Assessment of the North Shore Cedar Area For Potential Habitat Restoration Treatments

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1.0 INTRODUCTION

1.1 Reasons for assessment

The Cedar River Municipal Watershed (CRMW) is managed under the Cedar River Watershed Habitat Conservation Plan (HCP) which regulates its status and use, and defines general restoration goals and programs. The HCP identifies several restoration programs designed to restore natural processes and functions of aquatic, riparian, and upland forest ecosystems and enhance habitats for at-risk species. This assessment defines integrated restoration goals for the North Shore Cedar (NSC) area at the eastern end of Chester Morse Lake, and identifies areas where restoration projects could be planned to meet overall HCP goals. The assessment also compiles relevant information needed to design appropriate and effective habitat restoration treatments.

1.2 Assessment area and relationship to synthesis

In 2009 the Ecosystem Landscape Synthesis Team created a synergy map that identifies areas throughout the CRMW that have high potential for gaining synergistic benefit among restoration strategies and projects, ensuring the greatest ecological benefit for the investment (Erckmann et al. 2009). The assumption was that different restoration programs working in the same area would create greater functional benefits than if they were working in spatially distinct areas. The NSC assessment area was defined using the synergy map (Figure 1). We used the areas defined as medium to high synergy and encompassed the area generally north of the Cedar River, ranging from the McClellan Creek drainage in the west to the Roaring Creek drainage in the east. We included the medium synergy area south of the Cedar River, and extended the assessment to the northern border of the CRMW. The entire NSC assessment area comprises approximately 6,000 acres and ranges in elevation from 1,570 to 5,030 feet above sea level (asl) in the north half of T22N, R9E.

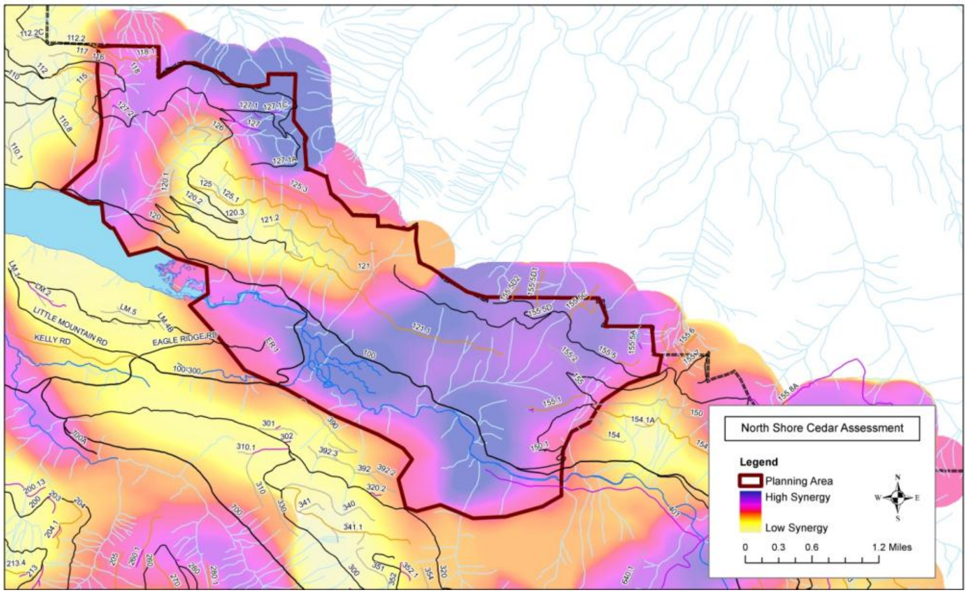

Figure 1. Synergy model of North Shore Cedar assessment area

1.3 Purpose of document

This assessment of habitat conditions provides the rationale for restoration treatments that include upland forest, riparian forest, and aquatic ecosystems. The document contains a summary of the current conditions, outlines where restoration actions would lead to landscape-level habitat improvement, and describes the necessary habitat elements that would improve habitat functions. Specific restoration projects and adaptive monitoring installations would be designed and planned by separate project teams. The document describes desired future conditions in general terms; goals for restoration projects are site specific and would be defined by project teams.

2.0 GENERAL ENVIRONMENTAL CONDITIONS

Information for Sections 2.1, 2.2, and 2.3 was taken from the Cedar River Municipal Watershed Aquatic Restoration Strategic Plan (Bohle et al. 2009).

2.1 Climate

The climate in the NSC Area is predominantly a marine-type typical of montane forests on the western slope of the central Cascade Mountain Range in Washington. Orographic lifting of the moisture-laden southwesterly and westerly winds results in heavy precipitation in this area. With increased elevation, a greater amount of winter precipitation falls as snow and marks the ecotone between the Western Hemlock and the Pacific Silver Fir Forest Zones. The ecotone occurs between 2,800 and 3,500 in elevation depending on aspect and is marked by a reduced dominance of Douglas-fir and increased abundance of Pacific silver fir. In general, the temperature decreases approximately 3° F with each 1,000 feet increase in elevation. Growing season in the basin generally begins in May and ends in October, but varies somewhat depending on aspect and elevation.

The average annual precipitation ranges from 100 to 120 inches, of which 80% falls within the months of October to April. Snowfall usually begins in the higher elevations in September, gradually working down to 3,000 feet by the last of October. The snowline in midwinter varies from 1,500 to 2,000 feet above sea level. Although snowfall continues until late spring, the maximum depth is usually reached during the first half of March. At this time of the year, snow depths above 3,000 feet range from 10 to 25 feet. The density of the snow pack increases from approximately 30 percent water the first of December to 45 percent water in March.

2.2 Geology

While a wide variety of distinct rock types and landforms exist within the watershed, four basic lithologies occur within the CRMW: Continental Glacial, Alpine Glacial, Snoqualmie Batholith, and Tertiary Volcanic and Sedimentary Rocks. Three of these are present in the NSC: Alpine Glacial, Tertiary Volcanic and Sedimentary Rocks, and Snoqualmie Batholith.

Within the upper watershed, alpine glaciation has produced numerous u-shaped valleys and left deposits which continue to exhibit a strong influence on the characteristics along the upper mainstem Cedar River. Valley hillslopes include areas veneered with glacial drift as well as inclusions of bedrock, alluvial fans, colluvium, and talus deposits. Due to the geometry of these u-shaped troughs, the linkage between stream and adjacent hillslope processes is highly variable and locally controlled by tributary incision into historic floodplain and glacial deposits. Where entrenchment has occurred, streams are often flanked by short, steep inner gorges, representing chronic source areas for sand and silt. Valley floors also include small alluvial fans, bogs, and Holocene alluvium. Alpine glacial deposits range from boulder till in uplands and upper valleys to gravel or sand outwash on the broad valley floors.

