have sufficient crown depth to respond fairly rapidly to the increased light availability that will result from the thinning. Continued crowding, however, could result in a loss of crown, decreased root development, and increased height to diameter ratios, resulting in “spindly” trees that are tall, but have small diameter and little root strength (Wonn and O’Hara 2001). If forests are left in this condition, trees can become so unstable that they often remain standing only by mutually supporting each other (Groome 1988). This increases the risk of large areas of windthrow during storm events and

decreases the ability of individual trees to respond to increased light when it does become available (Oliver and Larson 1996, Wonn and O'Hara 2001).

There is minimal risk to existing cultural resources as a result of the thinning operation. If any prehistoric cultural resources are discovered during the thinning treatment, the operation will be stopped and additional cultural surveys conducted. If necessary, the area around the resource will be buffered to ensure protection and a contract modification will be done. The thinning operation will minimize ground disturbance, using slash from harvested trees to protect the ground surface, which should help protect subsurface relicts, if they exist.

Uncertainty does exist about the exact response of trees, shrubs, herbs, and wildlife to the ecological thinning treatments (see section 9.1). These uncertainties pose little risk to the forest, however, and will be monitored for use in future habitat restoration projects.

8.2 Benefits

The primary benefit of ecological thinning relative to forest successional development is that it significantly shortens the time to the maturation stage (likely by 50 years or possibly much more), consequently providing LSF habitat to late-successional dependent species much sooner than would otherwise develop. Carey et al. (1999b) found that actively managing forests for biodiversity resulted in a much more rapid development of LSF conditions compared with no management (80 years versus 180 years to reach LSF conditions). In the short term, even standard thinning from below treatments have been shown to benefit many wildlife species. In closed-canopy forest stands that had never been thinned, there was no bat activity and very limited use by small mammals, birds, and amphibians (Aubry 1997, Aubry 2000, Erickson 1997, Manuwal and Pearson 1997, West 1997). Thinned forest stands showed much higher wildlife use than unthinned stands, both in these studies and in others (Hagar et al. 1996, Haveri and Carey 2000, Humes et al. 1999, Suzuki and Hayes 2003, Wilson and Carey 2000). The limited data available for variable density thinning indicates it provides even better current wildlife habitat than standard thinning from below (Carey and Johnson 1995). In addition, habitat elements such as deciduous trees and shrubs, snags, and DW are critical to numerous species and will be retained and enhanced during ecological thinning. Creating snags and supplementing existing DW will provide critical habitat elements in the near term that are used by approximately 110 wildlife species potentially occurring in the CRMW (Johnson and O'Neill 2001). Snags are generally deficient over much of the CRMW, and we anticipate the created snags will be used by a wide range of species as soon as they reach appropriate decay stages.

There is a large amount of data that indicates wider spacing of trees results in less instability (i.e., better root strength) and greater opportunity for crown differentiation (Oliver and Larson 1996). Over time, this lower density will reduce the risk of windthrow while facilitating forest development. In addition, a benefit may accrue to future cultural resources for native Americans, in that late-successional forests could support plants of cultural importance or create environments that might become spiritually important.

An additional benefit will be the removal of the extremely compacted ridge road, which has continued to be an artificial feature on the landscape for over 65 years. Removing the road and replanting to native vegetation will allow the forest to recover from past logging legacies.

8.3 Costs

We expect that the 700 Road Forest Habitat Restoration Project to be within the city's budget, but costs will exceed revenue based on costs already incurred (including staff time, cultural resource plan development and surveys, data collection, and engineering consultants), future anticipated costs (including monitoring, snag creation, harvest costs, and the post-thinning forest inventory), and projected revenues (based on the current market value of trees removed). Snag creation costs vary, depending on the technique (see Appendix IV), so an average of $30 per snag was used for this estimate.

9.0 MONITORING

9.1 Uncertainties

While the growth response of trees to standard thinning from below is well documented, the growth response of trees to ecological thinning may differ. In addition, the response of understory plants is less understood, particularly when using thinning solely to enhance the ecological and habitat value of a site. Because of these uncertainties, we will monitor the results of the different treatments and use the information in planning future habitat restoration projects. Other uncertainties include the ideal number of snags to create for current habitat use, and the best methods for snag creation. In deciding the number of snags to create, we used expert opinion and best professional judgement, balanced with achieving the other objectives and the cost of snag creation. We will create a variable number of snags across the Project Area using a variety of techniques, and monitor a sample of them for longevity, decay rate, and habitat use. Finally, the number and size of gaps, untreated skip areas and amount of down wood that should be created to increase habitat diversity and structural complexity is not known. To address this uncertainty, we will monitor plant and selected animal responses in the different sized gaps and units with augmented down wood.

9.2 Compliance Monitoring

A trained Contract Administrator will be on site daily during the ecological thinning operation to ensure that contract specifications and the marking and harvest guide (Appendix V) are followed, as well as to serve as the contact person in case any large snags or DW are found. Trees to be thinned will not be marked prior to the thinning, although a sample area may be marked as a training area and the thinning operators will be certified by the Contract Administrator. Compliance monitoring will also include a post-thinning forest inventory within one year of the completion of the ecological thinning, both to validate the projected tree densities and basal area of the thinning units, and to serve as the baseline for future monitoring in the thinned units. Leave tree densities that are within ten percent of our predicted values will be considered within acceptable limits for contract compliance. If results are outside of these limits we will evaluate corrective actions.

9.3 Effectiveness Monitoring

It is essential that responses to the restoration interventions and thinning techniques are monitored because of the experimental nature of the ecological thinning treatment and the range of treatments employed. Monitoring will allow managers and scientists to adaptively apply

knowledge gained on the Project Area to portions of the remaining forest to accelerate this type of forest toward late-successional habitat. Success in achieving the five ecological objectives (listed in Table 4) will be evaluated using a combination of monitoring techniques and measurements (Table 9). Our hypotheses about the effects of the ecological thinning on individual tree, canopy, understory and dead wood processes are listed in Figure 5.

Table 9. Monitoring techniques used to evaluate the success in achieving the five management objectives in the 700 Road Forest Habitat Restoration Project Area.

Objective	Monitoring Technique, Measurement
Maintain or Increase Growth Rate of Trees	Compare increment cores, dbh, height, percent live crown, and height to lowest live limb on representative trees in thinned and control plots
Increase Species Diversity; Facilitate Understory Development	Compare understory (shrub, fern and herbaceous vegetation) species presence and percent cover in thinned and control plots. Compare tree seedling regeneration in thinned and control plots.
Increase Structural Complexity	Compare height, height to lowest live limb, percent live crown, and presence of epicormic branching in thinned and control plots. Compare relative bat use in thinned and leave units.
Increase Snag Density; Facilitate Recruitment of Large-Diameter Snags and DW	Compare snag and DW density, diameter, height or length, and decay class in thinned and control plots. Compare snag creation techniques for decay rate, longevity, and habitat use. Compare relative bat use in thinned and leave units.
Protect Special Habitats/Water Quality	During ecological thinning and planting operations, ensure no equipment enters within 30 feet of the stream channels (contract compliance).

Our specific effectiveness monitoring key questions include:

1. How does the growth rate and other associated variables of trees retained in ecological thinning units compare to those in untreated leave units?
2. How does understory plant and tree seedling regeneration compare in thinned and leave units?
3. How is understory development affected by down wood creation?
4. How does understory plant and tree seedling regeneration compare in various sizes of gaps versus thinned areas and leave areas?
5. How do the leave tree variables, understory and tree seedling regeneration, and snag and DW compare among the different restoration treatments?
6. How do the different snag techniques compare, in terms of longevity, decay rate, and habitat use?

We will install 14 permanent monitoring plots. Two plots will be installed each in E2, E8, and L1 to compare the response from similar starting conditions to thinning 25% of the basal area, 35% of the basal area, and no thinning. We will install two plots each in the eastern and western portions of E6 to evaluate the understory responses to yarding versus leaving all the thinned trees on the forest floor. Two plots in E3 will be used to evaluate the response to our simulated "thin from above" prescription (by creating large numbers of snags). We will additionally install one

plot each in E1a and L4 to evaluate our decision that L4 would develop into the maturation phase quickly without thinning.

Initial baseline measurements will be taken during spring and summer of 2005. Monitoring plot layout will utilize the design for Permanent Sample Plots in CRMW, and will be placed on a random systematic grid developed for the entire CRMW (Munro et al. 2003). Trees and snags will be measured in a circular 1/5-ac slope-corrected plot (species, dbh, stratum, crown class, percent live crown, presence/type of damage, presence of mistletoe, presence of epicormic branching, decay class). Height will be estimated on all snags, and measured on a subsample of at least three trees per stratum, with a minimum of 12 trees measured for height. Crown radii will be measured on the height subsample trees. Three trees per stratum will also be cored for growth rate. At plot center, digital photographs will be taken in each of the four cardinal directions, and slope and aspect recorded. Transects (25 meters = 82 feet) will be established in the four cardinal directions from plot center, and used to measure DW. The first 52.7 feet from plot center (the amount enclosed by the tree plot) on each transect will be used to measure short shrubs (all shrubs except vine maple), using the line-intercept method. This same segment of the transect will be used as the center of a 2-meter (6.6 feet) belt transect, in which percent cover of tall shrubs (vine maple) will be estimated and number of seedlings and saplings will be counted by species by class (6 inches-4.5 feet in height, >4.5 feet tall 0-3 inches dbh, >4.5 feet tall 3-5 inches dbh). Percent cover of herbs (by species), mineral soil, rock, and duff will be estimated by cover class in one-meter square plots located at 10, 20, and 30 feet from plot center along the four transects (offset by four feet from the transect to avoid trampling). Canopy cover will be estimated using a densiometer at 20 feet from plot center along each of the four transects.

Rapid responses by overstory trees to the restoration treatments are not expected, so these trees will be monitored on the 14 plots ten years after the ecological thinning, with subsequent monitoring frequency to be decided at that time. Understory vegetation and tree regeneration will be monitored more frequently, at one and five years post-thinning, then coincident with the tree monitoring. If funding is available, we will also monitor understory vegetation and tree regeneration at three years post-thinning. This level of monitoring should allow evaluation of the successional trajectory in the thinned units and whether the objectives delineated in this management plan are being achieved.

We will monitor two each of the larger gaps (1/4ac, 1/2ac, and 3/4ac) in E1 and E2 for understory response and seedling regeneration. We will additionally monitor two of the small gaps in E7. Four transects will be placed in the four cardinal directions, extending from the center of the gap to the forest edge. Cover by shrub species will be measured using the line-intercept method. Percent cover of herbs (by species), small seedlings <6" in height, mineral soil, rock, and duff will be estimated by cover class in one-meter square plots in three plots per transect. The herb plots will be located 15 feet from the gap center, 15 feet from the forest edge, and equidistant between these two, offset from the transect by four feet. Saplings will be placed into one of three classes (6 inches-4.5 feet in height, >4.5 feet tall 0-3 inches dbh, >4.5 feet tall 3-5 inches dbh), and will counted by species in a two meter wide belt transect centered along each transect. Gaps will be monitored at one, five, and ten years post-gap creation, with the continuing monitoring schedule to be determined at that time. In addition, at five years we will visually inspect the forest edges surrounding the gap and, based on the understory response,

make a decision about whether to extend the transects into the surrounding forest. As with the other monitoring plots, if funding is available, the gaps will also be monitored at three years post-creation.

A sample of snags from each creation method will be permanently marked and monitored every five years for longevity, decay rate, and wildlife use. We will determine the exact number of created snags to monitor and the specific snag monitoring protocol once the final selection of trees (species and dbh) for snag creation is complete. This will occur after the thinning treatment, anticipated to start in 2005.

Watershed managers and scientists anticipate that implementation of the management actions specified in this plan will accelerate development of a naturally functioning late-successional forest, which will be documented by comparing monitoring results from the thinned versus untreated leave units. Monitoring may or may not indicate that future management actions (e.g., restoration planting, creation of snags or DW, hand thinning of understory trees) are warranted to achieve the management objectives.

9.4 Validation Monitoring

Certain wildlife species can serve as indicators of forest composition, structure and function. Their presence or level of activity in the Project Area may validate that the objective of accelerating LSF characteristics with respect to wildlife use is being achieved. Forest-dwelling bats use large-diameter snags and the thick or peeling bark of older trees for maternity colonies, as well as for day and night roosts. They forage in more open areas, such as canopy gaps found in old growth. Bat activity was found to be significantly higher (2.5 to 9.8 times as much activity) in old-growth forest (>200 years) than in mature and young unmanaged forests (35-195 years) (Thomas and West 1991). No bats were detected in managed 30-40 year old closed-canopy forests in a 2-year study (Erickson 1997). As such, bats may be useful indicator species to evaluate the structural complexity associated with late-successional forests.

This Project Area will be used as an experimental site to test the assumption that bats can be used as an indicator of late-successional conditions on a moderate growing site. Our key question is: How does relative bat use compare in thinned areas, in larger gaps, and in untreated leave units? We expect that bat foraging use will increase in thinned area and gaps within one year of the ecological thinning. Because maternity colonies and roosting sites require structures that will take considerable time to develop, we do not expect to find these colonies on the Project Area for many years. Baseline bat presence and relative use of E1 and E2 was conducted in June-August 2002 and 2003, by recording the ultrasonic calls using an ultrasonic detecting and recording devise (Titley Electronics). Limited bat use was found within the Project Area, though extensive use was documented over the adjacent Rex River. Bat calls will be analyzed to identify species or species groups. Monitoring bat use in the thinned areas in E1 and E2, in a sample of each size gap in E1 and E2, and in L1 and L3 will occur at one, five and ten years after the completion of the ecological thinning. This will enable us to determine if the density of leave trees provide habitat suitable for bat foraging, and whether bats will use the various sizes of gaps. Results will be included in the periodic monitoring reports.

10.0 IMPLEMENTATION AND DOCUMENTATION

10.1 Seattle City Council Ordinance

Selling surplus logs in excess of 250 MBF per year from the CRMW requires the approval of the Seattle City Council through issuance of an ordinance. An ordinance will be submitted to the City Council in the spring of 2005. Upon its approval, a copy of the ordinance will be included in Appendix VIII of this plan.

10.2 Contracts

Following the approval of the ordinance by the Seattle City Council, the City will award a contract for the ecological thinning work to a qualified contractor. The contract will specify a minimum bid, based on an appraisal of the value of the trees to be removed from the Ecological Thinning Units, as designated in this Plan. The invitation to bid will request proposals, including engineering designs, regarding how the Project Area will be thinned. The recommendations from the silvicultural engineer will be made available to prospective bidders, upon request. The contract will be sold to the highest bidder with the best project design that meets specific qualifications. A copy of the contract will be included in Appendix IX of this plan. This contract is anticipated to be completed in the spring of 2005. The thinning is expected to begin in 2005 and may take up to two years, with an estimated 3.5 million board feet of trees removed from the Project Area, with income generated from the sale of the trees used to offset most of the costs of the Project (including planning, data collection, cultural resources surveys, log removal, and monitoring).

The RT unit will be thinned using a separate contract, and the work may be included in other appropriate restoration thinning contracts.

10.3 Project Completion

A short report will be prepared, if needed, to describe any instances where field treatments were modified during implementation of the ecological and restoration thinning. The reasons for such modification will be described. Details such as skid trail locations will be recorded. The data from the post-treatment forest inventory will be included in this project completion report as Appendix X.

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Appendix I
Glossary of Terms

Adaptive management	As applied in the CRW-HCP, the process of adaptive management is defined with three basic elements: (i) an initial operational decision or project design made in the face of uncertainty about the impacts of the action; (ii) monitoring and research to determine impacts of actions; and (iii) changes to operations or project design in response to new information.
Aspect	The direction a slope faces with respect to the cardinal compass points. Fore example, a hillside facing east has an eastern aspect.
Basal area	The cross sectional area of a tree at breast height, usually summed by species over a given area.
Biodiversity	Biological diversity; the combination and interactions of genetic diversity, species composition, and ecological diversity (including factors such as age, form, structure, and location) in a given place at a given time.
Biological legacies	As defined in the CRW-HCP: Features of a previous forest that are retained at timber harvest or left after natural disturbances, including old-growth or other large diameter snags, stumps, live trees, logs, soil communities, hardwood trees, and shrubs. Also referred to as legacies.
Board feet	A measurement of lumber volume. A board foot is equal to 144 cubic inches of wood.
Canopy	The cover of branches and foliage formed collectively by the crowns of trees or other growth. Also used to describe layers of vegetation or foliage below the top layer of foliage in a forest, as when referring to the multi-layered canopies or multi-storied conditions typical of ecological old-growth forests.
Canopy closure	The degree to which the boles, branches, and foliage (canopy) block penetration of sunlight to the forest floor or obscures the sky; determined from measurements of density (percent closure) taken directly under the canopy.

Cedar River Watershed	An administrative unit of land owned by the City of Seattle for the purposes of providing a municipal water supply. The 91,346-acre municipal watershed within the upper part of the Cedar River Basin lies upstream from the City's water intake at Landsburg Diversion Dam. It is composed of eight major subbasins and 27 subbasins, 26 of which drain into the Cedar River. It supplies about 2/3 of the drinking water to Seattle Public Utilities' water service area.
Co-dominant trees	Trees or shrubs with crowns receiving full light from above, but comparatively little from the sides. Crowns usually form the general level of the canopy.
Competitive exclusion	A phase in which the canopy closes and competition among trees becomes intense in a developing stand. Also sometimes called stem exclusion.
Compliance monitoring	Monitoring performed to determine whether contracts are implemented as written.
Conifer	A tree belonging to the taxonomic order Gymnospermae, and comprising a wide range of trees that are mostly evergreen. Conifers bear cones and have needle-shaped or scalelike leaves.
Decay class	One of five recognizable stages of wood decay as a fallen tree decomposes and is reincorporated into the soil. Factors that categorize stages of decay include bark and twig presence or absence, log texture and shape, wood color, position relative to the ground, and presence or absence of invading roots (Maser and Trappe 1984).
Deciduous trees	Flowering trees, belonging to the taxonomic order Angiospermae, with relatively broad, flat leaves, as compared to conifers or needle-leaved trees.
Disturbance	Significant change in forest structure or composition through natural events (such as fire, flood, wind, earthquake, or disease) or human-caused events (forest management).
Dominant Tree	Trees with crowns receiving full light from above and partly from the side; usually larger than the average trees in the stand, with crowns that extend above the general level of the canopy and that are well developed but possibly somewhat crowded on the sides. A dominant tree is one which generally stands head and shoulders above all other trees in its vicinity.

Ecological thinning	As defined in the CRW-HCP: The experimental silvicultural practice of cutting, damaging, or otherwise killing some trees from some areas of older, overstocked, second-growth forest (typically over 30 years old). The intent of ecological thinning is to encourage development of the habitat structure and heterogeneity typical of late-successional and old-growth stands, characterized by a high level of vertical and horizontal stand structure, and to improve habitat quality for wildlife. It is expected that techniques will include variable-density thinning to create openings, develop a variety of tree diameter classes, develop understory vegetation, and recruit desired species; and creating snags and logs by uprooting trees, felling trees, topping trees, injecting trees with decay-producing fungus, and other methods. Ecological thinning does not have any commercial objectives. However, in those cases in which an excess of woody material is generated by felling trees, trees may be removed from the thinning site and may be sold or used in restoration projects on other sites.
Effectiveness monitoring	Monitoring to determine whether implemented restoration activities result in anticipated habitat conditions or effects on species.
Even-aged forest	A forest with minimal differences in age, generally less than 10 years, between trees.
Forest stand	A group of trees that possess sufficient uniformity in composition, structure, age, spatial arrangement, or condition to distinguish them from adjacent groups of trees. Also referred to as stand.
Forest succession	The sequential change in composition, abundance, and patterns of species that occurs as a forest matures after an event in which most of the trees are removed. The sequence of biological communities in a succession is called a sere, and the communities are called seral stages.
Habitat	The sum total of environmental conditions of a specific place occupied by plant or animal species or a population of such species. A species may require or use more than one type of habitat to complete its life cycle.

Habitat Conservation Plan (HCP)	As defined under Section 10 of the federal Endangered Species Act, a plan required for issuance of an incidental take permit for a listed species. Called "conservation plans" under the Act, HCPs can address multiple species, both listed and unlisted, and can be long term. HCPs provide for the conservation of the species addressed, and provide certainty for permit applicants through an implementation agreement between the Secretary of the Interior or Secretary of Commerce and a non-federal entity.
Interior forest conditions	Forest conditions that are largely not affected by edge effects, which occur where large openings abut the forest. Edge effects that are know to occur in some areas include penetration of light and wind, temperature changes, and increased predator activity. Interior forest condition are achieved at sufficient distance from an edge so that edge effects are minimal.
Landsburg Diversion Dam	The low dam at the site of the diversion for uptake of drinking water operated by Seattle Public Utilities, located at River Mile 21.8 of the Cedar River. As a run-of-the-river dam, it does not create a significant impoundment of water upstream. Also referred to as Landsburg Dam.
Late-successional forest	Forest in the later stages of forest succession; the sequential change in composition, abundance, and patterns of species that occurs as a forest matures. As used in the CRW-HCP, refers to conifer forests 120-189 years of age. Characterized by increasing biodiversity and forest structure, such as a number of canopy layers, large amounts of coarse woody debris, light gaps (canopy openings), and developed understory vegetation.
Legacies	See biological legacies.
Listed wildlife species, federal	Under the federal Endangered Species Act, species, or sub-unit of a species, formally listed in the Federal Register as endangered or threatened by the Secretary of the Interior or the Secretary of Commerce. A listing refers to the species or sub-unit by scientific and common name and specifies over what portion of its range it is endangered or threatened.
Macrolichen	A lichen is a symbiotic association between a fungus and a photosynthetic partner (green algae, cyanobacteria or both). Macrolichens include foliose (leaflike) and fruticose (shrublike) lichens.
Management prescriptions	A set of procedures designed to accomplish a specific management objective.

Monitoring	The process of collecting information to evaluate if objectives and anticipated results of a management plan are being realized or if implementation is proceeding as planned. This may include assessing the effects upon a species' habitat.
Native species	Any wildlife species naturally occurring in a specific area of Washington for purposes of breeding, resting, or foraging, excluding introduced species not found historically in this state; defined by WAC 232-12-297.
Old-growth conditions	Conditions in older conifer forest stands, with vertical and horizontal structural attributes sufficient to maintain some or all of the ecological functions of natural "ecological old-growth" forest, which is typically at least 200 years old and often much older.
Old-growth forest	As used in the CRW-HCP, native unharvested conifer forest in the Cedar River Municipal Watershed that is at least 190 years of age, but which does not necessarily exhibit "ecological old-growth" conditions.
Overstory	That portion of the trees, in a forest of more than one story, forming the upper or uppermost canopy layer.
Regeneration	The seedlings and saplings existing in a stand; the act of establishing young trees naturally or artificially.
Restoration planting	Planting of native trees, shrubs, and other plants to encourage development of habitat structure and heterogeneity, to improve habitat conditions for fish and wildlife, and to accelerate development of old-growth conditions or riparian forest function in previously harvested second growth.
Second-growth	Forest stands in the process of regrowth after an earlier cutting or disturbance.
Seral stage	A particular stage (ecological community) in a sere, or pattern of succession. As used in the CRW-HCP, applies to forest succession
Silviculture	The theory and practice of controlling the establishment, composition, growth, and quality of forest stands in order to achieve management objectives. Includes such actions as thinning, planting, fertilizing, and pruning.
Site index	The total height to which dominant trees of a given species will grow on a given site at some index age, often 50 or 100 years

Slope	A measure of the steepness of terrain, equal to the tangent of the angle of the average slope surface with the horizontal, expressed in percent. A 100 percent slope has an angle with the horizontal of 45 degrees, a 70% slope has an angle of 35 degrees, and a 30 percent slope has an angle of 17 degrees.
Snag	A standing dead tree.
Species	A unit of the biological classification system (taxonomic system) below the level of genus; a group of individual plants or animals (including subspecies and populations) that have common attributes and are capable of interbreeding. The federal Endangered Species Act defines species to include subspecies and any "distinct population segment" or "evolutionarily significant unit" of any species.
Stagnant Stand	Forest stands whose growth and development have all but ceased due to poor site and/or excessive density of trees (often termed stocking).
Stand	See forest stand.
Structure	The arrangement of the parts of an ecosystem, both vertically and horizontally.
Take	To harass, harm, pursue, hunt, wound, kill, trap, capture, or collect a federally listed threatened or endangered species, or to attempt to do so (ESA, Section 3[10]). Take is prohibited under federal law, except where authorized. Take may include disturbance of the listed species, nest, or habitat when disturbance is extensive enough to disrupt normal behavioral patterns for the species, although the affected individuals may not actually die.
Threatened species, federal	A designation as defined in the federal Endangered Species Act for a species that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future.
Type F waters	Perennial fish-bearing streams, as defined in WAC 222-16-030.
Type S waters	Shorelines of the state, as under chapter 90.58 RCW, in WAS 222-16-030.
Type 1-3 waters	In the context of the HCP, fish bearing waters. Definition based on WAC 222-16-031.

Understory	All forest vegetation growing under an overstory.
Validation Monitoring	Monitoring to determine cause and effect relationships, such as that between habitat and species.
Washington Administrative Code (WAC)	All current, permanent rules of each state agency, adopted pursuant to chapter 34.05 RCW.
Watershed	A basin contributing water, organic matter, dissolved nutrients, and sediments to a stream, lake, or ocean. As applied in the CRW-HCP, used to refer to the Cedar River Municipal Watershed above the Landsburg Diversion Dam and water intake, some of which does not drain into the Cedar River above the Landsburg water intake.
Wetland	Land where the water table is usually at or near the surface or the land is covered by shallow water and has one or more of the following attributes: the land supports, at least periodically, predominantly hydrophytic plants (plants adapted to water or waterlogged soil); substrate is predominantly undrained hydric soils; and/or the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season each year.

Appendix II: Ecological Thinning Unit E1 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 46

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	323.8	381.6
5																			0.0	0.0	0	323.8	381.6
6				18.5	3.6	0													18.5	3.6	0	323.8	381.6
7	7.6	2.0	153																7.6	2.0	153	305.3	377.9
8	13.8	4.5	479							6.6	2.4	199							20.4	6.9	678	297.6	375.9
9	15.6	6.5	626	5.0	2.3	149													20.6	8.8	775	277.2	369.0
10	16.4	8.7	827				3.4	2.0	203										19.8	10.7	1,030	256.6	360.2
11	19.6	12.9	1453																19.6	12.9	1,453	236.8	349.5
12	12.5	9.4	1023							2.9	2.3	290							15.4	11.7	1,312	217.2	336.6
13	21.5	19.3	2499	7.3	6.7	435				2.7	2.3	328				2.43	2.24	219	33.9	30.6	3,481	201.8	324.9
14	17.3	18.2	2154	3.1	3.1	93	4.0	4.2	573										24.4	25.5	2,820	167.9	294.3
15	11.1	13.2	1907							9.8	11.8	1698							20.9	25.1	3,605	143.5	268.8
16	15.1	21.0	3153	9.3	13.0	1,228	3.0	4.2	656										27.4	38.2	5,037	122.5	243.7
17	11.9	18.0	2825	3.1	4.7	361	3.0	4.8	694										17.9	27.5	3,879	95.2	205.6
18	12.5	22.2	2993	4.6	8.0	829				3.9	6.7	908							20.9	36.9	4,730	77.2	178.1
19	11.8	22.6	3459	1.2	2.3	314	2.3	4.4	625										15.3	29.3	4,398	56.3	141.2
20	4.3	9.1	1330	5.3	11.5	1,188	1.1	2.4	392										10.7	22.9	2,910	41.0	111.9
21	8.0	18.8	2872	2.1	5.1	570	1.8	4.3	897										11.9	28.2	4,339	30.4	88.9
22	2.5	6.4	1013				1.7	4.5	886										4.2	11.0	1,899	18.5	60.7
23	3.5	10.1	1780				0.9	2.5	345	0.7	2.1	458							5.1	14.7	2,583	14.3	49.8
24	2.2	7.0	1048																2.2	7.0	1,048	9.2	35.0
25																0.7299	2.4882	364.965	0.7	2.5	365	6.9	28.0
26	0.6	2.4	368				1.9	7.0	1,382										2.6	9.4	1,750	6.2	25.5
27				0.7	2.6	324	1.1	4.6	961										1.8	7.2	1,285	3.7	16.1
28																			0.0	0.0	0	1.8	8.9
29							0.5	2.4	544.269										0.5	2.4	544	1.8	8.9
30							1.3	6.5	1,356										1.3	6.5	1,356	1.3	6.5
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	208.0	232.4	31,960	60.0	62.9	5,492	26.0	53.9	9,514	26.6	27.8	3,881	0.0	0.0	0	3.2	4.7	584	323.8	381.6	51,430		
%	0.64	0.61	0.62	0.19	0.16	0.11	0.08	0.14	0.18	0.08	0.07	0.08	0.00	0.00	0.00	0.01	0.01	0.01					

% = Fraction of total number of tree species relative to unit total
TPA = Trees per Acre
BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

BF = Board Feet/acre (surrogate for volume of trees)
Shaded area = thinning pool
Bold outline = snag pool

Ecological Thinning Unit E1 - After 30% BA Thinning Applied to Target Species By DBH

Prescription **E1** **BA** **0.7** **Created Snags per Acre** **4**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%		**0.45**			**0.7**						**0.7**												
DBH range		**7-19**			**13-16**						**8-12**												
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	207.7	268.2
5																			0.0	0.0	0	207.7	268.2
6				18.5	3.6	0													18.5	3.6	0	207.7	268.2
7	3.4	0.9	69																3.4	0.9	69	189.2	264.5
8	6.2	2.0	216							4.6	1.7	139							10.9	3.7	355	185.8	263.6
9	7.0	2.9	282	5.0	2.3	149				0.0	0.0	0							12.0	5.2	431	174.9	259.9
10	7.4	3.9	372				3.4	2.0	203	0.0	0.0	0							10.8	5.9	575	162.9	254.7
11	8.8	5.8	654							0.0	0.0	0							8.8	5.8	654	152.2	248.7
12	5.6	4.2	460							2.0	1.6	203							7.7	5.8	663	143.3	242.9
13	9.7	8.7	1125	5.1	4.7	305				2.7	2.3	328				2.4	2.2	218.5	19.9	17.9	1,976	135.7	237.1
14	7.8	8.2	969	2.2	2.2	65	4.0	4.2	573										13.9	14.6	1,607	115.8	219.2
15	5.0	5.9	858							9.8	11.8	1698							14.0	16.8	2,556	101.8	204.6
16	6.8	9.4	1419	6.5	9.1	860	3.0	4.2	656	0.0	0.0	0							15.2	21.2	2,934	87.9	187.8
17	5.3	8.1	1271	3.1	4.7	361	3.0	4.8	694	0.0	0.0	0							10.6	16.2	2,325	72.7	166.5
18	5.6	10.0	1347	4.6	8.0	829				3.9	6.7	908							13.1	23.2	3,084	62.1	150.3
19	5.3	10.2	1556	1.2	2.3	314	2.3	4.4	625	0.0	0.0	0							7.9	15.3	2,495	48.9	127.1
20	4.3	9.1	1330	5.3	11.5	1188	1.1	2.4	392	0.0	0.0	0							10.7	22.9	2,910	41.0	111.9
21	8.0	18.8	2872	2.1	5.1	570	1.8	4.3	897	0.0	0.0	0							11.9	28.2	4,339	30.4	88.9
22	2.5	6.4	1013				1.7	4.5	886	0.0	0.0	0							4.2	11.0	1,899	18.5	60.7
23	3.5	10.1	1780				0.9	2.5	345	0.7	2.1	458							5.1	14.7	2,583	14.3	49.8
24	2.2	7.0	1048																2.2	7.0	1,048	9.2	35.0
25																0.7	2.5	365.0	0.7	2.5	365	6.9	28.0
26	0.6	2.4	368				1.9	7.0	1382										2.6	9.4	1,750	6.2	25.5
27				0.7	2.6	324	1.1	4.6	961	0.0	0.0	0							1.8	7.2	1,285	3.7	16.1
28																			0.0	0.0	0	1.8	8.9
29							0.5	2.4	544										0.5	2.4	544	1.8	8.9
30							1.3	6.5	1356	0.0	0.0	0							1.3	6.5	1,356	1.3	6.5
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	105.2	134.2	19,007	54.1	56.1	4,965	26.0	53.9	9,514	23.8	26.3	3,734	0.0	0.0	0	3.2	4.7	584	207.7	268.2	37,804		
%	0.51	0.50	0.50	0.26	0.21	0.13	0.13	0.20	0.25	0.11	0.10	0.10	0.00	0.00	0.00	0.02	0.02	0.02	0.64	0.70	0.74		
																		sq.spacing	19.0				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Ecological Thinning Unit E2 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 92

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	458.4	348.1
5																			0.0	0.0	0	458.4	348.1
6	25.4	4.8	230				4.6	1.0	91										29.9	5.8	322	458.4	348.1
7	31.4	8.5	775	9.7	2.3	195	12.8	3.3	255							4.7	1.3	141	58.6	15.5	1,367	428.4	342.3
8	28.6	9.8	886	3.6	1.3	72	3.6	1.3	72							4.2	1.3	126	40.0	13.6	1,156	369.8	326.8
9	44.8	19.1	1,681	13.4	5.4	422	2.4	0.9	96										60.5	25.5	2,199	329.9	313.2
10	30.0	15.8	1,431	9.5	5.0	299	1.7	0.9	104	2.2	1.2	129				2.5	1.2	100	45.8	24.1	2,062	269.3	287.7
11	29.0	18.9	1,852	1.9	1.3	95	5.0	3.4	333							1.9	1.2	112	37.8	24.8	2,392	223.5	263.6
12	16.9	12.9	1,455	5.3	4.0	279	3.2	2.4	254							1.6	1.3	112	27.1	20.6	2,101	185.7	238.8
13	25.8	23.0	2,860	8.7	7.6	608	7.8	7.1	835	4.1	3.6	369				4.3	3.8	374	50.7	45.1	5,047	158.7	218.2
14	9.2	9.5	1,093	3.8	3.8	293	9.1	9.5	1,120	1.2	1.2	157				1.3	1.3	130	24.7	25.4	2,792	107.9	173.1
15	9.9	12.0	1,650	4.4	5.3	445	0.8	1.0	126										15.2	18.3	2,222	83.2	147.7
16	6.1	8.3	1,133	4.6	6.4	617	5.1	6.8	833				0.68	0.94	162				16.4	22.5	2,746	68.0	129.4
17	7.0	10.8	1,581	1.8	2.7	248	5.5	8.4	1,019										14.2	21.9	2,848	51.6	106.9
18				3.0	5.3	559	4.9	8.4	1,183										7.9	13.6	1,742	37.3	85.1
19	1.3	2.5	346	2.0	3.9	448	4.3	8.1	1,175	0.6	1.2	164				0.6	1.3	147	8.8	16.9	2,279	29.4	71.4
20				1.3	2.8	260	6.7	14.3	2,109										7.9	17.1	2,369	20.6	54.5
21	0.5	1.2	184	1.1	2.7	315	2.0	4.8	909										3.6	8.8	1,408	12.6	37.5
22							2.4	6.2	937										2.4	6.2	937	9.0	28.7
23				0.5	1.4	159	3.0	8.5	1,522										3.4	9.8	1,681	6.6	22.6
24							0.4	1.2	233										0.4	1.2	233	3.2	12.7
25							0.4	1.2	235										0.4	1.2	235	2.8	11.5
26							0.3	1.3	229										0.3	1.3	229	2.4	10.3
27				0.4	1.4	179	1.0	3.7	718										1.3	5.2	897	2.1	9.1
28							0.3	1.3	235										0.3	1.3	235	0.8	3.9
29																			0.0	0.0	0	0.5	2.6
30							0.3	1.2	260										0.3	1.2	260	0.5	2.6
31																			0.0	0.0	0	0.2	1.4
32																			0.0	0.0	0	0.2	1.4
33				0.24	1.42	177													0.2	1.4	177	0.2	1.4
Total	265.9	157.3	17,158	75.2	63.9	5,671	87.4	106.3	14,884	8.1	7.2	819	0.7	0.9	162	21.1	12.6	1,242	458.4	348.1	39,935		
%	0.58	0.45	0.43	0.16	0.18	0.14	0.19	0.31	0.37	0.02	0.02	0.02	0.00	0.00	0.00	0.05	0.04	0.03					

TPA = Trees per Acre
BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)
BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

Shaded area = thinning pool
Bold outline = snag pool

Ecological Thinning Unit E2 - After 35% BA Thinning Applied to Target Species By DBH

Prescription **E2** **BA** **0.65** **Created Snags per Acre** **4**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%		**0.35**			**0.7**			**0.5**															
DBH range		**6-16**			**7-15**			**6-16**															
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	241.3	221.3
5																			0.0	0.0	0	241.3	221.3
6	8.9	1.7	81				2.3	0.5	46										11.2	2.2	126	241.3	221.3
7	11.0	3.0	271	6.8	1.6	136	6.4	1.7	128							4.7	1.3	141	28.9	7.5	676	230.2	219.1
8	10.0	3.4	310	2.5	0.9	50	1.8	0.6	36							4.2	1.3	126	18.5	6.2	522	201.3	211.6
9	15.7	6.7	588	9.4	3.8	296	1.2	0.5	48										26.2	10.9	932	182.8	205.3
10	10.5	5.5	501	6.6	3.5	209	0.9	0.5	52	2.2	1.2	129				2.5	1.2	100	22.6	11.9	991	156.5	194.4
11	10.2	6.6	648	1.3	0.9	67	2.5	1.7	166							1.9	1.2	112	15.9	10.4	993	133.9	182.5
12	5.9	4.5	509	3.7	2.8	196	1.6	1.2	127							1.6	1.3	112	12.9	9.8	944	118.0	172.1
13	9.0	8.1	1001	6.1	5.3	426	3.9	3.6	418	4.1	3.6	369				4.3	3.8	374	27.4	24.3	2,588	105.2	162.2
14	3.2	3.3	382	2.7	2.7	205	4.6	4.8	560	1.2	1.2	157				1.3	1.3	130	11.2	11.4	1,434	77.7	137.9
15	3.5	4.2	578	3.1	3.7	312	0.4	0.5	63										5.8	7.0	952	66.5	126.5
16	2.1	2.9	397	4.6	6.4	617	2.5	3.4	417				0.7	0.9	162				9.1	12.6	1,592	60.7	119.5
17	7.0	10.8	1581	1.8	2.7	248	5.5	8.4	1019										14.2	21.9	2,848	51.6	106.9
18				3.0	5.3	559	4.9	8.4	1183										7.9	13.6	1,742	37.3	85.1
19	1.3	2.5	346	2.0	3.9	448	4.3	8.1	1175	0.6	1.2	164				0.6	1.3	147	8.8	16.9	2,279	29.4	71.4
20				1.3	2.8	260	6.7	14.3	2109										7.9	17.1	2,369	20.6	54.5
21	0.5	1.2	184	1.1	2.7	315	2.0	4.8	909										3.6	8.8	1,408	12.6	37.5
22							2.4	6.2	937										2.4	6.2	937	9.0	28.7
23				0.5	1.4	159	3.0	8.5	1522										3.4	9.8	1,681	6.6	22.6
24							0.4	1.2	233										0.4	1.2	233	3.2	12.7
25							0.4	1.2	235										0.4	1.2	235	2.8	11.5
26							0.3	1.3	229										0.3	1.3	229	2.4	10.3
27				0.4	1.4	179	1.0	3.7	718										1.3	5.2	897	2.1	9.1
28							0.3	1.3	235										0.3	1.3	235	0.8	3.9
29							0.0	0.0	0										0.0	0.0	0	0.5	2.6
30							0.3	1.2	260										0.3	1.2	260	0.5	2.6
31																			0.0	0.0	0	0.2	1.4
32																			0.0	0.0	0	0.2	1.4
33				0.2	1.4	177.0													0.2	1.4	177	0.2	1.4
Total	98.8	64.5	7,377	57.1	53.1	4,858	59.3	87.4	12,824	8.1	7.2	819	0.7	0.9	162	21.1	12.6	1,242	241.3	221.3	27,282		
%	0.41	0.29	0.27	0.24	0.24	0.18	0.25	0.39	0.47	0.03	0.03	0.03	0.00	0.00	0.01	0.09	0.06	0.05	0.53	0.64	0.68		
																	sq.spacing		16.5				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Ecological Thinning Unit E3 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 41

