Chapter 2 Existing Conditions and Trends

Geology, Soils, and Hydrology

Geology

Mt Baker is an active, ice-clad volcano in the North Cascades of Washington state about 31 miles due east of the city of Bellingham. After Mt Rainier, it is the most heavily glaciated volcano of the Cascade volcanoes. The volume of snow and ice on Mt Baker (approximately 0.34 cubic miles) is greater than all the other Cascade volcanoes (except Rainier) combined (Gardner et al., 1976). Historically, debris flows and avalanches have been the primary hazard associated with the mountain. One of these flows has reached the Puget Sound by way of the Middle Fork Nooksack to Bellingham Bay, starting at Deming Glacier.

The analysis area contains several structural faults of the Cascades. Several known active fault systems are within and affect infrastructure developments in the watershed, including roads and trails.

Middle Fork Nooksack River Watershed

The geology of the headwaters of the Middle Fork is composed of pyroclastic and lava flow associated with Mt Baker. Extending downstream, the river passes through meta-sedimentary, meta-volcanic, and extensive deposits of glacial till. The valley has the characteristic U-shape valley of glacially-scoured basins. The stream has been actively down-cutting and has produced a V-shaped channel within the broader valley. Steep forested side-slopes occur along most of the river's length.

In the Middle Fork basin, glacial and recent alluvial deposits cover mudflow deposits and is a more confined valley than the South Fork basin within the analysis area. Only the lower portion of the Middle Fork basin is incised to any degree. The Clearwater basin (located within the Middle Fork Nooksack watershed) is a rock canyon with a valley floor of recent deposits of sand and gravelly material.

South Fork Nooksack River Watershed

The geology of the headwaters of the South Fork is composed primarily of meta-sediments, meta-volcanic and dunite mantle material that forms the dominant western mountain range. Much of the valley has the typical U-shape of glacially scoured basins resulting from past continental and later alpine glaciations. At the point where the South Fork flows into Whatcom County from Skagit County, a small gorge has been cut through phyllite and contains a unique kame moraine.

The South Fork basin consists of a wide, unconfined valley floor composed of glacial and stream sediments, into which the South Fork has carved a channel along its western margins. Extensive deep surface deposits of glacial till and lacustrine material occur within the valley bottom and the toes of slopes.

Bell Creek (located within the South Fork Nooksack watershed) is a low gradient channel with gravels of broken phyllite/argillite rock. The lower portion cascades through a steep, rock ravine. Wanlick Creek starts in sedimentary rock and cuts a narrow valley through glacial lacustine deposits downstream.

Faults Located within the Analysis Area

Faults are a major factor in shaping the drainage pattern of the river system. Faults are fractures in the bedrock along which there has been displacement of the sides, relative to one another, parallel to the fracture.

The major tributaries and forks follow faults (see Figure 4) due to the ease at which material can be eroded. These fault contacts were later scoured out by glacial ice and filled with retreating glacial deposits. When these fault zones plunge with the slope, failure is common and is easily triggered by surface disturbance or changes in surface hydrology.

During the Cretaceous Period, the major rock units moved into place as the result of one plate overriding another. These are called thrust faults and have a low angle of inclination (less than 45 degrees). The Twin Sisters thrust fault (also known as Bell Pass mélange) forms a unique assemblage of metamorphic rocks that flanks the east side of Twin Sisters Mountain. This fault crosses at Elbow Creek in a northwest-to-southeast direction.

Major rock units include the Elbow Lake Formation, the Chilliwack meta-sedimentary, and the Yellow Aster complex, and ultramafic rocks. The ultramafic rocks form the ridge complex to the west of the upper South Fork watershed. Loomis Mountain and Forest Divide are comprised of Chilliwack meta-sedimentary rocks.

Since the Cretaceous Period, this area was subject to additional strike-slip faulting and extension faulting (Tabor et al. in press). In Tabor et al. (in press), the structural mapping is well illustrated in cross sections showing the different rock units and fault relationships. Springs, seeps, and sag ponds are often evident as surface expressions of water presence in the margin of fault zones. It is extremely important to recognize that fault zones are zones of greater weathering and weakened rock structure and are important considerations when constructing roads and trails. Locations of the faults and type of rocks are important in relation to the major landslides in the watershed. Three landslides of significance are Elbow Lake, Old Olivine Quarry site at RM 31.0 (a partial fish migration barrier) and the area from Howard Creek to Hayden Creek. These areas will continue to be highly active natural sediment sources in the watershed.