Tertiary rocks are located in the upper Cedar River and include Miocene to Oligocene rocks of the Fifes Peak (Miocene), Eagle Gorge (Miocene and Oligocene), and Ohanapecosh (Oligocene) formations. Lithologies include basaltic andesite and basalt flows, breccia, crystal-lithic tuff, and volcaniclastic sedimentary rocks which are frequently highly fractured and weathered. Streams within these lithologies, while frequently steep (>8%), have fairly small drainage areas and limited stream power, resulting in small, narrow valley floors inset into valley walls. Relative to streams draining glacial deposits, the linkage between stream and hillslope processes is more direct and less variable in areas underlain by both volcanic Tertiary rocks and the relatively massive granites of the Snoqualmie batholith.

The Snoqualmie Batholith is located in the upper CRMW on the northern end of the catchment, primarily on the steep south facing valley walls along the upper Cedar River. The area is underlay by medium grained, mostly equi-granular Hornblende-biotite granodiorite and tonalite. Rocks of the Snoqualmie Batholith produce erosion resistant boulders and cobbles that can form coarse bedforms such as cascades and boulder steps that resist breakdown even during transport down steep channels. Similar to areas underlain by tertiary rocks elsewhere in the watershed, this bedrock is often overlain by undifferentiated glacial outwash and till underlie the lower portions of these areas which control and influence stream processes in comparable ways to those described above.

Although rocks from the Snoqualmie batholith tend to produce resistant boulders and cobbles whereas tertiary volcanic rocks tend to weather into less durable clasts, these differences did not translate into noticeable differences in channel characteristics. Stream inventories by Foster Wheeler and more recently by CRMW staff, support the hypothesis that streams underlain by these lithologies are controlled by the same suite of channel processes and have comparable sediment supply or transport regimes. In fact, the attributes used to distinguish between channel types, namely proximity and linkage to upstream mass wasting features (i.e., inner gorge topography, unstable bedrock hollows, and earthflow complexes), appear to be generally independent of lithology.

2.3 Hydrology and soils

Streams in the northern part of the basin are incised into steeper slopes, while the southern part of the basin has gentler terrain and lower gradient streams (Figure 2). The main stem of the Cedar River is classified as a Shoreline of the State and is fish bearing through the area. Upslope of the mainstem, tributary streams are generally classified as perennial and seasonal non-fishbearing.

The valley wall channels are characterized by high gradient headwater tributaries occurring along locally dissected, but generally planar mountain slopes. Steep, stairstepping, and bedrock scour channel are commonly associated with low order channels at the head of drainage networks. Some channels are deeply incised into the mountainslope, creating a high gradient inner gorge zone. Slope failures and active channel bed movement has contributed significant sediment loads to the mainstem Cedar River. Channel gradient decreases near the confluence with the mainstem Cedar. Along the mainstem Cedar River, floodplain development is extensive. Bank erosion and bank building processes are continuous, resulting in a laterally shifting channel. Smooth meander bends, extensive gravel bars, and large concentrations of woody debris are characteristic of this section of the Cedar River.

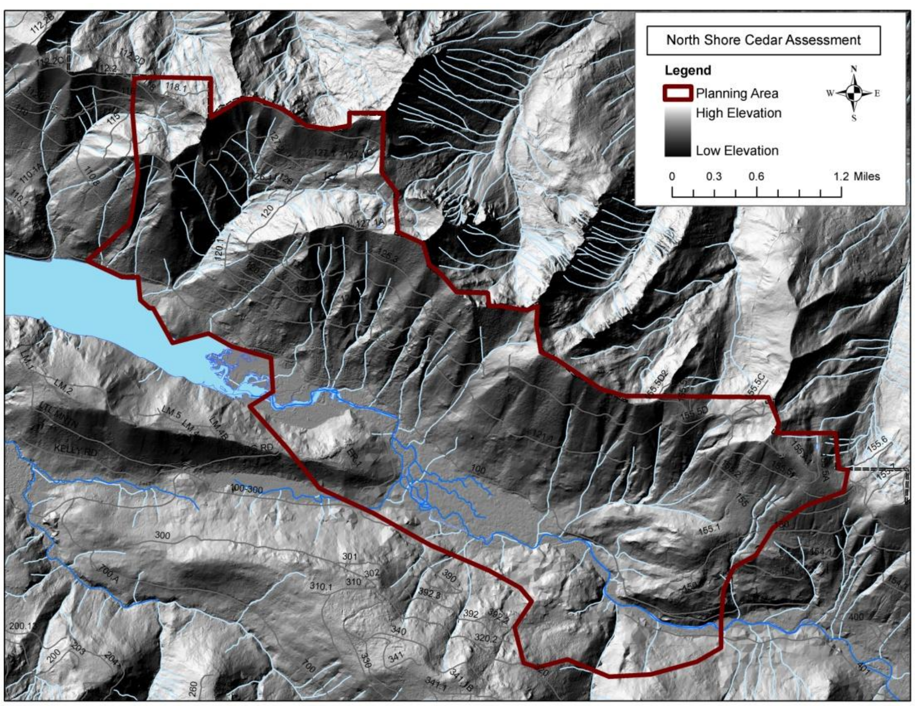

Figure 2. Varied topography in the North Shore Cedar assessment area

Within mid-elevation (roughly 1,000–3,500 ft) sub-basins in the rain and rain-on-snow dominated zones, historic timber harvest resulting in large stands of immature (<10 years old) timber may have resulted in short-term increases in the frequency or duration of bankfull flows. Currently the forest stands are older than ten years and have recovered the root strength that was lost in the decade(s) after clearcutting. Channels potentially sensitive to flood events tend to be low gradient depositional streams with gravel- and cobble-dominated beds and banks. In addition, channels tightly confined by valley walls or entrenched into glacio-fluvial deposits have less capacity to spread and dissipate flood flows, making them substantially more vulnerable to peak flow scour. The incision and erosion patterns that occurred in the past leave legacies on the landscape. They can continue to be areas of instability, so forest cover and natural hydrology should be maintained.

The major soils in the area are Kaleetan (volcanic ash and pumice over colluvium derived from andesite and till), Playco (volcanic ash and pumice over colluvium derived from andesite), and a shallower Nimue series soils (volcanic ash and pumice over colluvium derived from tuff breccia; volcanic ash and pumice over colluvium derived from extrusive igenous rock) on ridge tops. Within the eastern portion of the NSC a larger mix of soils are present, including Index, Philippa, Rubble Land, Tinkham, Teneriffe, and Reggad. The Cedar River floodplain mostly consists of Grotto (Aluvium) and Udifluvents (Alluvium) soils. The site tree growth potential (site index) decreases as elevation increases, from Site Class 3 near the river to Site Class 5 at high elevations along the ridge top.