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4							30.21	2.64											30.2	2.6	0	387.1	259.4
5																			0.0	0.0	0	356.9	256.8
6	13.3	2.4																	13.3	2.4	0	356.9	256.8
7	38.3	10.2	764	11.0	2.8	219	8.5	2.5	254	8.5	2.4	170							66.3	17.9	1,408	343.6	254.4
8	44.3	14.1	1,177	16.7	5.6	334	6.3	2.4	250										67.2	22.0	1,761	277.3	236.6
9	24.9	10.4	796	6.4	2.8	128	5.4	2.4	218	6.2	2.5	125							43.0	18.1	1,266	210.1	214.5
10	4.6	2.5	185				19.6	10.1	734	5.1	2.5	204							29.3	15.2	1,123	167.1	196.5
11	7.5	4.5	369	4.5	3.0	135	3.9	2.4	235										16.0	9.9	739	137.8	181.3
12	9.6	7.5	673	3.7	2.9	148				3.2	2.5	288							16.5	13.0	1,109	121.8	171.4
13	8.8	7.7	850				17.2	15.0	1,409										26.0	22.7	2,259	105.3	158.5
14	5.0	5.0	600	2.7	2.9	217				2.3	2.5	345							10.0	10.3	1,163	79.3	135.7
15	4.4	5.1	708				12.3	15.0	1,650										16.8	20.1	2,357	69.3	125.4
16							9.3	12.6	1,606										9.3	12.6	1,606	52.5	105.3
17	1.6	2.6	359				6.5	10.0	1,354										8.2	12.6	1,714	43.3	92.7
18				1.7	3.1	294	10.4	17.8	2,327										12.1	20.8	2,620	35.1	80.1
19							1.3	2.5	345										1.3	2.5	345	22.9	59.3
20	1.2	2.6	323				8.3	17.7	2,572										9.6	20.3	2,895	21.7	56.8
21	1.0	2.5	398				2.0	4.7	691										3.0	7.2	1,089	12.1	36.5
22							1.0	2.5	429										1.0	2.5	429	9.1	29.3
23				1.1	3.2	256	1.8	5.1	793										2.9	8.3	1,049	8.1	26.8
24										0.8	2.6	459							0.8	2.6	459	5.2	18.5
25							2.3	7.9	1,233										2.3	7.9	1,233	4.4	15.9
26							1.4	5.3	804										1.4	5.3	804	2.1	8.0
27																			0.0	0.0	0	0.6	2.6
28							0.6	2.6	438										0.6	2.6	438	0.6	2.6
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	164.7	77.0	7,202	47.8	26.3	1,731	148.3	141.2	17,341	26.2	14.9	1,592	0.0	0.0	0	0.0	0.0	0	387.1	259.4	27,866		
%	0.43	0.30	0.26	0.12	0.10	0.06	0.38	0.54	0.62	0.07	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00					

TPA = Trees per Acre
BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)
BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

Shaded area = thinning pool
Bold outline = snag pool

Ecological Thinning Unit E3 - After 30% BA Thinning Applied to Target Species By DBH

Prescription **E3** **BA** **0.7** **Created Snags per Acre** **11**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%		**0.35**						**0.6**															
DBH range		**6-15**						**7-16**															
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	208.4	175.9
5																			0.0	0.0	0	208.4	175.9
6	4.6	0.8	0																4.6	0.8	0	208.4	175.9
7	13.4	3.6	268	11.0	2.8	219	5.1	1.5	152	8.5	2.4	170							38.0	10.2	809	203.7	175.1
8	15.5	4.9	412	16.7	5.6	334	3.8	1.4	150										35.9	11.9	896	165.7	164.9
9	8.7	3.6	278	6.4	2.8	128	3.3	1.4	131	6.2	2.5	125							24.6	10.4	662	129.8	152.9
10	1.6	0.9	65				11.8	10.1	734	5.1	2.5	204							18.5	13.5	1,003	105.2	142.6
11	2.6	1.6	129	4.5	3.0	135	2.3	1.4	141										9.5	6.0	405	86.7	129.0
12	3.4	2.6	236	3.7	2.9	148	0.0			3.2	2.5	288							10.3	8.1	672	77.2	123.1
13	3.1	2.7	298				10.3	9.0	845										13.4	11.7	1,143	66.9	115.0
14	1.8	1.7	210	2.7	2.9	217	0.0	0.0	0	2.3	2.5	345							6.8	7.1	772	53.5	103.3
15	1.6	1.8	248				7.4	9.0	990										8.9	10.8	1,237	46.8	96.2
16							5.6	12.6	1606										5.6	12.6	1,606	37.8	85.4
17	1.6	2.6	359				6.5	10.0	1354										5.1	7.9	1,714	32.3	72.8
18				1.7	3.1	294	10.4	17.8	2327										8.2	14.2	2,620	27.1	64.9
19							1.3	2.5	345										0.8	1.6	345	18.9	50.8
20	1.2	2.6	323				8.3	17.7	2572										6.0	12.7	2,895	18.1	49.2
21	1.0	2.5	398				2.0	4.7	691										3.0	7.2	1,089	12.1	36.5
22							1.0	2.5	429										1.0	2.5	429	9.1	29.3
23				1.1	3.2	256	1.8	5.1	793										2.9	8.3	1,049	8.1	26.8
24										0.8	2.6	459							0.8	2.6	459	5.2	18.5
25							2.3	7.9	1233										2.3	7.9	1,233	4.4	15.9
26							1.4	5.3	804										1.4	5.3	804	2.1	8.0
27							0.0	0.0	0										0.0	0.0	0	0.6	2.6
28							0.6	2.6	438										0.6	2.6	438	0.6	2.6
29							0.0	0.0	0										0.0	0.0	0	0.0	0.0
30							0.0	0.0	0										0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	60.2	31.9	3,222	47.8	26.3	1,731	85.1	122.7	15,735	26.2	14.9	1,592	0.0	0.0	0	0.0	0.0	0	208.4	175.9	22,281		
%	0.29	0.18	0.14	0.23	0.15	0.08	0.41	0.70	0.71	0.13	0.08	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.68	0.80		
																		sq.spacing	20.3				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Ecological Thinning Unit E4 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 17

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	439.9	269.8
5																			0.0	0.0	0	439.9	269.8
6				28.3	5.6	283													28.3	5.6	283	439.9	269.8
7	64.7	15.9	1,026	21.3	5.7	425	21.2	5.2	424										107.2	26.8	1,875	411.6	264.3
8	28.9	10.6	1,158																28.9	10.6	1,158	304.5	237.5
9	23.7	10.5	950	17.5	6.9														41.3	17.4	950	275.5	226.9
10	29.0	15.8	1,539																29.0	15.8	1,539	234.3	209.5
11	50.6	31.4	3,506	8.6	5.7	689	15.2	10.5	1,139										74.4	47.5	5,334	205.3	193.7
12	33.9	26.2	3,254	8.9	6.4	621													42.8	32.6	3,875	130.9	146.2
13	5.6	5.2	675	6.9	6.4	695	5.8	5.3	575										18.3	16.9	1,945	88.1	113.6
14	15.0	16.0	2,147				9.9	10.6	1,439										24.9	26.6	3,586	69.8	96.7
15	8.5	10.4	1,691	5.2	6.4	261													13.7	16.8	1,952	44.8	70.1
16	4.0	5.3	729				7.6	10.6	1,443										11.6	15.9	2,172	31.2	53.3
17							6.7	10.6	1,481										6.7	10.6	1,481	19.5	37.4
18							3.0	5.3	720										3.0	5.3	720	12.8	26.8
19							2.7	5.3	808										2.7	5.3	808	9.8	21.5
20							5.0	10.6	1,497										5.0	10.6	1,497	7.1	16.2
21																			0.0	0.0	0	2.1	5.6
22							2.1	5.6	547										2.1	5.6	547	2.1	5.6
23																			0.0	0.0	0	0.0	0.0
24																			0.0	0.0	0	0.0	0.0
25																			0.0	0.0	0	0.0	0.0
26																			0.0	0.0	0	0.0	0.0
27																			0.0	0.0	0	0.0	0.0
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	264.0	147.2	16,674	96.7	43.0	2,973	79.2	79.6	10,073	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	439.9	269.8	29,721		
%	0.60	0.55	0.56	0.22	0.16	0.10	0.18	0.29	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					

TPA = Trees per Acre

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

Shaded area = thinning pool

Bold outline = snag pool

Ecological Thinning Unit E4 - After 30% BA Thinning Applied to Target Species By DBH

Prescription **E4** **BA** **0.7** **Created Snags per Acre** **4**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%	**0.35**			**0.8**			**0.5**																
DBH range	**6-13**			**6-9**			**7-13**																
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	247.5	177.6
5																			0.0	0.0	0	247.5	177.6
6				22.6	4.4	226													22.6	4.4	226	247.5	177.6
7	22.7	5.6	359	17.0	4.5	340	10.6	2.6	212										50.2	12.7	911	224.9	173.2
8	10.1	3.7	405																10.1	3.7	405	174.6	160.5
9	8.3	3.7	332	14.0	5.5	0													22.3	9.2	332	164.5	156.8
10	10.1	5.5	539																10.1	5.5	539	142.2	147.6
11	17.7	11.0	1227	8.6	5.7	689	7.6	5.2	570										31.4	20.3	2,485	132.0	142.1
12	11.9	9.2	1139	8.9	6.4	621													19.6	14.6	1,760	100.6	121.8
13	2.0	1.8	236	6.9	6.4	695	2.9	2.7	288										11.3	10.4	1,219	81.1	107.1
14	15.0	16.0	2147				9.9	10.6	1439										24.9	26.6	3,586	69.8	96.7
15	8.5	10.4	1691	5.2	6.4	261													13.7	16.8	1,952	44.8	70.1
16	4.0	5.3	729				7.6	10.6	1443										11.6	15.9	2,172	31.2	53.3
17							6.7	10.6	1481										6.7	10.6	1,481	19.5	37.4
18							3.0	5.3	720										3.0	5.3	720	12.8	26.8
19							2.7	5.3	808										2.7	5.3	808	9.8	21.5
20							5.0	10.6	1497										5.0	10.6	1,497	7.1	16.2
21																			0.0	0.0	0	2.1	5.6
22							2.1	5.6	547										2.1	5.6	547	2.1	5.6
23																			0.0	0.0	0	0.0	0.0
24																			0.0	0.0	0	0.0	0.0
25																			0.0	0.0	0	0.0	0.0
26																			0.0	0.0	0	0.0	0.0
27																			0.0	0.0	0	0.0	0.0
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	110.3	72.2	8,804	83.3	39.4	2,832	58.1	69.1	9,004	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	247.5	177.6	20,640		
%	0.45	0.41	0.43	0.34	0.22	0.14	0.23	0.39	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.66	0.69		
																		sq.spacing	16.6				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Ecological Thinning Unit E5 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 24

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	298.3	310.7
5																			0.0	0.0	0	298.3	310.7
6																			0.0	0.0	0	298.3	310.7
7	15.1	4.3	301																15.1	4.3	301	298.3	310.7
8	33.6	12.1	1,008	12.5	4.2	251													46.1	16.3	1,259	283.3	306.4
9	18.2	7.9	540																18.2	7.9	540	237.1	290.1
10	14.4	7.9	864				7.3	4.0	291										21.7	11.8	1,156	218.9	282.3
11	18.3	11.8	1,272																18.3	11.8	1,272	197.3	270.4
12	37.0	28.0	3,049																37.0	28.0	3,049	179.0	258.6
13	4.4	4.1	441	4.7	4.4	237	4.8	4.1	525										13.9	12.5	1,202	142.0	230.6
14	15.7	16.2	2,154				7.4	7.9	1,115										23.1	24.1	3,270	128.0	218.1
15	10.0	12.0	1,626				13.6	16.2	1,940										23.7	28.2	3,566	104.9	194.0
16	5.7	7.9	1,136				6.0	8.1	1,082										11.7	16.1	2,219	81.2	165.8
17	13.3	20.2	2,733	6.1	9.6	975													19.4	29.9	3,708	69.5	149.7
18	2.3	4.1	690				7.1	12.0	1,435										9.4	16.1	2,125	50.1	119.9
19							10.3	20.1	2,651										10.3	20.1	2,651	40.7	103.8
20							7.7	16.5	2,022										7.7	16.5	2,022	30.4	83.7
21							7.1	16.9	2,078										7.1	16.9	2,078	22.7	67.2
22							3.1	8.1	1,057										3.1	8.1	1,057	15.6	50.3
23							4.4	12.2	1,831										4.4	12.2	1,831	12.5	42.2
24							1.4	4.3	583										1.4	4.3	583	8.1	29.9
25							2.4	8.2	1,383										2.4	8.2	1,383	6.8	25.7
26							1.2	4.2	868										1.2	4.2	868	4.3	17.5
27							2.2	8.7	1,452										2.2	8.7	1,452	3.2	13.3
28																			0.0	0.0	0	0.9	4.6
29																			0.0	0.0	0	0.9	4.6
30							0.9	4.6	746										0.9	4.6	746	0.9	4.6
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	188.0	136.4	15,815	23.4	18.2	1,462	86.9	156.1	21,060	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	298.3	310.7	38,337		
%	0.63	0.44	0.41	0.08	0.06	0.04	0.29	0.50	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					

TPA = Trees per Acre

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

Shaded area = thinning pool

Bold outline = snag pool

Ecological Thinning Unit E5 - After 30% BA Thinning Applied to Target Species By DBH

Prescription **E5** **BA** **0.7** **Created Snags per Acre** **4**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%		**0.35**						**0.4**															
DBH range		**6-14**						**9-18**															
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	164.7	214.4
5																			0.0	0.0	0	164.7	214.4
6																			0.0	0.0	0	164.7	214.4
7	5.3	1.5	105																5.3	1.5	105	164.7	214.4
8	11.8	4.2	353	12.5	4.2	251													24.3	8.4	604	159.5	212.9
9	6.4	2.8	189																6.4	2.8	189	135.2	204.5
10	5.0	2.8	303				2.9	1.6	117										8.0	4.3	419	128.8	201.7
11	6.4	4.1	445																6.4	4.1	445	120.8	197.4
12	13.0	9.8	1067																13.0	9.8	1,067	114.4	193.2
13	1.5	1.4	154	4.7	4.4	237	1.9	1.6	210										7.7	7.0	601	101.5	183.4
14	5.5	5.7	754				3.0	3.2	446										7.7	8.0	1,200	93.8	176.4
15	10.0	12.0	1626				5.5	6.5	776										14.1	16.8	2,402	86.1	168.4
16	5.7	7.9	1136				2.4	3.3	433										7.5	10.4	1,569	72.0	151.6
17	13.3	20.2	2733	6.1	9.6	975													19.4	29.9	3,708	64.6	141.3
18	2.3	4.1	690				2.8	4.8	574										4.4	7.6	1,264	45.1	111.4
19							10.3	20.1	2651										10.3	20.1	2,651	40.7	103.8
20							7.7	16.5	2022										7.7	16.5	2,022	30.4	83.7
21							7.1	16.9	2078										7.1	16.9	2,078	22.7	67.2
22							3.1	8.1	1057										3.1	8.1	1,057	15.6	50.3
23							4.4	12.2	1831										4.4	12.2	1,831	12.5	42.2
24							1.4	4.3	583										1.4	4.3	583	8.1	29.9
25							2.4	8.2	1383										2.4	8.2	1,383	6.8	25.7
26							1.2	4.2	868										1.2	4.2	868	4.3	17.5
27							2.2	8.7	1452										2.2	8.7	1,452	3.2	13.3
28																			0.0	0.0	0	0.9	4.6
29							0.0	0.0	0										0.0	0.0	0	0.9	4.6
30							0.9	4.6	746										0.9	4.6	746	0.9	4.6
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	86.2	76.5	9,556	23.4	18.2	1,462	59.2	124.7	17,227	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	164.7	214.4	28,245		
%	0.52	0.36	0.34	0.14	0.08	0.05	0.36	0.58	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.69	0.74		
																		sq.spacing	24.4				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Ecological Thinning Unit E6 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 71

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	471.0	344.5
5																			0.0	0.0	0	471.0	344.5
6	69.9	13.9	921																69.9	13.9	921	471.0	344.5
7	48.6	12.6	986													9.20	2.46	184	57.8	15.1	1,170	401.1	330.5
8	53.0	18.5	1,985	7.9	2.8	238				6.58	2.30	197							67.6	23.6	2,421	343.3	315.4
9	26.2	11.4	947							5.31	2.35	213							31.6	13.8	1,159	275.8	291.8
10	35.6	18.4	2,067				4.1	2.2	247										39.7	20.7	2,314	244.2	278.0
11	36.5	23.2	2,761				7.3	4.6	544										43.8	27.8	3,305	204.5	257.4
12	15.3	11.4	1,433				3.1	2.4	214							3.20	2.52	224	21.5	16.3	1,871	160.7	229.6
13	22.9	20.6	2,493	3.0	2.8	271													25.9	23.3	2,764	139.2	213.3
14	30.9	32.1	3,925				4.3	4.6	666										35.2	36.6	4,590	113.2	190.0
15	11.4	13.6	1,961				1.9	2.3	262										13.2	15.9	2,223	78.1	153.3
16	6.6	9.2	1,215	2.3	3.1	117	3.4	4.6	645										12.3	16.8	1,977	64.8	137.4
17	10.4	16.1	2,088				1.5	2.4	351										11.9	18.5	2,438	52.5	120.6
18	1.3	2.3	260				2.6	4.5	655										3.9	6.8	915	40.6	102.1
19	2.5	4.7	564				2.4	4.6	597										4.8	9.3	1,160	36.7	95.2
20	5.3	11.3	1,713				4.2	9.1	1,303										9.6	20.4	3,017	31.9	85.9
21	2.0	4.8	683				5.0	11.8	1,686										7.0	16.6	2,369	22.3	65.5
22	1.8	4.6	793				3.5	9.1	1,627										5.3	13.8	2,421	15.4	49.0
23							2.5	7.3	1,241										2.5	7.3	1,241	10.1	35.2
24	0.7	2.3	402				0.7	2.3	475										1.5	4.6	877	7.6	27.9
25							1.3	4.6	840										1.3	4.6	840	6.1	23.3
26							2.6	9.5	1,724										2.6	9.5	1,724	4.8	18.8
27							0.6	2.2	574										0.6	2.2	574	2.2	9.2
28							1.1	4.6	857										1.1	4.6	857	1.6	7.0
29	0.5	2.3	415																0.5	2.3	415	0.5	2.3
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	381.3	233.3	27,612	13.3	8.6	626	52.1	92.9	14,510	11.9	4.6	410	0.0	0.0	0	12.4	5.0	408	471.0	344.5	43,566		
%	0.81	0.68	0.63	0.03	0.02	0.01	0.11	0.27	0.33	0.03	0.01	0.01	0.00	0.00	0.00	0.03	0.01	0.01					

TPA = Trees per Acre

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

Shaded area = thinning pool

Bold outline = snag pool

Ecological Thinning Unit E6- After 35% BA Thinning Applied to Target Species By DBH

Prescription **E6** **BA** **0.65** **Created Snags per Acre** **4**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%	**0.35**						**0.7**																
DBH range	**6-16**						**10-16**																
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	228.2	213.8
5																			0.0	0.0	0	228.2	213.8
6	24.5	4.9	322	0.0	0.0	0													24.5	4.9	322	228.2	213.8
7	17.0	4.4	345	0.0	0.0	0										9.2	2.5	184	26.2	6.9	529	203.7	209.0
8	18.6	6.5	695	7.9	2.8	238				6.6	2.3	197							33.1	11.6	1,130	177.5	202.1
9	9.2	4.0	331							5.3	2.3	213							14.5	6.3	544	144.4	190.5
10	12.5	6.5	724				2.9	1.6	173										15.3	8.0	896	129.9	184.2
11	12.8	8.1	966				5.1	3.2	381										17.9	11.3	1,347	114.6	176.2
12	5.3	4.0	502				2.1	1.7	150							3.2	2.5	224	10.7	8.2	876	96.7	164.8
13	8.0	7.2	873	3.0	2.8	271													11.0	10.0	1,143	86.0	156.7
14	10.8	11.2	1374				3.0	3.2	466										11.7	12.2	1,840	75.0	146.7
15	4.0	4.8	686				1.3	1.6	183										4.5	5.4	870	63.3	134.5
16	2.3	3.2	425	2.3	3.1	117	2.4	3.2	452										6.3	8.5	994	58.8	129.1
17	10.4	16.1	2088				1.5	2.4	351										11.9	18.5	2,438	52.5	120.6
18	1.3	2.3	260				2.6	4.5	655										3.9	6.8	915	40.6	102.1
19	2.5	4.7	564				2.4	4.6	597										4.8	9.3	1,160	36.7	95.2
20	5.3	11.3	1713				4.2	9.1	1303										9.6	20.4	3,017	31.9	85.9
21	2.0	4.8	683				5.0	11.8	1686										7.0	16.6	2,369	22.3	65.5
22	1.8	4.6	793				3.5	9.1	1627										5.3	13.8	2,421	15.4	49.0
23							2.5	7.3	1241										2.5	7.3	1,241	10.1	35.2
24	0.7	2.3	402				0.7	2.3	475										1.5	4.6	877	7.6	27.9
25							1.3	4.6	840										1.3	4.6	840	6.1	23.3
26							2.6	9.5	1724										2.6	9.5	1,724	4.8	18.8
27							0.6	2.2	574										0.6	2.2	574	2.2	9.2
28							1.1	4.6	857										1.1	4.6	857	1.6	7.0
29	0.5	2.3	415																0.5	2.3	415	0.5	2.3
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	149.4	113.1	14,160	13.3	8.6	626	44.9	86.7	13,736	11.9	4.6	410	0.0	0.0	0	12.4	5.0	408	228.2	213.8	29,341		
%	0.65	0.53	0.48	0.06	0.04	0.02	0.20	0.41	0.47	0.05	0.02	0.01	0.00	0.00	0.00	0.05	0.02	0.01	0.48	0.62	0.67		
																		sq.spacing	17.5				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Ecological Thinning Unit E7 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 19

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	428.0	183.2
5																			0.0	0.0	0	428.0	183.2
6	53.4	10.7	687				16.2	3.6	323.791										69.6	14.3	1,011	428.0	183.2
7	88.4	22.4	1,972	16.4	4.4	327.502													104.8	26.7	2,299	358.4	168.9
8	44.3	14.2	1,330				21.7	8.1	537.012										66.0	22.3	1,867	253.7	142.2
9	24.2	10.7	806				33.8	15.3	1170.95										58.0	26.0	1,977	187.6	119.9
10	19.4	10.6	908				34.7	17.8	1,316										54.1	28.4	2,223	129.6	93.9
11	16.0	10.5	957				6.5	4.3	259										22.4	14.8	1,216	75.5	65.5
12	4.8	3.5	384	6.4	4.6	191.468	4.7	3.7	188										15.9	11.8	763	53.1	50.7
13				5.0	4.3	250	17.4	15.1	1012.7										22.4	19.4	1,263	37.2	39.0
14																			0.0	0.0	0	14.8	19.6
15							6.0	7.1	681										6.0	7.1	681	14.8	19.6
16	2.5	3.5	355	3.3	4.4	200													5.9	7.9	555	8.8	12.5
17				2.9	4.6	234													2.9	4.6	234	2.9	4.6
18																			0.0	0.0	0	0.0	0.0
19																			0.0	0.0	0	0.0	0.0
20																			0.0	0.0	0	0.0	0.0
21																			0.0	0.0	0	0.0	0.0
22																			0.0	0.0	0	0.0	0.0
23																			0.0	0.0	0	0.0	0.0
24																			0.0	0.0	0	0.0	0.0
25																			0.0	0.0	0	0.0	0.0
26																			0.0	0.0	0	0.0	0.0
27																			0.0	0.0	0	0.0	0.0
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	253.1	86.1	7,398	34.0	22.2	1,203	140.9	74.9	5,488	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	428.0	183.2	14,090		
%	0.59	0.47	0.53	0.08	0.12	0.09	0.33	0.41	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					

TPA = Trees per Acre

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor) Shaded area = thinning pool

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor) Bold outline = snag pool

Ecological Thinning Unit E7- After Thinning in Gaps Applied to Target Species By DBH

Prescription **E7** **BA** **0.85** **Created Snags per Acre** **4**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%		**0.85**						**0.85**															
DBH range		**6-16**						**6-16**															
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	365.0	156.6
5																			0.0	0.0	0	365.0	156.6
6	45.4	9.1	584				13.8	3.1	275										59.1	12.2	859	365.0	156.6
7	75.1	19.0	1676	16.4	4.4	328													91.5	23.4	2,004	305.8	144.4
8	37.7	12.1	1131				18.4	6.8	456										56.1	18.9	1,587	214.3	121.0
9	20.6	9.1	685				28.7	13.0	995										49.3	22.1	1,680	158.2	102.1
10	16.5	9.0	771				29.5	15.1	1118										43.9	23.0	1,890	108.9	80.0
11	13.6	9.0	814				5.5	3.6	220										18.2	12.0	1,034	64.9	57.0
12	4.1	2.9	326	6.4	4.6	191	4.0	3.1	160										14.1	10.4	678	46.7	45.0
13				5.0	4.3	250	14.8	12.9	861										19.2	16.5	1,111	32.6	34.5
14																			0.0	0.0	0	13.5	18.0
15							5.1	6.0	579										5.1	6.0	579	13.5	18.0
16	2.2	3.0	301	3.3	4.4	200													5.5	7.4	502	8.4	12.0
17				2.9	4.6	234													2.9	4.6	234	2.9	4.6
18																			0.0	0.0	0	0.0	0.0
19																			0.0	0.0	0	0.0	0.0
20																			0.0	0.0	0	0.0	0.0
21																			0.0	0.0	0	0.0	0.0
22																			0.0	0.0	0	0.0	0.0
23																			0.0	0.0	0	0.0	0.0
24																			0.0	0.0	0	0.0	0.0
25																			0.0	0.0	0	0.0	0.0
26																			0.0	0.0	0	0.0	0.0
27																			0.0	0.0	0	0.0	0.0
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	215.1	73.2	6,288	34.0	22.2	1,203	119.8	63.7	4,665	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	365.0	156.6	12,157		
%	0.59	0.47	0.52	0.09	0.14	0.10	0.33	0.41	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.85	0.86		

Appendix II: Ecological Thinning Unit E8 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 12

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	370.8	313.4
5																			0.0	0.0	0	370.8	313.4
6																			0.0	0.0	0	370.8	313.4
7																			0.0	0.0	0	370.8	313.4
8	62.6	20.4	1,541																62.6	20.4	1,541	370.8	313.4
9	25.6	10.1	769																25.6	10.1	769	308.2	293.0
10	62.1	30.5	2,267				18.5	10.1	1,111										80.6	40.6	3,379	282.5	282.9
11	34.0	20.4	2,039																34.0	20.4	2,039	202.0	242.2
12	13.2	10.3	921																13.2	10.3	921	168.0	221.8
13	46.0	41.6	5,514																46.0	41.6	5,514	154.8	211.5
14				11.1	11.1	780													11.1	11.1	780	108.8	169.9
15	16.8	20.7	3,199																16.8	20.7	3,199	97.7	158.8
16	15.5	20.9	2,938	7.7	11.1	1,006	7.6	10.3	1,442										30.8	42.3	5,386	80.9	138.2
17	13.7	20.9	2,937				6.9	10.8	1,510										20.5	31.7	4,446	50.1	95.9
18	6.0	10.6	1,435				6.0	10.6	1,794										12.0	21.1	3,230	29.5	64.2
19							5.7	10.6	2,038										5.7	10.6	2,038	17.6	43.0
20							4.8	10.6	1,889										4.8	10.6	1,889	11.9	32.5
21																			0.0	0.0	0	7.1	21.9
22							4.3	10.8	1,974										4.3	10.8	1,974	7.1	21.9
23																			0.0	0.0	0	2.8	11.1
24																			0.0	0.0	0	2.8	11.1
25																			0.0	0.0	0	2.8	11.1
26																			0.0	0.0	0	2.8	11.1
27							2.8	11.1	1,782										2.8	11.1	1,782	2.8	11.1
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	295.4	206.4	23,560	18.9	22.1	1,785	56.5	84.8	13,540	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	370.8	313.4	38,886		
%	0.80	0.66	0.61	0.05	0.07	0.05	0.15	0.27	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					

TPA = Trees per Acre

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor) Shaded area = thinning pool

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor) Bold outline = snag pool

Ecological Thinning Unit E8- After 25% BA Thinning Applied to Target Species By DBH

Prescription E8 BA 0.75 Created Snags per Acre 4

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%		**0.55**						**0.55**															
DBH range		**8-15**						**10**															
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	241.4	234.1
5																			0.0	0.0	0	241.4	234.1
6																			0.0	0.0	0	241.4	234.1
7																			0.0	0.0	0	241.4	234.1
8	34.4	11.2	848																34.4	11.2	848	241.4	234.1
9	14.1	5.6	423																14.1	5.6	423	206.9	222.9
10	34.1	16.8	1247				10.2	5.6	611										44.3	22.4	1,858	192.8	217.4
11	18.7	11.2	1121																18.7	11.2	1,121	148.5	195.0
12	7.2	5.7	506																7.2	5.7	506	129.8	183.8
13	25.3	22.9	3033																25.3	22.9	3,033	122.6	178.1
14				11.1	11.1	780													11.1	11.1	780	97.3	155.2
15	9.3	11.4	1759																7.8	9.5	1,759	86.2	144.1
16	15.5	20.9	2938	7.7	11.1	1006	7.6	10.3	1442										28.3	39.0	5,386	78.4	134.6
17	13.7	20.9	2937				6.9	10.3	1442										20.5	31.2	4,378	50.1	95.6
18	6.0	10.6	1435				6.0	10.8	1510										12.0	21.4	2,945	29.5	64.4
19							5.7	10.6	2038										5.7	10.6	2,038	17.6	43.0
20							4.8	10.6	2038										4.8	10.6	2,038	11.9	32.5
21																			0.0	0.0	0	7.1	21.9
22							4.3	10.8	1974										4.3	10.8	1,974	7.1	21.9
23																			0.0	0.0	0	2.8	11.1
24																			0.0	0.0	0	2.8	11.1
25																			0.0	0.0	0	2.8	11.1
26																			0.0	0.0	0	2.8	11.1
27							2.8	11.1	1782										2.8	11.1	1,782	2.8	11.1
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	178.3	137.1	16,248	18.9	22.1	1,785	48.2	80.1	12,837	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	241.4	234.1	30,870		
%	0.74	0.59	0.53	0.08	0.09	0.06	0.20	0.34	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.75	0.79		
																		sq.spacing	16.9				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Ecological Thinning Unit E9 - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 36

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	374.2	268.1
5																			0.0	0.0	0	374.2	268.1
6	13.6	2.8		9.7	2.1														23.3	4.9	0	374.2	268.1
7	49.7	12.8	1,231				8.9	2.0											58.6	14.9	1,231	351.0	263.2
8	52.4	18.4	1,564																52.4	18.4	1,564	292.4	248.3
9	30.7	12.3	1,069																30.7	12.3	1,069	239.9	229.8
10	32.3	16.1	1,400				14.8	7.6	779										47.1	23.8	2,180	209.3	217.5
11	19.5	12.3	1,097				10.1	6.1	467										29.6	18.3	1,564	162.2	193.8
12	22.5	16.8	1,935				7.6	5.8	580										30.1	22.7	2,515	132.6	175.4
13	9.2	8.1	1,006	4.8	4.3	241	4.6	4.0	338										18.6	16.4	1,585	102.5	152.8
14	5.7	5.6	784				6.9	7.3	906										12.6	13.0	1,690	84.0	136.4
15	8.4	10.1	1,121				5.0	6.2	768										13.4	16.3	1,889	71.4	123.4
16	6.1	8.1	1,180				4.6	6.3	812										10.7	14.4	1,992	58.0	107.1
17	2.7	4.1	537				9.2	14.3	1,931	1.4	2.0	245							13.3	20.4	2,712	47.3	92.7
18	4.8	8.6	1,124	1.3	2.2	185	7.1	12.4	1,611										13.2	23.1	2,920	34.1	72.3
19	2.1	4.0	544	1.3	2.5	127	6.7	12.7	1,692										10.1	19.2	2,363	20.9	49.2
20	0.8	1.7	218				2.0	4.3	685										2.8	6.0	903	10.8	29.9
21							1.8	4.2	621										1.8	4.2	621	8.0	23.9
22							2.6	6.9	746										2.6	6.9	746	6.3	19.7
23							0.7	1.9	314										0.7	1.9	314	3.6	12.8
24							0.7	2.2	323										0.7	2.2	323	3.0	10.9
25							1.3	4.3	545										1.3	4.3	545	2.3	8.8
26																			0.0	0.0	0	1.0	4.5
27																			0.0	0.0	0	1.0	4.5
28							0.5	2.2	420										0.5	2.2	420	1.0	4.5
29																			0.0	0.0	0	0.5	2.3
30							0.5	2.3	284										0.5	2.3	284	0.5	2.3
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	260.3	142.0	14,809	17.1	11.1	553	95.5	113.0	13,823	1.4	2.0	245	0.0	0.0	0	0.0	0.0	0	374.2	268.1	29,430		
%	0.70	0.53	0.50	0.05	0.04	0.02	0.26	0.42	0.47	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00					

TPA = Trees per Acre

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor) Shaded area = thinning pool

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor) Bold outline = snag pool

Ecological Thinning Unit E9- After 30% BA Thinning Applied to Target Species By DBH

Prescription **E9** **BA** **0.7** **Created Snags per Acre** **4**

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning and Snag Creation			Cumulative Summary (by largest diameter)	
leave%		**0.35**						**0.6**															
DBH range		**9-16**						**10-16**															
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	271.9	194.5
5																			0.0	0.0	0	271.9	194.5
6	13.6	2.8	0	9.7	2.1	0													23.3	4.9	0	271.9	194.5
7	49.7	12.8	1231				8.9	2.0	0										58.6	14.9	1,231	248.7	189.5
8	52.4	18.4	1564																52.4	18.4	1,564	190.1	174.7
9	10.7	4.3	374																10.7	4.3	374	137.7	156.2
10	11.3	5.6	490				14.8	7.6	779										26.1	13.3	1,269	126.9	151.9
11	6.8	4.3	384				6.0	3.6	280										12.9	7.9	664	100.8	138.6
12	7.9	5.9	677				4.6	3.5	348										12.4	9.4	1,025	88.0	130.7
13	3.2	2.8	352	4.8	4.3	241	2.7	2.4	203										10.8	9.5	796	75.5	121.3
14	2.0	2.0	274				6.9	7.3	906										8.9	9.3	1,180	64.8	111.8
15	2.9	3.6	392				3.0	3.7	461										5.4	6.6	853	55.9	102.5
16	2.1	2.8	413				4.6	6.3	812										6.1	8.3	1,225	50.5	95.9
17	2.7	4.1	537				9.2	14.3	1931	1.4	2.0	245							12.2	18.7	2,712	44.4	87.6
18	4.8	8.6	1124	1.3	2.2	185	7.1	12.4	1611										12.1	21.2	2,920	32.2	68.9
19	2.1	4.0	544	1.3	2.5	127	6.7	12.7	1692										9.3	17.7	2,363	20.1	47.7
20	0.8	1.7	218				2.0	4.3	685										2.8	6.0	903	10.8	29.9
21							1.8	4.2	621										1.8	4.2	621	8.0	23.9
22							2.6	6.9	746										2.6	6.9	746	6.3	19.7
23							0.7	1.9	314										0.7	1.9	314	3.6	12.8
24							0.7	2.2	323										0.7	2.2	323	3.0	10.9
25							1.3	4.3	545										1.3	4.3	545	2.3	8.8
26							0.0	0.0	0										0.0	0.0	0	1.0	4.5
27							0.0	0.0	0										0.0	0.0	0	1.0	4.5
28							0.5	2.2	420										0.5	2.2	420	1.0	4.5
29							0.0	0.0	0										0.0	0.0	0	0.5	2.3
30							0.5	2.3	284										0.5	2.3	284	0.5	2.3
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	173.0	83.8	8,575	17.1	11.1	553	84.6	104.2	12,961	1.4	2.0	245	0.0	0.0	0	0.0	0.0	0	271.9	194.5	22,334		
%	0.64	0.43	0.38	0.06	0.06	0.02	0.31	0.54	0.58	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.73	0.76		
																		sq.spacing	12.7				

sq. spacing = average spacing of only those trees within thinning pool; all trees not in thinning pool are not included in this spacing