Debris avalanches have occurred at fairly regular intervals since 1958 (Frank et al., 1975). Smaller failures have occurred, like the 1980s rock fall (>200,000 cubic yards), which was observed in the upper Clearwater drainage off the ridge between Groat Mt and Grouse Ridge (Nichols personal communication).

Seismic Activity

The upper portion of the Middle and South Fork Nooksack watersheds is part of the Cascade subduction zone. A subduction earthquake, a thrust type earthquake caused by slip between converging plates, can exceed a magnitude of 8.0. The largest recorded earthquake in the state occurred December 14, 1872 (magnitude of 7.2) in the North Cascades. The latest significant earthquake in the state occurred February 28, 2001 in Nisqually, WA (magnitude of 6.8).

Documented seismic areas near the area include: South Whidbey Island Fault (Sam Johnson, 1996); Darrington Seismic Zone (Zollweg and Johnson, 1989); Day Lake Seismic Zone (Pringle et al. 1998); Deming Seismic Area (Hyde and Crandell 1978); and Bacus Hill, Sedro-Woolley (Bechtel Corp. Inc. 1979).

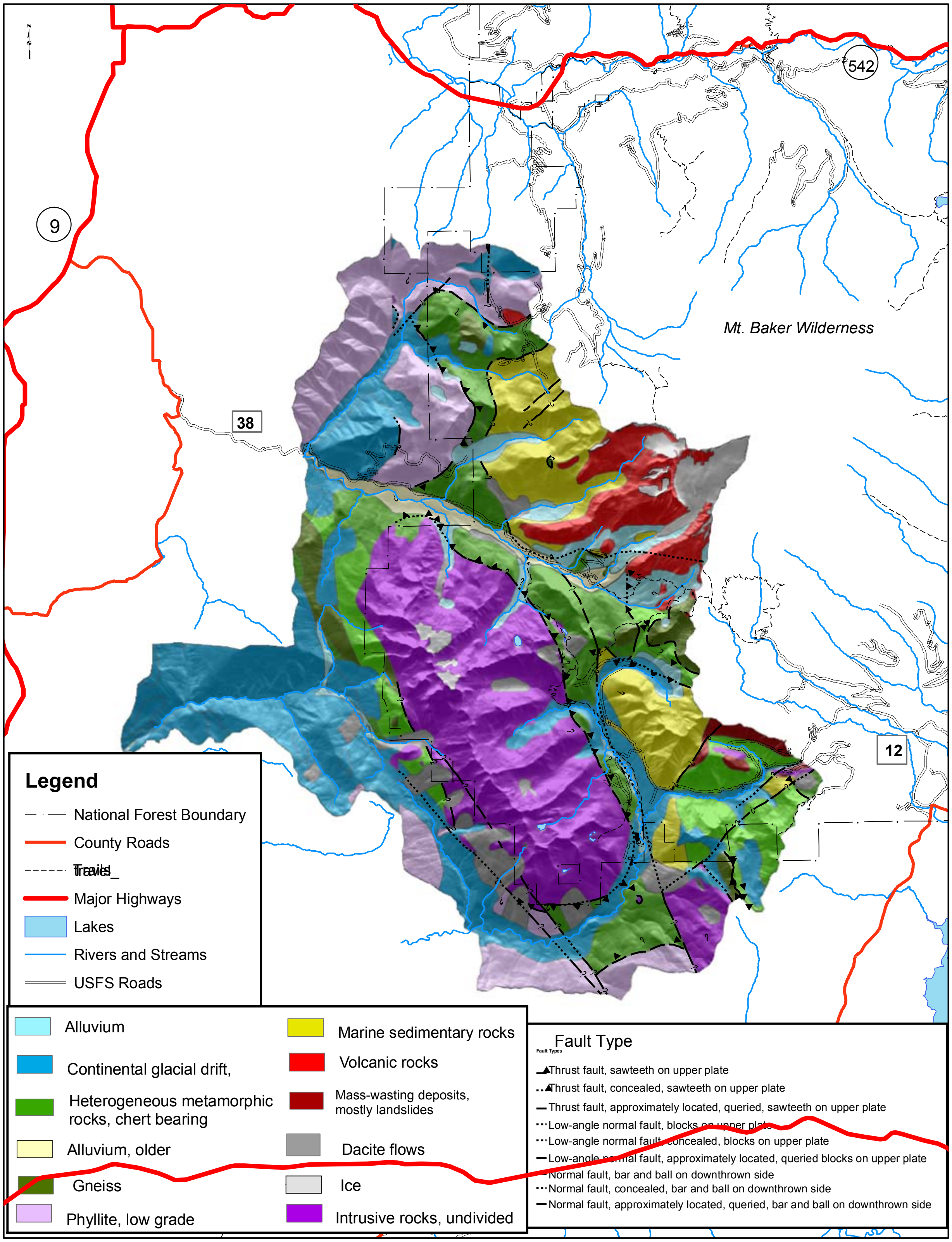
Mt Baker Volcanic Activity

Mt. Baker is a strato-volcano, a volcano that is composed of alternating layers of lava and aerial deposits of ash and rock. Strato-volcanoes have more frequent avalanches, rock falls, and debris flows on their steep slopes. Volcano slopes are particularly vulnerable to landslides because of the layered and joined volcanic rocks lying parallel to the mountain slopes. These layers are weakened by the effects of steam and hot ground water, and over-steepened by erosion. In addition, icefalls from glaciers can trigger landslides, and snow and ice add to the mobility of such slides (Dreidger and Kennard, 1986).

The massive 1.7 cubic mile rockslide/debris avalanche on the north side of Mt. St. Helens during the catastrophic eruption of May 18, 1980, was triggered by a moderate (magnitude 5.0) earthquake that followed eight weeks of intense earthquake activity beneath the volcano. In comparison, the most probable types of large mass movements that could occur as a result of the present thermal activity on Mt. Baker would be mudflows having speeds of as much as 30 miles per hour. The mudflows would originate from a mixture of snow, ice, and melt water, and avalanches of structurally weak clay-rich rocks that make up the rim of Sherman Crater.