2.4 Disturbance regime

The primary natural disturbance agents are wind, fire, pathogens, insects, and slope failures. Although strong east-west winds often are channeled through the Cedar River Valley and along Chester Morse Lake, there is little evidence of large wind-throw events in the NSC during the past several decades. Fire plays a role as an infrequent large scale disturbance agent, with return intervals of several hundred years. Native root pathogens (*Armillaria sp*, *Phenlinus sp*) are present, but currently create only small pockets of tree death, contributing to overall forest structural complexity. Little forest insect activity has been observed in the area.

Most recent slope failures have been associated with roads built to extract timber. These mid-slope roads were generally built in the 1970s, before current standards to protect the environment were developed.

2.5 Threats

The forest in NSC is at risk from fire and invasive organisms, such as insects and pathogens, because of its location within the watershed (a long border adjacent to public land that is expected to have increasing recreational pressure), its topographic position (an open south-facing slope), and geology (excessively well drained droughty growing site). Risk of fire and invasive organisms is likely to increase as recreation along north border increases, since people are the most common vector both for fire starts and invasive species introductions. If the forest is impacted due to fire or invasive organisms, the immediate proximity to the Cedar River and Chester Morse Lake makes this threat a significant threat to water quality.

Climate change is projected to increase the risk from these threats because of increased temperatures and moisture deficits during the summer (Mote and Salathé 2009). Warming will put additional stress on existing trees, especially on this exposed and droughty hillslope, therefore increasing tree susceptibility to forest insects and pathogens, native and non-native alike. Increased tree mortality combined with higher summer temperatures and reduced moisture will combine to increase the likelihood of fire ignition and spread.

3.0 HISTORICAL FOREST COMPOSITION AND MANAGMENT

The NSC forest is dominated by the Western Hemlock Zone below 3,000 feet, with Pacific Silver Fir Zone at higher elevations, and a very small amount of Mountain Hemlock Zone at the ridge top on the north boundary of the watershed.

In 1876, the office of the Surveyor General was created to survey lands of the western United States. Surveyors first reached the lower CRMW in 1891 and finished surveying the entire watershed in 1911. They documented trees species they encountered on their survey lines and within the NSC noted significant amounts of white pine on the south-facing slopes and cedar and spruce in the valley bottom.

Historical forest cover in the NSC was documented by a timber cruise conducted by King County in 1907. The area was divided into 10-acre parcels and merchantable timber estimated by species. Usually only trees containing more than 500 board feet of timber (20+ inch diameter at breast height) were accounted in the cruise. Most of the basin was covered by primary forest that was dominated by Douglas-fir (*Pseudotsuga menziesii*), with significant amounts of western hemlock (*Tsuga heterophylla*) and varying amounts of western white pine (*Pinus monticola*), western redcedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), noble fir (*Abies procera*), Pacific silver fir (*Abies amabilis*), and larch (*Larix sp*).

The earliest clearcut timber harvest was in the valley bottom in the 1930s and 1940. Much of the area on the lower slopes was cut from 1940 through 1955, with timber harvest at higher elevations taking place in the 1970s and 1980s (Figure 3).

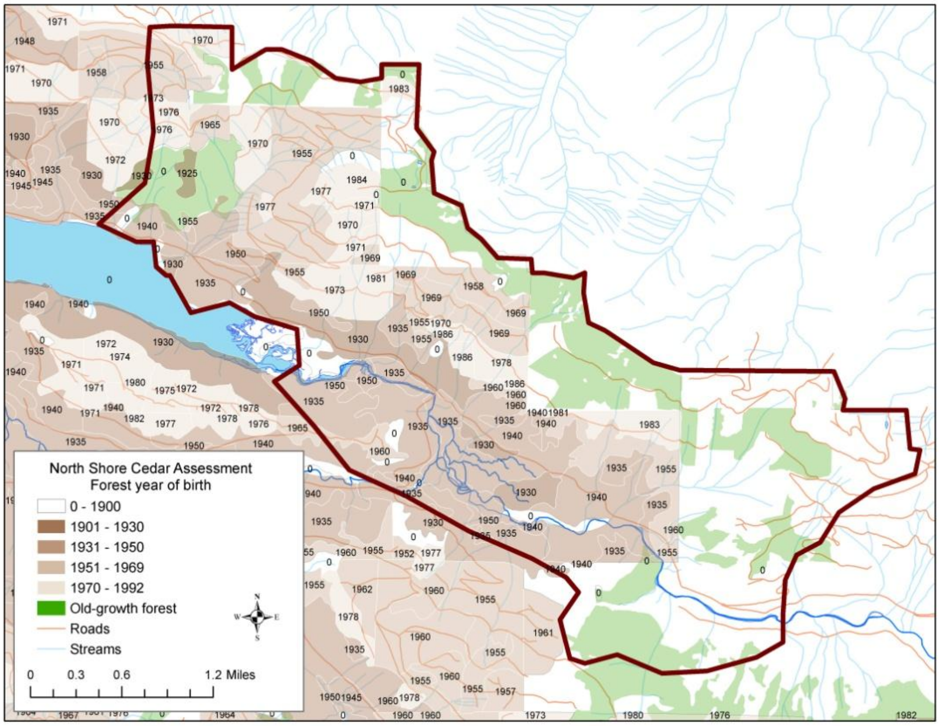

Figure 3. Year of forest original in the North Shore Cedar assessment area

Approximately 300 acres of the youngest forest was pre-commercially thinned to evenly spaced Douglas-fir plantations in 1995, with an approximate residual tree density of 300 trees per acre (tpa). In 2005, an additional 125 acres were thinned to about 300 tpa, with small gaps installed. In 2007, an additional 285 acres of dense young forest was thinned to varying leave tree densities (128 to 240 tpa), retaining all minor species and including small skips and gaps as part of the prescription for habitat restoration (Figure 4). In 2010, about 90 acres that had been thinned in 1995 had numerous small gaps installed. Some gaps retained scattered widely-spaced trees, while others were planted to western white pine and noble fir to help increase species diversity and structural complexity in these forests previously managed as homogenous plantations. Density of these young forests prior to thinning ranged up to 6,000 tpa.