Appendix II: Restoration Thinning Unit RT - Before Thin

SN/RFG, Appendix_II_012605.xls, 01/26/2005

Tree Data by species Acres = 14

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	392.3	169.1
5																			0.0	0.0	0	392.3	169.1
6	67.9	12.9	832				25.1	4.4											93.0	17.4	832	392.3	169.1
7	51.1	13.1	997																51.1	13.1	997	299.3	151.8
8	12.2	4.2	365	13.0	4.5	391	39.3	13.1	1179.04										64.5	21.9	1,934	248.2	138.6
9	10.5	4.1	316				31.8	14.0	1053.38										42.3	18.2	1,369	183.7	116.7
10	24.0	12.6	960	11.8	5.8	354.64	16.8	8.7	671										52.6	27.1	1,985	141.4	98.5
11	6.4	4.2	514	8.5	5.1	255.572	15.6	9.4	623										30.5	18.7	1,393	88.8	71.4
12							17.2	13.1	1,086										17.2	13.1	1,086	58.3	52.7
13							15.2	12.9	963.079										15.2	12.9	963	41.1	39.5
14				12.6	13.0	376.842	13.4	13.6	1,136										26.0	26.6	1,513	26.0	26.6
15																			0.0	0.0	0	0.0	0.0
16																			0.0	0.0	0	0.0	0.0
17																			0.0	0.0	0	0.0	0.0
18																			0.0	0.0	0	0.0	0.0
19																			0.0	0.0	0	0.0	0.0
20																			0.0	0.0	0	0.0	0.0
21																			0.0	0.0	0	0.0	0.0
22																			0.0	0.0	0	0.0	0.0
23																			0.0	0.0	0	0.0	0.0
24																			0.0	0.0	0	0.0	0.0
25																			0.0	0.0	0	0.0	0.0
26																			0.0	0.0	0	0.0	0.0
27																			0.0	0.0	0	0.0	0.0
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	172.1	51.3	3,984	45.9	28.5	1,378	174.2	89.3	6,712	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	392.3	169.1	12,073		
%	0.44	0.30	0.33	0.12	0.17	0.11	0.44	0.53	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					

TPA = Trees per Acre Shaded area = thinning pool

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

BA = Basal Area/acre in square feet (surrogate for light reaching forest floor)

Restoration Thinning Unit RT - After 30% BA Thinning Applied to Target Species By DBH

Prescription RT BA 0.7

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Noble Fir			Red Alder			Total Live after Thinning			Cumulative Summary (by largest diameter)	
leave%		**0.35**	**0.5**						**0.4**														
DBH range		**<=7"**	**8"**						**9-10**														
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4																			0.0	0.0	0	183.8	111.6
5																			0.0	0.0	0	183.8	111.6
6	0.0	0.0	0				0.0	0.0	0										0.0	0.0	0	183.8	111.6
7	0.0	0.0	0				0.0	0.0	0										0.0	0.0	0	183.8	111.6
8	6.1	2.1	182	13.0	4.5	391	0.0	0.0	0										19.1	6.7	573	183.8	111.6
9	10.5	4.1	316				12.7	5.6	421										23.2	9.8	737	164.7	104.9
10	24.0	12.6	960	11.8	5.8	355	16.8	8.7	671										52.6	26.0	1,985	141.4	95.2
11	6.4	4.2	514	8.5	5.1	256	15.6	9.4	623										30.5	18.0	1,393	88.8	69.2
12							17.2	13.1	1086										17.2	12.4	1,086	58.3	51.2
13							15.2	12.9	963										15.2	12.2	963	41.1	38.8
14				12.6	13.0	377	13.4	13.6	1136										26.0	26.6	1,513	26.0	26.6
15																			0.0	0.0	0	0.0	0.0
16																			0.0	0.0	0	0.0	0.0
17																			0.0	0.0	0	0.0	0.0
18																			0.0	0.0	0	0.0	0.0
19																			0.0	0.0	0	0.0	0.0
20																			0.0	0.0	0	0.0	0.0
21																			0.0	0.0	0	0.0	0.0
22																			0.0	0.0	0	0.0	0.0
23																			0.0	0.0	0	0.0	0.0
24																			0.0	0.0	0	0.0	0.0
25																			0.0	0.0	0	0.0	0.0
26																			0.0	0.0	0	0.0	0.0
27																			0.0	0.0	0	0.0	0.0
28																			0.0	0.0	0	0.0	0.0
29																			0.0	0.0	0	0.0	0.0
30																			0.0	0.0	0	0.0	0.0
31																			0.0	0.0	0	0.0	0.0
32																			0.0	0.0	0	0.0	0.0
33																			0.0	0.0	0	0.0	0.0
Total	47.0	23.1	1,972	45.9	28.5	1,378	90.8	63.3	4,901	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	183.8	111.6	8,250		
%	0.26	0.21	0.24	0.25	0.26	0.17	0.49	0.57	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.66	0.68		
																	sq.spacing		15.4				

Reserve Unit L2

Tree Data by species Acres = 26

SN/RFG, Appendix_II_012605.xls, 01/26/2005

	Western Hemlock			Western Redcedar			Douglas Fir			Pacific Silver Fir			Total Live			Cumulative Summary (by largest diameter)	
dbh	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA	BF	TPA	BA
4													0.0	0.0	0	430.5	201.2
5													0.0	0.0	0	430.5	201.2
6	46.94	9.52	624	18.99	3.48		15.13	3.17					81.1	16.2	624	430.5	201.2
7	84.88	22.00	1,949	27.20	7.32	245							112.1	29.3	2,194	349.4	185.0
8	28.92	9.09	966	12.54	3.85		8.45	3.10	169	8.88	3.10	266	58.8	19.1	1,402	237.3	155.7
9	13.27	5.86	531	8.43	3.32	253	14.55	6.06	505	6.71	2.96	268	43.0	18.2	1,557	178.5	136.6
10	22.53	12.13	1,006	13.25	7.23	465	6.30	3.10	252				42.1	22.5	1,722	135.6	118.4
11	10.18	6.72	591	11.09	7.32	333	4.59	3.03	276				25.9	17.1	1,199	93.5	95.9
12	3.86	3.03	232				9.42	7.12	377				13.3	10.1	608	67.6	78.9
13	3.22	2.96	354				3.29	3.03	132				6.5	6.0	485	54.4	68.7
14	14.12	15.09	1,945	3.97	3.95	238							18.1	19.0	2,183	47.9	62.7
15	4.88	5.99	780				7.35	9.03	883				12.2	15.0	1,663	29.8	43.7
16	2.75	3.61	385							2.17	3.03	412	4.9	6.6	798	17.5	28.7
17	1.92	3.03	404				7.90	12.26	1,659				9.8	15.3	2,063	12.6	22.0
18													0.0	0.0	0	2.8	6.7
19													0.0	0.0	0	2.8	6.7
20							1.39	3.03	320				1.4	3.0	320	2.8	6.7
21													0.0	0.0	0	1.4	3.7
22							1.40	3.69	475				1.4	3.7	475	1.4	3.7
23													0.0	0.0	0	0.0	0.0
24													0.0	0.0	0	0.0	0.0
25													0.0	0.0	0	0.0	0.0
26													0.0	0.0	0	0.0	0.0
27													0.0	0.0	0	0.0	0.0
28													0.0	0.0	0	0.0	0.0
29													0.0	0.0	0	0.0	0.0
30													0.0	0.0	0	0.0	0.0
31													0.0	0.0	0	0.0	0.0
32													0.0	0.0	0	0.0	0.0
33													0.0	0.0	0	0.0	0.0
Total	237.5	99.0	9,766	95.5	36.5	1,534	79.8	56.6	5,046	17.8	9.1	947	430.5	201.2	17,293		

Appendix III. List of wildlife species potentially occurring on the 700 Road Forest Habitat Restoration Project Area, currently and in the future. Asterisks denote CRW-HCP species of concern.

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic													
Group	**Common Name**	**Scientific Name**	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	**other**
Invertebrates (incomplete list)																						
Insects	Carabid Beetle*	*Omus dejeanii*		X	X	X	X	X	X	X												
	Johnson's (Mistletoe) Hairstreak*	*Mitoura johnsoni*				X	X	X										X				
Mollusks	Blue-gray Taildropper*	*Prophysaon coeruleum*					X	X					X									moist
	Oregon Megomphix*	*Megomphix hemphilla*					X	X					X									
	Papillose Taildropper*	*Prophysaon dubium*					X	X		X			X								X	moist
	Puget Oregonian*	*Cryptomastix devia*		X			X	X		X			X								X	moist
Amphibians (8 species)																						
Salamanders	Northwestern Salamander*	*Ambystoma gracile*		X	X	X	X	X	X	X	X		X							X	X	
	Long-toed Salamander*	*Ambystoma macrodactylum*	X	X	X	X	X	X	X	X	X		X							X	X	
	Ensatina	*Ensatina eschscholtzii*	X	X	X	X	X	X					X	X								
	Western Redback Salamander*	*Plethodon vehiculum*	X	X	X	X	X	X					X								X	<3600'
	Roughskin Newt*	*Taricha granulosa*	X	X	X	X	X	X	X	X	X		X						X	X		
Frogs/Toads	Western Toad*	*Bufo boreas*	X	X	X	X	X	X	X	X	X		X									moist
	Pacific Treefrog	*Pseudacris regilla*	X	X	X	X	X	X	X	X	X											
	Northern Red-legged Frog*	*Rana aurora aurora*		X	X	X	X	X	X	X	X		X									
Reptiles (4 species)																						
Snakes	Rubber Boa	*Charina bottae*	X	X	X	X	X	X		X			X								X	burrows
	Western Terrestrial Garter Snake	*Thamnophis elegans*	X	X	X	X	X	X	X	X	X											burrows
	Northwestern Garter Snake	*Thamnophis ordinoides*	X	X	X	X	X	X														burrows
	Common Garter Snake	*Thamnophis sirtalis*	X	X	X	X	X	X	X	X	X								X			burrows
Birds (50 species)																						
Alcids	Marbled Murrelet*	*Brachyrhamphus marmoratus*					X	X									X	X				moss
Vultures	Turkey Vulture	*Cathartes aura*				X	X	X					X	X	X	X					X	cliffs, caves
Hawks	Sharp-shinned Hawk	*Accipiter striatus*			X	X	X			X		X								X		
	Cooper's Hawk	*Accipiter cooperii*		X	X	X	X	X		X		X								X		
	Northern Goshawk*	*Accipiter gentilis*		X	X		X	X		X			X	X				X	X	X		tree deformities
	Red-tailed Hawk	*Buteo jamaicensis*	X	X	X	X	X	X						X				X	X	X	X	cliffs
Falcons	American Kestrel	*Falco sparverius*	X		X	X	X	X						X	X					X	X	
Grouse/Quail	Blue Grouse	*Dendragapus obscurus*	X				X	X	X	X			X					X	X		X	springs
	Ruffed Grouse	*Bonasa umbellus*	X		X	X			X	X			X						X		X	springs
Owls	Western Screech Owl	*Otus kennicottii*		X	X	X	X	X		X				X	X							
	Great Horned Owl	*Bubo virginianus*	X	X	X	X	X	X						X	X	X		X		X	X	caves, cliffs
	Northern Pygmy Owl	*Glaucidium gnoma*		X	X	X	X	X						X	X							

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic													
Group	Common Name	Scientific Name	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	other
	Northern Spotted Owl*	*Strix occidentalis caurina*					X	X				X	X	X	X	X	X	X				flying squirrels
	Barred Owl	*Strix varia*				X	X	X	X	X				X	X	X		X				
	Northern Saw-whet Owl	*Aegolius acadicus*				X	X	X		X				X	X							
Swifts	Vaux's Swift*	*Chaetura vauxi*					X	X				X		X	X	X						insects
Woodpeckers	Red-breasted Sapsucker	*Sphyrapicus ruber*		X	X	X	X	X				X		X	X							
	Downy Woodpecker	*Picoides pubescens*		X	X	X	X	X				X		X	X							
	Hairy Woodpecker	*Picoides villosus*		X	X	X	X	X				X		X	X							
	Northern Flicker	*Colaptes auratus*		X	X	X	X	X						X	X	X				X		
	Pileated Woodpecker*	*Dryocopus pileatus*	X	X	X	X	X	X				X	X	X	X	X						insects
Flycatchers	Olive-sided Flycatcher*	*Contopus cooperi*	X	X	X	X	X	X		X		X		X						X		emergent trees
	Pacific-slope Flycatcher	*Empidonax difficilis*				X	X	X	X			X		X								
Corvids	Gray Jay	*Perisoreus canadensis*	X	X	X	X	X	X														
	Steller's Jay	*Cyanocitta stelleri*		X	X	X	X	X														
	American Crow	*Corvus brachyrhynchos*	X	X	X	X	X	X		X										X		
	Common Raven	*Corvus corax*					X	X													X	cliffs, caves
Tits/	Black-capped Chickadee	*Poecile atricapillus*	X	X	X	X	X	X				X	X	X	X				X	X		
Nuthatches/	Chestnut-backed Chickadee	*Poecile rufescens*		X	X	X	X	X				X		X	X							
Creepers	Mountain Chickadee	*Poecile gambeli*	X	X	X	X	X	X				X		X	X				X	X		
	Red-breasted Nuthatch	*Sitta canadensis*		X	X	X	X	X				X		X	X							bark
	Brown Creeper*	*Certhia americana*	X	X	X		X	X				X		X	X							moist, bark
Wrens	Winter Wren	*Troglodytes troglodytes*		X	X		X	X					X		X				X			moss, bark
Kinglets/	Golden-crowned Kinglet	*Regulus satrapa*		X	X		X	X				X										lichens
Thrushes	Townsend's Solitaire	*Myadestes townsendi*	X	X	X	X	X	X					X									
	Swainson's Thrush	*Catharus ustulatus*		X	X		X	X				X							X			moist conditions
	American Robin	*Turdus migratorius*	X	X	X	X	X	X												X		
	Hermit Thrush	*Catharus guttatus*	X	X	X		X	X											X			
	Varied Thrush	*Ixoreus naevius*		X	X	X	X	X											X			litter
Vireos	Cassins Vireo	*Vireo cassinii*		X	X			X				X										oak
	Warbling Vireo	*Vireo gilvus*		X	X			X		X		X							X	X	X	
	Red-eyed Vireo	*Vireo olivaceus*		X	X			X	X			X										
	Hutton's Vireo	*Vireo huttoni*		X	X			X		X		X							X	X		
Warblers	Townsend's Warbler	*Dendroica townsendi*		X	X	X	X	X				X										
Tanagers	Western Tanager	*Piranga ludoviciana*		X	X	X	X	X				X								X		
Sparrows	Dark-eyed Junco	*Junco hyemalis*	X	X	X		X	X					X						X	X		
Finches	Pine Siskin	*Carduelis pinus*		X	X	X	X	X				X							X			
	Purple Finch	*Carpodacus purpureus*	X	X	X		X	X				X							X			flowers

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic													
Group	Common Name	Scientific Name	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	other
	Red Crossbill	*Loxia curvirostra*					X	X				X							X			
	Evening Grosbeak	*Coccothraustes vespertinus*			X	X	X	X				X										
Mammals (42 species)																						
Bats	Big Brown Bat*	*Eptesicus fuscus*	X		X		X	X	X	X	X			X	X	X				X	X	bark, caves
	Silver-haired Bat*	*Lasionycteris noctivagans*					X	X	X	X	X			X	X	X					X	bark, caves
	Hoary Bat*	*Lasiurus cinereus*	X	X	X		X	X	X	X	X	X		X					X	X		caves
	Townsend's Big-eared Bat*	*Plecotus townsendii*	X				X	X	X	X	X	X				X				X		caves
	California Myotis*	*Myotis californicus*		X			X	X			X			X	X	X					X	bark, caves
	Long-eared Myotis*	*Myotis evotis*		X	X		X	X			X			X					X		X	bark, caves
	Keen's Myotis*	*Myotis keenii*					X	X			X			X	X	X				X	X	caves
	Little Brown Myotis*	*Myotis lucifugus*					X	X			X			X	X	X				X	X	bark, caves
	Fringed Myotis*	*Myotis thysanodes*	X				X	X			X			X	X	X				X	X	bark, caves
	Yuma Myotis*	*Myotis yumanensis*	X	X	X		X	X		X	X			X	X	X				X	X	bark, caves
	Long-legged Myotis*	*Myotis volans*	X	X	X		X	X			X			X	X	X				X	X	bark, caves
Shrews	Masked Shrew*	*Sorex cinereus*		X	X	X	X	X		X			X						X			moist, litter, burrows
	Montane Shrew	*Sorex monticolus*	X	X	X	X	X	X		X			X						X			litter, fungi, burrows
	Vagrant Shrew	*Sorex vagrans*	X	X	X	X	X	X	X	X									X			litter
	Trowbridge's Shrew	*Sorex trowbridgii*		X	X	X	X	X					X									fungi, burrows, litter
Moles	Shrew-mole	*Neurotrichus gibsii*	X	X	X	X	X	X	X				X									litter, burrows
	Coast Mole	*Scapanus orarius*	X				X	X					X						X			litter, burrows
Rats/Mice	Bushy-tailed Woodrat	*Neotoma cinerea*	X				X	X					X	X	X	X		X	X		X	fungi, caves, cliffs
	Deer Mouse	*Peromyscus maniculatus*	X	X	X	X							X						X	X		fungi, bark, litter, burrows
	Keen's Deer Mouse	*Peromyscus keeni*					X	X					X									
	Southern Red-backed Vole	*Clethrionomys gapperi*		X			X	X					X						X			fungi, litter, lichens
	Heather Vole	*Phenacomys intermedius*	X	X	X	X				X		X							X			burrows
	Pacific Jumping Mouse	*Zapus trinotatus*	X			X				X		X	X						X	X		fungi, burrows
Squirrels	Cascade Golden-mantled Ground Squirrel	*Spermophilus saturatus*	X	X	X	X	X	X					X								X	burrows, open forest
	Douglas' Squirrel	*Tamiasciurus douglasii*					X	X				X	X				X		X	X		fungi
	Northern Flying Squirrel	*Glaucomys sabrinus*					X	X					X	X	X	X	X	X				fungi, litter, moss
Mtn Beavers	Mountain Beaver	*Aplodontia rufa*		X	X	X	X	X					X						X			burrows, deep moist soil
Porcupines	Porcupine	*Erethizon dorsatum*	X			X	X	X					X			X			X	X	X	
Bear	Black Bear	*Ursus americanus*	X	X	X		X	X					X	X		X			X	X	X	tubers, bark, caves
Procyonids	Raccoon	*Procyon lotor*	X	X	X	X	X	X	X	X			X	X	X	X			X		X	burrows
Mustelids	Marten*	*Martes americana*					X	X	X	X		X	X	X	X		X	X	X		X	burrows, stumps
	Fisher*	*Martes pennanti*					X	X		X			X	X	X	X	X	X	X			cliffs, stumps
	Short-tailed Weasel (Ermine)	*Mustela erminea*		X	X	X	X	X		X			X								X	burrows

			Habitat Association[1]									Habitat Elements[1]										
			Forest Stage						Aquatic													
Group	**Common Name**	**Scientific Name**	Open	Hardwood	Mixed	Young	Mature	Old-growth	Rivers, Streams	Wetlands/Riparian	Lakes, Ponds	Canopy Layers	Downed Wood	Snags	Tree Cavities	Hollow Trees	Large Branches	Mistletoe	Shrubs, Forbs, Grasses	Edges	Rocks/Talus	**other**
	Long-tailed Weasel	*Mustela frenata*	X	X	X	X	X	X		X			X	X	X						X	burrows
	Striped Skunk	*Mephitis mephitis*	X	X	X	X	X	X		X			X	X							X	bark, litter, burrows
	Spotted Skunk	*Spilogale gracilis*		X	X	X	X	X					X	X	X	X					X	tubers, litter, burrows, cliffs
Cats	Cougar	*Felis concolor*	X	X	X	X	X	X					X				X				X	cliffs
	Bobcat	*Lynx rufus*	X	X	X	X	X	X					X						X		X	cliffs, caves
Canids	Red Fox	*Vulpes vulpes*	X							X			X						X	X		burrows, berry-producing shrubs
	Coyote	*Canis latrans*	X	X	X	X	X	X		X									X			burrows, berry-producing shrubs
Deer/Bovids	Elk	*Cervus elaphus*	X	X	X		X	X		X			X						X	X		
	Black-tail Deer	*Odocoileus hemionus*	X	X	X		X	X		X			X						X	X		

[1]Source: Cedar River Watershed Habitat Conservation Plan (CRW-HCP), Johnson and O'Neil (2001), Christy and West (1993), CRMW staff professional judgement

APPENDIX IV
SNAG CREATION TECHNIQUES: EFFECTIVENESS AND COSTS

The information presented here is from a series of phone calls to wildlife biologists, researchers, and contract administrators on the state and national forests in Oregon and Washington. There have been a variety of snag creation projects in the PNW in the past 30 or so years, but very limited monitoring. The monitoring results presented here are often fairly preliminary though some are from more rigorous statistical designs. The trends, however, are informative and help suggest considerations and likely results of snag creation projects.

Penny Harris and Ruby Seitz on the McKenzie River RD (Willamette NF) have done an exceptional job of monitoring their snag creation projects. Their data is compiled in Table 1, which compares the effectiveness and temporal scale of different techniques. Their bottom line recommendation is to use a variety of methods to create diverse and sustainable snag habitat. Snag use appears somewhat dependent on treatment type. Blasted and sawtopped trees provided the most opportunity for foraging *cavities* (penetrate the sapwood, but aren't large enough for nesting) while both girdling and inoculating showed a similar number of *holes* (do not penetrate the sapwood) as blasting. Sawtopping, though a very small sample size (n = 12, while the others were between 139 and 160), provided only foraging cavities, suggesting more accelerated decay than the other methods. As far as nesting cavities, blasting and sawtopping showed the greatest number of potential nest cavities. Potential nest cavities are beginning after about 10 years for both of these treatments.

Hallett et al. (2001) compared rates of mortality and decay between sawtopping and girdling. All treatments were done above the first whorl of branches at a height greater than 10m. They found that topped trees died faster but lasted longer as snags. Topped trees had cavities sooner (after 3 years in some cases) and had more conks and forage activity than girdled trees. In several cases the girdled trees appeared to heal over. This work as well as that of Harris and Seitz suggests that after treated trees die, they appear to be progressing through the typical snag decay classes, but rate of progression through decay classes is influenced by treatment type.

A monitoring review by the Mount Baker RD compared mortality and use among blasted, swatopped, and girdled trees. Blasted trees may be progressing a bit faster than girdled trees but there was no difference in mortality between sawtopped and blasted trees.

Similar to the McKenzie River RD, the Mount Baker RD did find that number of limbs remaining had a significant influence on mortality. As shown in Figure 1, trees that had more than 10 limbs remaining had a less than 40% chance of dying. Trees were monitored in 1998 but snags were created between 1985 and 1995. Most snags were 5 years old or less. It is likely that the results of this study are somewhat confounded by time since treatment since it is not clear that all treatments were done in all years.

Snag Creation Method	Natural disturbances simulated	Tree mortality	Advanced decay	Foraging use	Nesting use	Fall down rate
Topping with 4 live limbs left	wind breakage, lightning	1-3 years		2-4 years after mortality	8-12 years after mortality	*beginning 20-25 years after mortality*
high girdling with 4 live limbs left	beetle infestation, defoliators, frost damage	4-8 years		1-2 years after mortality	8-12 years after mortality	*beginning 20-25 years after mortality*
Inoculation with stem decays	stem decays	does not kill tree	*8-10 years*	Incidental	*20-30 years after inoculation*	same as any green tree
Inoculation with stem decays and sawtopping/girdling with 4 live limbs left	wind breakage, lightning strikes in trees with stem decay, hollow trees, frost damage	1-8 years	*3-5 years*	2-4 years after mortality	8-10 years after mortality	*beginning 20-30 years after mortality*
Inoculation with stem decays and sawtopping/girdling with >4 live limbs left	wind breakage, lightning strikes in trees with stem decay, hollow trees, frost damage	*30-35 years*	*3-8 years*	1-2 years after mortality	8-10 years after mortality	*40-60 years or more after treatment*

Table 1: one year of snag creation monitoring data about 8 years after the oldest treatment. Data from Penny Harris and Ruby Seitz, McKenzie River Ranger District, Willamette National Forest. Text in *italics* denotes hypothesized results not yet observed.

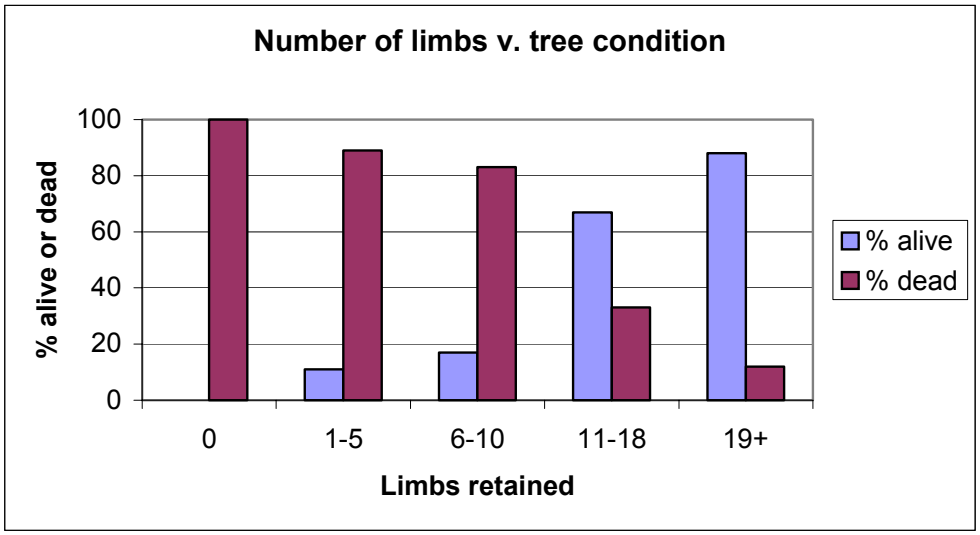

Figure 1: Number of limbs retained in relation to the percent of trees alive or dead 3 or more years after treatment. Data from Gay, 1998.

Don Gay, wildlife biologist on the Mount Baker RD, suggested that we also include natural snag creation in our list of options. Leaving clumps of trees to allow competitive exclusion to exist will create snags that we know will serve as good habitat.

Catherine Parks at the PNW LaGrande Research Station is the current lead on much of the work with heart rot inoculation. Next year she will be doing a lot of monitoring on her recent work. So far she has been using inoculum in operational Forest Service field trials. At this point, they can not supply it to anyone else. She does have a paper almost ready for publication that describes her procedure for growing out inoculum (and she would be willing to share that with us if we want). She suggested that Paul Stamets (in the mushroom growing business in Shelton) may have the lab and equipment required to contract out the growing. She did some work with the Darrington RD, who is planning to monitor and dissect some trees this year to examine effectiveness of inoculation.

Rayonier Timber Inc. has a study on their land in conjunction with a researcher from Arkansas State. Their initial results (Huss et al. 2002) suggest that inoculation was successful in introducing the fungal species to the tree. In conversations with Dan Varland (wildlife biologist for Rayonier) he said that six years post-treatment they are beginning to see conks on treated western hemlocks (near the inoculation hole) but not in Douglas fir.

ECONOMICS

Table 2 provides numbers from projects administered by Penny Harris on the McKenzie River RD (*Harris*) and from a publication by Jeff Lewis of Washington Department of Fish and Wildlife that collected data from contracts (*Lewis 1*) and interviews with contractors (*Lewis 2*). Costs on the McKenzie River contracts included treatment and data collection by the contractor.

This data consisted of tree species, dbh, height at treatment, treatment, number of live limbs below treatment, insect and wildlife use, and if inoculated, fungi species and aspect of PVC pipes.

Treatment Type	**Cost per tree**		
	Harris	*Lewis 1*	*Lewis 2*
Sawtopping	$38	$35	$37
Girdling	$30	$27.50	$19.50
Topping with blasting		$47.50	$44
Fungal inoculation	$40	$24	$33
Sawtopping and inoculating with 3 dowels above the 6th live limb	$46		
Sawtopping and inoculating with 2 dowels at 50% of the live crown	$46		
Girdling and inoculating with 3 dowels above the 6th live limb	$37		
Cavity creation		$34	$51
Cavity creation after blasting/sawtopping		$15	$17.50
Limbing		$32	$32

Table 2: Costs per tree of various snag creation treatments. *Harris* is data from contracts let on the McKenzie River RD. *Lewis 1* are values collected by Jeff Lewis from contracts throughout Washington stated. *Lewis 2*are values collected from contractors in the same study.

In the Harris data, the inoculum cost an additional $8-$9 per dowel, so three dowels would add an additional $24-$27/tree. With all the treatments there is an economy of scale such that the price per tree goes down as the contract involves more trees. In general, the Forest Service did snag creation work about 10 years ago and hasn't done much since. There are a few contracts going out now, and gradually people are trying more creative methods.

There are contradictory evaluations of the costs of sawtopping v. blasting. One biologist found sawtopping more expensive because it involved an individual actually climbing a tree with a chainsaw. In this case, blasting was done by hoisting explosives to the top of the tree and did not involve climbing. In contrast, others felt that blasting was more dangerous and therefore more expensive.

Topping and cavity creation was done in the CRMW in the early 1990's. Dwayne has some information about this. His sense is that most of the trees eventually blew down, as they were in very exposed areas (clearcuts). The cost was also much higher, and based on both his estimates and those of Sonny Paz (wildlife biologist for the North Bend RD who administered some of the snag creation in the watershed at the time) the range was between $300 and $600 per tree. The contractor (Tim Brown) is considered by himself and some within the agencies as an expert in snag creation techniques. Dwayne felt he took longer than necessary on the work and he may charge significantly higher rates than other contractors.

GENERAL RECOMMENDATIONS

1. Maintain existing snag structure
2. Leave dense patches of existing trees either around snags or so that snags will be formed naturally by competitive exclusion
3. Use a variety of techniques, species, and size classes and monitor results

Currently, there are several tested techniques, each providing a different rate of tree mortality. In a project like the 700 Road it may make sense to use multiple techniques, yielding snags at different points through time, rather than using a single technique which would kill all the trees at roughly the same time. Varying treated tree size and species will also expand the timeframe over which snags will be created.

The variable rate of decay and mortality from each technique goes hand in hand with the type of habitat each ultimately creates. Some techniques may not result in nesting habitat (for example, rot in hemlock may progress so fast that the tree falls before it can be used for nesting or removing all live limbs would kill a tree before rot can develop). But these techniques may still prove useful for forage. We don't really have enough long-term data to evaluate the progression of treated trees from forage providers to nesting providers. Current research interests (e.g., those of Andy Carey) seem to be exploring the balance between killing a tree before it can provide nesting habitat and having to wait 30 years before the tree provides any kind of habitat. This may involve techniques such as varying the numbers of branches left in conjunction with using heart rot inoculum.

It is important to identify what type of habitat is being targeted with the treatments, as different treatments and species of fungal inoculums will decay trees differently. Mechanical treatments alone (e.g., girdling or topping) will allow decay to establish first in the sapwood, providing foraging habitat. Using heartrot inoculum either alone or in conjunction with one of the mechanical treatments will accelerate decay from the inside.

CONTACTS

Phyllis Reed – MBS Darrington RD: 360-436-1155 x216
Wildlife biologist. Involved in some inoculation monitoring and they are planning to dissect some trees this year to examine the results (about 5 years post-treatment).

Dan Varland – Rayonier: 360-538-4582
Wildlife biologist for Rayonier, oversaw inoculation experiment on their lands in collaboration with researchers from Arkansas State University.

Penny Harris – WNF McKenzie River RD: 541-822-7265

Ruby Seitz – WNF McKenzie River RD: 541-822-7256
Penny and Ruby both have worked to do a lot of monitoring and some analysis of their results on their past 8+ years of snag creation work. Also have good cost figures.

Catherine Parks – LaGrande RD: 541-962-6531
Involved in the majority of inoculation studies throughout the region.

Kim Mellon – wildlife ecologist at the Regional Office: 503-808-2677

Has been trying to compile information on monitoring from the various projects throughout the region. Involved in creating DecAid.

Dale Oberlag – MBS Skykomish RD: 360-677-2414 x638
Wildlife biologist. Somewhat new to the district, but has access to contracts from the last 2-4 years and may be flying a contract this year as well.

Andy Carey – PNW Research Station Olympia: 360-753-7688
Done a variety of snag and cavity creation research in the PNW and places east for many years.

OTHER RESOURCES

Bull, E.L., C.G. Parks, and T.R. Torgersen. 1997. Trees and logs important to wildlife in the interior Columbia River Basin. USDA Forest Service general technical report PSW-GTR-391.

Gay, D. 1998. Results of 1998 KV wildlife tree monitoring program (pilot year). Unpublished report.

Hallett, J.G., T. Lopez, MA. O'Connell, and M.A. Borysewicz. 2001. Decay dynamics and avian use of artificially created snags. Northwest Science 75(4): 378-386.

Huss, M.J., J.C. Bednarz, D.M. Juliano, and D.E. Varland. 2002. The efficacy of inoculating fungi into conifer trees to promote cavity excavation by woodpeckers in managed forests in western Washington. USDA Forest Service general technical report PSW-GTR-181.

Harris, P.J., R. Seitz. 2002. Four dimensional snag creation and monitoring. A power point presentation showing results for the first year of monitoring after a variety of snag creation treatments over an 8 year time span.

Lewis, J.C. 1998. Creating snags and wildlife trees in commercial forest landscapes. Western Journal of Applied Forestry, 13(3): 97-101.

Local contractors providing professional snag and wildlife tree creation services (January 1997). From Jeff Lewis

Gray Owl Services Inc. (contact: Steve Dibiase) Seattle, 206-919-0873
Seattle Tree Service (contact: Mike Stanton) Lynnwood, 206-542-0286
Forest Sampling Systems (contact: Mike Ardington) Olympia, 360-956-3448

APPENDIX V
INDIVIDUAL MARKING/HARVEST GUIDES BY UNIT FOR 700 ROAD FOREST HABITAT RESTORATION PROJECT

UNIT E1 TARGET STAND PRESCRIPTION

Live Trees

- The thinning pool of trees that may be cut consists of the following species and diameter limits:
  - Western hemlock: 6 to 19 inches
  - Western red-cedar: 13 to 16 inches
  - Pacific silver fir: 8 to 12 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- Western hemlock should be cut preferentially over Western red-cedar or Pacific silver fir.
- Approximately 112 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This amounts to a spacing of about 19 feet plus or minus 4 feet per tree. Note this spacing is to be used as if the reserve trees were not present - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 116 trees per acre (see snag discussion below).
- Residual live trees per acre: 208 per acre
  - Approximately 108 reserve trees,
  - Approximately 105 live trees from the harvest pool
- Residual basal area per acre: 268 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should **not** be harvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre between the diameter limits of 15 and 19 inches western hemlock will be selected for conversion to snags.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - Trees selected for conversion to snags shall be clumped rather than scattered across the unit, as much as possible, however no more than 20 trees may be clumped representing 5 acres worth.
  - Live trees selected for snags will be painted with yellow paint on two sides of the tree with a large letter S (large is 12 inches in length and 1 inch wide) by the fellers and/or the feller-buncher/processor operator.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.

- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Skips and Gaps

- Three larger gaps and skips have been physically marked in this unit. All trees in larger gaps will be cut, except trees marked as L (live), S (snag), or D (down).
- In addition, 20 small gaps of 0.04ac (50 feet diameter) will be created in this unit, approximately one gap every 1.3 acres.
- 20 small skips of 0.04ac (50 feet diameter) will be left unthinned, approximately one skip every 1.3 acres.
  - Skip and gap diameters (approx. 50 feet) are measured from the stem edge of the border trees.
  - Skip and gap shape should be approximately round.
  - Small skips and gaps should be evenly distributed throughout unit. Gaps can be located close to existing skid trails. Skips should be placed in dense patches of small diameter trees (below harvest pool) or around existing snags.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

Streams

- There is one stream that flow through this unit, about 1.27 miles east on the 700 from the junction of the 300/700 roads.
- No trees may be cut if their drip line falls within the bankfull width of the channel or any associated wetland or seep.
- Any trees cut near the stream channel will be felled away from the stream.
- No trees will be yarded through the stream channel unless there will be no disturbance either to the ground or the residual canopy.
- Large woody debris (LWD) enhancement
  - One tree will be felled across the stream channel about every 100 feet.
  - Source LWD trees will be from the harvest pool.
  - Source LWD trees should not be selected if they are within the drip line of the channel.
  - Source LWD trees should be within 30 feet of the channel edge.
  - Should the top and/or the butt portion of the LWD tree interfere with yarding, that portion no closer than ten feet outside the bankfull width of the channel may be bucked and yarded as part of the sale.
- The stream splits into two channels just below the 700 road. The above restrictions apply to both of these stream channels.

UNITS E1 AND E2 GAPS AND SKIPS LAYOUT AND MARKING GUIDELINE

Note: The Gaps and Skips located in units E1, E2, and E8 have been marked. The following guide represents information for the Contractor on how gaps and skips were selected and marked on the ground.

Location, Marking, And Tree Selection Guideline

The following road distances are from the junction of the 300 and 700 roads. Use the vehicle odometer (in 1/10 mile increments) to estimate the distances. Exact placement is not required. The distance into the unit is an estimate based on traveling at a right angle from the road. Take a compass bearing from the road and follow it until you reach the desired distance.

Road and Foot Travel Distances for Gaps and Skips

Gap/Skip Number	Unit	Road Distance (in miles)	Road #	Distance Into Gap/Skip	Gap/Skip Circle Size (ac)
G1	E1	.12	700A	211	¼
S1	E1	.16	700A	131	¼
G2	E1	.29	700	206	½
S2	E1	.34	700A	338	½
G4	E1	.78	700	329	¼
S4	E1	.82	700	316	¼
G6	E1	1.39	700	373	¾
S6	E1	1.45	700	431	¾
G7	E2	.24	700	370	¼
S7	E2	.29	700	467	¼
G8	E2	.31	300	378	½
S8	E2	.35	300	450	½
G9	E2	.37	700	403	¾
S9	E2	.45	700	508	¾
G10	E2	.61	700	258	¼
S10	E2	.65	700	301	¼
G11	E2	.61	700	703	½
S11	E2	.64	700	755	½
G12	E2	.52	300	240	½
S12	E2	.56	300	197	½

The approximate plot center is at the designated distance and bearing from the road. At this point select the closest tree and make it the plot center. Put the appropriate tagging and flagging so that it will be easily visible from the outside edge of the gap or skip. One person will remain at plot center and use the laser rangefinder to direct the second person at the plot edge. The person at the edge will attach the appropriate tags. Enough line trees should be marked so that there is no question about the position of the line.

Skip and Gap Size

There will be three sizes of gaps and skips, ¼, ½, and ¾ acre.