Geologic records show that at least eight massive mudflows have occurred over the past 10,000 years. The largest known mudflow had an estimated volume of between 48 million and 60 million cubic yards, and extends at least 16.8 miles down the valley of the Middle Fork of the Nooksack River (Frank et al., 1975). Following the 1843 formation of Sherman Crater, two collapses on its east side produced lahars, the first and larger of which flowed into the natural Baker Lake, raising its level at least ten feet (USGS, 2000). In 1891, about 20 million cubic yards of rock fell from the northeast slopes, producing a lahar that traveled more than six miles and covered one square mile (USGS, 2000).

Figure 4 Geology



Approximately thirty-six million cubic yards of unstable material remains at Sherman Crater. An earthquake, steam explosion, or eruption could provide a suitable trigger to initiate movement of some or all of this volume (Frank et al., 1977). Frequency of mudflows may have increased, as shown by the geologic record of the last 500-600 years (Hyde and Crandell, 1978).

There is also evidence of several lava flows and tephra eruptions during the past 10,000 years. The latest of these eruptions could have taken place as late as the mid 1800s (Hyde and Crandell, 1978). Folsom (1970) believed that probable volcanic events occurred in 1843, 1854, 1858, 1859, and 1870. USGS (2000) concludes that lahars are the greatest hazard at Mt. Baker, and when magmatic activity does recur, all watersheds will be at risk. Mt. Baker has two fumarole fields, Dorr on the northeast slope of Mt. Baker, and Sherman Crater about six tenths of a mile south of the volcano's summit. According to USGS (2000) the Dorr Fumaroles are a potential site of hydro volcanic explosion.

Steep headwalls on the north flank are also at risk of flank collapse, but Sherman Crater is considered the most likely area on Mt. Baker for renewed failure. USGS (2000) has mapped hazard zones surrounding Mt. Baker. Inundation Zone 1 includes the lower valleys down the Nooksack and Skagit Rivers to saltwater. Both seismic activity and gas emissions associated with the mountain are monitored. USGS works with federal, state, provincial and local agencies to prepare for disruption that might accompany renewed activity.

Geomorphology

Lava flows from Mt. Baker have also influenced many of the current landforms in the analysis area. Volcanic rocks and lava flows are today's ridges. Erosion continues to wear away the ridges on each side of a valley. A lava flow may eventually become a ridge perched above the eroded canyons. Examples of this are the Rankin Creek area and the Wallace Creek Divide on the southwest side of Mt. Baker. What was a valley becomes a ridge top through erosion. These areas are normally very stable. Another distinguishing landform is Seward Peak and Black Buttes, which was the older Mt Baker volcanic cone.