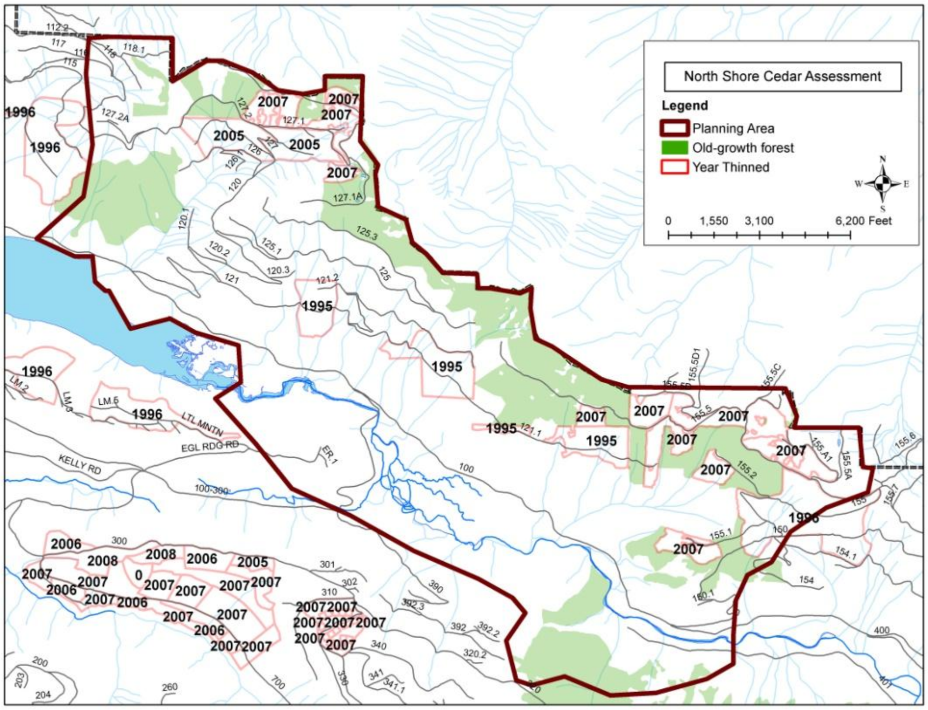

Figure 4. Year of thinning of young forest patches in the North Shore Cedar assessment area.

4.0 CURRENT FOREST CHARACTERISTICS

The valley bottom near the Cedar River is dominated by deciduous trees, with scattered large conifers, including western red cedar, Sitka spruce, western hemlock, and Douglas-fir. The hillslope is predominantly conifer, but with significant patches of deciduous-dominated forest in riparian areas and gullies. Much of the deciduous forest on the hillslope is dominated by 70+ year-old red alder (*Alnus rubra*) that is beginning to senesce.

Four permanent vegetation sample plots (PSP) established between 2003 and 2006 are located in old-growth forest patches within the NSC. One is near the valley bottom at 2,252 feet asl, two in the mid-slope (2,706 and 3,430 feet asl) and one near the ridge top at 4,376 feet asl. The lowest elevation plot averaged 70 live trees per acre, with the remaining higher elevation plots averaging about 190 trees per acre. The three lower elevation plots have two to four times as many live western hemlock as Douglas-fir trees. However, the Douglas-fir trees are much larger, averaging 20 to 40 inches diameter at breast height (dbh) and 90 to 185 feet in height compared to 11 to 26 inches dbh and 70 to 145 feet tall western hemlock. All three plots have a few western red cedar, with no other tree species documented. The ridge top plot is dominated by small Pacific silver fir, averaging only 12 inches in diameter, with large numbers of mountain hemlock (*Tsuga mertensiana*) that average 18 inches dbh.

A single PSP is located in dense second-growth 35 to 40 year old conifer forest at approximately mid-slope. This plot averages 525 live trees per acre, is dominated by Pacific silver fir, with significant numbers of noble fir, Douglas-fir and western hemlock. Average dbh of all species is only 7 to 9 inches.

In 2006-2007, International Forestry Consultants conducted an inventory of 1,120 acres of the NSC area north of the Cedar River to the 121.1 road. Plot data were collected at a sample intensity of 1 plot per 4 acres or a minimum of 8 plots per forested inventory type ≥10 acres. A minimum of 5 plots were taken in types < 10 acres. A total of 289 plots were taken. The dominant species by volume are Douglas-fir and western hemlock with an average volume of 31 Mbf (thousand board feet) per acre, with Douglas-fir being the dominant species on the south facing slopes above the road.

The forest near the bottom of the slope, just north of the 100 Road for 300 to 400 feet, is generally better developed, with larger trees and more complex structure, than the forest further upslope. That mid-slope forest is generally denser, with smaller trees, more uniform canopy, high levels of canopy closure, little dead wood, and little understory.

5.0 CURRENT ISSUES

5.1 Unstable slopes

Much of the steep hillside is inherently unstable, with moderate to high landslide and surface erosion hazard. There are several existing and historical landslides that have occurred on the hillslope, with several debris torrent-dominated channels. There are seven inner gorge areas either within or adjacent to the NSC. Four are associated with Green Point, McClellan, and Roaring Creeks. The most active are two inner gorges in the western portions of the area and are dissected by the 121, 121.1, 121.2, 120.3, and 125 Roads.

5.2 Roads

Roads built to extract timber in the 1970s are a major contributor to slope instability and landslides. The mid-slope 121 and 121.1 Roads are unstable and will be decommissioned as soon as forest habitat restoration projects accessed from them are complete (in 2011 and 2012). Other unstable roads on the slope have already been decommissioned, and the remaining roads are stable. Long-term decommissioning plans for some of these roads are currently under development.

5.3 Special and sensitive habitats

Special and sensitive habitats are located throughout the NSC (Figure 5). The Cedar River and its associated floodplain, wetlands, wall-based channels and other tributaries, and riparian forest (463 acres) are of critical importance to federally listed bull trout (*Salvelinus confluentus*) and their primary prey species, pygmy whitefish (*Prosopium coulteri)*. This area is also prime habitat for numerous birds, small mammals, ungulates, and small carnivores. This area is currently in very good habitat condition, with no known issues created by roads or other past management activities.

There are 1,169 acres of old-growth forest within the NSC, primarily in small patches scattered along the northern border, but also south of the Cedar River in the southeastern portion of the NSC. In addition, there is one patch of old-growth forest just west of McClellan Creek in the southwestern portion of the NSC. Small patches of rocky habitats consisting of talus slopes and rock outcrops (a total of 343 acres) are found throughout the steeper areas, often associated with the old-growth forest patches.

Finally there are a few meadows, small headwater wetlands, and shrub-dominated areas, primarily in the northwestern portion of the NSC near Alice Lakes and the headwaters of McClellan Creek. These small wetlands are generally in very good condition and provide some of the only high elevation amphibian breeding habitat along the northern border of the watershed.