Each skip and gap will be a circle in shape with the following radii:

¼	58.88
½	83.26
¾	101.98

Skip and Gap Placement

A SKIP **may be placed** over a stream channel. It is preferable to place skips around existing large snags and down wood. A GAP **may not** be closer than 50 feet to a stream. Use operational logistic considerations when placing the SKIP or Gap on the topography (i.e., leave sufficient space around the skip or gap so that logging equipment can maneuver around them).

Marking (all tagging is at eye level)

Marking Plot Center Tree

On four sides, using the reverse side of the Boundary Tags, staple two signs (one on top of the other) marked either with an S or G with the appropriate Gap or Skip number. These should be placed right next to each other. On the top and bottom of the marked Boundary tags staple a pink card in a horizontal position right next to the unit signs. Above these signs staple a series of three pink tags in a horizontal position separated by the width of the card on the same four sides as you placed the skip or gap signs.

Marking Gap and Skip Boundaries

Gap: On each line tree staple a double Boundary Sign using the reverse side. Place these reversed tags both on the inside of the Gap facing toward the plot center and on the opposite side of the tree facing away from plot center. Mark all tags with a G and appropriate gap number with a water-resistant felt tip pen. Be sure to use enough staples so that the tags will remain on the tree for several years. Enough line trees should be marked that there will be no question as to the plot boundary.

Skip: On each line tree of the skip instillation, place reversed Boundary Signs facing toward plot center using an S and the appropriate skip number. On the outside of the line tree staple a Boundary Sign with a pink flag on top and bottom.

Tree Selection Within the Gap

The following types and numbers of trees will be selected within the gaps

Gap Size	Live Trees Left	Trees For Snag Creation	Trees for DW Creation
¼ acre	0	0	0
½	2	2	2
¾	3	3	3

Live Tree Selection L

These trees are to represent the largest trees within the gap. They should represent the conifer tree species generally found within the stand. As an example Douglas-fir would be the choice in a western hemlock/Douglas-fir stand. If one of the largest trees happens to be a multi-top large limb tree (wolf-tree type), this may be considered along with the other trees. Do not select a

smaller (wolf tree) tree in favor of a larger sound dominant. There is no need to measure for the largest trees – visual estimates are sufficient. Live trees should be selected without regard to where they lay within the gap. If the three best trees are clumped, mark them anyway.

NOTE: Since all deciduous trees will be left within the matrix, they will not be selected as a live leave tree within the gap.

Live trees should be painted with orange paint on two sides with a large letter **L**. One side facing the plot center, the other on the opposite side.

Live Tree for Snag Conversion ***S***

The selection for these trees should be from the largest dominant trees (don't spend time measuring diameters) after the Live Leave trees have been selected. Deciduous trees may be considered in the selection for live trees to be converted to snags. They must be in the largest tree mix to be considered. A species mix is preferable if they exist as part of the largest trees. When selecting the trees to be converted, be sure that they can be climbed safely.

Trees for snag conversion should be painted with orange paint on two sides with a large letter **S**.

Live Trees for Down Wood ***D***

These will normally be the last trees you select. These again will be selected from the largest live trees (visual estimate). They may be of any species, with a mixture of species preferable. The selection of these trees should generally be from the edge of the gap, to ensure the maximum amount of wood on the ground as possible. The portion that falls outside of the gap is available for removal. Try to select the trees so they will parallel each other when they are felled. If, however, the best selection will cross each other when felled, this is acceptable. We will buck at the crossing so that the trees lay on the ground, providing more rapid decomposition.

Trees for down wood conversion should be painted with orange paint on two sides with a large letter **D**.

UNIT E2 TARGET STAND PRESCRIPTION

Live Trees

- The thinning pool of trees that may be cut consists of the following species and diameter limits:
  - Western hemlock: 6 to 16 inches
  - Douglas-fir: 6 to 16 inches
  - Western red-cedar: 6 to 15 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- Species preference for cutting is Western hemlock > Douglas-fir > western red-cedar.
- Approximately 217 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This amounts to a spacing of about 16 feet plus or minus 3 feet. Note this spacing is to be used as if the reserve trees were not present - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 221 trees per acre (see snag discussion below).
- Residual live trees per acre: 241
  - Approximately 85 reserve trees,
  - Approximately 160 trees from the harvest pool.
- Residual basal area per acre: 221 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre between the diameter limits of 13 and 16 inches for western hemlock and Douglas-fir, and between 13 and 15 inches for western red-cedar within the harvest pool will be selected for conversion to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - Trees selected for conversion to snags shall be clumped rather than scattered across the unit, as much as possible, however no more than 20 trees may be clumped representing five acres worth in any one location.
  - Live trees selected for snags will be painted with yellow paint on two sides of the tree with a large letter S (large is 12 inches in length and 1 inch wide) by the fellers and/or the feller/buncher or processor operator.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Skips and Gaps

- Six larger gaps and six skips have been physically marked in this unit. All trees in larger gaps will be cut, except trees marked as L (live), S (snag), or D (down). No trees will be cut in skips.
- In addition, 46 small gaps of 0.04ac (50 feet diameter) will be created in this unit, approximately one gap every 2 acres.
- 46 small skips of 0.04ac (50 feet diameter) will be left unthinned, approximately one skip every 2 acres.
    - Skip and gap diameters (approx. 50 feet) are measured from the stem edge of the border trees.
    - Skip and gap shape should be approximately round.
    - Small skips and gaps should be evenly distributed throughout unit. Gaps can be located close to existing skid trails. Skips should be placed in dense patches of small diameter trees (below harvest pool) or around existing snags.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

Streams

- There are two streams that flow through this unit. One stream runs through the unit beginning at the junction of the 300/700 roads. The other is a continuation of the stream at the end of the road 700a.
- No trees may be cut if their drip line falls within the bankfull width of the channel.
- Trees cut near the stream will be felled away from the stream.
- No trees will be yarded through the stream channel unless there will be no disturbance either to the ground or the residual canopy.
- Large woody debris (LWD) enhancement
    - One tree will be felled across the stream channel about every 100 feet.
    - Source LWD trees will be from the harvest pool: Douglas-fir 14 to 17 inches, western hemlock 14 and 15 inches, and western red cedar 14 and 15 inches.
    - Source LWD trees should not be selected if they are within the drip line of the channel.
    - Source LWD trees should be within 30 feet of the channel edge.
    - Should the top and/or the butt portion of the LWD tree interfere with yarding, that portion no closer than ten feet outside the bankfull width of the channel may be bucked and yarded as part of the sale.

UNIT E3 TARGET STAND PRESCRIPTION

Live Trees

- The thinning pool of trees that may be cut consists of the following species and diameter limits:
  - Western hemlock: 6 to 15 inches
  - Douglas-fir: 6 to 16 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- Western hemlock will be preferentially selected for cutting over Douglas-fir.
- 168 live trees per acre will be cut from the harvest pool and removed from the unit. This represents a spacing of about 20 feet plus or minus 4 feet for variability.
- For snag creation, eleven (11) live trees per acre will be selected from western hemlock (between 17 and 20 inches) and Douglas-fir (between 17 and 20 inches).
- Residual live trees per acre: 208
  - Approximately 103 reserve trees,
  - Approximately 106 trees from the harvest pool.
- Residual basal area per acre: 176 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Eleven live trees per acre will be selected from western hemlock (between 17 and 20 inches) and Douglas-fir (between 17 and 20 inches).
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These selected live trees may be clumped where possible so long as the diameter qualifications are met, however no more than 20 trees may be clumped.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.

- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

Skips and Gaps

- 51 small gaps of 0.04ac (50 feet diameter) will be created in this unit, approximately one gap every 0.8 acres.
- 51 small skips 0.04ac (50 feet diameter) will be left unthinned, approximately one skip every 0.8 acres.
  - Skip and gap diameters (approx. 50 feet) are measured from the stem edge of the border trees.
  - Skip and gap shape should be approximately round.
  - Small skips and gaps should be evenly distributed throughout unit. Gaps can be located close to existing skid trails. Skips should be placed in dense patches of small diameter trees (below harvest pool) or around existing snags.

UNIT E4 TARGET STAND PRESCRIPTION

Live Trees

- The thinning pool of trees that may be cut consists of the following species and diameter limits:
  - Western hemlock: 6 to 13 inches
  - Douglas-fir: 6 to 13 inches
  - Western red cedar: 6 to 9 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- Species preference for cutting is western hemlock > Douglas-fir > western red-cedar.
- About 188 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This represents a spacing of about 17 feet plus or minus 4 feet for spacing variability and flexibility. This spacing is made as if the reserve trees were not present - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 172 trees per acre (see snag discussion below).
- Residual live trees per acre: 248
  - Approximately 94 reserve trees,
  - Approximately 158 trees from the harvest pool.
- Residual basal area per acre: 178 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre between the diameter limits of 10 and 13 inches for Douglas-fir and western hemlock will be selected for conversion to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - Trees selected for conversion to snags shall be clumped rather than scattered across the unit, as much as possible
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Skips and Gaps

- 21 small gaps of 0.04ac (50 feet diameter) will be created in this unit, approximately one gap every 0.8 acres.
- 21 small skips 0.04ac (50 feet diameter) will be left unthinned, approximately one skip every 0.8 acres.
  - Skip and gap diameters (approx. 50 feet) are measured from the stem edge of the border trees.
  - Skip and gap shape should be approximately round.
  - Small skips and gaps should be evenly distributed throughout unit. Gaps can be located close to existing skid trails. Skips should be placed in dense patches of small diameter trees (below harvest pool) or around existing snags.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E5 TARGET STAND PRESCRIPTION

Live Trees

- The thinning pool of trees that may be cut consists of the following species and diameter limits:
  - Western hemlock: 6 to 14 inches
  - Douglas-fir: 6 to 18 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- Approximately 129 live trees per acre will be cut across all diameters from within the harvest pool and removed from the unit. This represents a spacing of about 24 feet with an allowance of plus or minus 5 feet for flexibility in selection. The spacing is made as if the reserve trees did not exist - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 133 trees per acre (see snag discussion below).
- Residual live trees per acre: 165
  - Approximately 96 reserve trees,
  - Approximately 73 trees from the harvest pool.
- Residual basal area per acre: 214 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live Douglas-fir trees per acre, between the diameter limits of 13 and 18 inches within the harvest pool will be selected for conversion to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These trees may be clumped in-groups of no more than 20 trees representing five acres so long as the size limitation is adhered to. Scattered clumps are desirable, whenever possible.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Skips and Gaps

- 30 small gaps of 0.04ac (50 feet diameter) will be created in this unit, approximately one gap every 0.8 acres.
- 30 small skips 0.04ac (50 feet diameter) will be left unthinned, approximately one skip every 0.8 acres.
  - Skip and gap diameters (approx. 50 feet) are measured from the stem edge of the border trees.
  - Skip and gap shape should be approximately round.
  - Small skips and gaps should be evenly distributed throughout unit. Gaps can be located close to existing skid trails. Skips should be placed in dense patches of small diameter trees (below harvest pool) or around existing snags.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E6 TARGET STAND PRESCRIPTION

Live Trees

- No trees may be cut exceeding the following diameter limits:
  - Western hemlock: 6 to 16 inches
  - Douglas-fir: 6 to 16 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- Western hemlock will be preferentially selected for cutting over Douglas-fir.
- About 239 live trees per acre will be cut across all diameters from within this harvest pool and removed from the unit. This represents a spacing of approximately 18 feet with a plus or minus 3 feet for variation in selection. This spacing is made as if the reserve trees did not exist - do not space off of reserve trees. Four snags per acre will be created from within the harvest pool to bring the effective removal of live trees to 192 trees per acre (see snag discussion below).
- Residual live trees per acre: 228
  - Approximately 90 reserve trees,
  - Approximately 142 trees from the harvest pool.
- Residual basal area per acre: 214 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre will be selected from the harvest pool within the following diameters limits western hemlock and Douglas-fir 13 to 16 inches.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - The selected trees may be clumped in groups no larger than 20 trees so long as they meet the size criteria. Clumping is preferred to scattered.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Skips and Gaps

- 89 small gaps of 0.04ac (50 feet diameter) will be created in this unit, approximately one gap every 0.8 acres.
- 89 small skips 0.04ac (50 feet diameter) will be left unthinned, approximately one skip every 0.8 acres.
  - Skip and gap diameters (approx. 50 feet) are measured from the stem edge of the border trees.
  - Skip and gap shape should be approximately round.
  - Small skips and gaps should be evenly distributed throughout unit. Gaps can be located close to existing skid trails. Skips should be placed in dense patches of small diameter trees (below harvest pool) or around existing snags.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

Streams

- There is one stream that approximately bisects the unit. There are overflow or secondary channels that have been flagged with white flagging and are also considered part of the stream channel.
- No trees may be cut if their drip line falls within the bankfull width of the channel.
- Trees cut adjacent to the full bank width of the stream will be felled away from the stream.
- No trees will be yarded through the stream channel unless there will be no disturbance either to the ground or the residual canopy.
- Large woody debris (LWD) enhancement
  - One tree will be felled across the stream channel about every 100 feet.
  - Source LWD trees will be from the harvest pool.
  - Source LWD trees should not be selected if they are within the drip line of the channel.
  - Source LWD trees should be within 30 feet of the channel edge.
  - Should the top and/or the butt portion of the LWD tree interfere with yarding, that portion no closer than ten feet outside the bankfull width of the channel may be bucked and yarded as part of the sale.

UNIT E7 TARGET STAND PRESCRIPTION

- Trees in this unit will be cut in a group selection, with no matrix thinning and no log yarding.
- All western hemlock and Douglas-fir smaller than 17 inches will be cut in groups, with a total area of 2.85 acres.
- No other trees may be cut unless marked by the Contract Administrator.
- Groups will be of variable size and will be scattered throughout the unit:
  - Cut three (3) groups of 120 feet diameter (0.25 acre);
  - Cut eight (8) groups of 75 feet diameter (0.10 acre);
  - Cut fourteen (14) groups of 55 feet diameter (0.05 acre);
  - Cut twenty (20) groups of 40 feet diameter (0.03 acre).
- Groups will be located to contain few trees that are not in the thinning pool.
  - The boundary of the larger groups can be irregular to exclude reserve trees. Irregular shaped gaps should approximate selected ground area (see above).
  - Group diameters are measured from the stem edge of boundary trees.
  - Groups may contain snags.
- Residual basal area per acre: 157 ft^2

Snags

- Live trees for snag creation:
  - Four live trees per acre between the diameter limits of 10 and 13 inches for western hemlock and Douglas-fir will be selected to be converted to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These trees may be clumped up to 20 trees so long as they meet the size criteria, otherwise they may be scattered. Clumping is preferred.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

UNIT E8 TARGET STAND PRESCRIPTION

Live Trees

- The thinning pool of trees that may be cut consists of the following species and diameter limits:
  - Western hemlock: 6 to 15 inches
  - Douglas-fir: 6 to 15 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- About 126 live trees per acre will be cut across all diameters from within this harvest pool and removed from the unit. This represents a spacing of approximately 17 feet with a plus or minus 3 feet for variation in selection. This spacing is made as if the reserve trees did not exist - do not space off of reserve trees. Four snags per acre will be created from the snag creation pool (described below) to bring the effective removal of live trees to 130 trees per acre.
- Residual live trees per acre: 241
  - Approximately 92 reserve trees,
  - Approximately 153 from within the harvest pool.
- Residual basal area per acre: 234 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre, between the diameter limits of 12 and 16 inches DBH of western hemlock will be selected to be converted to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These trees may be clumped up to 20 trees so long as they meet the size criteria, otherwise they may be scattered. Clumping is preferred.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
  - No live trees shall be selected for snags that are within 1 and ½ times the expected height of the snag to an active road.
  - These trees will be marked with a large letter S (12 inches tall and 1 inch thick) in yellow paint on two sides of the selected tree by the contractor either prior to cutting or during cutting.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.

- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

Skips and Gaps

- 9 small gaps of 0.04ac (50 feet diameter) will be created in this unit, approximately one gap every 1.3 acres.
- 9 small skips 0.04ac (50 feet diameter) will be left unthinned, approximately one skip every 1.3 acres.
    - Skip and gap diameters (approx. 50 feet) are measured from the stem edge of the border trees.
    - Skip and gap shape should be approximately round.
    - Small skips and gaps should be evenly distributed throughout unit. Gaps can be located close to existing skid trails. Skips should be placed in dense patches of small diameter trees (below harvest pool) or around existing snags.

UNIT E9 TARGET STAND PRESCRIPTION

Live Trees

- The thinning pool of trees that may be cut consists of the following species and diameter limits:
  - Western hemlock: 9 to 16 inches
  - Douglas-fir: 9 to 16 inches
- No other trees may be harvested unless marked by the Contract Administrator.
- About 99 live trees per acre will be cut across all diameters from within this harvest pool.
- Trees within the thinning pool will be spaced off larger reserve trees and within the thinning pool by an average square spacing of 18 feet plus or minus 4 feet.
- Residual live trees per acre: 272
  - Approximately 186 reserve trees,
  - Approximately 90 from within the harvest pool.
- Residual basal area per acre: 195 ft^2
- Trees within the harvest pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms should be left unharvested, if at all possible.

Snags

- Live trees for snag creation:
  - Four live trees per acre, between the diameter limits of 15 and 19 inches DBH of western hemlock and Douglas-fir will be selected to be converted to snags.
  - Tree species will be selected in the proportion in which they occur within this unit.
  - These trees may be clumped up to 20 trees so long as they meet the size criteria, otherwise they may be scattered. Clumping is preferred.
  - Live trees selected for conversion to snags will not be felled or treated during logging operations.
- No existing snags shall be cut unless necessary for safety. If any snags need to be cut for safety, consider high stumping to at least 16 feet. Any snag cut or topped for safety will remain on site where felled.
- Any existing snags found which are >30 inches in diameter, and >30 feet in height will be left and buffered pending notification of the Contract Administrator, who will do a ground review and make a decision about whether or not to keep and buffer the snag.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered, contact the Contract Administrator, who will do a ground review and made a decision about bucking and moving it.

APPENDIX VI
CRMW ECOLOGICAL HARVEST ENGINEERING DESIGN: THE 700 ROAD FOREST HABITAT RESTORATION UNIT

700 Road Forest Habitat Restoration Unit

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CRMW Ecological Harvest Engineering design: The 700 Road Forest Habitat Restoration Project

INTRODUCTION

Spring of 2003, Silvicultural Engineering visited the 700 Road Forest Habitat Restoration Project site and subsequently reviewed the draft site management plan including the ecological objectives silvicultural prescriptions, and provided comments on the cutting guidelines.

PROBLEM STATEMENT

In September 2003, Silvicultural Engineering was asked for expertise in harvest engineering design, with options—Settings—that address several constraints.

The constraints are:

1. No ground based machinery may cross a stream channel or travel within 30 feet of a stream.
2. All logs must be yarded away from streams.
3. Minimal ground disturbance over the entire project area.
4. Cable logging must have at least one-end suspension.
5. Skyline yarding must not damage live crowns of retained trees.
6. Live tops must not be broken and live crown ratios must not be reduced below 40%.
7. Minimal bark and root damage as described below;

> Bark damage -one or more scars on a trunk of a tree exposing the cambium layer more than 40 square inches;
>
> Root damage -a leave tree with more than 1/3 of the circumference of its root system injured such that the cambium layer is exposed.

Based on this direction, CRMW staff and Silvicultural Engineering worked together to develop the data for the harvest setting design process. A coordinated effort between the CRMW engineering, GIS, and ecology staff initiated this analysis. Amy Labarge and her staff prepared forest ecology and silvicultural prescriptions. Marti Spencer (CRMW), Silvicultural Engineering, and Pacific Forest Resources (Steve Faulkner) scoped prospective road reconstruction and landing placement.

The result of this effort detailed the harvest engineering idiosyncrasies of each of seven Ecological Thinning Units (ETU), plus one Restoration Thinning Unit (RTU). While there may be limitations in terms of the CRMW-qualified logging contractors, equipment specifications should not be an obstacle for implementing setting designs. Financial considerations are not ignored but these settings emphasize ecological restoration goals.

This document will provide City of Seattle staff and prospective logging contractors the information they need to propose specific logging systems. Proposals may be judged more fairly if the initial design criteria are made explicit. Variations from these designs are expected as contracts become finalized

METHODS

A. Forest engineering scenarios for ground based operations will be designated trails with roadside landings. Mechanized harvest is the preferred system because of the concern for site degradation.

B. Forest engineering for the steep slope settings includes four typical scenarios.

(1) A small mobile yarder (e.g. swing yarder) with intermediate supports to provide full suspension. Logs are yarded uphill and hauled on reconstructed road 311, east to the 310, onto the 300 mainline, and out of the watershed. These settings require several thousand feet of road reconstruction, landings, and some new road construction.

(2) A larger tower (e.g. TMY-70) set up to yard downhill on the 700 spur. A spar tree or mobile tower will be used along the ridge line with tailholds set up to 40 feet. Logs are hauled west on 700 spur to the 300 mainline. This option requires rough development of ridgeline access for tailholds.

(3) Helicopter yarding would land the logs directly onto the 700 mainline, at the western end of the planning area near the 300 rd Jct.. No road work will be required. Extensive landing development on existing road would be required to safely operate an airship and log loading facility simultaneously.

(4) A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces of the ridge units (E-3,4.5.6 7) and helicopter for the remainder on the ridge top An expanded heli-landing would be designed for repeated use in developing future Ecological Thinning Units. This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per a contract (e.g. "slashed so all material lays on the ground").

These scenarios, generally, increase incrementally in cost and complexity.

A design process made realistic comparisons between the feasibility of the skyline scenarios—Settings—based on a number of design elements (Berg and Schiess 1997). The first step is build PLANS (Twito et al. 1987). There are several steps to this that allow CRW-GIS data to be imported and analyzed.

A USGS format DEM is converted to a DTM

ARC covers (e.g. Roads, Streams, ETU boundaries) exported in an ungenerated format.

The line work (e.g. Roads, Streams, Unit boundaries) superimposed on DTM

Once built, a variety of skyline options can be compared based on the technical descriptions and solutions from PLANS. CRW can now design specific corridors in PLANS, field verify (and adjust GIS, based on field observations), and then suggest setting configurations to purchasers. The advantage being the reliability that ecological design elements are sufficiently reserved.

Detailed analysis in LoggerPC (OSU & USFS-PNW R-6) offers insight into the lateral pulling capabilities from these leads, often complicated by the introduction of intermediate supports. However, given the relatively small log size (e.g. 19 inch dbh), spacing of 150-200 feet between settings is not unreasonable (e.g. lateral yarding of 75-100 feet).

Ecological Setting Design

Design Issues on the 700 road

Silvicultural Design Element—Timber size

CRMW staff developed silvicultural prescriptions, designed to accelerate recovery of these forest stands to a late seral condition. A reasonable attempt must be made to estimate the expected payloads from these prescriptions. The equipment specified must be sufficient to fully suspend most of the logs.

(1) Estimate the distribution of log weights (from the inventory data and (e.g. Gholz, H.L. et al. 1979).
(2) Estimate target payload (~75% of Size distribution from above)
(3) Accumulate logs to achieve reasonable skyline or helicopter payloads

Payload analysis for skyline design requires plotting the distribution of logs by size (typically, DBH is used as a surrogate for size; (e.g. Gholz equations). This is accumulated from the inventory data by planning unit and species. A point is established (e.g. 75% point) where a specified yarder can easily suspend most of the logs. Inventory information allows a more reasoned estimate of target payload for equipment selection. The abundance of small diameter material (as per CRMW inventory data) to be removed seems to indicate that most payloads will be well below equipment technical design capability.

Equipment Design Elements

Yarders are picked from those that are available in the industry and are keyed to the target payloads, capability to safely operate, and technical specifications (e.g. maximum yarding distance, suspension requirements, and tower and tailhold anchoring requirements).

On the uphill yarding option, limitations on the equipment includes the lack of sufficient guy trees for large towers. Also, the ridge top terrain is such that long guy wires required for large towers (e.g. Skagit 090 90 foot tower) will not reach the slope if rigged properly at about 45^0 from the top of the tower.

For downhill yarding, presence of tall tail trees on the ridge top may limit the actual locations of yarding corridors. There appears to be sufficient anchor trees for tower settings along both the 700 and 300 roads.

Setting Design Elements

Feasible settings are proposed (PLANS, Local knowledge, best professional judgement). The setting locations are geographic information. The actual skyline roads are field verified; as DTM/DEM data accuracy is realistically only 80-90 percent. Tail trees and guy anchors are verified at this time as well.

Advances in laser imagery (LIDAR) give CRMW the opportunity to apply state of the art, landscape level imagery to the surface DEM. The details on the landform surface that LIDAR is detects are stunning (e.g. hidden roads, stream centerlines, geologic event remnants).

Ecological Design Elements -- Structural Retention (STR) Design

Once feasible skyline settings are proposed structural retention (STR) can be super-imposed on the landscape. Questions will arise about the level and type of biological legacies that are retained.

Because the skylines are designed for full suspension and the forest is fairly young, consideration for log "flyways" –yarding roads—would simplify some of the uphill yarding options. Placement of STR will be within the guidelines provided for in the silvicultural prescriptions.

Cost

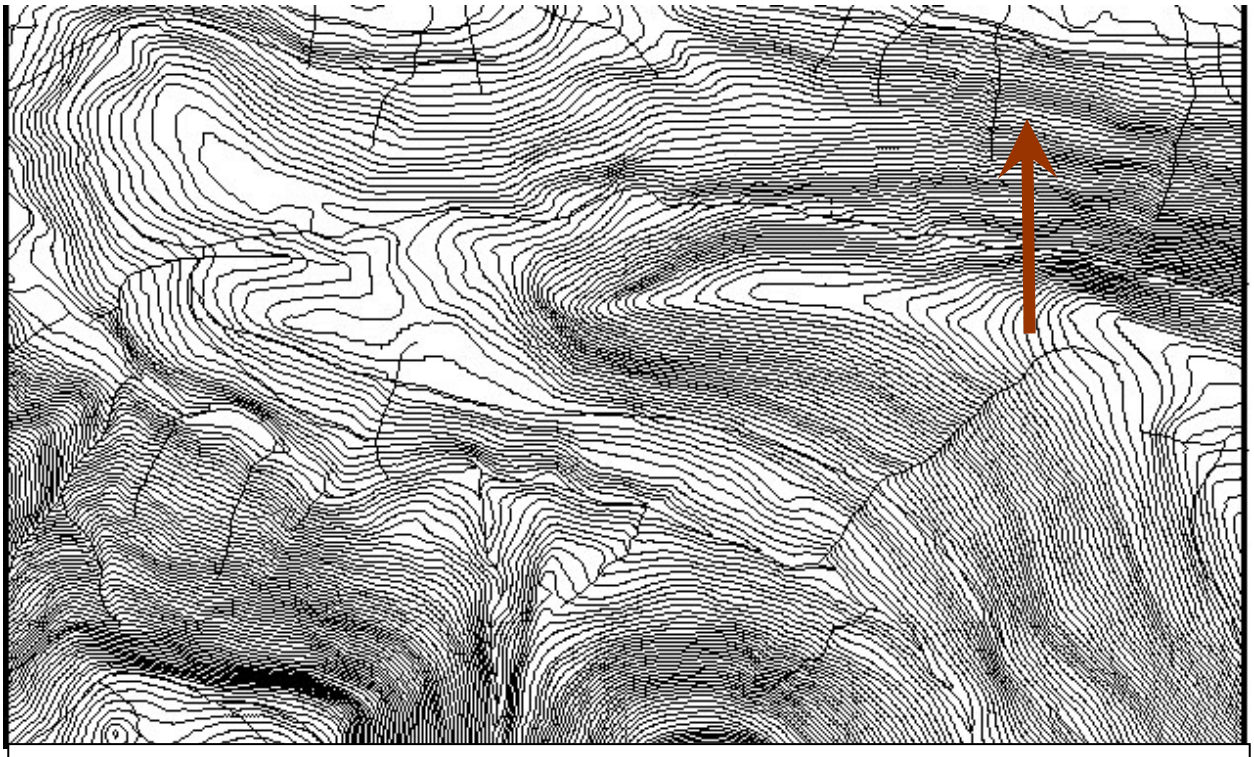
Detailed financial analysis requires information about the equipment, timber value, and amenity (e.g. ecological, aesthetic) value. All of these vary widely but some estimate must be made.

Ground based logging is limited to the mechanized processor-forwarder systems because of the soil disturbance constraints. Cost vary but range between $125-$150 per Mbf. These systems are limited to terrain of less than 35% slope.

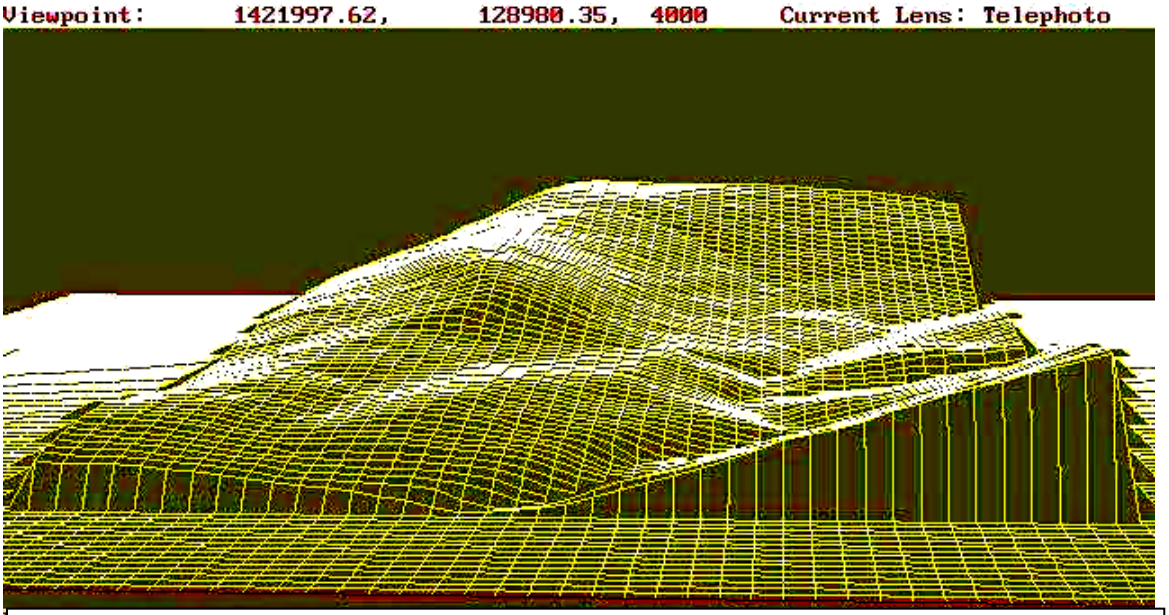
Here, both of the skyline options (between $165-$240 per Mbf), are less expensive than the helicopter option. The smaller tower with intermediate supports may be only slightly less than that of the larger machine used in the downhill yarding due mainly to the extra work setting up numerous intermediate supports.

While helicopter logging costs (in excess of $250-$300 per Mbf for a small ship) are high, there is a trade-off in the lower road building costs, which are limited to haul road and landing improvements.

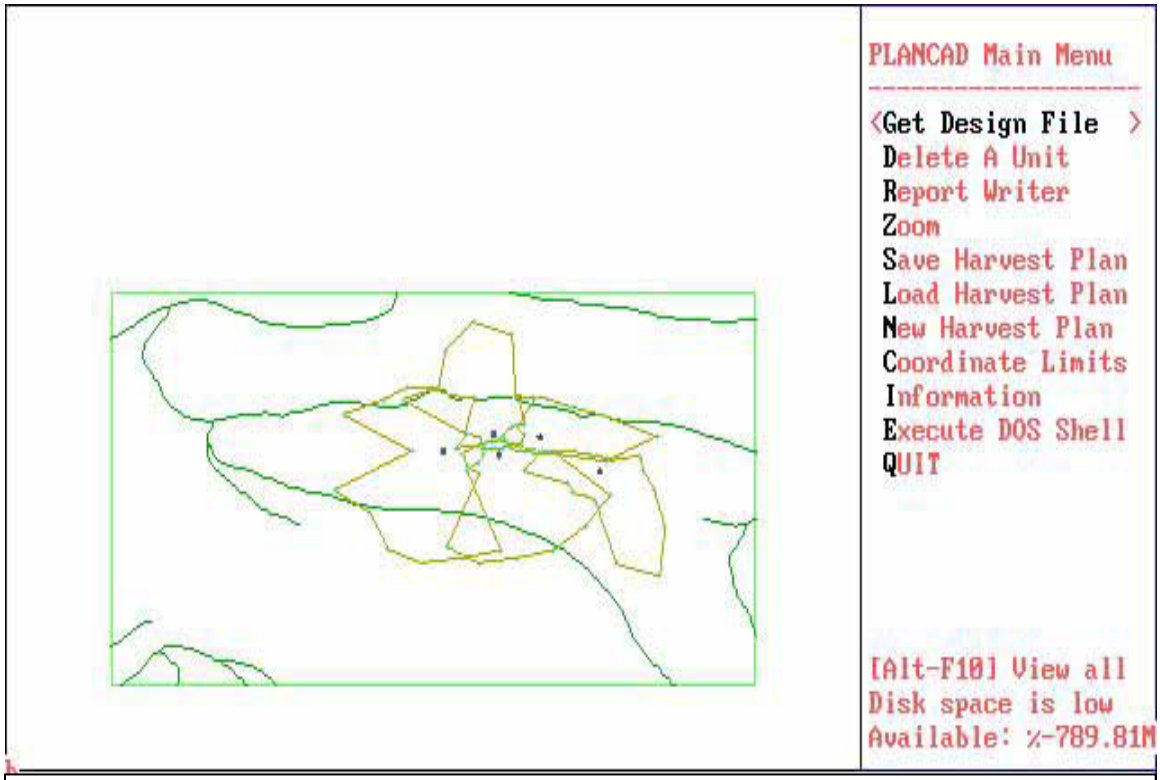
RESULTS



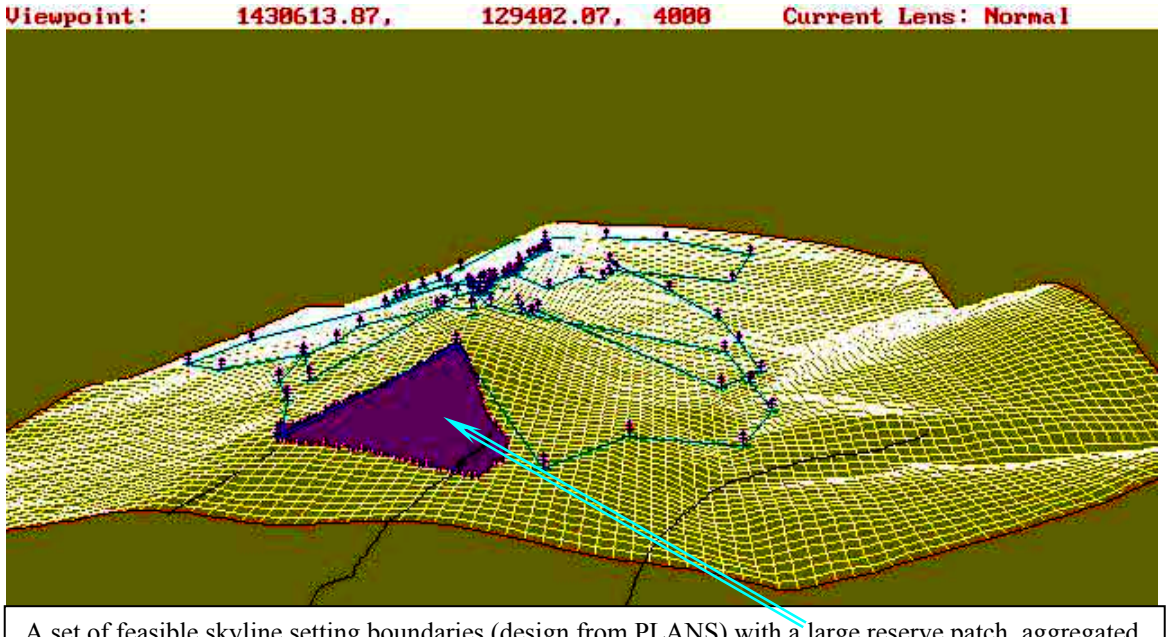
Geographic Extent of DTM with Streams and Roads from CRW-GIS



DEM data converted to DTM, viewed from the West, looking east over planning area.



Settings with tower locations to cover ridge in the middle-East portion of planning area.



A set of feasible skyline setting boundaries (design from PLANS) with a large reserve patch, aggregated structural retention, STR. STR is based on skipping several radial yarding roads. Individual tree STR may also designed along individual skyline locations. View if looking east at about 4000 feet elevation.

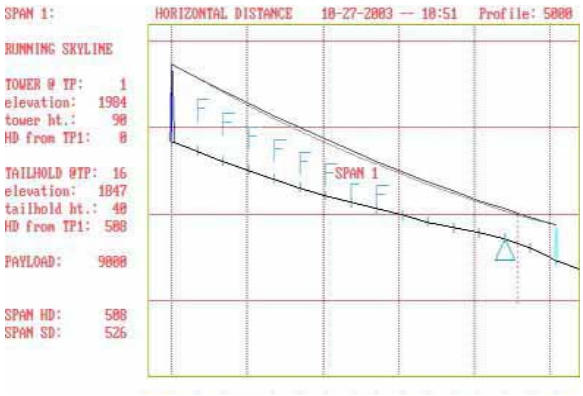
Ecological Thinning Unit E 1

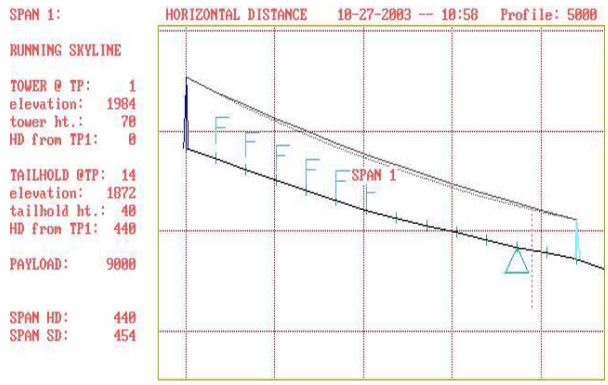
Ground Based

While the terrain barely meets the criteria on the western end of this unit, a system of parallel corridors placed such that logs can be forwarded west to the spur off of the 700 main line.

Skyline

Two stream crossings and steep slopes push the remainder of this unit towards some kind of light skyline configuration. Parallel yarding roads will be placed perpendicular to the mainline with the landings on the mainline. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. Sufficient tail trees exist in the riparian zone below to enable elevated tailholds (e.g. 40 foot high), improving deflection. Field location of skyline location will be necessary as STR gaps and skips have already been located on the ground.