South Fork Nooksack

Below Elbow Lake Creek, the watershed is a broad gentle valley. This is where the South Fork Nooksack River has down-cut through the glacial outwash which caps glacial lake sediment (i.e. lacustrine deposits). During the retreat of the continental ice sheet 10,000-13,000 years ago, ice filled the Nooksack and Skagit valleys and blocked the South Fork Nooksack River valley. The glacial ice acted as a dam and formed a lake, flooding the South Fork valley. During this time, a thick layer of clay, sand and gravel was deposited in the old valley. When the ice withdrew, rapid deposition of sand and gravels covered these glacial deposits forming a broad outwash plain. When the glacial ice retreated and the outwash dam had been flushed away by the Nooksack

River, the South Fork Nooksack River rapidly eroded downward, making a slot in the outwash-covered plain, down through the glacial sediments to bedrock.

The South Fork Nooksack watershed contains two major faults: A thrust fault (where ground on one side of the fault moves up and over adjacent ground) along the eastern margins of Twin Sisters, and a high angle fault which is an in-filled fault trace, which the South Fork follows. In-filled fault traces are locations where glacial ice scoured out the zone of weakness and these hollows were later filled with retreating glacial deposits. These fault traces can be observed in Elbow Creek where landslides are prevalent and south of Bell Creek where multiple slides occurred in the harvest unit adjacent to the stream channel. Below Wanlick Creek, the South Fork follows the thrust fault where it meets a series of high angle faults, which are also in-filled fault traces. Howard Creek, an in-filled fault trace, isolates meta-sedimentary rocks, i.e. phyllites from ultramafic material, i.e. dunite. At present, Howard Creek is supplying gravel and sand to the South Fork Nooksack River channel.

Loomis Mountain is primarily meta-sedimentary rock, phyllite and argillite rocks capped with meta-volcanic rock. In this meta-sedimentary rock unit, failures are easily identified by concave, convergent topography and expressed as wide inner gorge areas.

These weathering zones are the direct result of an alteration of a mechanically weak or marginally competent rock by shearing or faulting. High concentrations of subsurface water are commonly associated with these weathering zones. Changes in surface and subsurface water routing that are commonly associated with clear cutting and road construction may increase the amount of water in these shear zones and result in a higher frequency of inner gorge and slope failures. Two areas where this can be seen are the valley walls of Bell Creek and Wanlick Creek on the north and south side of Loomis Mountain, respectively.

Due to rock weathering characteristics, the bedload in Wanlick Creek is primarily fine platty gravel except in areas directly below feeder banks of coarse glacial outwash composed of sand and gravel. In Bell Creek where there are no feeder banks of outwash material, the bedload gravels are all small, flake-shaped gravel.

Middle Fork Nooksack

In the Middle Fork, huge landslides off Mt. Baker filled the middle of its valley floor, from present day Sherman Peak downstream to the confluence of the Middle and North Forks of the Nooksack River (Hyde and Crandell 1978). In some cases these landslides were so large that they ran to Bellingham Bay (Hyde and Crandell 1978). These huge landslides covered the earlier fine glacial lake deposits and coarser sand and gravel outwash material. In the upper reach of the Middle Fork below Ridley Creek, the river channel is now reworking coarse bedload deposits of cobbles and gravels from Deming Glacier.

The upper portion of the Middle Fork Nooksack watershed is a narrow, steep-sided, rock canyon with a valley floor of glacial outwash and recent fluvial deposits of sand and gravel. In this area, the river has low gradient and is primarily filled with water from melting glaciers. The meltwater distributes and mobilizes glacial outwash sediment across the valley.

Bedrock in this area consists of various types of igneous, metamorphic and sedimentary rocks. Most of these rocks are altered, metamorphosed sea floor sediments and volcanic rocks that are exposed as a series of nappe, or rock units that were folded and then faulted into place. These units start below recent Mt. Baker flows (Tabor et al. in press).

These rock units, composed of different material, erode at different rates. For example, Twin Sisters is an area three and a half miles wide by ten miles long and is primarily composed of dunite, an unaltered mantle material that erodes very slowly. Due to this slow erosion rate, glacial ice sculpted a picturesque and classic alpine mountain.