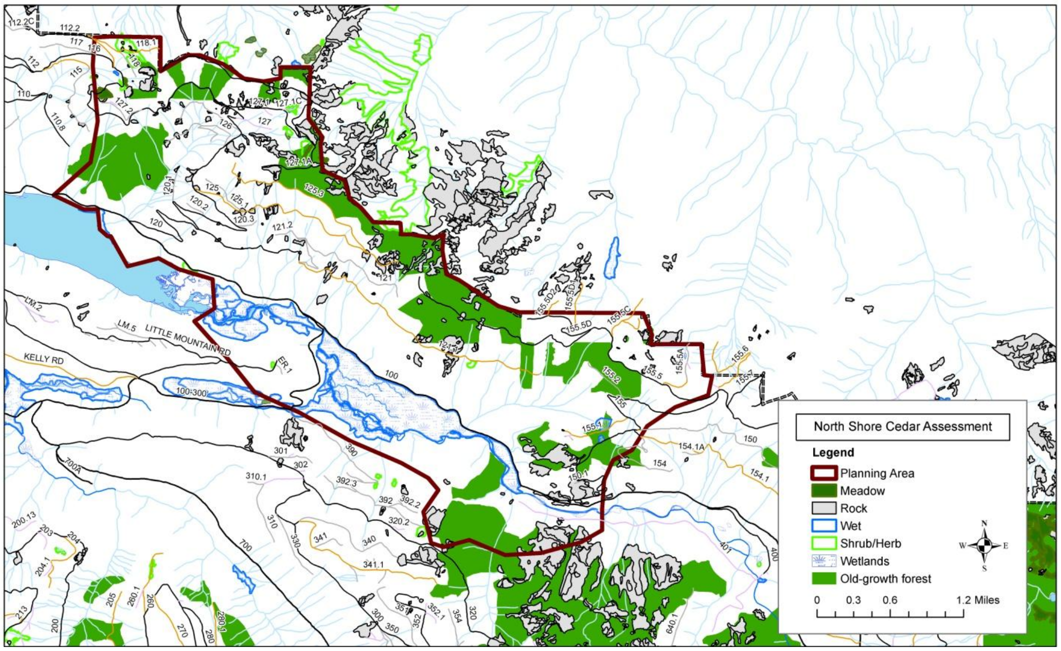

Figure 5. Special and sensitive habitats within the North Shore Cedar assessment area.

5.3 Habitat quality and connectivity

Past land management, primarily clearcut logging with associated road building, has resulted in few high quality forest habitat patches in the NSC. The remaining old-growth forest patches are small, fragmented, and surrounded by large areas of even-aged young forest that have few biological legacies such as large diameter snags and logs. These even-aged forest patches provide generally poor habitat quality and impair connectivity between key habitats such as the old-growth forest patches, riparian forest, and depressional wetlands for numerous species listed in the HCP.

The Douglas-fir plantations thinned in 1995 are dominated by one or two tree species, typically were thinned to even spacing between trees, and have little dead wood, either standing or down, which provides limited habitat quality. The older even-aged second-growth forest has some tree species diversity, but because the trees are so dense in many areas there is very little understory development, particularly as you move upslope from the valley bottom. Additionally, there is little dead wood, standing or down, throughout this forest, and low structural complexity within forest patches.

The second-growth forest provides generally poor habitat for old-growth forest dependent species such as marbled murrelet (*Brachyramphus marmoratus)* and northern spotted owl (*Strix* *occidentalis*). Existing old-growth habitat in the NSC could potentially provide dispersal and foraging habitat for northern spotted owl, although the small and fragmented nature of the old-growth forest makes it highly unlikely for nesting habitat (Figure 6). However, there is reasonable potential for the old-growth forest to be used for nesting by marbled murrelet (Figure 7). Murrelets were documented flying over and adjacent to the NSC area during a 2005-2007 study (flight tracks illustrated in Figure 7). If the birds detected adequate nest trees, they could easily use the NSC area.

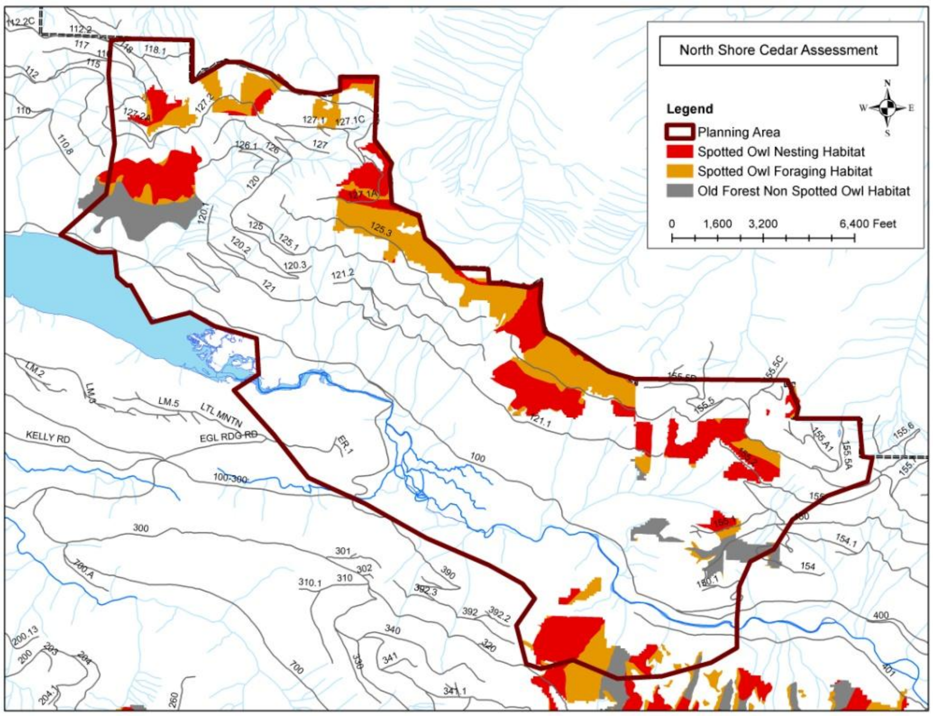

Figure 6. Potential spotted owl habitat within the North Shore Cedar assessment area.

Many species, including small carnivores such as American marten (*Martes americana*), use both riparian corridors and ridge lines as travel corridors. NSC has a series of parallel channels and ridges running north to south. These physical features provide connectivity from the valley bottom to the higher elevation ridge that comprises the watershed's northern border. Much of the adjacent habitat north of the border consists of old-growth forest patches, with extensive rock and talus slopes. Wide-ranging species such as marten and ungulates are highly likely to use both sides of the ridge, so providing high quality habitat corridors from the valley bottom at the Cedar River to the ridge top will benefit several species, both those listed in the HCP as well as others.