Skylines can be smaller than designed because the probable payload will be less that the design payload of 9000 pounds. However, if deflection—minimal ground-lead—is a strong constraint then a larger machine would be recommended.

Also, these same settings may be used to log the adjacent units to the north (See Ecological Thinning Unit E 5 & 6 below).

Gaps will be best centered on yarding roads (for ease of yarding) because of the high level of STR in the remainder of the stand.

Helicopter

A small ship will yard these payloads easily to the main line. While expensive there will be minimal ground and residual tree damage.

Recommendations

1. Ground Based

A system of parallel corridors placed on the western end of this unit, such that logs can be forwarded west to the spur off of the 700 main line.

2. Skyline

Parallel yarding roads are placed perpendicular to the 700 mainline with landings on the mainline. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. Sufficient tail trees exist in the riparian zone below to enable elevated tailholds (e.g. 40 foot high), improving deflection. Field location of skyline location will be necessary as STR gaps and skips have already been located on the ground. Gaps are centered on yarding roads (for ease of yarding) because of the high level of STR.

Skylines can be smaller than designed (e.g. in PLANS) because the probable payload will be less that the design payload of 9000 pounds. I recommend a larger machine to improve deflection because of

the minimal ground-lead constraint and proximity to the stream below. These same settings would be used to log the adjacent units to the north (See Ecological Thinning Unit E 4, 5, & 6 below).

Ecological Thinning Unit E 2

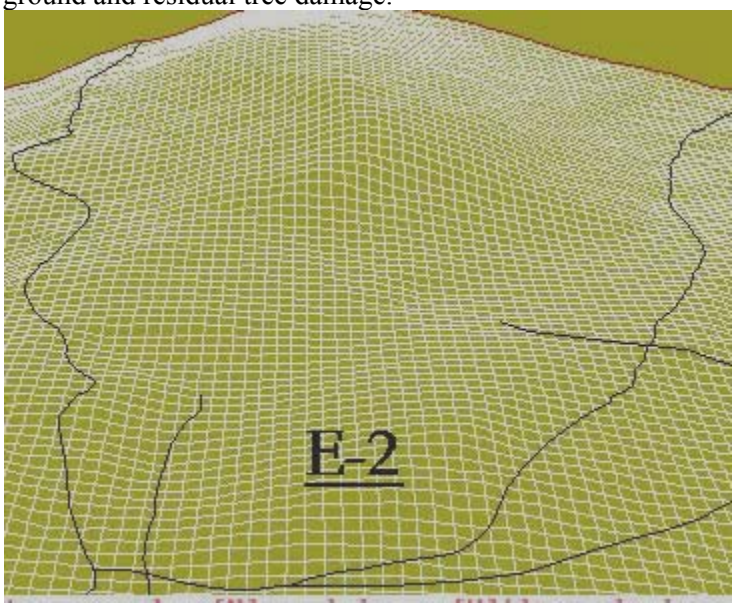
Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded west to the main line. There are two streams that are identified. Forwarding raods will have to be designed to avoid the riparian reserves but should not affect production

Skyline Not necessary

Helicopter

A small ship will yard these payloads easily to the main line. While expensive (~$250-300/Mbf) there will be minimal ground and residual tree damage.



Recommendations

Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded west to the 700 main line. There are two streams that are identified. Forwarding roads will be designed to avoid the riparian reserves so as not to affect production.

Logs from a skyline setting for ETU-3 could be forwarded, saving the cost of building a log loading landing.

Ecological Thinning Unit E 3

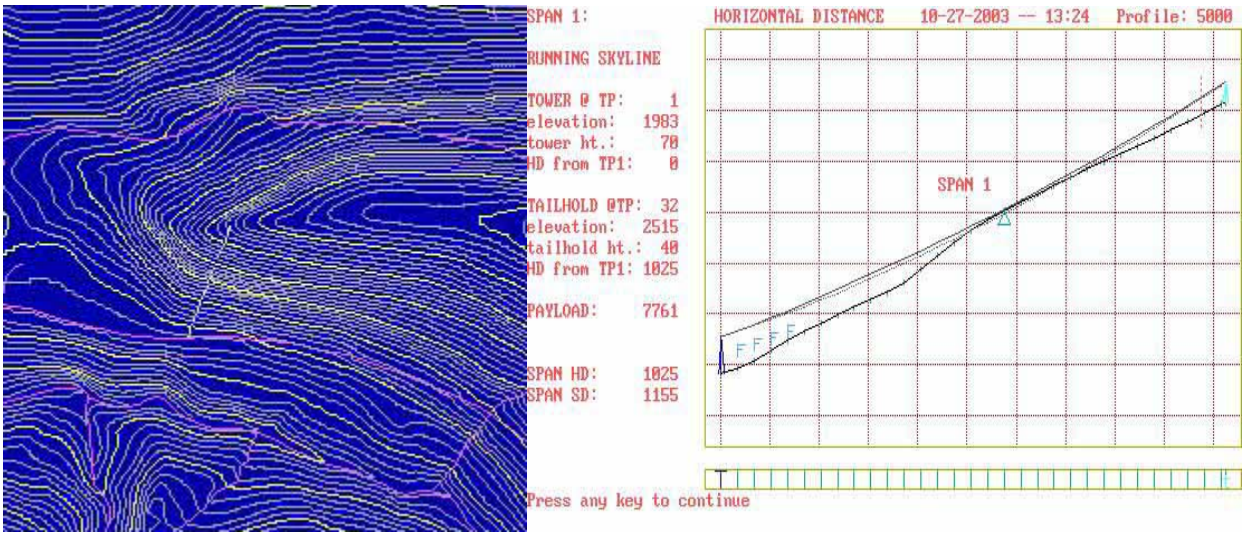
Ground Based

The terrain is unacceptable for entire unit. A small patch on the west end may be accessed with the ground based system described in Ecological Thinning Unit E 2

Skyline

A small tower (~70 foot tall Thunderbird TMY-70) will be able to yard both North and South to the main line. However, full-suspension with a 40 foot tailblock is limited the lower half of the slope as depicted below. Full suspension will require the use of intermediate supports—both time consuming and expensive. The face to the west is problematic with out building a road to the bottom of the hill out on the flat in Ecological Thinning Unit E 2.

Building a road west all the way out to the top of the ridge will be expensive will allow a central landing to cover the entire west end of Ecological Thinning Unit E 3. This will still require intermediate supports to yard uphill. This is feasible only if a road is built and the road will not likely be built large enough to mobilize a TMY-70 type tower. A smaller machine will still pull the payloads uphill but with more settings and less lateral yarding capability.



Helicopter

A small ship will yard these payloads west to the main line. While expensive, there will be minimal ground and residual tree damage.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces and helicopter for the remainder may also be feasible. This option would yard downhill the lower slopes, what timber is left will be heli-logged and taken west to an expanded landing. The expanded landing would be designed for repeated use in developing future Ecological Thinning Units.

This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. "slashed so all material lays on the ground").

Recommendations

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces and helicopter for the remainder may also be feasible. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. This option yards the lower slopes downhill, with intermediate supports to extend yarding as far as possible. Remaining timber will be heli-logged and taken west to an expanded landing. A small ship will yard these payloads west to the 300 or4 700 main line. The addition of intermediate supports extends the range of yarding while reducing the amount of helicopter yarding. This may be a cost saving measure in general.

As an option, a small temporary access to the western base of the ridge would allow a small skyline yarding downhill into ETU-2. This set up will reduce the amount of helicopter yarding required in ETU-3.

Ecological Thinning Unit E 4

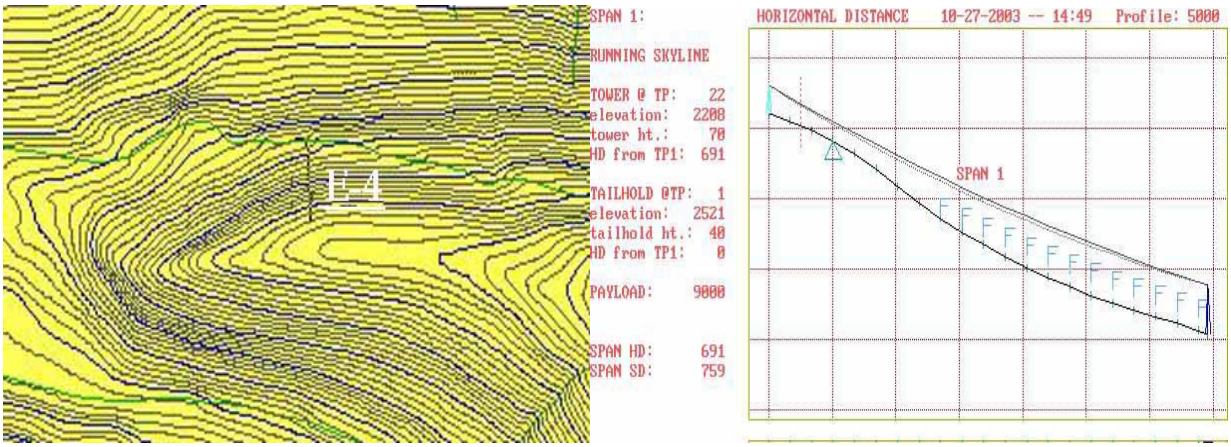
Ground Based

The terrain is unacceptable for entire unit.

Skyline

A small tower (~70 foot tall Thunderbird TMY-70) will be able to yard downhill to the North, landing logs on the main line. Full-suspension with a 40 foot tailblock is limited the lower half of the slope as depicted below. Full suspension for the full span to the ridge top requires intermediate supports.

Building a road west along the top of the ridge, while expensive, allows a series of parallel settings to cover the entire north face of Ecological Thinning Unit E 4. These settings require intermediate supports to yard uphill and is feasible only if a road is built. A smaller machine than the tall tower used for downhill (e.g. TMY 70) will still pull the payloads uphill but with more settings and less lateral yarding capability.



Helicopter

A small ship will yard these payloads easily to the main line. While expensive there will be minimal ground and residual tree damage.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face. A helicopter can be used for the remainder. This option would yard downhill the lower slopes, what timber is left will be heli-logged and taken west to an expanded landing. The expanded landing would be designed for repeated use in developing future Ecological Thinning Units.

This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. “slashed so all material lays on the ground”).

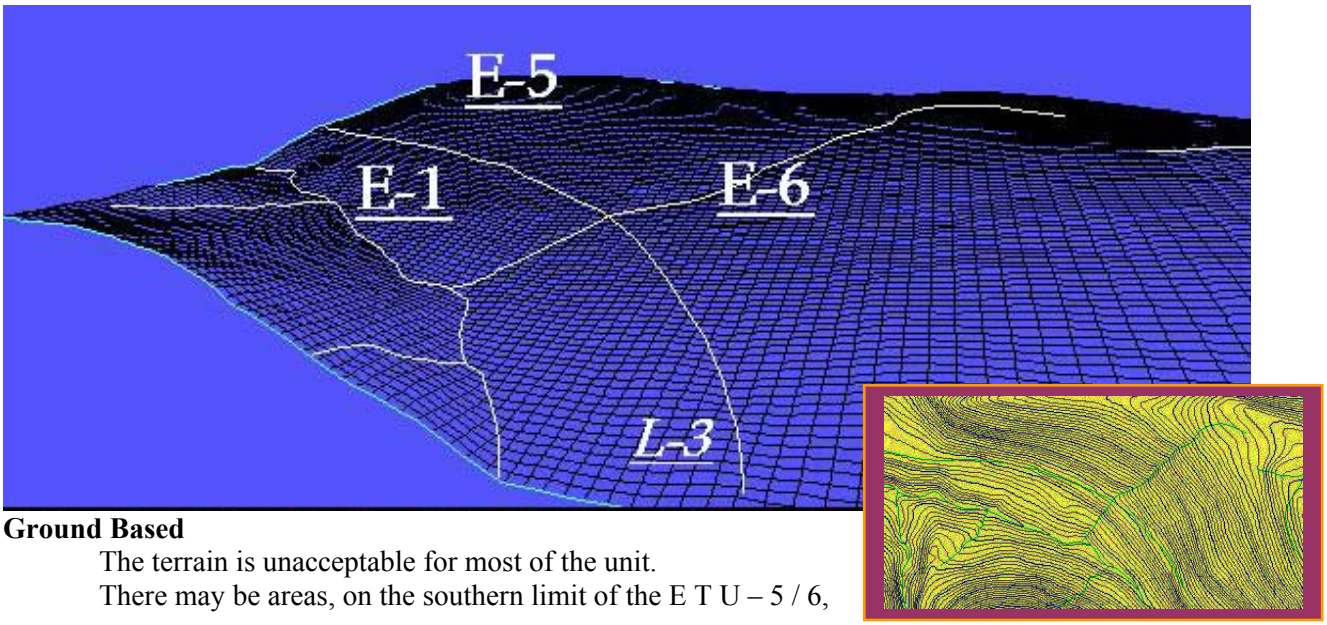
Recommendations

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the North and South faces and helicopter for the remainder may also be feasible. There appears to be sufficiently large trees and stumps to anchor tower guylines along the road. This option yards the lower slopes downhill, with intermediate supports to extend yarding as far as possible. Remaining timber will be heli-logged and taken west to an expanded landing. A small ship will yard these payloads west to the 300 or4 700 main line. The addition of intermediate supports extends the range of yarding while reducing the amount of helicopter yarding. This may be a cost saving measure in general.

As an option, a small temporary access to the western base of the ridge would allow a small skyline yarding downhill into ETU-2. This set up will reduce the amount of helicopter yarding required in ETU-3.

Ecological Thinning Units E 5 & 6



Ground Based

The terrain is unacceptable for most of the unit.

There may be areas, on the southern limit of the E T U – 5 / 6,

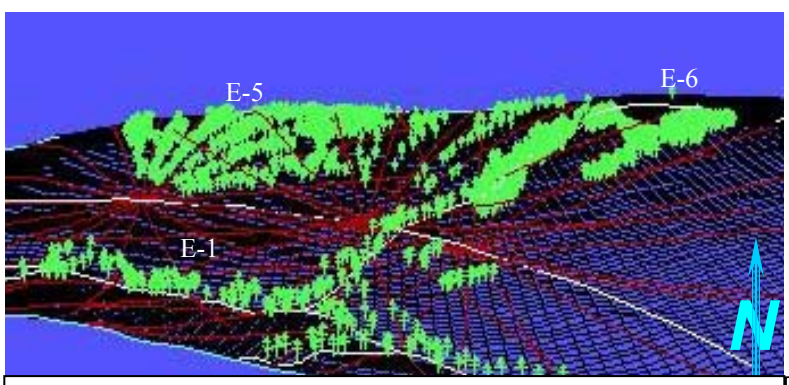
and where some careful layout could yield several more settings in the basin.

Skyline

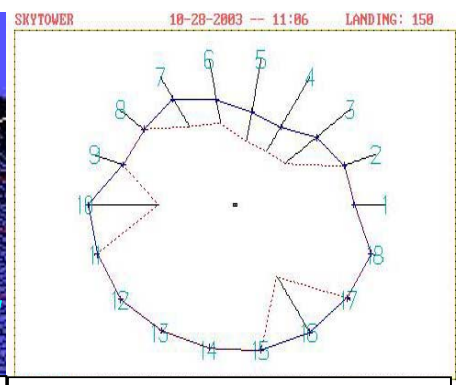
Numerous challenges offered by this setting, constrain the setting design. There is no crossing of the stream, as provided by the constraints above. The cutting prescription need not be modified. However, there is latitude in STR selection so as to gain optimal yarding efficiency with in the constraints.

As example, displayed here is a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face. This requires tall tail trees (e.g. ~100 ft for a 40 ft tailhold or better) and will most likely be from the pool of some of the largest trees on the site.

One of the best settings, which takes advantage of the natural bowl shape of the little catchment in the middle of Ecological Thinning Unit E-6, is displayed to show the possible configuration of a riparian adjacent landing. This is a central landing and represents how close a tower might sit relative to the adjacent RMZ.

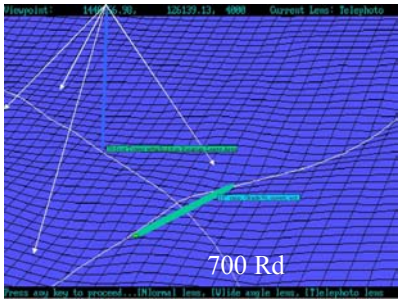


ETU- 5 & 6 with an example of STR arranged for operational efficiency.



Setting Boundary for ETU-6 with modified corridor configurations.

At the most extreme, lacking all other guy line opportunities, residual reserve trees can be used to safely anchor skyline towers. Selection would be for trees that would provide good quality habitat as snags.



Helicopter

A small ship will yard these payloads easily to the main line. While expensive, there will be minimal ground and residual tree damage. This option avoids expensive road building along the ridge but requires the development of modified landings for the ship and log deck.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face. A helicopter can be used for the remainder. This option would yard downhill the lower slopes, what timber is left will be heli-logged and taken west to an expanded landing. The expanded landing would be designed for repeated use in developing future Ecological Thinning Units.

This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. "slashed so all material lays on the ground").

Recommendations

These settings offered numerous challenges that constrain the design. There is no stream crossings, as provided by the constraints above. The cutting prescription need not be modified. However, if given some latitude in STR selection, there may gains in yarding efficiency that would optimize cost and ecological goals—within the given constraints.

Ground Based

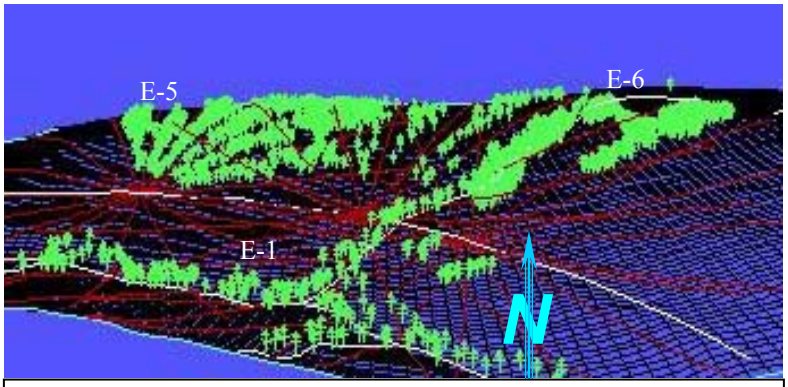
There may be areas, on the southern and eastern limit of the E T U – 5 / 6 where some careful layout could yield several more settings in the basin.

Combination Setting

A combination of a small tower (~70 foot tall) that will downhill yard the timber from the lower portions of the North face and a helicopter for the remainder. This option would yard the lower slopes downhill, what timber is left will be heli-logged and taken west or east log landings at either the 300-700 rd intersection of to the 300-310 rd intersection. A small ship will yard these payloads easily to the main line.

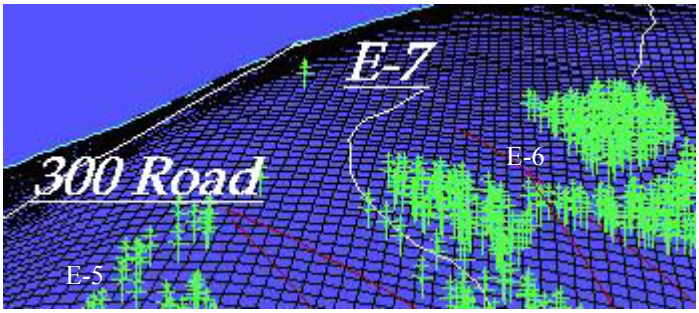
As example (cited in the comprehensive report), a small tower (~70 foot tall) would reach farther for the downhill yarding of the lower portions of the North face. Tall tail trees will be retained as STR on the site. Residual reserve trees can be used to safely anchor skyline towers. Selection would be for safe trees that would provide good quality habitat as snags.

One of the best settings, which takes advantage of the natural bowl shape of the little catchment in the middle of Ecological Thinning Unit E-6, is displayed to show the possible configuration of a riparian adjacent landing. This is a central landing and represents how close a tower might sit relative to the adjacent RMZ. Additional, Parallel settings along the 700 mainline can be used to minimize the residual stand damage and are necessary to log below the 700 road in ETU-1.



ETU- 5 & 6 with an example of STR arranged for operational efficiency.

Ecological Thinning Unit E 7



Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded east to the new road construction (311?) and then west to the main line

Skyline

Not necessary

Helicopter

A small ship will yard these payloads easily to the main line. While expensive there will be minimal ground and residual tree damage. This option avoids expensive road building along the ridge. Non-merchantable material will be slashed and left on site as per the contract (e.g. "slashed so all material lays on the ground").

Recommendations

Ground Based

The terrain meets the criteria for the entire unit. A system of parallel corridors placed such that logs can be forwarded east along existing grades (311?) to the 300 Main line then west.

Restoration Thinning Unit 1

As the material is all non-merchantable,

Ground Based

Not feasible

Skyline

Not necessary.

Helicopter

Not necessary.

This unit should be slashed on site (e.g. PCT). A specification in the contract should state that the material will lay on the ground (e.g. cut to ~approx 4 feet in length). Spacing should be about 18 feet, leaving trees only 10 inches and better. This selection rule will randomize residual pattern and rid the stand of suppression stems. By the inventory, that would be about 130 tpa, half fir, and the other quarters are redcedar and hemlock. Selection can favor isolated Noble fir, yellow cedar, mountain hemlock, and hardwoods.

Recommendations

As the material is all non-merchantable, this unit should be slashed on site (e.g. PCT). A specification in the contract should state that the material will lay on the ground (e.g. cut to ~approx 4 feet in length). Cost will be greater to lay material on the ground but it will reduce fuels risk and more rapidly be incorporated into useable site nutrition.

Spacing should be about 18 feet, leaving trees only 10 inches and better. This selection rule will randomize residual pattern and rid the stand of suppression stems. By the inventory, that would be about 130 tpa, half fir, and the other quarters are redcedar and hemlock. Selection can favor isolated Noble fir, yellow cedar, mountain hemlock, and hardwoods.

DISCUSSION

While more detailed analysis is possible, these are the essential concepts one will use to convey CRW intent with the harvest methods.

Timber cruises already are quite sophisticated. The key is to develop methods to extract and compute parameters, such as log sizes and weights for payload analysis.

Harvest planning can be more efficient if done along side the silvicultural and ecological design. As an after thought, the unit boundaries may seem awkward and misplaced. The design process should work together and often requires iteration. Once boundaries become static, the harvest planning process can become cumbersome while trying to fit designs to arbitrary landscape delineation.

There are numerous ways to solve problems that arise as a result of unit by unit harvest plans. The efficiency is gained by looking more broadly and with more detailed information on terrain and timber. Digital terrain models being developed now using LIDAR technology have proven effective

beyond expectations, identifying detailed landforms that may indicate instability, previous road cuts, and more sophisticated hydrologic patterns.

CONCLUSIONS

The 700 road ETU is a difficult piece of ground; steep ground, limited access, and small timber offer challenges in the overall design. Harvest costs alone are not the driver but every effort should be made to minimize costs when timber receipts are expected to be low.

These recommendations are one set of solutions that certainly have room for design improvements and modifications as more information accumulates.

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Berg, D.R., and P. Schiess. 1996. Setting level design for biological legacies in Clayoquot Sound, British Columbia. In Clayoquot Symposium CD-ROM. MacMillan-Bloedel, Ltd.

Gholz, H.L. et al. 1979. Equations for estimating biomass and leaf area of plants in the PNW. Res Pap. 41 FRL, School of Forestry, Oregon State University, Corvallis

Twito et al. 1987. Preliminary, Logging Analysis System PLANS:Overview. PNW-GTR-199 Feb 1987

Appendix VII
Ridge Road Decommissioning Plan

This decommissioning plan was not completed because in final project redesigns (February 2006, see As-Bilt Report, Appendix X) it was determined that the ridge road may not used for project implementation. Entering the middle of the project area to decommission that road would cause greater disturbance than leaving it in its current state.

Appendix VIII
Seattle City Council Ordinance

Council Bill Number: 115228
Ordinance Number: 121793

AN ORDINANCE relating to the Cedar River Watershed; authorizing an "**ecological thinning**" project, in accordance with the Cedar River Watershed Habitat Conservation Plan (HCP), in Sections 27, 28, 33 and 34, Township 22, North, Range 9, East, W.M.; declaring the logs resulting from said project to be surplus to the City's needs; authorizing the sale of such logs pursuant to applicable City contracting and surplus property sale procedures; and directing deposit of the proceeds therefrom to the Water Fund for the purposes of the HCP implementation.

Date introduced/referred: April 18, 2005
Date passed: May 2, 2005
Status: Passed
Vote: 9-0
Date of Mayor's signature: May 10, 2005
(about the signature date)

Committee: Utilities and Technology
Sponsor: COMPTON

Index Terms: THREATENED-AND-ENDANGERED-SPECIES, WATERSHEDS, FISH, ENVIRONMENTAL-PROTECTION, TREES, TIMBER, SALES, TIMBERLANDS, CEDAR-RIVER, WATER-SUPPLY, FORESTS

Text

AN ORDINANCE relating to the Cedar River Watershed; authorizing an "ecological thinning" project, in accordance with the Cedar River Watershed Habitat Conservation Plan (HCP), in Sections 27, 28, 33 and 34, Township 22, North, Range 9, East, W.M.; declaring the logs resulting from said project to be surplus to the City's needs; authorizing the sale of such logs pursuant to applicable City contracting and surplus property sale procedures; and directing

deposit of the proceeds therefrom to the Water Fund for the purposes of the HCP implementation.

WHEREAS, in 1999, following several years of technical studies, negotiations with federal and state agencies and review by public groups and individuals, the City Council adopted Resolution 29977 authorizing the Mayor to submit the Final HCP and other related documents for federal review and issuance of an "incidental take permit" under the federal Endangered Species Act, and to execute on behalf of the City the HCP and related agreements, which together establish the City's long-term commitments regarding watershed habitat protection and mitigation for impacts resulting from the presence and operation of certain City-owned facilities; and

WHEREAS, the HCP describes, among other subjects, the City's planned forest management practices, including the use of "ecological thinning" to accelerate development of old-growth conditions, improve habitat for species dependent on older forest, and control risks of catastrophic events in certain existing densely-stocked second-growth stands; and

WHEREAS, in 2000, the City received the incidental take permit and executed the HCP and related agreements; and

WHEREAS, in 2002, the City Council passed Ordinance 121040, which clarified certain differences between the forest management policies

contained in the Secondary Use Policies (adopted by Ordinance 114632) and those contained in the HCP; prohibited the harvesting of trees for commercial purposes on City-owned land within the Watershed; authorized the cutting of trees for certain limited non-commercial reasons (including ecological thinning); provided limited authority for the sale of logs resulting from such non-commercial cutting; and dedicated the proceeds from such sales for the purpose of offsetting the costs of the HCP; and

WHEREAS, in 2002, the City Council passed Ordinance 121039, which authorized the first ecological thinning project under the HCP, which was completed in 2003; and

WHEREAS, following field surveys and other technical considerations, Seattle Public Utilities staff have recommended for the second ecological thinning project under the HCP a second-growth stand located in Sections 27, 28, 33 and 34, Township 22, North, Range 9 East, W.M., and consisting of approximately 477 acres, of which approximately 358 acres will receive ecological thinning treatment; and

WHEREAS, this planned ecological thinning project is estimated to result in approximately 2,800,000 board feet of merchantable logs, among the vegetation that would be cut; NOW, THEREFORE,

BE IT ORDAINED BY THE CITY OF SEATTLE AS FOLLOWS:

Section 1. The Director of Seattle Public Utilities is hereby authorized to contract, pursuant to applicable City contracting or surplus property sale procedures, and subject to the right of first refusal granted to Mountain Tree Farm Company by the 1962 Cedar River Watershed Cooperative Agreement, for the service of ecological thinning of a second-growth forest stand located in Sections 27, 28, 33 and 34, Township 22 North, Range 9 East, W.M., and consisting of approximately 477 acres, of which approximately 358 acres will receive ecological thinning treatment under the principles and procedures described in the Cedar River Watershed Habitat Conservation Plan (HCP), which contract may provide for the sale and removal of merchantable logs down as a result of such ecological thinning. A public hearing having been held, the logs resulting from the ecological thinning project authorized by this ordinance are hereby declared to be surplus to the City's needs. The Director of Seattle Public Utilities is further authorized to conduct all related monitoring, surveys, and other such activities as may be required by the City's commitments in the HCP and by applicable permit requirements.

Section 2. All proceeds from the sale of logs authorized by Section 1 of this ordinance shall be deposited in the Water Fund (43000) and further dedicated for the exclusive purpose of offsetting the costs of implementing the HCP, including the projects, programs and activities

described in the HCP documents and those that educate the public about them.

Section 3. Any act taken pursuant to the authority and prior to the effective date of this ordinance is hereby ratified and confirmed.

Section 4. This ordinance shall take effect and be in force thirty (30) days from and after its approval by the Mayor, but if not approved and returned by the Mayor within ten (10) days after presentation, it shall take effect as provided by Municipal Code Section 1.04.020.

Passed by the City Council the ____ day of _____, 2005, and signed by me in open session in authentication of its passage this _____ day of _____, 2005.

_____

President _____of the City Council

Approved by me this ____ day of _____, 2005.

_____

Gregory J. Nickels, Mayor

Filed by me this ____ day of _____, 2005.

_____

City Clerk

3/7/05

version #3

Fiscal Note

Appendix IX
Implementation Contract

SEATTLE PUBLIC UTILITIES

CEDAR RIVER MUNICIPAL WATERSHED

700 ROAD FOREST HABITAT

RESTORATION SERVICE CONTRACT

CONTRACT NO. 0000001777

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DRAFT

SEATTLE PUBLIC UTILITIES

700 ROAD FOREST HABITAT RESTORATION

SERVICE CONTRACT

Seattle Public Utilities, having advertised a contract, at which the Contractor was the successful bidder; and the parties hereto desiring to record their agreement; now therefore,

In consideration of the premises and promises hereinafter contained, unless provided otherwise herein, Seattle Public Utilities, hereinafter referred to as the "City," agrees to sell and permit _____, hereinafter referred to as the "Contractor," to cut, remove, and purchase designated trees.

This contract consists of the following seven sections: A - General Terms, B - Roads, C – Payments and Securities, D - Watershed Security and Protection, E – Log Definitions and Accountability, F – Operations, G – Damages; and the following six schedules: A - Project Map, B - Watershed Access and Water Quality Regulations, C – Volume Estimates, D – Unit Prescriptions, E – Plan of Operations, and F – Haul Route Map.

THIS CONTRACT SETS FORTH THE ENTIRE TERMS AND CONDITIONS. NO OTHER DOCUMENT, COMMERCIAL CONTRACT, ACCEPTANCE OR ACKNOWLEDGEMENT SHALL BE EFFECTIVE OR BINDING UPON THE CITY OF SEATTLE UNLESS EXPRESSLY AGREED TO IN WRITING BY THE UNDERSIGNED SCIENCE, SUSTAINABILITY AND WATERSHEDS BRANCH EXECUTIVE.

It WITNESS WHEREOF, the Parties hereto have executed this contract as of the ___ day of _____, 2006.
Authorized by Ordinance No. **121793**

THE CITY OF SEATTLE

By _____
Nancy Ahern
Seattle Public Utilities, Science, Sustainability and Watersheds Branch Executive

CONTRACTOR

By _____

Printed Name: Michael Archambault, Sr.

Title: President, A&R Cable Thinning, Inc.

INTRODUCTION

A. PURPOSE

This contract is being issued by authorization of the City of Seattle through Ordinance Number: **121793**, passed **May 2nd, 2005,** by the Seattle City Council and signed by the Mayor on **May 10th,2005**.

The Cedar River Municipal Watershed (CRMW) is owned and managed by the City of Seattle as a municipal water supply that serves approximately 1.3 million people in the Seattle metropolitan area. The watershed is currently managed under a 50-year Habitat Conservation Plan (HCP), which was approved in 2000. "The overall goal of the HCP is to implement conservation strategies designed to protect and restore habitats of all species of concern that may be affected by the facilities and operations of the City of Seattle on the Cedar River, while allowing the City to continue to provide high quality drinking water and reasonably priced electricity to the region." (CRW-HCP: 2.4-43).

The watershed is being managed as an ecological reserve using an ecosystem approach, with the goals of protecting and restoring aquatic, riparian, and forest habitats. No timber harvest for commercial purposes may be conducted under the HCP. However, HCP forest habitat restoration program calls for silvicultural manipulations, including thinning and planting, which will be employed to achieve ecological objectives including:

1) accelerate the development of old forest characteristics,
2) provide wildlife habitat for targeted species, and
3) enhance natural biological diversity.

The **700 Road Forest Habitat Restoration Project** is the second ecological thinning project to be planned and implemented under the HCP forest habitat restoration program. This project involves thinning **338** acres, creating gaps and snags, retaining skips and increasing the amount of down wood on the forest floor in order to meet the ecological objectives that include:

1) maintaining or increasing the growth rate of trees,
2) increasing plant species diversity and facilitating understory development,
3) increasing forest structural complexity,
4) creating and facilitating maintenance and recruitment of large-diameter snags and down wood, and
5) protecting special habitats and water quality.

The project planning team has determined that more trees will be thinned than need to be retained as down wood on the site, so a portion of the trees will be removed and sold while others will be cut and left on the ground. The Seattle City Council has authorized this removal and sale of trees from the project area via Ordinance 121793. The planning process and ordinance passage relied upon extensive public involvement, including scientific experts, tribes and representatives of the environmental community. Given City Council authority, the City may now implement the 700 Road project and is therefore advertising this service contract.

B. DESCRIPTION OF SERVICES

The services to be provided by the Contractor/s, all subject to the specifications within this contract, include the following three bid items:

> **Bid item #1. Ecologically thin approximately 140 acres of conifer in units E1a, E1b, E1c, E3, E5 and E6 using hand-felling methods <u>and</u> purchase and remove said conifer using cable yarding methods.**
>
> **Bid item #2. Ecologically thin approximately 93 acres of conifer in unit E2 using mechanized harvesters or hand-felling methods <u>and</u> purchase and remove approximately 90 acres of said conifer using cable <u>or</u> forwarding yarding methods. Approximately 3 acres of this unit is to be cut and left on the ground within a riparian management zone.**
>
> **Bid item #3. Cut-and-leave certain prescribed trees using hand-felling methods on approximately 105 acres of conifer in units E4, E7, E8, and E9.**

All services required under this contract are at the Contractor's own expense. **Title to the trees designated for cutting and removal, as specified in Schedule D - *Unit Prescriptions*, passes to the Contractor when said trees are cut and shall be paid for at the contract price as stated in Section A-2, *Products Sold*.** Title to trees that are cut outside the specifications in *Schedule D – Unit Prescriptions* remains with the City. Contractor bears the risk of loss or damage to, and has an insurable interest in said cut trees designated for removal. In the event any said cut trees designated for removal are destroyed, damaged, or stolen, whether the cause is foreseeable or unforeseeable, the trees shall be paid for by Contractor at the contract price. Violation of this contract shall have no effect on this provision. Title to the trees cut but not removed from the contract area within the time specified in this contract shall revert to the City.

The following sections outline the specific terms and requirements for the Contractor to perform the above mentioned services.

<u>SECTION A. GENERAL TERMS.</u>

A-1. DEFINITIONS

1. City: This refers to the City of Seattle, State of Washington, United States of America.

2. Contractor: This refers to the successful "bidder" who is awarded a service contract authorizing the purchase and removal of surplus trees from City land within the Cedar River Watershed.

3. CA: This refers to the City's Contract Administrator.

4. Parties: Refers to both the City and Contractor and includes all officers, employees, and agents (including all subcontractors and consultants), and invitees of both the City and the Contractor.

5. Bidders: Refers to the respondents who submit bids for this service contract.

6. Director: Refers to the Director, Watershed Services Division, Seattle Public Utilities. This is the person responsible for all management activities within the Cedar River Watershed.

7. Executive Director: Refers to the Director of the Science, Sustainability and Watersheds Branch of Seattle Public Utilities and is the direct supervisor of the Director, Watershed Services Division.

A-2. PRODUCTS SOLD.
Estimated volume for bid item 1 is 1,419 tons of second growth conifer and hardwood.
Estimated volume for bid item 2 is 1,144 tons of second growth conifer.

These volume estimates are based on the City's contract cruise of the project area by Atterbury Consultants and Atterbury's projections of volumes to be removed based on the prescriptions for each unit. These projections were then revised by City staff to reflect changes to the original prescriptions and additional volume included in yarding corridors. Refer to *Schedule C - Volume Estimates* for a more detailed description of volume estimates. The maximum amount of volume authorized to be sold under this contract by City of Seattle Ordinance Number 121793 is 2.8 million board feet. If, during the exercising of this contract, the volume removed by the Contractor/s reaches the maximum allowable volume, then all cutting and yarding shall cease. The City and the Contractor shall cooperate closely on monitoring volume removal throughout the course of this contract. The conversion factor under this contract for converting "MBF" (thousand board feet) to tons shall be 8 tons per thousand board feet.

A-3. CONTRACT AREA AND OPERATING AUTHORITY.
Surplus trees removed from the contract area are located within all or portions of Sections 27, 28, 33, and 34 of T.22 N., R. 9 E., Willamette Meridian. The contract area includes 338 acres, of which, approximately 108 acres are to be treated by cutting and leaving the trees on the ground and 230 acres that are to be thinned with the cut trees removed. Refer to *Schedule A* for a map of the project area and the individual units.

The City hereby agrees to sell and permit the Contractor to cut and remove certain trees designated for removal under the terms and specifications of this contract and as specifically describe in *Schedule D- Unit Prescriptions,* and *Schedule E – Plan of Operations.*

A-4. COMPLIANCE WITH ALL LAWS.
The Contractor shall comply with all statutes, regulations, laws, and permits that apply to this contract. While within the Cedar River Watershed, the Contractor and its employees, representatives, and subcontractors shall engage only in those activities expressly authorized by this contract.

A-5. WATERSHED ACCESS.
This contract serves as authority to access City property. Access is subject to the *Cedar Access Permit System*, *Schedule B - Watershed Access and Water Quality Control Regulations and Section D-9, Watershed Security Alerts*. Access to the watershed under the auspices of this contract for any other purpose is not allowed.

A-6 INSPECTION BY CONTRACTOR.
Contractor has had the opportunity to inspect the trees and contract area and enters into this contract in reliance on Contractor's own estimate of volume and value and not by reason of any representation by the City, including reliance upon the City's volume estimates.

A-7. CONTRACT PERIOD.
The Contractor shall begin work as agreed upon in *Schedule E – Operations Plan*, item *OP-4, Operations Schedule and Production Rate* and upon receipt of written notice to proceed from the City. The City will acknowledge in writing when work is complete. **Contractor shall remove the trees conveyed and complete all required work prior to November 30th, 2007.**

A-8. CONTRACT TERM ADJUSTMENT.

The Contractor may request an adjustment in the contract term. Such requests shall be submitted in writing, must be received by the City within 30 days after the start of interruption or delay, and must indicate the actual or anticipated length of interruption or delay. The City will grant the adjustment if the cause for contract term adjustment is beyond the Contractor's control as determined by the City, or if the City deems an extension to be in its best interest.

A-9. CONTRACT AREA ADJUSTMENT.
The City and the Contractor may agree to modify contract unit boundaries. Trees that are added as a result from any modification of boundaries shall become a part of this contract and shall be paid for at the contract rate. The Contractor shall not be required to pay for any trees that may be excluded as a result of modification to boundaries.

A-10. TREE ADJUSTMENT.
Any trees not designated for removal that must be removed in the course of operations shall be approved and designated by the CA upon the Contractor's request. Added trees shall be paid for at the contract payment rate. If the added trees or harvesting conditions are significantly different from those originally appraised by the City, the City shall determine new rates.

The City and the Contractor agree that in some cases, certain trees designated for removal may need to be left for protection purposes such as to prevent damage to adjacent trees or to protect other resources. No compensation shall be required by the City in this case.

A-11. WARRANTIES.
The City does not warrant any of the following:

a. The merchantability of the trees.

b. The condition of the trees. The trees are conveyed "as is".

c. The estimated volume, quality, or grade of the trees. The description of the trees conveyed in this agreement is an estimate only, made for the sole purpose of identification.

e. Items which extend beyond the description of the face of this contract.

A-12. LIMITATION ON DAMAGES.
In the event of a breach of any warranty by the City, the liability of the City shall be limited to a return of the initial deposit, unapplied payment, and credit for unamortized improvements made by the Contractor. The City shall not be liable for damages, whether direct or consequential.

A-13. SCOPE OF CITY ADVICE.
No advice by the City regarding the method or manner of performing shall constitute a representation or warranty that the result of such method or manner will conform to the contract, or create any liability to the City because of such advice.

A-14. RESPONSIBILITY FOR WORK.
All work, equipment and materials necessary to perform this contract shall be the responsibility of the Contractor. Any damage to improvements such as, but not limited to: roads, bridges, fences, gates or power lines, except as provided in *A-15, Exceptions,* shall be repaired promptly to the satisfaction of the City at the Contractor's expense during the contract period unless an operating release has been issued.

A- 15. EXCEPTIONS.
Exceptions to the Contractor's responsibility in *A-14, Responsibility for Work*, shall be limited exclusively to the following. These exceptions shall not apply should damages occur due to Contractor's failure to take reasonable precautions or to exercise sound harvesting practices.

a. The City shall bear the cost to repair any existing roadway or section of required road completed to the point that an authorization to haul has been issued where such damage was not caused by the contractor, its employees, agents, or invitees, including independent contractors.

b. The City shall repair any part of the required roads that suffer catastrophic damage. Catastrophic damage is defined as damage resulting from earthquakes, volcanic eruptions, landslides, and floods. If no additional haul routes are available following catastrophic damage, the City makes no guarantees as to the scheduling of repairs but does guarantee that a haul route will be reestablished within a reasonable time period of time.

The above exceptions shall not apply should damages occur because of the Contractor's failure to take reasonable precautions or to exercise sound practices. Nothing contained in *A-15 (Exceptions)*, shall be construed as relieving the Contractor of responsibility for, or damage resulting from, the Contractor's operations or negligence, nor shall the Contractor be relieved from full responsibility for completing any work or furnishing any materials necessary to effect repair of said damage.

A-16. INDEMNIFICATION
Except as limited below, the Contractor shall indemnify and hold harmless the City from all costs, claims, actions, liability, and damages of any nature arising out of the Contractor's negligence in connection with this contract or the Contractor's violation of any of the terms or conditions of this contract. Notwithstanding the foregoing, the Contractor shall be liable to the City for all costs, claims, actions, liability, and damages of any nature arising out of the Contractor's violation of any of the restrictions in this contract without regard to whether the Contractor is negligent.

Except as limited below or expressly provided for elsewhere in this contract, the Contractor shall release the City from all liability for additional compensation, loss or damage to the Contractor arising out of the Contractor's use of or presence upon the roads or other areas covered by this contract.

Except as limited below, if a claim or legal action is asserted or brought against the Contractor and the City, the Contractor shall pay any and all reasonable legal expense that the City shall incur in connection with such claim or action. The City shall have sole discretion to select the attorney (s) to provide its defense; however, the Contractor is liable to pay for such legal expenses only to the extent they are reasonable.

Except as limited below, the Contractor shall pay all reasonable legal expenses that the City may incur in prosecution of any claim or legal action to enforce any and all provisions of this contract, including this indemnification and release, if the City "substantially prevails" in such claim or action or if the case is settled. Whether the City "substantially prevails" shall be determined based on the standards established by the federal courts under 15 U.S.C –26. Such determination shall be deemed to arise under the jurisdiction of the United States District Court for the Western District of Washington. In any litigation between the City and the Contractor in connection with this contract, the City shall not be obligated to pay any legal expenses of the Contractor unless required to do so by Washington law and the City's claim or defense in question was frivolous and asserted in bad faith.

The terms of the indemnification and release herein provided shall not apply to the extent any liability for loss or damage is caused by the sole negligence of the City. In such case, the Contractor shall not be obligated to pay the

City the portion of the City's liability and legal expenses which corresponds to the degree of negligence attributed to the City; however, the Contractor shall be obligated to pay the City the portion of the City's liability and legal expenses which corresponds to the degree of negligence or liability, if strict liability, attributed to the Contractor.

The terms of the indemnification and release herein provided shall not apply to the extent that any liability, loss, cost, and/or damage herein covered results from the gross negligence or willful misconduct of the City.

As to the City only, the Contractor waives any immunity under industrial insurance, Title 51 RCW, it may have to claim brought against it by the City in connection with this contract.

The City and the Contractor specifically agree that this contract does not contemplate or anticipate that the Contractor shall recover lost profits or damages for any other work that the Contractor may not perform as a result of any breach by the City of this Contract or other act or omission of the City in connection with this contract.

The term "legal expenses" as used in this provision shall include, but not be limited to, reasonable attorney fees, paralegal and legal support staff expenses, costs of arbitration, mediation, expert witnesses, exhibits, reasonable investigations, and reimbursement for all time, expense and overhead of all City personnel, employees, or consultants assisting in the defense of legal action or in responding to or investigating a claim or demand.

A-17. NOTICES.

All notices required under this contract must be given within the time required. Failure to provide timely notice shall bar the Contractor from obtaining additional compensation or damages from the City. Prejudice to the City shall be deemed to have occurred as result of the failure to give a timely notice without the need for additional proof.

No waiver of timely notice requirements or any other requirement or right of the City under this contract, including this provision, shall be found, unless such waiver is in writing, is given by the Director of Watershed Services Division, and is expressly stated to be a waiver.

Notices required to be given under the following clauses shall be in writing and shall be delivered to the Party's authorized agent or sent by certified mail to the Party's post office address:

Violation of Contract (A-23)
Suspension of Operations (A-24)

The address to be used for mailing to the City will be Director, Watershed Services Division, Seattle Public Utilities, 19901 Cedar Falls Road S.E., North Bend, Washington 98045. The address to be used for mailing to the Contractor will be:

_____.

All other notices required to be given under this contract shall be in writing and delivered to the authorized agents or mailed to the party's post office address. The Contractor agrees to notify the City of any change of address.

A-18. INSURANCE REQUIREMENTS.

A. General

1. Prior to undertaking any Work under this Contract, the Contractor shall file with the City acceptable evidence of insurance as specified herein. The term "insurance" herein shall be deemed to include "self-insurance."

2. Failure of the Contractor to fully comply with the insurance requirements herein will be considered a material breach of Contract and, at the option of the City, will be cause for such action as may be available to the City under other provisions of the Contract or otherwise in law, including immediate termination of the Contract.

3. The cost of furnishing insurance shall be incidental to and included in the Bid item prices Bid by the Contractor for the various Bid items of Work listed in the Bid Form.

B. Required Coverages and Limits of Liability

1. COMMERCIAL GENERAL LIABILITY ("CGL") insurance, including:
   a. Premises/Operations (including Mobile Equipment coverage)
   b. Products/Completed Operations
   c. Contractual
   d. Independent Contractors
   e. Stop Gap/Employers Liability

   The minimum limits of liability shall be not less than $1,000,000 each occurrence combined single limit bodily injury and property damage ("CSL BI/PD") except $1,000,000 each accident/each employee with respect to Stop Gap/Employers Liability. If the Work includes excavation of soils or the demolition of any structure below grade, CGL insurance may not exclude perils of explosion, collapse, underground property damage, subsidence or similar perils.

2. AUTOMOBILE LIABILITY insurance, including coverage for owned, non-owned, leased or hired vehicles designed for travel on public roads. The minimum limits of liability shall be not less than $1,000,000 CSL BI/PD. If the Work requires the transportation of pollutants, ISO endorsement CA 99 48 and the MCS 90 endorsement are required.

3. EXCESS/UMBRELLA LIABILITY insurance if required to increase the CGL and Automobile Liability total minimum limits of liability to $2,000,000 CSL BI/PD.

4. WATERCRAFT LIABILITY insurance, including coverage for owned and non-owned watercraft as required if utilized in the performance of the Work. The minimum limits of liability shall be not less than $1,000,000 CSL BI/PD.

5. WORKER'S COMPENSATION insurance for industrial injury to the Contractor's employees in accordance with the provisions of Title 51 of the Revised Code of Washington ("RCW"). The Contractor shall, in addition, be responsible for ensuring that Workers' Compensation Insurance is in force for all employees of any subcontractor of any tier that provides services under the Contract. Additionally, if the Contract requires working, or the use of watercraft, on or around a navigable waterway, the Contractor shall, as it shall be legally required, provide evidence of United States Longshoremen's and Harbor Workers' (USL&H) coverage and coverage for Jones Act (Marine Employers Liability) in compliance with federal statutes. If the Contractor is qualified as a self-insurer in accordance with RCW 51.14, Contractor shall so certify to the City by submitting a letter signed by a corporate officer and shall furnish additional information as the City may require.

6. POLLUTION LIABILITY insurance if the Work involves remediation, abatement, disposal, transporting or other handling any pollutant. The minimum limits of liability shall be not less than $1,000,000 each claim.

7. RAILROAD PROTECTIVE LIABILITY insurance as required by any railroad.

THE LIMITS OF LIABILITY STATED HEREIN ARE MINIMUM LIMITS OF LIABILITY ONLY. THEY EXPRESSLY SHALL NOT BE INTERPRETED TO LIMIT THE LIABILITY OF THE CONTRACTOR OR THAT OF ANY OF ITS INSURERS OR SELF-INSURERS.

C. Conditions (Not Applicable to Insurance Procured under Title 51 RCW)

1. The insurance shall be subject to approval by the City as to company, form and coverage.
2. Insurers shall be:
   a. Licensed to do business in the State of Washington and having a current A.M. Best's rating of not less than A- and Financial Size category VII, or
   b. Filed as surplus lines by a Washington licensed surplus line broker, or
   c. As may otherwise be approved by the City;
3. Insurance shall:
   a. Be maintained in full force and effect through the Physical Completion Date;
   b. Protect the City of Seattle within the policy limits from losses, claims, actions, damages, and expenses arising out or resulting from the Contractor's performance or lack of performance under this Contract;
   c. Except for Workers Compensation, include the City of Seattle as an additional insured for primary and non-contributory limits of liability subject to a separation of insureds clause. Such additional insured status shall extend to the full limits of liability maintained by the Contractor under all its insurance and/or self-insurance programs, whether such coverage is primary, excess, contingent or otherwise.
   d. Not be cancelled until after thirty (30) days written notice has been delivered to the City, except ten (10) days written notice as respects cancellation for non-payment of premium, unless a forty-five (45) day notice period is specified in RCW 48.18.290 ("Cancellation by insurer).
4. If any portions of the Work are subcontracted by the Contractor, the subcontractor may provide the insurance required under its subcontracted scope of work PROVIDED THAT the Contractor require, in its written agreement with the subcontractor, that the subcontractor comply with the requirements under this **Section A-18 INSURANCE REQUIREMENTS**.
5. Claims Made Forms

   If any policy required by this **Section A-18 INSURANCE REQUIREMENTS** is written on a claims made form, the retroactive date shall be prior to or coincident with the effective date of this Contract. The Contractor shall maintain the claim made form coverage continuously in force for a minimum of three (3) years following the Completion Date of the Contract and shall annually provide the City with evidence of renewal coverage. If renewal of the claims made form of coverage becomes unavailable or economically prohibitive, in lieu thereof the Contractor shall purchase an extended reporting period ("Tail") that shall run at least through the Completion Date, or execute another form of guarantee acceptable to the City to assure financial responsibility of liability for services performed.
6. Deductibles and Self-Insured Retentions

   If the Contractor's insurance contains any deductible or self-insured retention, the Contractor shall cause such deductible or self-insured retention to be clearly disclosed on the evidence of insurance. The Contractor shall provide such information as the City may require to assess the Contractor's financial risk bearing capacity. The Contractor shall be responsible for payment of such deductible or self-insured retention. The City reserves the right to reject any insurance policy with a deductible or self-insured retention for which the Contractor's financial risk bearing capacity cannot be demonstrated to the satisfaction of the City. If the Contractor maintains a self-insured retention, it shall separately issue a letter to the City that states that it will protect the City of Seattle under its self-insured retention as if a commercial insurance policy with additional insured status were in force and provide detailed information as to where a tender of claim should be directed.

7. Subcontractors

The City does not exercise any control over whether the Contractor subcontracts Work or with whom it may subcontract any such Work. The Contractor's insurers shall cover the liability of subcontractors of any tier. In addition, the Contractor shall, wherever feasible, require its subcontractors to include the City of Seattle as an additional insured under CGL, Automobile liability and, where required, Watercraft liability and Pollution liability for primary and noncontributory limits of liability.

D. Evidence of Insurance (Not Applicable to Statutory Washington State Workers Compensation Insurance Procured under Title 51 RCW)

1. Evidence of insurance shall be submitted to the City with the signed Contract. It shall be comprised of certification of insurance with a description of coverages, limits of liability and conditions in sufficient detail to demonstrate compliance with **Section A-18 INSURANCE REQUIREMENTS** and
   a. As respects CGL insurance, certification shall specifically include a copy of the actual designated additional insured endorsement or blanket additional insured policy wording that documents that "The City of Seattle" is an additional insured for primary and non-contributory limits of liability. If such additional insured endorsement or policy wording does not clearly and unambiguously specify that additional insured status is for primary and noncontributory limits of liability, additional endorsement or policy wording documenting this must be attached.
   b. As respects all coverages, documentation is required that notice of cancellation will not take effect until after thirty (30) days written notice has been delivered or mailed to the City of Seattle, except ten (10) days written notice as respects cancellation for non-payment of premium, unless a forty-five (45) days notice period is specified in RCW 48.18.290 ("Cancellation by insurer).

2. The certificate holder shall be:

The City of Seattle
Attn: Amy Labarge
19901 Cedar Falls Road SE
North Bend, WA 98045
Fax: (206) 233-1527

A copy shall be sent either by facsimile to (206) 470-1279 or as an email attachment to riskmanagement@Seattle.com . When sent electronically, the sender adopts the document received by the City of Seattle as a duplicate original and adopts the signature on the transmitted copy as the sender's certifying authorized representative's original signature.

E. [RESERVED]

A-19. AGENTS.

The City's rights and duties will be exercised by **Nancy Ahern, Executive Director of Seattle Public Utilities, Science, Sustainability and Watersheds Branch, at:**

700 5th Ave., Suite 4900; PO Box 34018; Seattle, WA 98124-4018

The Director will be responsible for administering the contract and will notify the Contractor in writing who will be the City Contract Administrator (CA) of record. Only the Director has the authority to waive, modify, or amend the

terms of this contract. Only the Executive Director has the authority to bind the City to any affirmation, representation or warranty concerning the trees conveyed beyond the terms of this contract

The Contractor is required to have a person on site during all operations who is authorized to receive instructions and notices from the City. The Contractor shall inform the City in writing who is authorized to receive instructions and notices from the City, and any limits to this person's authority.

A-20. ASSIGNMENT.
No rights or interest in this contract shall be assigned to another party by the Contractor without prior written permission of the City. Any attempted assignment shall be void and ineffective for all purposes unless made in conformity with this paragraph. Contractor may perform any duty through a delegate, but the Contractor is not thereby relieved of any duty to perform, or any liability for violation. Any assignee or delegate shall be bound by the terms of this contract.

A-21. MODIFICATIONS.
Waivers, modification or amendments of the terms of this contract shall be invalid and without legal effect if not in writing and signed by the Contractor and the City.

A-22. CONTRACT COMPLETE.
This contract is the final expression of the Parties' agreement. There are no understandings, agreements, or representations expressed or implied, which are not specified in this contract.

A-23. VIOLATION OF CONTRACT.

a. If the Contractor violates any provision of this contract, the CA will issue a written violation notice and may suspend operations. If the Contractor fails to remedy the violation within a timeframe determined by the CA, the City may terminate the rights of the Contractor under this contract.

b. If the contract expires pursuant to *A-7 Contract Period*, without the Contractor having performed all its duties under this contract, the Contractor's right to operate terminates and the Contractor shall not have the right to remedy the violation. This provision shall not relieve the Contractor of any payment obligations hereunder.

c. The City has the right to remedy the violation in the absence of any indicated attempt by the Contractor or if the Contractor is unable to do so, as determined by the City. Any expense incurred by the City in remedying a violation shall be charged to the Contractor and shall be paid by the Contractor to the City within thirty days of receipt of billing.

c. If the Contractor's violation is a result of a failure to make a payment for charges when due, in addition to the application of provisions of a. and b. above, a late fee shall accrue on the unpaid balance at a rate of 12 percent per annum computed on a daily basis until paid.

A-24. SUSPENSION OF OPERATIONS
The CA may immediately suspend any Contractor operations under this contract, when in the opinion of the City, the City would suffer damage if the operation were allowed to continue. Such suspension notice shall be in writing stating the cause of the suspension.

The Contractor shall be in violation of this contract if the operation continues after the suspension notice or if the operation resumes without prior written approval from the City.

The Contractor may request a modification of a suspension within 30 days of the start of suspension through the dispute resolution process under clause *A-26 Contract Right of Dispute Resolution.* If this process results in a finding that the suspension exceeded the time reasonably necessary to stop or prevent damage to the City, the Contractor is entitled to a contract term adjustment under clause *A-8 Contract Term Adjustment*, for the actual interruption or delay in operations caused by the excessive suspension.

A-25. UNAUTHORIZED ACTIVITY.
Any cutting, removal, or damage of trees by the Contractor or the Contractor's delegate or agent inconsistent with the terms of this contract, including *Schedule D - Unit Prescriptions*, or State law is unauthorized. Such activity may subject the Contractor to liability triple the appraised value of the trees, as determined by the City, of said trees, and result in criminal prosecution.

A-26. CONTRACTOR RIGHT OF DISPUTE RESOLUTION.
The following procedures apply in the event of a dispute regarding interpretation or administration of the contract.

a. In the event of a dispute, the Contractor must make a written request for resolution to the Director prior to seeking other relief. The request for resolution must be received by the Director no later than thirty days after the circumstances giving rise to this dispute have occurred. The Director may at his/her sole discretion extend the time for filing a request for resolution and such extension must be in writing and signed by the Director.

b. The Director will issue a written decision on the Contractor's request within 15 working days.

c. If the Contractor is not satisfied with the Director's decision, the Contractor may, within 15 working days of receipt of the Director's decision, make a written request for resolution to the **Executive Director, at 710 Second Avenue, Seattle, Washington 98104.**

d. Unless otherwise agreed, a conference will be held within 15 working days of the receipt by the Executive Director of Contractor's request. The Contractor and the Director will have the opportunity to present their positions to the Executive Director. The Executive Director will issue a resolution within 15 working days of the conference, which shall be the final resolution of the dispute.

This dispute resolution procedure must be followed prior to commencement of legal action under this contract, and failure to comply with this procedure shall bar any legal action under this contract.

A-27. CONTRACT RELEASE.
A contracting release is a written document, signed by the City and the Contractor, indicating that the Contractor has been relieved of certain rights or responsibilities with regard to the entire or a portion of the contract. Upon issuance of an entire contract release, all Contractor's rights under this contract shall expire.

A-28. PRE-WORK MEETING, SITE VISIT AND DEVELOPMENT OF OPERATIONS PLAN
The City and the Contractor shall meet to review this contract, examine the contract area and develop *Schedule E – Operations Plan* before beginning any operations. The final Operations Plan shall be signed by the Contractor and the City and shall become a part of this contract. If the City and the Contractor cannot agree upon a mutually acceptable Operations Plan, the City reserves the right to terminate this contract.

A-29. ANTI-LOBBYING
All firms are hereby placed on formal notice that no City employees are to be lobbied, either individually or collectively, concerning this project. Firms and their agents who intend to submit qualifications, or have submitted qualifications, for this project are hereby placed on formal notice that they are not to contact City personnel for such purposes as holding meetings of introduction, meals, or meetings relating to the selection process outside of those specifically scheduled by the City for negotiations. Any such lobbying activities may cause immediate disqualification for this project.

A-30. ANTI-COLLUSION
No Bidder will divulge, discuss or compare their quote with other Bidders and will not collude with any other Bidder or party. Note: No premiums, rebates or gratuities to any employee or agent are permitted, with, prior to, or after any delivery of materials. Any such violation will result in the cancellation and/or return of material (as applicable) and the removal from the Bidders list.

A-31. INDEPENDENT CONTRACTOR.
It is the intention and understanding of the Parties that Contractor shall be an independent contractor and that City shall be neither liable for nor obligated to pay sick leave, vacation pay or any other benefit of employment, nor to pay any social security or other tax that may arise as an incident of employment. The Contractor shall pay all income and other taxes as due. Industrial or other insurance that is purchased for the benefit of the Contractor shall not be deemed to convert this Contract to an employment contract. It is recognized that Contractor may or will be performing work during the term for other parties and that the City is not the exclusive user of the services that Contractor provides.

A-32. INSPECTION.
The Work shall be subject, at all times, to inspection by and with approval of the City, but the making (or failure or delay in making) such inspection or approval shall not relieve Contractor of responsibility for performance of the Work in accordance with this Contract, notwithstanding the City's knowledge of defective or noncomplying performance, its substantiality or the ease of its discovery. Contractor shall provide sufficient, safe, and proper facilities and equipment for such inspection and free access to such facilities.

A-33. PERFORMANCE.
Acceptance by the City of unsatisfactory performance with or without objection or reservation shall not waive the right to claim damage for breach, or terminate the contract, nor constitute a waiver of requirements for satisfactory performance of any obligation remaining to be performed by Contractor.

A-34. LICENSES AND SIMILAR AUTHORIZATIONS
Contractor, at no expense to the City, shall secure and maintain in full force and effect during the term of this Contract all required licenses, permits, and similar legal authorizations, and comply with all requirements thereof.

A-35. AFFIRMATIVE EFFORTS FOR UTILIZATION OF WOMEN AND MINORITY SUBCONTRACTING AND EMPLOYMENT
Contractor shall utilize affirmative efforts to promote and encourage participation by women and minority businesses on subcontracting opportunities within the Contract scope of work. Contractor agrees to such efforts as a condition of the contract. Affirmative efforts shall include those that have been agreed upon between the City and the Contractor as a result of the Contractor proposal response.

Record-Keeping: Contractor shall maintain, for at least 12 months after the expiration or earlier termination of this Contract, relevant records and information necessary to document Contractor affirmative efforts to achieve women

and minority business participation, including solicitations to subcontractors and suppliers, all subcontractor and supplier proposals received, and all subcontractors and suppliers actually utilized under this Contract. The City shall have the right to inspect and copy such records.

Contractor shall ensure that all employees, particularly supervisors, are aware of, and adhere to their obligation to maintain a working environment free from discriminatory conduct, including but not limited to harassment and intimidation of minorities, women, or WMBE businesses.

Non-Discrimination: Contractor shall not create barriers to open and fair opportunities for WMBEs to participate in any City contract and to obtain or compete for contracts and subcontracts as sources of supplies, equipment, construction and services.

Sanctions for Violation: Any violation of the mandatory requirements of the provisions of this section, or a violation of SMC Ch. 14.04, SMC Ch. 14.10, SMC Ch. 20.45, or other local, state or federal non-discrimination laws, shall be a material breach of contract for which the Contractor may be subject to damages and sanctions provided for by the Contract and by applicable law. Contractors in violation of this shall be subject to debarment from City contracting activities in accordance with SMC Ch. 20.70.

A-36. EQUAL EMPLOYMENT OPPORTUNITY AND OUTREACH.

Contractor shall not discriminate against any employee or applicant for employment because of race, religion, creed, age, color, sex, marital status, sexual orientation, gender identity, political ideology, ancestry, national origin, or the presence of any sensory, mental or physical handicap, unless based upon a bona fide occupational qualification. Contractor shall take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their creed, religion, race, age, color, sex, national origin, marital status, political ideology, ancestry, sexual orientation, gender identity, or the presence of any sensory, mental or physical handicap. Such action shall include, but not be limited to the following: employment, upgrading, promotion, demotion, or transfer; recruitment or recruitment advertising, layoff or termination, rates of pay, or other forms of compensation and selection for training, including apprenticeship. The Contractor shall post in conspicuous places, available to employees and applicants for employment, notices as provided by the City setting forth the provisions of this nondiscrimination clause.

Contractor shall furnish to the Director of Executive Administration (or his/her designee), upon request and on such form as may be provided therefore, a report of the affirmative action taken by the Contractor in implementing the requirements of this section, and will permit access to the Contractor's records of employment, employment advertisements, application forms, other pertinent data and records requested by the Director of Executive Administration for the purposes of investigation to determine compliance with the requirements of this section.

If, upon investigation, the Director of Executive Administration finds probable cause to believe that the Contractor has failed to comply with any of the requirements of this section, the Contractor shall be so notified in writing. The Director of Executive Administration shall give the Contractor an opportunity to be heard, after ten calendar days' notice. If, after the Contractor's opportunity to be heard, the Director of Executive Administration still finds probable cause, he/she may suspend the Contract and/or withhold any funds due or to become due to the Contractor, pending compliance by the Contractor with the requirements of this section.

A-37. EQUAL BENEFITS.

Compliance with SMC Ch. 20.45: The Contractor shall comply with the requirements of SMC Ch. 20.45 and Equal Benefits Program Rules implementing such requirements, under which the Contractor is obligated to provide the same or equivalent benefits ("equal benefits") to its employees with domestic partners as the Contractor provides to its employees with spouses. At the City's request, the Contractor shall provide complete information and verification of the Contractor's compliance with SMC Ch. 20.45. Failure to cooperate with such a request shall constitute a material breach of this Contract. (For further information about SMC Ch. 20.45 and the Equal Benefits Program Rules call (206) 684-0430 or review information at: http://cityofseattle.net/contract/equalbenefits/

Remedies for Violations of SMC Ch. 20.45: Any violation of this Section shall be a material breach of Contract for which the City may:

a. Require Contractor to pay actual damages for each day that the Contractor is in violation of SMC Ch. 20.45 during the term of the Contract; or
b. Terminate the Contract; or
c. Disqualify Contractor from bidding on or being awarded a City contract for a period of up to five (5) years; or
d. Impose such other remedies as specifically provided for in SMC Ch. 20.45 and the Equal Benefits Program Rules promulgated thereunder.

A-38. AMERICAN WITH DISABILITIES ACT

Contractor shall comply with all applicable provisions of the Americans with Disabilities Act of 1990 (ADA) in performing its obligations under this Contract. In particular, if the Contractor is providing services, programs or activities to City employees or members of the public as part of this Contract, the Contractor shall not deny participation or the benefits of such services, programs, or activities, to people with disabilities on the basis of such disability. Failure to comply with the provisions of the ADA shall be a material breach of, and grounds for the immediate termination of, this Contract.

A-39. AUDIT

Upon request, Contractor shall permit the City, and any other governmental agency involved in the funding of the Work ("Agency"), to inspect and audit all pertinent books and records of Contractor, any subcontractor, or any other person or entity that performed work in connection with or related to the Work, at any and all times deemed necessary by the City or Agency, including up to six years after the final payment or release of withheld amounts has been made under this Contract. Such inspection and audit shall occur in King County, Washington or other such reasonable location as the City or Agency selects. The Contractor shall supply the City with, or shall permit the City to make, a copy of any books and records and any portion thereof. The Contractor shall ensure that such inspection, audit and copying right of the City and Agency is a condition of any subcontract, agreement or other arrangement under which any other person or entity is permitted to perform work under this Contract.

A-40. CONTRACTUAL RELATIONSHIP

The relationship of Contractor to the City by reason of this Contract shall be that of an independent contractor. This Contract does not authorize Contractor to act as the agent or legal representative of the City for any purpose whatsoever. Contractor is not granted any express or implied right or authority to assume or create any obligation or responsibility on behalf of or in the name of the City or to bind the City in any manner or thing whatsoever.

A-41. SUPERVISION AND COORDINATION.
Contractor shall:

- Competently and efficiently, supervise and direct the implementation and completion of all contract requirements specified herein.
- Designate in its bid or proposal to the City, a representative(s) with the authority to legally commit Contractor's firm. All communications given or received from the Contractor's representative shall be binding on the Contractor.
- Promote and offer to Purchasers only those materials, equipment and/or services as stated herein and allowed for by contractual requirements. Violation of this condition will be grounds for contract termination.

A-42. INTELLECTUAL PROPERTY RIGHTS.
Patents: Contractor hereby assigns to the City all rights in any invention, improvement, or discovery, together with all related information, including but not limited to, designs, specifications, data, patent rights and findings developed in connection with the performance of Contract or any subcontract hereunder. Notwithstanding the above, the Contractor does not convey to the City, nor does the City obtain, any right to any document or material utilized by Contractor that was created or produced separate from this Contract or was preexisting material (not already owned by the City), provided that the Contractor has clearly identified in writing such material as preexisting prior to commencement of the Work. To the extent that preexisting materials are incorporated into the Work, the Contractor grants the City an irrevocable, non-exclusive right and/or license to use, execute, reproduce, display, and transfer the preexisting material, but only as an inseparable part of the Work.

Copyrights: For materials and documents prepared by Contractor in connection with the Work, Contractor shall retain the copyright (including the right of reuse) whether or not the Work is completed. Contractor grants to the City a non-exclusive, irrevocable, unlimited, royalty-free license to use every document and all other materials prepared by the Contractor for the City under this Contract. If requested by the City, a copy of all drawing, prints, plans, field notes, reports, documents, files, input materials, output materials, the media upon which they are located (including cards, tapes, discs and other storage facilities), software programs or packages (including source code or codes, object codes, upgrades, revisions, modifications, and any related materials) and/or any other related documents or materials which are developed solely for, and paid for by, the City in connection with the performance of the Work, shall be promptly delivered to the City.

The City may make and retain copies of such documents for its information and reference in connection with their use on the project. The Contractor does not represent or warrant that such documents are suitable for reuse by the City, or others, on extensions of the project, or on any other project.

A-43. PROPRIETARY AND CONFIDENTIAL INFORMATION.
The parties agree that they will not permit the duplication or disclosure of any information designated in advance by the other party as "Confidential and Proprietary" to any person (other than its own employee, agent, or representative who must have such information for the performance of that party's obligations hereunder) unless such duplication, use or disclosure is specifically authorized in writing by the other party or is required by law. "Confidential and Proprietary" information does not include ideas, concepts, know-how or techniques related to information that, at the time of disclosure, is in the public domain unless the entry of that information into the public domain is a result of any breach of this Contract. Likewise, "Confidential and Proprietary" information does not apply to information that is independently developed, already possessed without obligation of confidentiality, or rightfully obtained from a third party without an obligation of confidentiality.

Contractor's Understanding and Obligations

1. Contractor understands that any records (including but not limited to bid or proposal submittals, the Contract, and any other contract materials) it submits to the City, or that are used by the City even if the Contractor possesses the records, are public records under Washington State law, RCW Chapter 42.17. Public records must be promptly disclosed upon request unless a statute exempts them from disclosure. Contractor also understands that even if part of a record is exempt from disclosure, the rest of that record generally must be disclosed.

2. Contractor must separate and clearly mark as "proprietary" information all records related to this Contract or the performance of this Contract that the Contractor believes are exempt from disclosure. Contractor is to be familiar with potentially-applicable public-disclosure exemptions and the limits of those exemptions, and will mark as "proprietary" only information that the Contractor believes legitimately fits within an exemption.

3. If the City notifies the Contractor of a public disclosure request, and the Contractor believes records are exempt from disclosure, it is the Contractor responsibility to make a determination and pursue a lawsuit under RCW 42.17.330 to enjoin disclosure. The Contractor must obtain the injunction and serve it on the City before the close of business on the tenth business day after the City sent notification to the Contractor. It is the Contractor's discretionary decision whether to file the lawsuit.

4. If Contractor does not timely obtain and serve an injunction, the Contractor is deemed to have authorized releasing the record.

5. Notwithstanding the above, the Contractor must not take any action that would affect (a) the City's ability to use goods and services provided under this Contract or (b) the Contractor's obligations under this Contract.

6. Contractor will fully cooperate with the City in identifying and assembling records in case of any public disclosure request.

City's Obligations

1. City will disclose those parts of records the Contractor has marked as "proprietary information" only to authorized persons unless: (a) City discloses the records in response to a public disclosure request or (b) the Contractor has given the City express advance written permission to disclose the records. "Authorized persons" means those City officers, employees, contractors and consultants for whom the proprietary information is necessary to perform their duties or obligations to the City. The term "proprietary information" does not include ideas, concepts, know-how or techniques related to any information that, at the time of disclosure, is in the public domain, unless the entry of that information into the public domain is a result of a breach of this Contract.

2. If the City receives a public disclosure request for records that Contractor has marked as "proprietary information", the City may promptly notify the Contractor of the request. The City may postpone disclosing these records for ten business days after it has sent notification to the Contractor, in order to allow the Contractor to file a lawsuit under RCW 42.17.330 to enjoin disclosure. It is the Contractor's discretionary decision whether to file the lawsuit.

3. If the City has notified Contractor of a public disclosure request, and the Contractor has not obtained an injunction and served the City with that injunction by the close of business on the tenth business day after the City sent notice, the City may disclose the record.

4. The City has no other obligations concerning records the Contractor has marked as "proprietary information" under this Contract. The City has no obligation to claim any exemption from disclosure. The City is not obligated or liable to the Contractor for any records that the City releases in compliance with this Section.

A-44. TERMINATION.

a. For Cause: The City may terminate this Contract if the Contractor is in material breach of any of the terms of this Contract, and such breach has not been corrected to the City's reasonable satisfaction in a timely manner.

b. For The City's Convenience: The City may terminate this Contract at any time, without cause and for any reason including the City's convenience, upon written notice to the Contractor.

c. Nonappropriation of Funds: The City may terminate this Contract at any time without notice due to nonappropriation of funds, whether such funds are local, state or federal grants.

d. Acts of Insolvency: The City may terminate this Contract by written notice to Contractor if the Contractor becomes insolvent, makes a general assignment for the benefit of creditors, suffers or permits the appointment of a receiver for its business or assets, becomes subject to any proceeding under any bankruptcy or insolvency law whether domestic or foreign, or is wound up or liquidated, voluntarily or otherwise.

e. Notice: Notice of termination pursuant to this section shall be given by the party terminating this Contract to the other not less than five (5) business days prior to the effective date of termination.

f. Actions Upon Termination: In the event of termination not the fault of the Contractor, the Contractor shall be paid for the services properly performed prior to termination, together with any reimbursable expenses then due, but in no event shall such compensation exceed the maximum compensation to be paid under the Contract. The Contractor agrees that this payment shall fully and adequately compensate the Contractor and all subcontractors for all profits, costs, expenses, losses, liabilities, damages, taxes, and charges of any kind whatsoever (whether foreseen or unforeseen) attributable to the termination of this Contract. Upon termination for any reason, the Contractor shall provide the City with the most current design documents, contract documents, writings and other product it has completed to the date of termination, along with copies of all project-related correspondence and similar items. The City shall have the same rights to use these materials as if termination had not occurred; provided, however, that the City shall indemnify and hold the Contractor harmless from any claims, losses or damages to the extent caused by modifications made by the City to the Contractor's work product.

g. Termination for Gratuities: Notwithstanding items above, the City may, by written notice to Contractor, terminate Contractor's right to proceed under this Contract upon one (1) calendar day's notice, if the City finds that any gratuity in the form of entertainment, a gift, or otherwise, was offered to or given by the Contractor or any agent therefore to any City official, officer or employee.

A-45. FORCE MAJEURE; SUSPENSION AND TERMINATION

In the event that either party is unable to perform any of its material obligations under this Agreement because of a natural disaster or action or decree of a superior governmental body (hereinafter referred to as a "Force Majeure Event" or "Event"), the party that has been so affected immediately shall give notice to the other party and shall do everything possible to resume performance.

Upon receipt of such notice, the affected party shall be excused from such performance as is affected by the Force Majeure Event for the period of such Event; but if the period of the non-performance exceeds fifteen (15) days from

the date of the other party's receipt of the notice of the Force Majeure Event, the party that has not had its ability to perform so affected may terminate this Agreement by giving written notice of termination to the party suffering from the effect of the Event. If such Event affects the delivery date or warranty provisions of this Agreement, such date or warranty period shall automatically be extended for a period equal to the duration of such Event.

A-46. DEBARMENT:

In accordance with SMC Ch. 20.70, the Director of Executive Administration or designee may debar a Vendor from entering into a Contract with the City or from acting as a subcontractor on any Contract with the City for up to five years after determining that any of the following reasons exist:

a. Contractor has received overall performance evaluations of deficient, inadequate, or substandard performance on three or more City Contracts.

b. Contractor failed to comply with City ordinances or Contract terms, including but not limited to, ordinance or Contract terms relating to small business utilization, discrimination, prevailing wage requirements, equal benefits, or apprentice utilization.

c. Contractor abandoned, surrendered, or failed to complete or to perform work on or in connection with a City Contract.

d. Contractor failed to comply with Contract provisions, including but not limited to quality of workmanship, timeliness of performance, and safety standards.

e. Contractor submitted false or intentionally misleading documents, reports, invoices, or other statements to the City in connection with a Contract.

f. Contractor colluded with another contractor to restrain competition.

g. Contractor committed fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a Contract for the City or any other government entity.

h. Contractor failed to cooperate in a City debarment investigation.

i. Contractor failed to comply with SMC 14.04, SMC Ch. 14.10, SMC Ch. 20.42, or SMC Ch. 20.45, or other local, State, or federal non-discrimination laws.