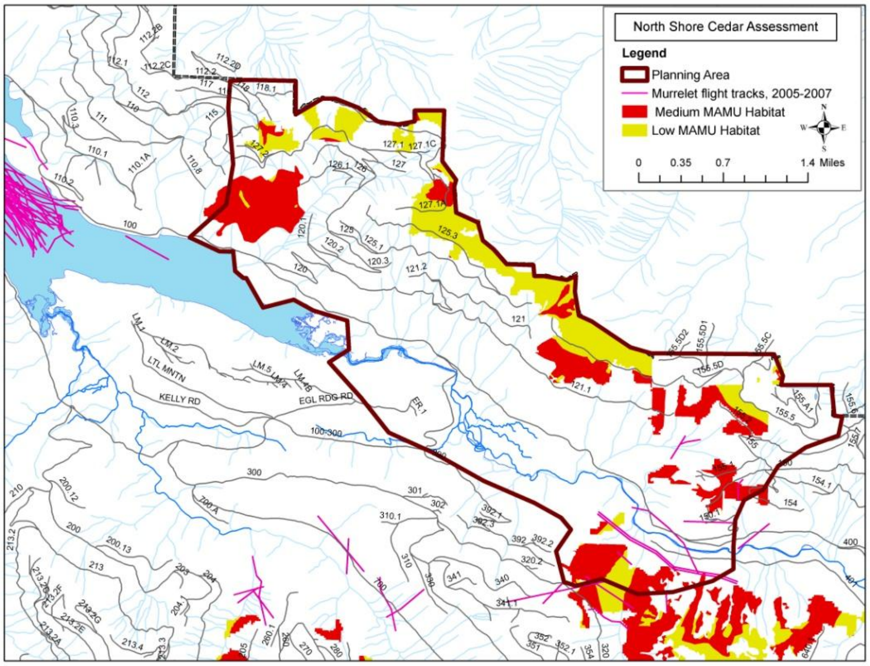

Figure 7. Potential marbled murrelet habitat and recorded murrelet flight tracks in and near the North Shore Cedar assessment area.

The 14 amphibian species listed in the HCP (including eight pond-breeding and four stream-breeding species) integrate aquatic, riparian, and upland habitat. They require several types of key habitats to complete their life cycle, including small ponds, depressional wetlands, or streams for breeding and early life stage development, as well as high quality riparian and upland forest for adult life stages. Key forest habitat elements that they require include numerous large diameter (generally >16 inches) downed logs, stable microclimatic temperatures, and an abundant food source, primarily insects and invertebrates. In turn, these prey species require several habitat elements, including dead wood and a variety of tree and shrub species. Deciduous tree and tall shrub species (e.g., vine maple) typically support greater abundance and diversity of insects and invertebrates. Several frog species typically migrate or disperse over distances of one kilometer, or 0.6 miles, from their breeding areas, meaning that much of the NSC is potential amphibian dispersal or migratory habitat (Figure 8).

Because the south-facing slope of the NSC is generally warm and dry, even the old-growth forest does not provide optimal amphibian habitat. However, in 2011 two individual Larch Mountain salamanders (*Plethodon larselli*), a federal species of concern endemic to Washington and Oregon, were found in the NSC near the 121.1 Road. This finding marks the only documented presence of this species in the CRMW to date. Larch Mountain salamander is a terrestrial species that is associated with talus slopes and occurs in a patchy distribution because of its specialized habitat requirements. The species is likely present in other areas within the NSC where talus slopes are present.

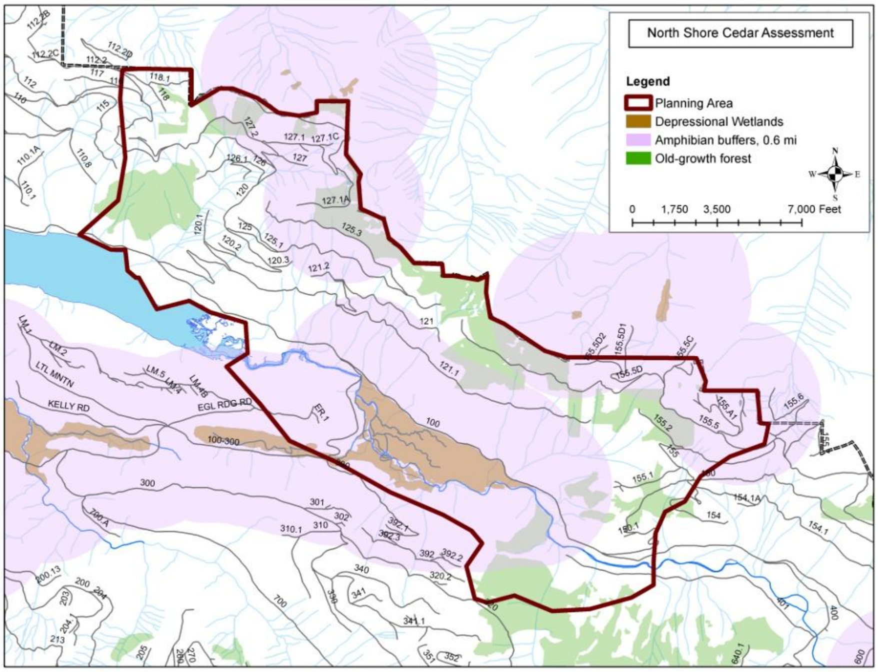

Figure 8. Potential amphibian dispersal or migratory habitat within the North Shore Cedar assessment area.

Tailed frogs (*Ascaphus truei)* are known to breed in Roaring Creek, and if McClellan Creek has perennial portions, it may also provide tailed frog breeding habitat. Adult tailed frogs are closely tied to flowing streams and will stay in and near the creeks throughout their lives, although they may move up and down the stream. The remaining streams within the NSC are ephemeral, so they are unlikely to provide tailed frog habitat. The headwaters of McClellan Creek, consisting of wet meadows provides breeding habitat for Cascades frog (*Rana cascadae*), northwestern salamander (*Ambystoma gracile*), and likely long-toed salamander (*Ambystoma macrodyctylum*).

Riparian areas of concern for amphibian habitat include the shore of Chester Morse Lake from the Cedar River to McClellan Creek (portions are breeding habitat for western toads (*Bufo boreas*), the forest around Roaring Creek and its tributaries, the forest along McClellan Creek and its tributaries, the forest around the headwaters of McClellan Creek, and the riparian forest north of the Eagle Ridge fen and Eagle Creek.

Active roads can pose increased risk of mortality for some species (both from predators and vehicles), and heavily traveled roads can create sufficient disturbance to disrupt normal movement patterns of many mammal species. Creating large patches of roadless areas will benefit many species, especially those that are sensitive to human-caused disturbance, such as breeding marbled murrelets and northern goshawk (*Accipiter gentilis).* Removing the 121.1 road will not only help stabilize the slope, but will also create a 1,400-acre patch of roadless habitat (Figure 9) that will benefit many of the species listed in the HCP.

There are no remaining man-made fish passage barriers within the NSC. The mainstem Cedar River and wall-based channels provide high quality spawning habitat for bull trout and other native fish species.

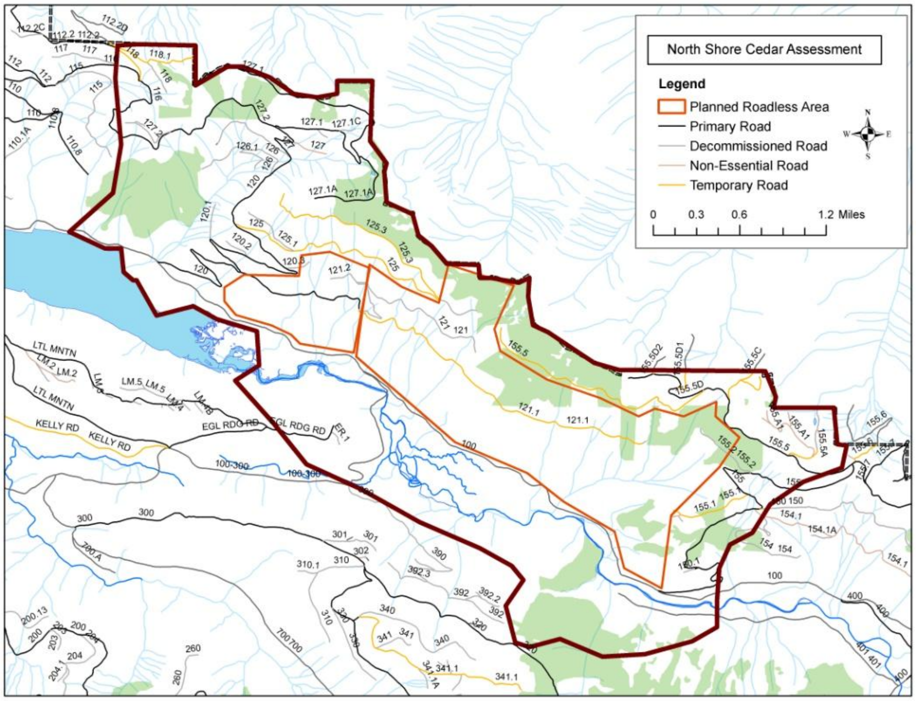

Figure 9. Planned roadless area within the North Shore Cedar assessment area.

5.4 Invasive species

There are numerous invasive plant species throughout the NSC area (Figure 10). Species legally required for control include yellow hawkweed *(Hieracium caespitosum*) and tansy ragwort (*Senecio jacobaea*). Other invasive species that are recommended for control and could pose an ecological risk include Scot's broom (*Cytisus scoparius*), Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), common hawkweed (*Hieracium lachenalii)*, common tansy (*Tanacetum vulgare)*, Saint John's wort (*Hypericum perforatum)*, and both Himalayan and evergreen blackberry (*Rubus armeniacus, R. laciniatus*). Scot's broom is particularly dense in patches along the 121.1 Road and could easily spread to already open areas or newly thinned areas. Common hawkweed is also widespread along the 121 system and thrives in dry open areas such as the south-facing slope of the NSC. There are generally smaller amounts of the other species. Risks posed by these invasive species include supplanting or suppressing native understory and thereby decreasing the resilience of the system, as well as providing poor wildlife habitat.

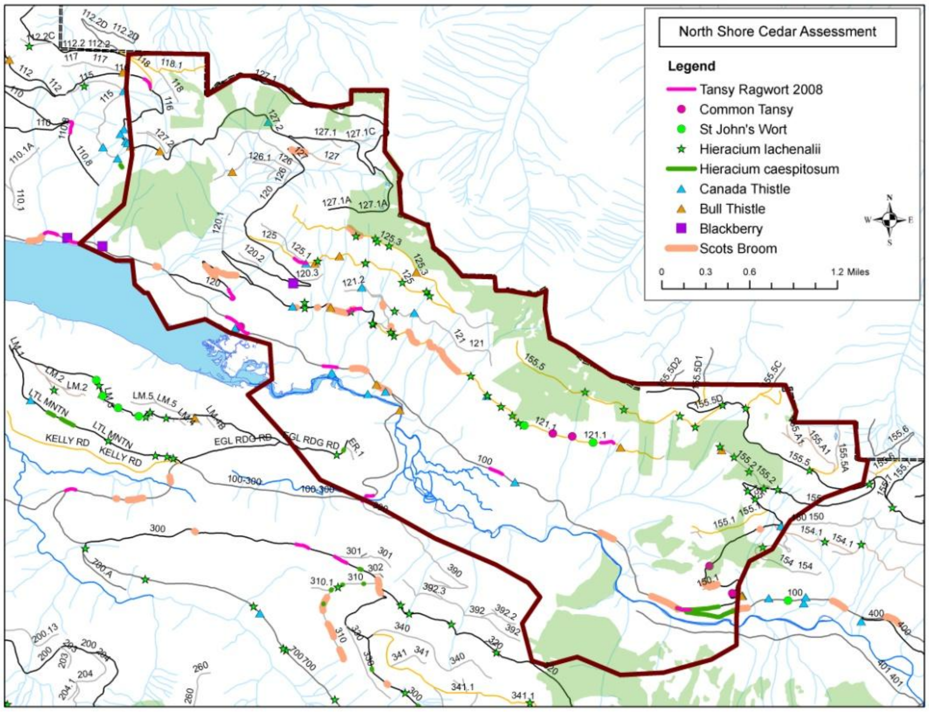

Figure 10. Invasive plant species within the North Shore Cedar assessment area**.**

6.0 HABITAT RESTORATION GOALS

6.1 Protect and increase habitat quality and connectivity

Our first goal is to protect and increase habitat quality and restore habitat connectivity for key species where it has been disrupted by human-caused disturbance or management activities. Strategies include connecting habitat for old-growth forest-dependent species (old-growth forest to old-growth forest) and wide ranging terrestrial species (valley bottom to ridge top), which will be accomplished by creating roadless areas and enhancing currently low quality forest habitat. A main component of increasing habitat connectivity is to enhance second-growth forest habitat that has few plant species, simple structure, dense trees, closed canopy, or little dead wood. Habitat improvement would be accomplished by increasing number and proportion of plant species (both overstory and understory), diversification of canopy structure, increasing forest horizontal structural complexity, and increasing key habitat elements such as dead wood and larger diameter trees in homogeneous forest stands.

Aquatic habitat connectivity and habitat quality in the Cedar River is already high, so our goal there is to protect and maintain the existing aquatic habitat. Aquatic habitat quality in the smaller streams and tributaries on the hillslope has not been evaluated. If it is found to be poor, the goal will be to improve habitat using methods such as wood replacement where it will not contribute to slope destabilization.

Because special habitats and sensitive areas such as the Cedar River floodplain are of such high habitat importance to federally listed and other HCP-listed species and relatively rare on the landscape, it is critical to protect them from human caused disturbance. The majority of the sensitive and special habitats in the NSC are in very good condition. Any restoration projects must protect not only the existing habitat and the functions they provide, but also the natural processes that shape and maintain them. Because global climate change may bring significant changes to natural processes, we may need to monitor some of these habitats for future deleterious changes. If a downward trend in habitat quality and functions is detected, we may need to implement restoration projects at that time.

6.2 Protect and restore resilience

Increasing resilience of both the habitats and wildlife in the NSC is our second goal.