The Director may issue an Order of Debarment after adhering to the procedures specified in SMC 20.70.050. The rights and remedies of the City under these provisions are in addition to any other rights and remedies provided by law or under the Contract.

A-47. USE OF RECYCLED CONTENT PAPER

Contractors are to duplex all materials that are prepared for the City under this Contract, whether such materials are printed or copied, except when impracticable to do so due to the nature of the product being produced. Contractors are to use 100% post consumer recycled content, chlorine-free paper in such products that are produced for the City, whenever practicable, and to use other paper-saving and recycling measures in business they conduct with and for the City. This directive is executed under the Mayor's Executive Order, issued February 13, 2005.

A-48. WORKERS RIGHT TO KNOW.

"Right to Know" legislation required the Department of Labor and Industries to establish a program to make employers and employees more aware of the hazardous substances in their work environment. WAC 296-62-054 requires among other things that all manufacturers/distributors of hazardous substances, including any of the items listed on this ITB, RFP or contract bid and subsequent award, must include with each delivery completed Material Safety Data Sheets (MSDS) for each hazardous material. Additionally, each container of hazardous material must

be appropriately labeled with: the identity of the hazardous material, appropriate hazardous warnings, and the Name and Address of the chemical manufacturer, improper, or other responsible party.

Labor and Industries may levy appropriate fines against employers for noncompliance and agencies may withhold payment pending receipt of a legible copy of the MSDS. OSHA Form 20 is not acceptable in lieu of this requirement unless it is modified to include appropriate information relative to "carcinogenic ingredients: and "routes of entry" of the product(s) in question.

A-49. MISCELLANEOUS PROVISIONS.

a. Amendments: No modification of this Contract shall be effective unless in writing and signed by an authorized representative of each of the parties hereto.

b. Conflict: In the event of conflict between contract documents and applicable laws, codes, ordinances or regulations, the most stringent or legally binding requirement shall govern and be considered a part of this contract to afford City the maximum benefits.

c. Liens, Claims and Encumbrances: All materials, equipment, or services shall be free of all liens, claims or encumbrances of any kind and if the City requests a formal release of same shall be delivered to the City.

d. Binding Contract: This Contract shall not be binding until signed by both parties. The provisions, covenants and conditions in this Contract shall bind the parties, their legal heirs, representatives, successors, and assigns.

e. Applicable Law/Venue: This Contract shall be construed and interpreted in accordance with the laws of the State of Washington. The venue of any action brought hereunder shall be in the Superior Court for King County.

f. Remedies Cumulative: Rights under this Contract are cumulative and nonexclusive of any other remedy at law or in equity.

g. Captions: All titles, including sections or subsections, are for convenience only and do not define or limit the contents.

h. Severability: Any term or provision of this Contract found to be prohibited by law shall be ineffective to the extent of such prohibition without invalidating the remainder of the Contract.

SECTION B. USE OF CITY ROADS

B-1. ROAD USE AUTHORITY.

The Contractor is authorized to use the following City roads for transporting forest products, heavy equipment, and personnel:
Cedar Falls Road from Circle Gate to 101 Gate
Road 101
Road 100
Road 200
Road 300

Road 100/300
Road 700
Road 700a

Refer to the maps in *Schedule A and Schedule F* for locations of roads that are permitted for use under this contract.

B-2. HAUL ROUTES
Refer to item *B-1 Road Use Authority* and *Schedule F – Haul Routes* for designated haul routes. Access to the watershed for all Contractor vehicles and log trucks will be through Gate 101 at Cedar Falls. This gate is accessed from Interstate 90, exit 32, and Cedar Falls Road SE in North Bend. The primary haul route inside the watershed follows roads 101, 100, 200, 300 and 700. An alternate haul route will be used during periods of possible road maintenance or unanticipated repair to Road 200. This route follows roads 101, 100, 100/300, 300, and 700. This route is approximately 5 miles longer. For maintenance responsibility, refer to *Section F-8, Haul Road Betterment and Maintenance.*

B-3. ROAD USE RESERVATION.
The City shall have the right to use all existing roads on City land and extend such rights to others.

SECTION C. PAYMENTS AND SECURITIES

C-1. PAYMENT FOR TREES AND SERVICES.
Contractor agrees to pay the City the following rate per ton for the trees conveyed under this contract:

BID ITEM #1 All conifer species $ 4.11 per ton

BID ITEM #2 All conifer species $ 6.21 per ton

Contractor requires the following rate to be paid by the City for "Cut-and-Leave services:

BID ITEM #3 $ 198.30 /acre

C-2. CONTRACTOR'S GUARANTEE OF PAYMENT.
Contractor will pay for trees prior to cutting or will guarantee payment by posting an approved payment security. The amount of cash or payment security shall be determined by the City and shall equal or exceed the value of the trees to be cut over a one month period. The amount of advance payments will be determined once the contractor has been selected and *Schedule E - Operations Plan* is finalized and becomes part of this contract. The Operations Plan establishes the estimated rate of volume to be cut by the Contractor. If the Contractor cuts more timber than what is allowed for by the advance payment or payment security, the Contractor will be in violation of the contract. All unsecured timber falling and yarding or hauling shall cease until payment is made. If payment is not received within ten days following a violation, the Contractor will be in default of this contract and lose all rights provided for under this contract. Payment security shall remain in force until all weight receipts have been accounted for and the final billing has been determined by the City.

C-3. BILLING PROCEDURE.

The City will compute and forward to the Contractor statements of charges on a 30-day billing cycle. Refer to *Section E-5, City Approval of Log Weighing Facilities* for required submittal of weight receipts and load ticket receipts. Payments shall be delivered on or before the date shown on the billing statement to the following address:

Watershed Services Division Division
Seattle Public Utilities
19901 Cedar Falls Road S.E.
North Bend, WA 98045
Attention: Amy LaBarge

C-4. PAYMENT ACCOUNT REFUND.
Advance payments remaining on account above the value for the charges shall be returned to the Contractor within 30 days following the final report of charges. Refunds not made within the 30-day period will accrue interest equal to 12 percent per annum computed on a daily basis until paid.

C-5. PAYMENT FOR TREES OR OTHER FOREST PRODUCTS DESTROYED, DAMAGED, STOLEN.
Trees or other forest products which are destroyed, damaged, or stolen shall be paid for by Contractor on demand of the City. If no rate is fixed for a particular forest product, the appraised value will be determined by the City. Such activity may subject the Contractor to liability for triple the appraised value, as determined by the City, of said trees and may result in prosecution.

C-6. CONTRACT BOND.
Concurrent with the execution of this Contract, Contractor shall furnish to the RFP Coordinator, a contract bond (payment and performance) or Letter of Credit in the amount of **$30,000 (thirty-thousand dollars).** Contractor shall be named as Principal and the City shall be named as Obligee.

The Bond or Letter of Credit ("instrument") shall be conditioned upon full performance of all obligations imposed upon the Contractor in this Contract, including payment for any damages caused by operations for the required contract term.

The instrument shall be subject to approval by the City Attorney as to company, form and sufficiency of surety. If the instrument is found by the City Attorney to be flawed, the Contractor must correct the flaw within twelve (12) working days after the date of written notification to the Contractor that the bond is flawed or this Contract shall be terminated.

The Bond must be executed by a company that is included in the U. S. Department of the Treasury's Listing of Approved Sureties (Circular 570), and is included on the Washington State Insurance Commissioner's Authorized Insurance Company List.

The Letter of Credit must be executed by a Banking Institution that has a current Moody's rating of B or better.

C-7. CONTRACT BOND REDUCTION
The City may reduce the performance security after an operating release has been issued if the City determines that adequate security exists for any remaining obligations of Contractor.

C-8. TAXES.
Contractor shall be responsible for payment of all taxes or fees associated with the harvesting of the trees conveyed in this contract. The City, upon execution of this contract, will notify the State Department of Revenue of the

conveyance of trees under this contract by submitting a "Disposition Certification for Export Restricted Timber"(form REV 62 0084e-1)

C-9. OTHER DEPOSITS.
There shall be a $100.00 (one hundred dollar) deposit for each branding hammer issued to the Contractor by the City.

SECTION D. WATERSHED PROTECTION

D-1. ENVIRONMENTAL PROTECTION.
Contractor acknowledges and agrees that this project is in the Cedar River Municipal Watershed which provides drinking water to over 1.3 million customers and will take all precautions to protect the City's water supply. In addition, the Contractor agrees to conduct all operations in accord with the provisions, terms and conditions of *Schedule B - Cedar River Municipal Watershed Access, Water Quality and Control Regulations* attached to and made part of this contract. Any person found to be in violation of these regulations or other water protection measures provided for under this contract, at the City's option, may be barred from conducting business in the watershed or gaining access.

D-2. EQUIPMENT WASHES
To minimize the introduction of invasive alien organisms, all heavy equipment, log trucks, utility and passenger vehicles, shall be pressure washed or steam cleaned, including undercarriage, and inspected by designated SPU personnel prior to initial entry into the watershed . If any equipment or vehicle leaves the watershed and returns after running off-pavement (asphalt or concrete), that equipment and vehicle shall again be pressure washed or steam cleaned, including undercarriage, and inspected by designated SPU personnel prior to re-entry into the watershed.

D-3. SANITATION.
The Contractor shall provide commercial sanitary facilities and litter containers for the contract area. Sanitary facilities and servicing is subject to the requirements in *Section II* of *Schedule B* of this contract. Sanitary facilities shall be in a location that is easily accessible and convenient to all employees, delegates or others having authority to be within the contract area. These facilities shall be maintained and made available during all phases of the operation, including but not limited to the felling portion of the operation. All refuse, including petroleum products resulting from this operation shall be removed from the watershed concurrently with the completion of each setting or operating area. "Refuse" as referred to in this clause does not include logging slash. Failure to comply with the above requirements shall constitute a violation of this contract and is a violation of *Section IV* of the Cedar River Municipal Watershed Access, Water Quality and Control Regulations.

D-4. PREVENTION OF OIL SPILLS.
All operations shall comply with *Section II*, *Hazardous Materials* in the Cedar River Municipal Watershed Access, Water Quality and Control Regulations. In addition, operations shall be conducted in such a manner as to prevent the discharge of hazardous materials, including petroleum products, into water or air or onto ground. All containers of oil or oil products kept in the watershed, including tanks or containers in vehicles shall be kept in a condition that ensures that contamination of the soil or ground cover does not occur. ***All equipment shall be maintained in a condition that limits leakage of fluids***. Equipment maintenance activities, such as oil changes, shall be undertaken so that no oil or other hazardous materials reach the ground. Normal maintenance and refueling shall be carried out with oil absorbent pads, as described below, deployed at the service or fueling locations.

Contractor shall maintain at all loading sites and on all mobile machinery, a sufficient quantity of absorbent pads capable of effectively absorbing oils, hazardous liquids, hydrocarbons, organic solvents, mineral and vegetable oil spills. Minimum sheet size of these pads shall be no less than 34" x 38" x 3/8". All road crossings over flowing or non-flowing streams shall be equipped with absorbent booms stored in waterproof and animal proof containers and clearly marked with a sign showing their location. Minimum size of these booms shall be 5" x 5" x 10' double booms. A minimum of four double booms per stream crossing is required.

No hazardous or solid waste shall be disposed of by abandonment, burial, or burning on City land. In the event of a spill, prompt action shall be taken to deploy absorbent pads and contain spills. Contaminated pads, any contaminated soil, and any hazardous or solid waste shall be promptly removed from the watershed and disposed of at a legally acceptable location. Proof of such disposal shall be provided to the City. Any such spill shall be immediately reported to the Watershed Services Division Office at Cedar Falls, the Department of Ecology and the Contract Administrator.

D-5. FIRE PREVENTION.

The Contractor shall comply with all State and County fire regulations, the City's fire regulations in *Schedule B - Watershed Access, Water Quality and Control Regulations*, and the following additional requirement:

Operations During Periods of Low Humidity

It shall be the responsibility of the Contractor to maintain on site, in good working condition, a sling psychrometer and appropriate tables to convert readings taken to establish relative humidity. When relative humidity drops below 40%, the Contractor shall record hourly relative humidity readings and provide these recordings to the City upon request. When relative humidity drops to 30% or lower within the contract area, all operations must cease unless authority to continue is granted by the CA in writing. If, in the opinion of the City, the combination of fuel moisture levels, wind speed and relative humidity above 30% represent an increased fire risk, the City may require operations to shutdown. The Contractor shall bear responsibility for confirming the daily fire precaution levels for the 659N shutdown zone and adjusting operations according to the daily fire precaution level regulations.

D-6. PROTECTION OF CULTURAL RESOURCES.

The Cedar River Watershed has long history of human habitation dating back at least 9,000 years. Remains and artifacts of pre-historic and historic use are scattered throughout the watershed. If an object or site is 50 years old or older, it is protected by local, State and Federal laws. Protecting cultural resources is very important to the City of Seattle and the living descendants of former watershed inhabitants.

Contractors are required to protect cultural resources. Under no circumstances are contractors permitted to disturb or remove cultural resources. Examples of older cultural resources may include artifacts such as tools, fragments of rocks left behind from the fabrication of tools, or culturally modified trees such as cedar trees that show signs of bark peeling. Examples of more recent cultural resources may include past homestead debris such as buildings and foundation remains, wells, woodstoves, bedframes, garbage and garbage piles or pits. Other objects could be associated with railroads and logging such as old camp sites, remains of trestles, rails, ties and spikes, steam donkeys, cables, saws, or dump sites.

In the event the City or the Contractor discover prehistoric or historic sites of at least 50 years old in the project area, the Contractor shall immediately stop all operations that could potentially disturb the site, promptly flag the site for future reference, and notify the CA. The City may unilaterally modify or cancel this contract to protect an area, site, or object.

In the event of contract modification under this Clause *(D-6, Protection of Cultural Resources)*, the Contractor shall be reimbursed for any additional work or extra work required for the protection of identified site or objects as

required by the City. Amount of reimbursement shall be determined by the City and shall be in the form of a reduction in contract payments unless agreed otherwise in writing.

Intentional destruction, disturbance, or the removal of any cultural resources is a breech of this contract. If the Contractor deliberately disturbs or destroys any cultural resources, the Contractor shall bear costs of restoration, provided that such payment shall not relieve Contractor from civil or criminal remedies otherwise provided by law.

Before operations commence, the Contractor and all employees of the Contractor are required to read and sign a copy of the City's Cultural Resource Protection Form.

D-7. PROTECTION OF HABITAT OF ENDANGERED, THREATENED, AND SENSITIVE SPECIES.
The Contractor shall take appropriate measures to protect any location that becomes known where special measures are needed for the protection of plants or animals listed or under consideration to be listed as threatened or endangered under the Endangered Species Act of 1973, as amended, or under state law, or identified to be sensitive by the City. Discovery and/or knowledge of such locations by either party shall be promptly reported to the other party.

In the event of contract modification under this *Clause D-7 (Protection of Habitat of Endangered, Threatened, and Sensitive Species)*, Contractor shall be reimbursed for any additional work or extra protection required for the protection of habitat of endangered, threatened, and sensitive species, as required by the City. Amount of reimbursement shall be determined by the City and shall be in the form of a reduction in contract payment rates unless agreed otherwise in writing.

Contractor shall protect all known and identified areas needing special measures for the protection of plants or animals listed or potentially available to be listed as threatened or endangered under the Endangered Species Act of 1973, as amended, or as sensitive to the City, against destruction, obliteration, removal or damage during Contractor's operations. Contractor shall bear costs of restoration, provided that such payment shall not relieve Contractor from civil or criminal remedies otherwise provided by law.

D-8. PRESERVATION OF MARKERS.
Any legal land subdivision survey corners and witness objects are to be preserved. If such are destroyed or disturbed, Contractor shall, at own expense, have a licensed land surveyor re-establish them.

D-9. WATERSHED SECURITY AND HOMELAND SECURITY ADVISORY SYSTEM
The Cedar River Watershed is subject to various levels of homeland security threats and regulates its management activities accordingly. The City reserves the right to restrict access to the Contractor and Contractor personnel when the City deems such security threats warrant this action.

SECTION E. LOG DEFINITIONS AND ACCOUNTABILITY.

E-1. MERCHANTABLE LOGS.
Any trees that are designated for cutting and removal under this contract that, at minimum, contain10 board feet net scale (typically 5 inches scaling diameter and 12 feet in length) are considered merchantable and shall be removed and weighed unless waived by the City. The City may treat failure to utilize and remove merchantable material left on the contract area as a violation of this contract. At the City's option, merchantable material that is left on the contract area may be scaled and converted to weight by the City or a third party scaling organization and billed to the Contractor at the contract payment rate. All costs associated with the scaling and computing the billing will be borne by the Contractor.

Logs not meeting the lowest sawmill grades shall be left in place.

E-2. BRANDS.
Each end of logs ten inches or larger in diameter will be branded with log brands, furnished by the City, at the time logs are yarded to the landing. Both ends of all logs will be painted with durable red paint at the time logs are yarded to the landing.

E-3. LOAD TICKETS.
Contractor shall complete and use load tickets as directed by the Contract Administrator. Load tickets, furnished by the City, must be fixed to each log load prior to leaving the landing.

E-4. LOAD RECEIPT BOOKS.
Contractor shall maintain a written record of all log loads using a load receipt book, furnished by the City. A copy of the load receipt must be kept in the cab of each log truck and returned to the City along with the corresponding weight receipt. Contractor shall account for all load receipt books issued by the Contract Administrator. Each load receipt book must be returned to the Contract Administrator upon completion.

In addition to maintaining load receipt books, the Contractor is required to maintain a truck load register, tracking the load ticket number, number of logs, date, time, destination, and truck number or driver's name, for each loaded truck that leaves the loading site. Log trucks leaving the loading area without a properly completed load receipt is a violation of this contract and may result in termination of this contract. The Contractor shall pay the City $1,500 (one thousand five-hundred dollars) for any loaded log truck found leaving the loading area without a properly completed load ticket receipt.

E-5. LOST LOADS
The City will treat load ticket receipts not accounted for as lost loads unless the City receives the corresponding weight receipts. The Contractor shall pay for the value of lost loads in addition to costs associated with computing the billing for lost loads**. The value of lost loads will be based on the contract bid price per ton x 1.25 x 35 (thirty-five) tons.**

E-6. CITY APPROVAL OF LOG WEIGHING FACILITIES.
The weighing facilities must be approved by the City prior to logs being hauled. Scales must be state certified. The City reserves the right to verify load weight, at City expense, and revoke previously authorized weighing facilities. **Contractor must provide the City with copies of each weight receipt along with the corresponding load ticket receipts within 7 days of the date on each load ticket receipt. Costs for weighing will be paid by the Contractor and paid directly to the approved weighing facility.**

E-7. LOG EXPORT RESTRICTIONS.
All logs being removed under this contract are export restricted. Contractor shall adhere to all laws and regulations currently in effect or applicable to the sale of public timber. Contractor shall be responsible for completing and filing with the State of Washington, Department of Revenue, all forms required under *Chapter 240-15 WAC LOG EXPORT RESTRICTIONS* for the harvesting of export restricted timber.

SECTION F. OPERATIONS.

Refer to *Schedule E - Operations Plan* for specific operational provisions and requirements, as agreed upon between the City and the Contractor as part of the pre-work meeting and site visit and *Schedule D – Unit Prescriptions for other operational references and requirements.*

F-1. OPERATOR CERTIFICATION AND COMPLIANCE MONITORING

Prior to Contractor commencing full operations, the CA will certify all harvester and chain saw operators as to their ability to follow thinning prescriptions and operational guidelines in *Schedule D - Unit Prescriptions, Schedule E – Plan of Operations, and Section F – Operations,* by following the process outlined below.

a. The CA shall mark leave trees in a limited area of the contract area and/or explain the thinning prescriptions to the operator.

b. The operator shall then thin trees in a predetermined area outside the marked area and be evaluated by the CA as to having met the prescriptions and operational guidelines. If the CA determines that requirements in Schedules D and F were adequately met, then the operator will be certified.

c. If the CA finds that the prescriptions and/or operational guidelines were not met by the operator, the CA shall explain the prescriptions and guidelines again and reevaluate the operator on an additional predetermined area. If the CA finds that the prescriptions and operational guidelines were now met by the operator, the CA shall certify the operator.

d. If the CA finds the operator unable to follow the thinning prescriptions or operational guidelines, the operator shall not be allowed to perform the prescription activities. Only certified operators shall be allowed to fall trees in the contract area.

Throughout project implementation, the CA shall monitor the compliance of the thinning operation with the individual unit prescriptions in *Schedule D* and notify the operator of deviations from the prescriptions. The CA shall work with the operator to correct the deviation and/or suggest changes to meet the prescriptions. If the operator continues to deviate from the prescriptions the CA shall stop the operation and declare the contractor out of compliance. Compliance threshold for stand density is 10% (ten percent) for the prescribed targets of trees per acre and basal area, and 20% (twenty percent) for area of small skips and gaps located by the operator.

F-2. LANDINGS

a. Landings shall be located on existing roads and shall be approved by the CA prior to use.

b. Landing debris shall be disposed of as specified in *Schedule E – Operations Plan.*

c. At landing locations, road surfaces and ditches shall be restored to their original condition once log decks have been removed .

F-3. HARVESTING EQUIPMENT

a. Yarding

All units requiring yarding under this contract shall be cable yarded with the exception of Unit E-2. In Unit E-2, the Contractor may use cable yarding **or** forwarders. The types of cable yarding equipment and forwarders to be used is subject to City approval.

b. Felling and Processing

a. Hand felling is required in all units with the exception of unit E2. On slopes less than 40% in unit E2, mechanized harvesting is permitted.. Mechanized harvesters are subject to City approval.

b. Stump heights shall not exceed 12 inches unless base of tree is obstructed.

c. Trees that are hand-felled must be topped and limbed prior to yarding.

No equipment is permitted to operate within 30 feet of any stream channel, or in areas devoid of trees, wetlands, or areas with plants such as devils club or skunk cabbage which indicate wet soil conditions.

Operations shall be suspended during periods of wet weather or wet soil conditions when rutting occurs.

F-4. YARDING REQUIREMENTS

a. Cable and processor yarding corridor widths shall conform to the specifications in *Schedule D – Unit Prescriptions* and *Schedule E – Operations Plan.* Cable and processor yarding corridors shall be flagged and approved by the CA prior to felling operations.

b. Placement of cable and processor yarding corridors should avoid trees outside the thinning pool whenever possible.

c. One-end suspension of logs is required for all yarding operations except through stream corridors where full-suspension of logs is required. Stream corridors are measured to the outer edge of the bankfull width, or channel migration zone, whichever is greater.

d. Trees within the thinning pool that are designated for cutting along yarding corridors shall be left standing as rub trees until all tributary volume to the trail or corridor has been removed. If trees within the thinning pool are designated as leave trees and are used as rub trees, comparable trees shall be left in their place. If it is necessary to use trees outside the thinning pool as rub trees, these trees shall be protected from damage and shall not be cut. If these trees are damaged, as specified in *F-9, Damage to leave trees,* the Contractor, at Contractor's expense, agrees to recruit these for future snags by topping at heights specified by the CA.

e. Operators shall make every effort to minimize damage to all small, non-merchantable trees outside of yarding corridors. Particular attention shall be given to minor species such as hardwoods (including vine maple), cedars, pacific yew and true firs.

F-5. CUT-TO-LEAVE UNIT REQUIREMENTS

If the Contractor's work includes bid item # 3, the felling of trees in cut-to-leave units, tree felling shall conform to the specifications in *Schedule D – Unit Prescriptions,* and *Schedule E – Operations Plan.*

F-6. RIDGE TRAIL CLEAN-UP

Trees along the ridge trail, as identified in *Schedule A – Project Map,* shall be directionally felled away from the trail to provide pedestrian access for future monitoring. If trees must be felled across the trail for safety reasons, these trees shall be bucked as directed by the CA.

F-7. BLOCKING OF ROADS

Blocking of roads during felling, yarding and loading operations is permitted. Roads must be passable at the end of each day when operations have ceased unless the CA grants permission to allow a road to remain blocked for an

extended period. The Contractor shall use safety warning signs on all roads leading into active operation sites and notify the CA in advance of any road blockages.

F-8. HAUL ROAD BETTERMENT AND MAINTENANCE.

There is no haul road betterment required by the contractor under this contract. Normal routine road maintenance will be the responsibility of the City**.** Any special maintenance or repair required due to the Contractor's operations will be the responsibility of the Contractor. Special maintenance includes any repairs required due to Contractor operations. This includes repairs of any rutting or other damage to road surfaces, damage to ditches, culverts, bridges, gates, signs or any other road improvements. All limbs and non-merchantable material must be removed from roads and the clearing limits of roads. No material shall be left in ditches. Material may be deposited outside the clearing-limits. Road and roadside clean-up shall be kept current with operations.

Prior to any seasonal shutdowns, the Contractor shall inspect all culverts and ditches and remove all logging related debris as directed by the CA.

F-9. SOIL DAMAGE

Soil damage consists of soil disturbance and soil compaction. Soil damage is defined as areas that have exposed mineral soil resulting from the use of heavy equipment. Excess soil damage exists when more than **10% of any unit** has soil damage. Landings are exempt from soil damage calculations. Excess soil damage constitutes a violation of this contract. Soil damage will be measured using grid based transects. When the CA determines excess soil damage exists, operations on the setting will be shutdown. Excess soil damage shall be paid for by Contractor using twice the rate of the percent that exceeds the limit of damage x the bid price. This value will be added to the bid price and applied to the estimated area and tonnage for the setting in violation. Area will be determined using a G.P.S. and tonnage will be derived from the project appraisal. Operations may resume when the Contractor and the City agree upon a plan that will bring operations back into compliance. The Contractor may be required to install waterbar and/ or apply grass seed and straw to disturbed areas as directed by the CA. Seed and straw mix will be provided by the City.

F-10. DAMAGE TO LEAVE TREES

Damage to leave trees within ground-based, and flat or uphill cable yarding **settings** shall not exceed **10%** of leave trees. Damage to leave trees within downhill cable **settings** shall not exceed **15%** of the leave trees. Damage to a leave tree exists if any of the following are present:

a. the cambium is exposed in excess of **30 square inches** or,
b. more than 1/3 of the circumference of a leave tree's root system have been injured from severing or cambium exposure or,
c. the live crown ratio has been reduced from damage to below 30% or,
d. a leave treetop has been broken.

The City shall consider damage to small sub-merchantable trees as being unavoidable in some cases due to operational feasibility and safety. In these cases, damage to these trees will not be included in the overall damage surveys. Because the City considers these small trees to be an important component of future forest structure, the Contractor shall make every effort to minimize damage to these small sized trees.

The value of damaged leave trees in excess of the percentages stated above shall be paid for by the Contractor at the rate of $250.00 (two-hundred and fifty dollars) per tree.

F-11. SNAG RECRUITMENT

Trees that are damaged, as defined in *F-9* above, shall be girdled or topped as directed by the CA for the purpose of snag recruitment.

F-12. OPEATIONAL SAFETY

a. The Contractor shall post safety warning signs on all roads leading into active operation sites.

b. Vehicle speed on all watershed roads shall not exceed 25 m.p.h. unless otherwise posted.

c. All Contractor vehicles shall travel with lights on at all times.

d. All Contractor log trucks and oversized loads shall use CB radios for the transmission of their location while driving on all watershed roads.

F-13. DAMAGE TO CITY PROPERTY

Any damage to City property resulting from the Contractor's operations shall be repaired by the Contractor at Contractor's expense. Damage includes, but is not limited to, rutting, erosion along yarding corridors or skid trails, any damage to roads and associated road improvements, cultural resource sites, riparian zones, streams or wetlands.

F-14. EQUIPMENT LEFT ON CITY LAND.

All equipment owned or in the possession of the Contractor or its delegates shall be removed from the contract area and other City land by the termination date of this contract or upon written notice by the City to the Contractor. Equipment remaining unclaimed on City land 30 days after the expiration of the contract period or following notification by the City is subject to disposition as provided by law. The Contractor shall pay to the City all costs of moving, storing and disposing of such equipment. The City shall not be responsible for any damages to or loss of the equipment or damage caused by the moving, storage or disposal of the equipment.

SECTION G. DAMAGES

G-1. LIQUIDATED DAMAGES.

This clause provides for payments by Contractor to the City for certain violations of the terms of this contract. These payments are agreed to as liquidated damages and not as penalties. They are reasonable estimates of anticipated harm to the City caused by Contractor's violation due to the difficulty of proving loss and the inconvenience or non-feasibility of obtaining an adequate remedy. They also recognize Contractor's need for more certainty in assessing its responsibilities under this contract.

Contractor's failure to pay for all of the trees sold in this agreement prior to the expiration of Contractor's operating authority results in substantial injury to the City. The value of the trees sold at the time of violation is not readily ascertainable. Contractor's failure to perform disrupts the City's management plans, the actual cost of which is difficult to assess. A re-contract involves additional time and expense and is not an adequate remedy. Therefore, Contractor agrees to pay the City as liquidated damages a sum calculated using the following formula:

LD =.35V-ID-R+C+A

Where:

LD = Liquidated Damage value.

V = Bid Value remaining at the date of violation of contract, which is the unpaid portion of the contract bid price.

ID = Initial Deposit paid at date of contract that has not been applied to timber payments.

R = Unamortized value of roads constructed based on City's appraised value of cost for roads built but not utilized by Contractor prior to violation of Contract

C = Charges assessed for contract requirements completed prior to violation of contract but not paid for.

A= Administrative Fee = $_2,500_

In no event shall the liquidated damage be less than zero. Interest on the liquidated damage is owed from the date of violation until final payment, calculated using the following formula:

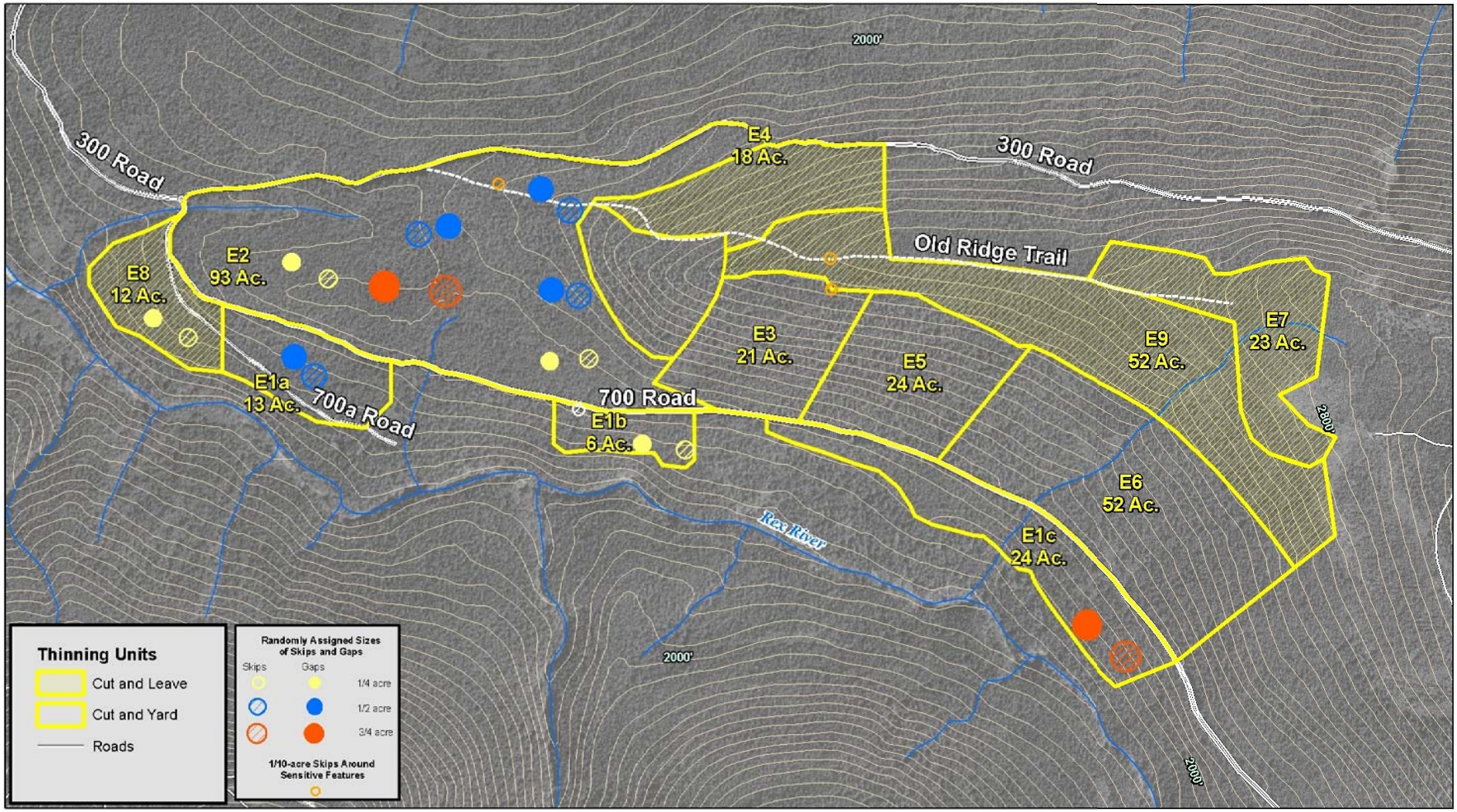
Interest = r x LD x N

Where:

r = Daily equivalent of an annual interest at current interest rate as established by WAC 332-100-030.

LD = Liquidated Damage value.

N = Number of days from date of violation to date payment is received..



Schedule A
700 Road Forest Habitat Restoration Project

0 405 810 1,620 2,430 3,240
Feet
One Inch equals 600 Feet

Contour interval is 40 feet.

T22N, R9E, WM

April 26, 2006.
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wshed2/usr4/carto/maps/700Rd_ET_scd_A_06.mxd

Seattle Public Utilities
Watershed Services Division

SCHEDULE B

CEDAR RIVER MUNICIPAL WATERSHED
ACCESS, WATER QUALITY AND CONTROL REGULATIONS

This regulation was modified in August 2003 and supercedes all previous regulations.

The Cedar River Municipal Watershed is the primary source of drinking water for the Seattle Metropolitan area. Compliance with State and Federal drinking water quality regulations requires that land within the boundary of the Watershed be subject to strict access and water quality protection controls. Therefore, all persons entering the Watershed shall comply with the following regulations:

Section I: ACCESS REGULATIONS

1) Access to the Watershed is by permit only. Only those persons who are actually engaged in authorized Watershed Services Division activities and are properly registered with Seattle Public Utilities shall be permitted access.

2) Permittee shall maintain a current list of the names of all employees and other persons entering the Watershed on his or her behalf. Required information for each person shall include a photocopy of a driver's license or other acceptable photo identification, the person's name and place of residence, phone number, vehicle descriptions with license numbers, destination within watershed and duration of visit.
The list, along with copies of photo ID's shall be submitted to the Watershed Protection Supervisor at the office of Watershed Services Division Division at the Cedar River Watershed, 19901 Cedar Falls Rd., S.E., North Bend, WA 98045, prior to entering the watershed.

3) Proof of an insurance policy for each vehicle must be provided naming City of Seattle as additional insured with minimum liability coverage of $250,000 per person, $500,000 per accident, and $250,000 property damage. The City reserves the right to adjust liability coverage.

4) Access to the Watershed will only be allowed through the gate at the main entrance to the Cedar Falls Watershed Services Division Headquarters except as otherwise approved by the Watershed Protection Supervisor. Hours of access will be determined by the Watershed Protection Supervisor or designee.

5) All vehicles used in association with any work or research project shall display a vehicle permit card issued by the Watershed Protection Supervisor or designee. The vehicle permit card is valid only for the vehicle for which it is issued and is not transferable. No unauthorized riders are allowed.

6) Access is permitted in the Watersheds only at such times as said persons are on direct work assignment.

7) Wandering from the work area or engaging in any activity other than that authorized by the Watershed Protection Supervisor is not permitted.

8) Permittee shall instruct all persons who enter the Watershed on his or her behalf as to the nature of the Watershed and the serious consequences arising from failure to comply with these access regulations.

9) The Permittee shall provide a copy of these access regulations to all employees and agents who enter the Watersheds.

10) A copy of these regulations shall be posted in a conspicuous place at each work site.

11) Access permits are not assignable and any assignment of a permit shall be cause for revocation.

Section II: WATER QUALITY REGULATIONS

Sanitary Facilities

1) Human waste shall not be deposited on or below the surface of the ground or in any surface waterbodies.

2) Permittees performing work at stationary work sites are required to provide approved, commercial sanitary facilities.

(a) Location of sanitary facilities shall be subject to approval by a Watershed Protection Inspector.

(b) Sanitary facilities shall be placed on flat surfaces and adequately protected against upset.

(c) Sanitary facilities shall be serviced by a professional servicing provider on a schedule approved by the Watershed Protection Supervisor or designee.

(d) Permittee shall remove work site sanitary facilities at the completion of the job in a timely manner.

Litter and Job Site Clean-up

1) Garbage and all forms of litter or refuse shall not be deposited on or below the surface of the ground or in any surface waterbodies.

(a) Permittee shall provide an approved receptacle for garbage.

(b) Garbage receptacles must have a suitable cover that restricts animal access and prevents wind from blowing contents out of receptacle.

2) Permittees performing work at stationary work sites shall remove all equipment, materials and refuse from the work site upon completion of the job. Any exceptions must be approved by the Watershed Protection Supervisor.

Hazardous Materials

1) Certain activities may require the Permittee to provide absorbant pads or absorbant booms. The type, size and quantity will be determined by the Watershed Protection Supervisor.

2) Permittee vehicles and equipment must be in good working order and maintained in a condition that prevents leakage of fluids. Vehicles and equipment will be subject to inspection and approval by a Watershed Protection Inspector.

3) Hazardous materials including any oil or any other petroleum base products shall not be discharged into the air or deposited on or below the surface of the ground or in any surface waterbodies. Any containers of oil or oil products shall be maintained in a condition that prevents any leakage. Equipment maintenance activities shall be undertaken so that no oil or other hazardous materials reach the ground. Normal maintenance and refueling shall be carried out using oil absorbent pads. In the event of a spill of any amount, prompt action shall be taken to mitigate the spill. The Watershed Protection Supervisor is to be notified immediately.

4) Pesticides or fertilizers shall not be applied in the Watershed.

Equipment Washes

1) All equipment and/or objects (boats, barges, chains, ropes, hoses, monitoring equipment, turbidity curtains, sandbags, etc.) that could come into contact with surface water (reservoir or tributaries) must be new, or disinfected by the user and inspected by designated SPU personnel. These measures are implemented to prevent the introduction of bacteria or nuisance or exotic species into the drinking water sources. Disinfectant procedures will be directed and supervised by a Watershed Protection Inspector.