> "Ecosystem resilience is defined as the amount of disturbance a system can absorb and still remain within the same state (Holling 1973, 1996). The concept includes the ability of an ecosystem to reorganize and renew itself following change, thereby preventing dramatic shifts to undesirable states (Elmquist et al. 2003). Biological diversity and ecological redundancy (where numerous species or species groups fulfill the same function) play a substantial role in ecosystem resilience (Peterson et al. 1998)." *Quote from the Landscape Synthesis Plan (Erckmann et al. 2009)*

We presume that resilience of the second-growth forest in the NSC is relatively low because much of the forest is dominated by one or two species and has a generally uniform closed canopy. Conversely, resilience of the old-growth forest patches is higher because of the more varied canopy and species composition. Forest resilience can be enhanced when there are numerous plant species (tree, shrub, herb) present, with significant proportions in each species. Then, for example, if one tree species suffers high mortality from an insect pest or pathogen, the forest may be able to rebound with the remaining species without losing critical habitat and other ecological functions.

Wildlife population resilience can be enhanced if the habitat supports both abundant species and high populations, particularly those at the base of the food chain (i.e., small mammals, amphibians, insects). This can be accomplished by providing key habitat elements such as abundant dead wood (snags and logs), a variety of plant species, and different habitat patches that will support a variety of understory plants.

Our goal of enhancing resilience dovetails with Goal #1. Restoring native plant communities, native forest complexity and diversity, and providing key habitat elements will enhance habitat quality and connectivity, while simultaneously increasing resilience for both the forest and wildlife populations.

6.3 Restore natural slope processes and rates

Our final major goal is to restore natural slope processes and rates of those processes. Past management, primarily road building and timber extraction, has accelerated the rate of landslides on this already unstable slope. Our goals are to avoid any further human-caused destabilization of the slopes, to remove all road-related and any other human-caused triggers for landslides, and reduce or eliminate human-caused increases in surface erosion. All restoration projects (including increasing resilience, forest habitat restoration, and road decommissioning work) would be designed with natural slope processes in mind.

7.0 COMPLETED PROJECTS

Numerous studies and projects have been completed in and near the Cedar River, including channel cross sections, scour studies, a Cedar River delta plant community monitoring study, conifer underplanting, and riparian characterization plots. Fish studies include bull trout spawning surveys, a juvenile bull trout/rainbow trout movement study, a bull trout acoustic telemetry study, a bull trout redd inundation study, a bull trout spawning impedance study, pygmy whitefish spawning surveys, a pygmy whitefish mark/recapture study, and a pygmy whitefish time to hatch study.

There have been road improvement projects completed along the core roads in the NSC improving water flow and drainage, as well as routine maintenance. There have also been two stream crossings that were upgraded so that they can handle peak stream flows without damaging the roads (McClellan Creek and Eagle Creek bridges). Numerous roads and road segments have been decommissioned over the past 15 years, increasing slope stability. These include:

- 1996: 120.1, 120.2, 120.3, 125.1, 121 end, 121.2, 125.1
- 1999: 126, 126.1
- 2001: 127.2A, 118 end, 120 end
- 2002: 155.2
- 2004: ER.1
- 2009: 125.1, 125.3, 125
- 2011: 121.1

Several invasive terrestrial plant species have been targeted for control within the NSC, including tansy ragwort (controlled since 2002), yellow hawkweed (controlled since 2005), and limited Scot's broom, Himalayan blackberry, Canada thistle, and bull thistle control. Completed forest thinning and planting projects were already described in Section 3.

8.0 ONGOING AND PLANNED PROJECTS

This evaluation identified one primary area within the NSC that could benefit from forest habitat restoration work and help fulfill Restoration Goals One and Two: the 55 to 80 year-old second-growth forest between the 100 and 121.1 Roads. It encompasses about 465 acres and stretches from Roaring Creek in the east for about two miles to the west. In 2010, a forest habitat restoration project was planned and laid out in the field, with specific objectives to increase forest horizontal structural complexity throughout the hillslope, increase both horizontal and vertical structural complexity as well as understory development within treatment patches, increase plant species diversity, increase dead wood habitat, and facilitate individual large tree, branch, and canopy development that may provide future marbled murrelet nesting habitat. It included scattered small patches of thinned forest (mean size 1.6 ac), small gaps (mean size 0.25 ac), and individual tree release, with planting in some gaps and low density planting in alder-dominated riparian areas where the alder are starting to senesce and little tree recruitment is occurring. All wood was left, either as logs or snags, to increase that critical habitat component. Implementation of the portions of the project near the 121.1 Road started in fall of 2010 and was completed in 2011.

As soon as forest habitat restoration patches that needed to be accessed from the 121.1 Road were completed, the 121.1 Road and most of the 121 Road was decommissioned. Removing and stabilizing this road bed helped to address Restoration Goal Three. Areas of these roads that were currently infested with invasive plants were planted densely with conifers that will help suppress them and eventually shade them out over the long term. The area on the 121.1 Road near the site where the Larch Mountain salamander was found was only lightly scarified so as not to disturb any salamanders present, and wood placed on the decommissioned roadbed to provide cover and a movement route across the road.

In 2013 portions of the young forest off the 155.5 Road were restoration thinned. Future planting within the restoration thinning units in the NSC may be considered to enhance tree species diversity. Potential thinning or planting in the older patches of second-growth forests between the 100 and 121 Road will also be evaluated.

There may be a LWD placement for the Cedar River at mouth of Roaring Creek. In addition, there may be a planting project in the Cedar River floodplain, from Roaring Creek west to Camp 18, to help stabilize the channel and floodplain.

9.0 MONITORING AND ADAPTIVE MANAGEMENT

Selected plants installed in the small created canopy gaps between the 100 and 121.1 Roads will be monitored. White pine blister rust-resistant western white pine were installed in several gaps to try and bring this species closer to historical levels, as well as to increase the diversity of drought tolerant trees that may be well adapted to a warming climate. Percent survival, growth, and vigor under various light regimes will be important information to use in future restoration planting projects. In addition, survival of all planted stock in areas with high levels of downed wood will be critical data as we move forward with other forest habitat restoration projects.

Because of the high habitat importance of the special and sensitive habitats within the NSC and their potential sensitivity to climate change, these areas, plus the surrounding habitat, will be monitored periodically. Particular areas of focus include meadows, wetlands, and riparian areas. These areas may degrade due to factors such as invasive species, changes in hydrology, and tree invasion into the meadows. If significant degradation of the special habitats or areas surrounding them is seen, restoration and habitat enhancement projects will be considered at that time.

Forest patches adjacent to talus on the dry, south-facing hillslope are important habitat components for certain amphibian species. If we experience predicted warmer, drier summers, existing tree species may experience increased mortality rates. Forest health in this area will be monitored along with the rest of the municipal watershed's forests and if increased mortality rates are observed, then projects enhancing forest resilience and possibly recovery, such as planting a more drought resistant species mix and increasing downed wood to help retain soil moisture, will be considered.

10.0 REFERENCES

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