2) All earthmoving equipment, logging trucks or any other vehicles as determined by SPU shall be pressure washed or steam cleaned, including undercarriage, prior to each entry into the Watershed.

Erosion

1) All work shall be performed in a manner that prevents erosion or siltation.

(a) Where culverts, ditches or drainage are deemed necessary for protection of the water supply, such facilities shall be constructed by the Permittee at his or her expense. All work will require prior approval by a Watershed engineer or designee.

(b) Upon completion of work, all roads shall be left in such a condition as to not induce soil erosion, or to become channels for the collection of surface runoff, and shall be so treated by the Permittee to accomplish this result to the satisfaction of the Watershed Protection Supervisor or designee.

Section III: CONTROL REGULATIONS

Gates

1) All gates are installed to control access and protect water quality and shall be kept locked at all times.

2) Only authorized persons or agencies under special agreement are permitted to use access gates other than the main entrance gate at Cedar Falls.

3) The Cedar River Municipal Watershed Gate and Door Access Policy procedures are to be strictly adhered.

Fire Protection

1) Permittees are subject to the Watershed Fire Prevention Regulations.

2) Campfires/warming fires are not permitted.

3) Fireworks are not allowed.

Camping

1) No camps or housing facilities may be constructed or maintained within the Watersheds without approval of the Watershed Inspector Supervisor or designee.

Safety

1) The City does not warrant the condition of any watershed road and Permittee(s) use roads at their own risk.

2) Permittee shall use seatbelts and drive with headlights on. Vehicle speed shall not exceed 25 mph unless otherwise posted.

3) The use of alcohol and illegal drugs is strictly forbidden.

Firearms

1) Firearms are not permitted within the Watershed except by commissioned law enforcement personnel.

Section IV: FAILURE TO COMPLY

1) Any person found to be in violation of any of these regulations may be denied further access to the Watershed and may be subject to legal prosecution.

2) If there is probable cause to believe that there has been a violation of the aforestated regulations, then any such vehicle or vehicles as may appear to be involved in such violations may be stopped and inspected by Seattle Public Utilities personnel. The refusal by the operator of any such designated vehicle to permit such inspection may be deemed sufficient reason to deny that operator further access to the Watersheds.

All operations in the Watersheds shall be conducted in compliance with all other applicable Federal, State, and local laws, rules and regulations for the protection of domestic water supplies. The Access, Water Quality and Control Regulations established by the Utility are subject to change from time to time as conditions require.

Chuck Clark, Director
Seattle Public Utilities

For information regarding access, water quality and control issues or for the name of the Watershed Protection Supervisor contact the Watershed Services Division Division at 19901 Cedar Falls Road S.E., North Bend, Washington, 98045, phone (425)888-1507 or (206)233-1510.

SCHEDULE C

VOLUME ESTIMATES FOR THINNING UNITS OF THE 700 ROAD FOREST HABITAT RESTORATION PROJECT

Volume Estimates for Bid Item 2

Unit: **E2** **Acres:** **93**

			DBH Class (inch)								
Species		**Unit Total**	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*
WH	*Height (ft.)*		52	54	66	75	83	93	99	104	116
	MBF	855	19	100	176	229	180	125	20	3	3
	CCF	2260	38	250	472	617	480	334	53	8	8
	Tons	6,840	153	800	1,408	1,831	1,440	1000	160	24	24
DF	*Height (ft.)*		53	60	76	80	89	98	105	110	118
	MBF	329	8	17	5	38	94	63	43	47	14
	CCF	674	13	33	10	79	196	131	88	96	28
	Tons	2,632	64	136	40	304	752	504	344	376	112
RC	*Height (ft.)*		41	56	57	69	75	81	89	94	97
	MBF	128	4	12	13	27	21	24	15	7	5
	CCF	387	9	35	42	85	67	72	44	20	13.
	Tons	1,024	32	96	104	216	168	192	120	56	40
SF	*Height (ft.)*				62	75	79	107	100		
	MBF	15			2	4	4	2	3		
	CCF	40			5	11	12	5	7		
	Tons	120			16	32	32	16	24		
RA	*Height (ft.)*			53	64	75	79			99	
	MBF	19		3	2	7	4			3	
	CCF	52		8	5	21	11			7	
	Tons	152		24	16	56	32			24	

Note: Height estiamtes for trees are calcualted as averages for 2 inch diameter classes.

Volume Estimates for Bid Item 1

Unit:	E1	Acres:	43								
						DBH	Class	(inch)			
Species		**Unit Total**	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*
WH	*Height (ft.)*			54	65	75	86	99	102	108	108
	MBF	129		23	29	35	38		2	2	
	CCF	338		57	78	93	102		4	4	
	Tons	1,032		184	232	280	304		16	16	
DF	*Height (ft.)*					83		97	103	112	
	MBF	103				9		66	12	16	
	CCF	213				20		136	24	33	
	Tons	824				72		528	96	128	
RC	*Height (ft.)*				54	64			89		
	MBF	3			1	1			1		
	CCF	9			2	3			4		
	Tons	24			8	8			8		
SF	*Height (ft.)*			48	58	72	82				
	MBF	4		1	1	1	1				
	CCF	12		4	2	3	3				
	Tons	32		8	8	8	8				
		129		23	29	35	38		2	2	
RA	*Height (ft.)*	338		57	78	93	102		4	4	
	MBF	1,032		184	232	280	304		16	16	
	CCF										
	Tons					83		97	103	112	

Note: Table Unit E1 combines volume estimates for sub-units E1a, E1b, and E1c.

Volume Estimates for Bid Item 1 continued

Unit:	E3	Acres:	21								
						DBH	Class	(inch)			
Species		Unit Total	6	8	10	12	14	16	18	20	22
WH	*Height (ft.)*			51	64	77	85		97	106	
	MBF	129		23	29	35	38		2	2	
	CCF	338		57	78	93	102		4	4	
	Tons	1,032		184	232	280	304		16	16	
DF	*Height (ft.)*					83		97	103	112	
	MBF	103				9		66	12	16	
	CCF	213				20		136	24	33	
	Tons	824				72		528	96	128	
RC	*Height (ft.)*				54	64			89		
	MBF	3			1	1			1		
	CCF	9			2	3			4		
	Tons	24			8	8			8		
SF	*Height (ft.)*			48	58	72	82				
	MBF	4		1	1	1	1				
	CCF	12		4	2	3	3				
	Tons	32		8	8	8	8				

Unit:	E5	Acres:	24								
						DBH	Class	(inch)			
Species		Unit Total	6	8	10	12	14	16	18	20	22
WH	*Height (ft.)*			58	75	75	88	95	99		
	MBF	117		19	19	44	21	10	4		
	CCF	312		49	50	119	57	26	11		
	Tons	936		152	152	352	168	80	32		
DF	*Height (ft.)*				80	83	91	95	101	110	113
	MBF	121			7	7	32	34	21	15	5
	CCF	249			14	15	66	70	44	30	10
	Tons	968			56	56	256	272	168	120	40
RC	*Height (ft.)*			48			72		88		
	MBF	4		1			1		2		
	CCF	12		2			3		7		
	Tons	32		8			8		16		

Volume Estimates for Bid Item 1 continued

Unit:	E6	Acres:	52								
						DBH	Class	(inch)			
Species		**Unit Total**	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*
WH	*Height (ft.)*		43	55	70	80	89	95	100	103	106
	MBF	443	24	46	79	78	136	56	11	10	3
	CCF	1151	44	116	210	208	360	148	30	26	9
	Tons	3,544	192	368	632	624	1,088	448	88	80	24
DF	*Height (ft.)*				71	95	99	99	109	111	114
	MBF	62			6	8	8	13	7	13	7
	CCF	130			13	17	17	27	15	26	15
	Tons	496			48	64	64	104	56	104	56
RC	*Height (ft.)*			64			79	81			
	MBF	3		1			1	1			
	CCF	11		3			4	4			
	Tons	24		8			8	8			
SF	*Height (ft.)*			59	72						
	MBF	2		1	1						
	CCF	5		2	3						
	Tons	16		8	8						
RA	*Height (ft.)*			52		75					
	MBF	2		1		1					
	CCF	5		2		3					
	Tons	16		8		8					

Volume Estimates for Bid Item 3

Note: Timber volumes in Bid Item 3 will be cut only and not yarded.

Unit:	**E4**	**Acres:**	**18**								
						DBH	**Class**	**(inch)**			
Species		**Unit Total**	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*
WH	*Height (ft.)*		62	58	71	78	90	96			
	MBF	137	10	23	57	43	2	2			
	CCF	354	22	57	151	115	5	4.			
	Tons	1,096	80	184	456	344	16	16			
DF	*Height (ft.)*		49			83	88	97	102	106	
	MBF	7				1	2	1	2	1	
	CCF	12				2	3	2	4	1	
	Tons	56				8	16	8	16	8	
RC	*Height (ft.)*		48	53		74	85	78			
	MBF	2		1		1					
	CCF	6		2		2	1	1			
	Tons	16		8		8					

Unit:	**E7**	**Acres:**	**23**								
						DBH	**Class**	**(inch)**			
Species		**Unit Total**	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*
WH	*Height (ft.)*		51	60	66	75		85			
	MBF	20	4	6	5	3		2			
	CCF	48	8	14	13	8		5			
	Tons	160	32	48	40	24		16			
DF	*Height (ft.)*		47	51	68	75	79	84			
	MBF	16		1	6	3	4	2			
	CCF	35	1	2	13	7	8	4			
	Tons	128		8	48	24	32	16			
RC	*Height (ft.)*			63		66	68	80			
	MBF	3		1		1		1			
	CCF	8		2		4		2			
	Tons	24		8		8		8			

Unit:	E8	Acres:	12								
						DBH	Class	(inch)			
Species		**Unit Total**	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*
WH	*Height (ft.)*			54	66	78	82	96	99		
	MBF	78		10	27	13	21	5	2		
	CCF	206		25	74	35	55	12	5		
	Tons	624		80	216	104	168	40	16		
DF	*Height (ft.)*				70			98	104	113	
	MBF	10			6			1	2	1	
	CCF	20			12			2	4	2	
	Tons	80			48			8	16	8	
RC	*Height (ft.)*						75	78			
	MBF	2					1	1			
	CCF	4					2	2			
	Tons	16					8	8			

Unit:	E9	Acres:	52								
						DBH	Class	(inch)			
Species		**Unit Total**	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*
WH	*Height (ft.)*				65	78	83	91			
	MBF	290			72	106	49	63			
	CCF	777			196	283	130	168			
	Tons	2,320			576	848	392	504			
DF	*Height (ft.)*				71	84	89	96			
	MBF	104			26	15	26	37			
	CCF	217			55	31	54	77			
	Tons	832			208	120	208	296			

SCHEDULE D

INDIVIDUAL UNIT PRESCRIPTIONS FOR THE 700 ROAD FOREST HABITAT RESTORATION PROJECT

GENERAL THINNING AND YARDING PRESCRIPTION

Live Trees

- Trees shall be cut only from within the specified thinning pool.
- No other trees shall be cut outside the thinning pool unless marked by the Contract Administrator, including vine maple and other hardwood species.
- Trees within the thinning pool with apparent damage (such as broken top, forked top, crook), signs of rot, or mistletoe brooms shall **not** be harvested, unless required for worker safety.
- No existing snags ≥12" DBH shall be cut unless necessary for safety. If cutting snags is deemed necessary, consider high stumping to at least 16 feet. Any snag cut or topped for safety shall remain on site where felled.
- Any existing snags found which are >30 inches DBH, and >30 feet in height shall be left and buffered with standing live trees, pending notification of the Contract Administrator.
- Skid trails and yarding corridors shall be flagged and approved by the Contract Administrator prior to cutting and use.

Skips and Gaps

- Larger gaps and skips are physically marked in units E1, E2, and E8. All trees in larger gaps shall be cut and removed, except trees marked as L (live), S (snag), or DW (down wood). No trees shall be cut in skips. The boundary of large skips has been flagged with pink tags and are marked "Boundary of Contract Area" and shall not be entered with yarding equipment.
- In addition, small gaps of 0.04ac (50 feet diameter) shall be created in units and located at operator's discretion. The number of small gaps are defined in the tabular prescription below.
- A number of small skips of 0.04ac (50 feet diameter) shall be left unthinned, located at operator discretion. No trees shall be cut in skips and they shall not be entered with yarding equipment.
- The contractor shall determine the location of small skips and gaps and mark them with flagging. Skip and gap diameters (approx. 50 feet) shall be measured from the stem edge of the border trees. Skip and gap shape shall be approximately round. Small skips and gaps shall be evenly distributed throughout each unit. No more than half the number of small gaps may be located on existing skid trails or yarding corridors.

Down Wood

- No existing down wood shall be removed from the site.
- If down wood <30 inches in diameter is interfering with operations, the part that is interfering may be bucked and pushed out of the way.
- If larger existing down wood (≥30 inches in diameter) is encountered and interferes with operations, the Contract Administrator shall be notified, who will make a decision about bucking and moving it.

Streams

Three Type Np stream flows through the project area in units E1c, E2, and E6.

- No trees shall be harvested within the 50 feet no-harvest buffer from the bankfull width of the stream channel. The no-harvest buffer is marked with flagging.
- Trees cut near the buffer shall be felled away from the stream.

- No trees shall be yarded through the no-harvest buffer unless there will be no disturbance either to the ground or the residual canopy.

Large woody debris (LWD) enhancement:

- One tree shall be felled across the stream channel about every 100 feet. These trees may be selected within the no-harvest buffer.
- Source LWD trees shall be selected from Western hemlock, 6 to 19 inches DBH.

Tabular Unit Prescriptions for Bid Item 1

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
1	32 acres	Hemlock 6"-19" Redcedar 12"-16" Silver fir 7"-12"	WH>RC>SF	space only within thinning pool, do not space off reserve trees	21 ± 4 feet	302 TPA	209 TPA
						369 sqft.	280 sqft.
43 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	5 acres	14 feet		19"	90' distance		
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	2.3 acres	3/4 acre	1	19"	marked in field		
		1/2 acre	1	19"	marked in field		
		1/4 acre	1	19"	marked in field		
		1/25 acre	20	thinning pool	selected by operator		
	Skips	Size (ac.)	Count		Location		
	2.3 acres	3/4 acre	1		marked in field		
		1/2 acre	1		marked in field		
		1/4 acre	1		marked in field		
		1/25 acre	20		selected by operator		
	Reserve Areas	Size (ac.)	Count		Location		
	RMZ	1	1		Np-type stream, 50' buffer marked in field		
	Cultural resource site	1	1		historic camp, marked in field		

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
3	13 acres	Hemlock 6"-17" Douglas-fir 6"-17"		thin from below residual BA 184		344 TPA	183 TPA
						293 sqft.	183 sqft.
21 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	2 acres alternating	16 feet	1000 feet	19"	150' distance		
		16 feet	500 feet	19"	150' distance		
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	0.5 acres total	1/25 acre	12	thinning pool	operator selected within leave strips		
	Skips	Size (ac.)	Count		Location		
	5.5 acres total	1/25 acre	12		operator selected within leave strips		
	50' leave strips	1.15	6		100' distance		
	Reserve Areas	Size (ac.)	Count		Location		
	no reserve areas						

Tabular Unit Prescriptions for Bid Item 1 continued

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
5	12 acres	Hemlock 6"-14" Douglas-fir 6"-18"		space only within thinning pool, do not space off reserve trees	30 ± 5 feet	283 TPA	142 TPA
						308 sqft.	201 sqft.
24 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	2 acres alternating	16 feet	1000 feet	19"	150' distance		
		16 feet	500 feet	19"	150' distance		
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	0.5 acres total	1/25 acre	12	thinning pool	operator selected within leave strips		
	Skips	Size (ac.)	Count		Location		
	9.5 acres total	1/25 acre	12		operator selected within leave strips		
	50' leave strips	1.15	6		100' distance		
	Reserve Areas	Size (ac.)	Count		Location		
	no reserve areas						

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
6	24 acres	Hemlock 6"-16" Douglas-fir 6"-16"	WH>DF	space only within thinning pool, do not space off reserve trees	16 ± 3 feet	478 TPA	261 TPA
						366 sqft.	242 sqft.
52 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	3.6 acres alternating	16 feet	1000 feet	19"	150' distance		
		16 feet	500 feet	19"	150' distance		
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	0.8 acres	1/25 acre	20	thinning pool	operator selected within leave strips		
	Skips	Size (ac.)	Count		Location		
	23.5 acres total	1/25 acre	20		operator selected within leave strips		
	50' leave strips	1.15	15		100' distance		
	Reserve Areas	Size (ac.)	Count		Location		
	RMZ	2.5	1		Np-type stream, 50' buffer marked in field		

Tabular Unit Prescriptions for Bid Item 2

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
2	60 acres	Hemlock 6"-16" Douglas-fir 6"-16" Redcedar 6"-15"	WH>DF>RC	space only within thinning pool, do not space off reserve trees	18 ± 3 feet	426 TPA	247 TPA
						339 sqft.	229 sqft.
93 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	12 acres	14 feet		19"	90' distance		
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	4.2 acres	3/4 acre	1	19"	marked in field		
		1/2 acre	3	19"	marked in field		
		1/4 acre	2	19"	marked in field		
		1/25 acre	36	thinning pool	selected by operator		
	Skips	Size (ac.)	Count		Location		
	4.2 acres	3/4 acre	1		marked in field		
		1/2 acre	3		marked in field		
		1/4 acre	2		marked in field		
		1/25 acre	36		selected by operator		
	Reserve Areas	Size (ac.)	Count		Location		
	RMZ	3	2		2 Np-type streams, 50' buffer marked in field		
	Reserve Areas	10	1		marked in field		

Notes: Stand densities before and after thinning are given in trees per acre (TPA) and basal area (square feet per acre, sqft.).

Tabular Unit Prescriptions for Bid Item 3

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
4	16 acres	Hemlock 6"-13"		space only within thinning pool, do not space off reserve trees	26 ± 5 feet	370 TPA	224 TPA
						237 sqft.	165 sqft.
18 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	no yarding						
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	0.9 acres	1/25 acre	22	thinning pool	selected by operator		
	Skips	Size (ac.)	Count		Location		
	0.9 acres	1/25 acre	22		selected by operator		
	Reserve Areas	Size (ac.)	Count		Location		
	no reserve areas						

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
7	No thinning						
23 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	no yarding						
	Gaps	Size (ac.)	Count	Max. Tree Size	Location	Comments	
	2.2 acres total	120 feet diam.	3	only WH and DF max.16" DBH	selected by operator	cut no hardwoods	
		75 feet diam.	8	only WH and DF max.16" DBH	selected by operator		
		55 feet diam.	14	only WH and DF max.16" DBH	selected by operator		
		40 feet diam.	20	only WH and DF max.16" DBH	selected by operator		
	Skips	Size (ac.)	Count		Location		
	rest of unit	20 ac.			matrix		
	Reserve Areas	Size (ac.)	Count		Location		
	no reserve areas						

Commnets: Gaps in Unit 7 shall be distributed throughout the unit. Gap locations shall be selected to contain no more than 2 reserve trees per gap (outside thinning pool, >16 inch DBH). Retain all hardwoods and shrubs in gaps. Gap diameters are measured from the stem edge of boundary trees.

Tabular Unit Prescriptions for Bid Item 3 continued

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
8	11 acres	Hemlock 8"-15" Douglas-fir 8"-15"		space only within thinning pool, do not space off reserve trees	18 ± 3 feet	348 TPA	252 TPA
						310 sqft.	250 sqft.
12 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	no yarding						
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	0.6 acres total	1/4 acre	1	19" DBH	marked in field		
		1/25 acre	9	19" DBH	selected by operator		
	Skips	Size (ac.)	Count		Location		
	0.6 acres total	1/25 acre	9		selected by operator		
	Reserve Areas	Size (ac.)	Count		Location		
	no reserve areas						

Unit	Acres Thinned	Thinning Pool	Thinning Preference	Spacing Rules	Spacing in Thinning Pool	Before thinning	After thinning
9	52 acres	Hemlock 9"-16" Douglas-fir 9"-16"	WH>DF	release dominant reserve trees (>17"DBH)		323 TPA	241 TPA
						252 sqft.	187 sqft.
52 acres	Yarding Corridors	Width	Length	Max. Tree Size	Location		
	no yarding						
	Gaps	Size (ac.)	Count	Max. Tree Size	Location		
	No gaps						
	Skips	Size (ac.)	Count		Location		
	0.2 acres	1/10 acre	2		marked in field		
	Reserve Areas	Size (ac.)	Count		Location		
	no reserve areas						

Comments: Trees within the thinning pool shall be spaced off larger reserve trees to a residual basal area of 187 square feet per acre.

SCHEDULE E - OPERATIONS PLAN
for the
700 Road Forest Habitat Restoration Project
(to be completed following signing of contract)

Following signing of the contract, this Operations Plan shall be completed and signed by the Contractor and the City following agreement between the two parties and shall become a part of the 700 Road Forest Habitat Restoration Project Service Contract. Setion F of the Contract contains further Operational provisions that must be followed by the Contractor. Any changes to this plan, other than changes in personnel, must be requested in writing by the Contractor and approved by the City. If changes to this plan require a modification of the bid rate, then the City and the Contractor must mutually agree to any rate change and document it in writing as a contract amendment.

Project Operations Goal

"Achieve prescription standards while minimizing damage to soils, residual trees and other sensitive resources, while conducting operations in a safe and efficient manner at a reasonable cost."

OP – 1. PURCHASER INFORMATION

COMPANY NAME: A&R Cable Thinning
COMPANY OWNER: Mike Archambault
ADDRESS: P.O. Box 4338, Nooksack, WA 98276
PHONE: (360) 966-4820 CELL: (360) 815-4565
COMPANY INSURER: Washington Contract Loggers Assoc./ American Forest Casualty, RPG
INSURER PHONE: 1-800-422-0074

OP – 2 CREW AND CONTRACTORS

Mike Archambault Sr.
Equipment: K501 Cable Yarder
Other Responsibilities: Operations Manager, Corridor and skip and gap lay-out
Address: P.O. Box 4338, Nooksack, WA 98276
Home phone: 360-966-2498
Cell: (360) 815-4565
Fax: 360-966-4820
E-mail: archie7991@yahoo.com
Vehicle Make and License No: 2001 F350 / A49071P
Driver's License Number: ARCHAME445RN

Mike Archambault Jr. - 1st in charge on landing
Equipment: Loader and Danzco Pull-Through Delimber
Address: 4090 Morgan Rd. Sumas, WA 98295
Phone: 360-988-8521
Vehicle Make and License No: 2004 F350 / A21015Z
Driver's License Number: ARCHAME25905

Adam Archambault
Equipment: K501 Cable Yarder, Super Eagle Carriage
Other Responsiblities: choker setting

Address: P.O. box 4304 Nooksack, WA 98276
Phone: 360-393-0342
Vehicle Make and License No: 1988 Toyota / A18260J
Driver's License Number: ARCHAAT144CF

Adam Levine
Equipment: K501 Cable Yarder, Super Eagle Carriage
Other Responsiblities: choker setting
Address: 514 Sterling St. Sedro Woolley, WA 98284
Phone: 360-840-3259
Vehicle Make and License No: NA/ is not an insured driver for A & R Cable
Driver's License Number: LAVINAL117CR

Brady Johnson
Job: Choker Setter
Address: 402 Township St. Sedro Woolley, WA 98284
Phone: 360-855-2618
Vehicle Make and License No: NA/ is not an insured driver for A & R Cable
Driver's License Number: no valid drivers license

Additional crew members and drivers will be added via the CAPS permit system, as needed.

Cutting Crew: Davidson Timber Cutting
Mark Davidson, Owner
Address: 17715 S. Spada Snohomish, WA 98290
Phone: 360-568-4149
Vehicle Make and License Number: _____
Driver's License Number: _____

Additional crew members and drivers will be added via the CAPS permit system, as needed.

Log Truck Company: Rob Graham Trucking
Rob Graham, Owner
Address: 2607 E. Smith Rd. Bellingham, WA 98226
Phone: 360-592-9931
Vehicle Make and License Number: _____
Driver's License Number: _____

Additional crew members and drivers will be added via the CAPS permit system, as needed.

OP – 3. EQUIPMENT SPECIFICATIONS

1. Danzco Pull-Through Delimber (for use on landings only; moved in via lowboy or tilt bed dump truck)

2. Loader 1996 Thunderbird 634, weight 68,000 lbs, width 11'6" (moved in via lowboy)

2. K-501 Yarder with 41' tower/ K501 yarder mounted on GI truck (moved in via lowboy)

3. Super Eagle Carriage / motorized, slack pulling carriage (moved in via pickup truck)

4. Fire Trailer / 500 gallon DNR approved (hauled behind pickup truck)

5. Shop Bus / shop truck with pertinent tools, hazmat cleanup, welder

OP- 4 OPERATIONS SCHEDULE AND PRODUCTION RATE

OPERATIONS TO COMMENCE WITHIN THE FOLLOWING DATES: July 10th for lay-out of initial corridors and skips and gaps (to facilitate preparation for operator certification). Pre-work meeting and operator certification to commence as early as July 25th. Cutting and yarding to immediately follow certification.

ESTIMATED PRODUCTION RATE (loads/day): 2-3

ESTIMATED NUMBER SIDES OPERATING CONCURANTLY: 1

ESTIMATED COMPLETION DATE: November 29, 2007

OP – 5. CUTTING PLAN

Refer to the Operations Map for the type of cutting designated for each unit, Section F-3, *Harvesting Equipment*, Section F-8, *Soil Damage*, Section F-9, *Damage to leave trees*, and Schedule D, *Unit Prescriptions*.

The prework meeting with cutters in attendance will take place before certification of cutters. All the units requiring cable yarding under this contract will be yarded with the K501. The specific types of cable yarding equipment used will be subject to City approval. Corridor marking, skips and gaps, tree removal selection will be approved by a City employee. Corridors, skips and gaps will be flagged distinct colors, and Contractor will provide flagging legend. Hand felling, limbing, and bucking will be done in all units prior to yarding. All trees will be manufactured to ensure minimum damage to leave trees. Uphill corridors will be cut to maximum width of 14 feet; downhill yarding corridors will be cut to a maximum width of 16 feet. Great care will be taken in the corridor marking to prevent cutting of largest or dominant trees (outside the thinning pool).

Units E1a, b, and c will be implemented first, and subsequent sequencing of units will be mutually agreed to by the Contractor and City. The City's preferred sequencing is as follows: E1a, b, c, E6, E3, E2, and E5, but this sequencing may be altered. Unit E2 may be cut and yarded out of sequence to allow for sap flow window. Units E8 and E4 may be yarded if the volume cap of 2.8 Mmbf allowed by City Ordinance has not been reached and if the Contractor and City mutually agree to a bid rate. Cut-and-leave units E7 and E9 will be cut during the fall/winter months.

OP – 6. YARDING PLAN

Refer to the Operations Plan Map for approximate landing locations and the designated yarding method for each unit, Section F-4, *Yarding Requirements*, Section F-8, *Soil Damage*, F-9, *Damage to Leave Trees*, and Schedule D, *Unit Prescriptions*.

Corridor placement to be determined on site. This will ultimately determine landing locations and yarding methods for each unit. Anchor stumps, tail trees, and support trees play a vital role in establishing landing sites. These trees and stumps will be marked by the Contractor. If trees need to be cut to create anchor stumps, those trees must be within the thinning pool. A & R Cable will pick the best possible mix in an effort to minimize soil and leave tree damage. In all cases, safety for crew and equipment will factor into the proper placement if the afore mentioned items. We understand Schedule D in it's entirety and will comply.

OP – 7. LANDING AND ROAD CLEAN-UP

Refer to the Operations Plan Map for approximate landing locations, Section F-2, *Landings,* and Section F-7, *Haul Road Betterment and Maintenance.*

Section F-2 and F-7 have been read and understood in their entirety. Will leave landing sites, roads, and ditches in City approved conditions. Warning signs indicating "logging operations" and "road closure" will also be on site during time of operation.

Refer to F-8, repair of any damage to roads, as well.

OP – 8. FIRE PREVENTION PLAN

Refer to Schedule B- *Watershed Access and Water Quality Control Regulations* and Section D-5, *Fire Prevention*.

Schedule B: section 1 / access regulations has been read and understood.
Schedule B: section 2 / water quality regulations has been read and understood.
A & R Cable understands that we are working in 659N zone and will comply with all City and state regulations.
The City will check fire tools and water tank periodically.

OP – 9. SANITATION PLAN

Refer to Schedule B- *Watershed Access and Water Quality Control Regulations*, and Section D-3, *Sanitation*.

Schedule B: section 3 / sanitary facility will be provided and used by A & R Cable and will be maintained by City-approved professional service.

OP – 10. HAZMAT PLAN

Refer to Schedule B- *Watershed Access and Water Quality Control Regulations* and Section D-4, *Prevention of Oil Spills.*

Vegetable based oils will be provided by A & R Cable if the City agrees to price adjustment. Also, City approved absorbent pads will be on site at all times for equipment and saw refueling in the brush.

Contractor will notify the City immediately in the event of any spill. City will perform spot check to ensure equipment is free of leaks.

OP-11. EMERGENCY RESPONSE PLAN

Department of Labor & Industry approved response plan will be onsite in multiple vehicles at all times, and a copy will be provided to the City. Crew will be educated in the proper procedure for relaying range, township, and all pertinent information (driving directions, helicopter landing site) to emergency response personnel. Necessary first aid supplies will be on site at all times. The Contractor will immediately notify the City in the event of any emergency.

OP-12. COMMUNICATIONS PLAN

CB radios with predetermined channel will be used in all crewbuses and log trucks. One (1) City radios will be used for communication between City staff and A & R employees. Cell phones are also on site. If cell phone and City issued handheld radio cannot reliably call to Cedar Falls Headquarters, then a sattelite phone will be required. In such an event, the City will compensate the Contractor for the additional cost.

OP-13. SAFETY PLAN

CB's will be used on roads to ensure drivers safety. Drivers of A & R Cable vehicles and all subcontractors, including log trucks, will comply with stated City speed limits. Drivers should expect other vehicles around every corner, as not all vehicles are equipped with CB's. Road warning signs will be provided by the Contractor, and haul routes will be posted by the City. The Contractor will immediately notify the City in the event of any emergency.

CITY OF SEATTLE

By _____

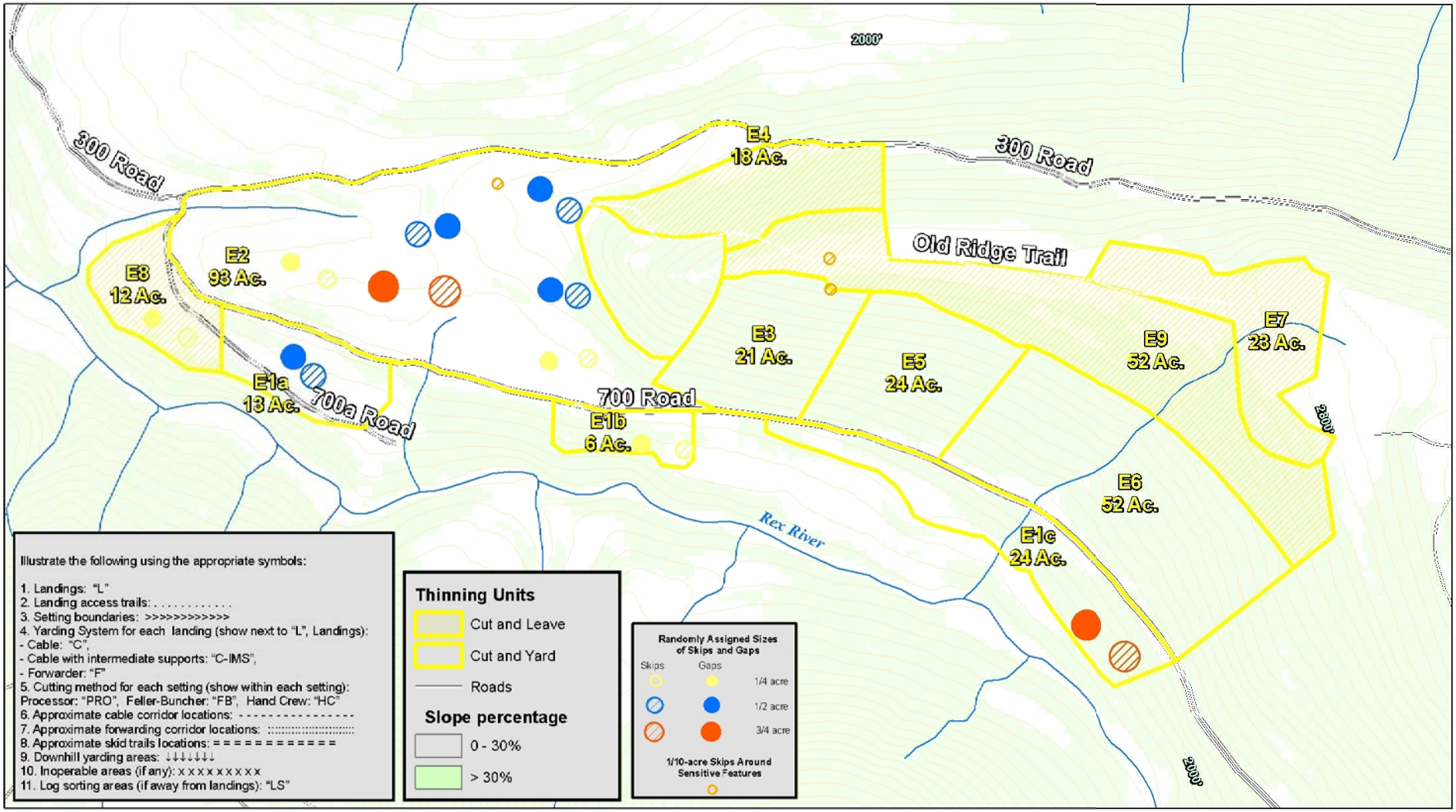
Nancy Ahern
Seattle Public Utilities Science, Sustainability and Watersheds Branch Executive

CONTRACTOR

By _____

Printed Name: Michael Archambault, Sr.

Title: President, A&R Cable Thinning, Inc.



Schedule E - Operations Plan Map

NOTE: This Schedule is to be completed by the City and the Contractor prior to the start of operations.

700 Road Forest Habitat Restoration Project

T22N, R9E, WM

Contour interval is 40 feet.

0 405 810 1,620 2,430 3,240
Feet
One Inch equals 600 Feet

April 26, 2006.

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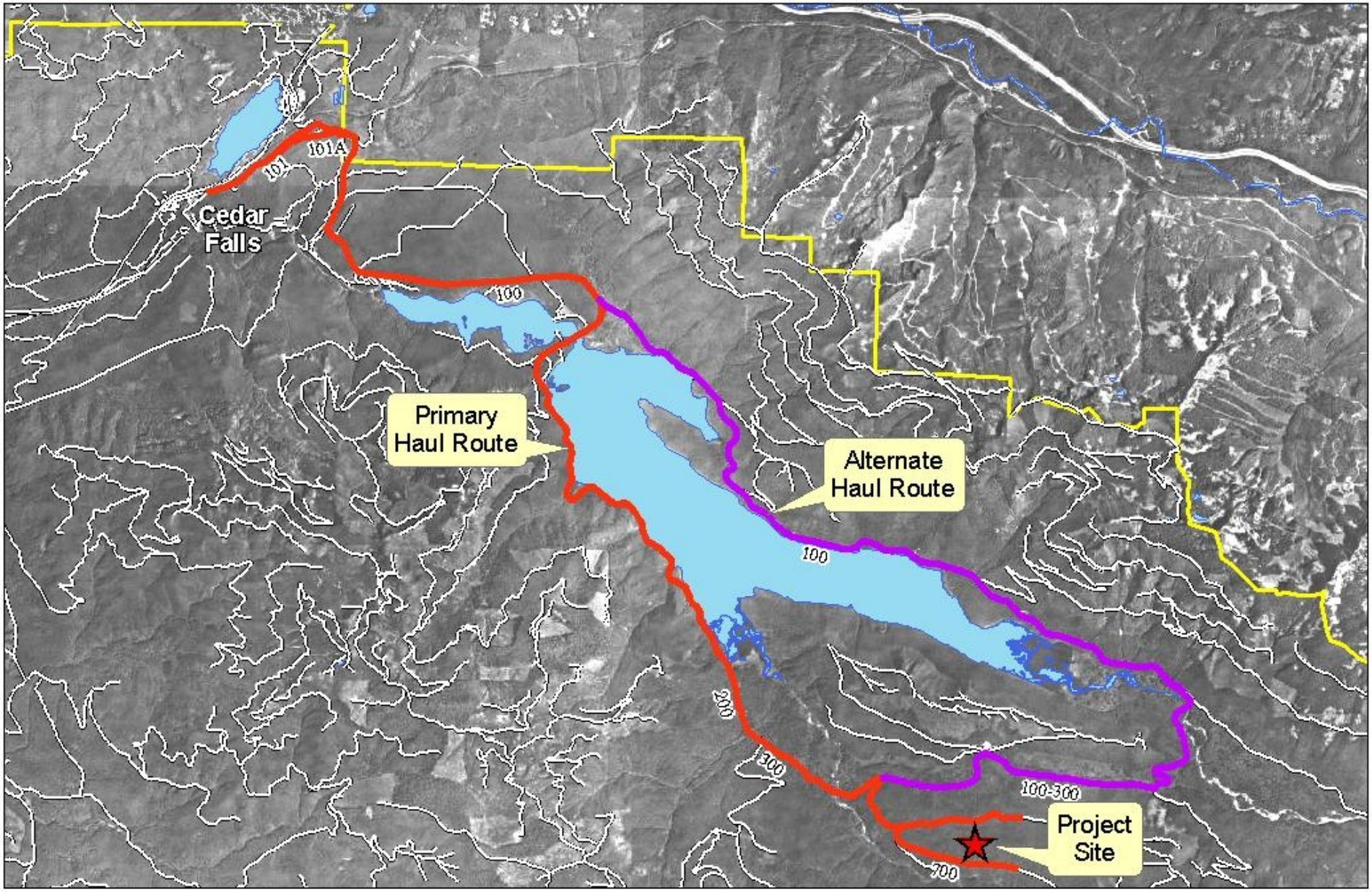
wshed2//usr4/carto/maps/700Rd_ET_scd_E_06.mxd

Seattle Public Utilities
Watershed Services Division



August 3, 2005
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wshed2:/usr4/carto/maps/700Rd_ET_haul.mxd

700 Road Forest Restoration Project
Schedule F - Haul Routes

Seattle Public Utilities
Watershed Management Division

0 0.5 1 2 3 4 Miles

N