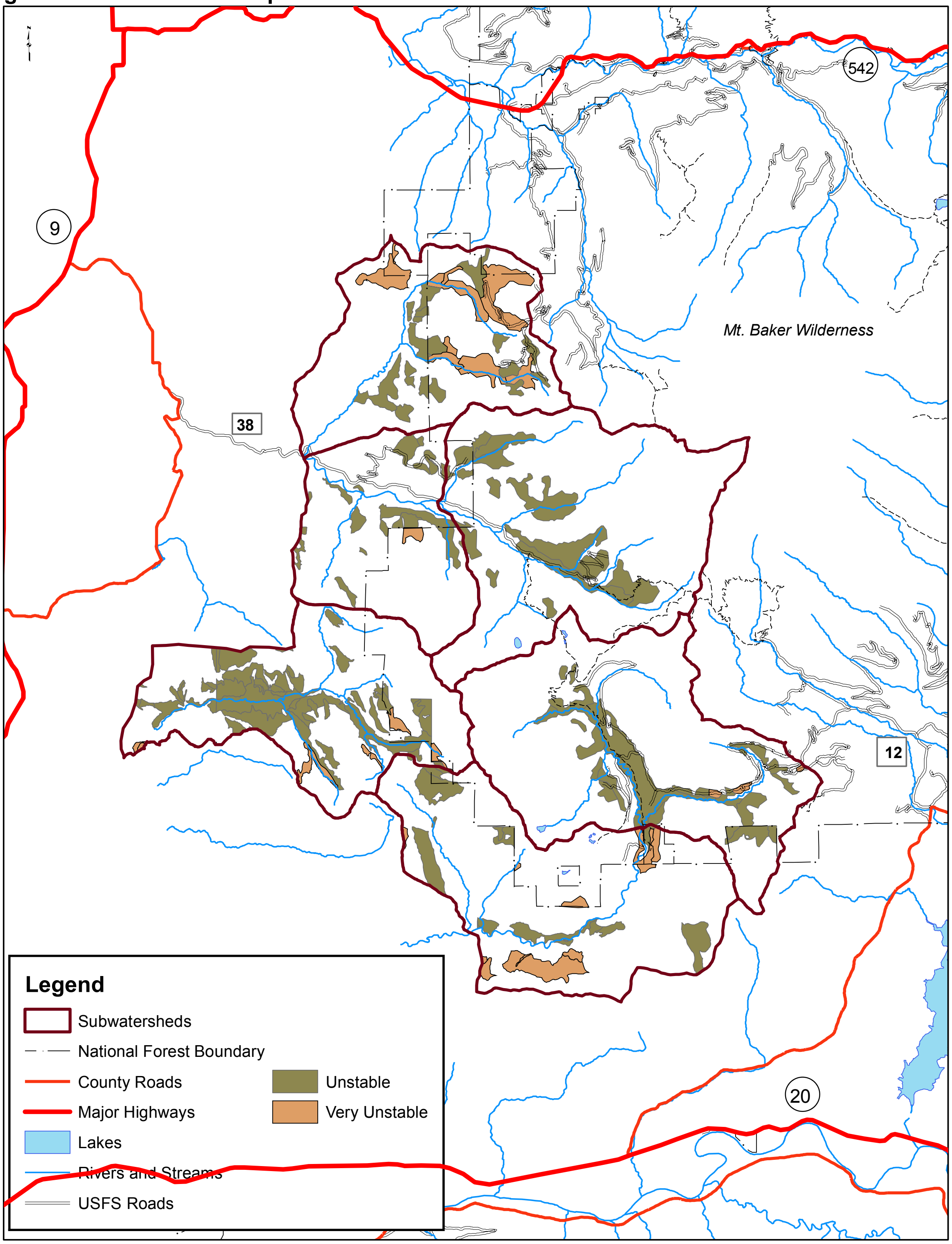
Soil Stability

Soil types that are prone to land sliding in the Northwest Cascade Region (Skagit /Nooksack) have similar glacial history, parent material, landform, and texture. This is evident when comparing the results of Heller (1978), Paulson (1996), Parks (1992) and Peak Northwest (1986).

Increases in slope and water are major factors in soil instability. General areas where unstable soils are most likely to occur are the glacial lake sediments margins, along the steep side slopes, margins of in-filled channels, and faulted stream channels (Fiksdal and Brunengo 1981, Hale 1992). The Unstable Soils Map (Figure 5) shows unstable soil types which are NOT the same as unstable slopes. This map does not include the slope of the terrain nor the water table information necessary for identifying unstable hillslopes. Unstable slopes (and therefore Riparian Reserves associated with them) will be identified on the ground in the event that any ground-disturbing projects are analyzed through the NEPA process for this area. Soils that are displayed as unstable might not lead to mass failures with most surface disturbance but are unstable if they occur on steep slopes where water is concentrated .

The glacial lake sediment margins are affected by percolation of ground water. The level of ground water rises during wet periods. This results in an increase in pore pressure (the pressure of water in the spaces between particles in the soil) in the coarser layers of varves (layered glacial lake sediments). The increase in the pore water pressure can bring about spontaneous failure in slopes (Terzaghi and Peck 1961). Timber harvest and large fires change soil moisture and the way snow accumulates and melts. When snow melts rapidly or melts at a period of high water, failures in glacial lake sediments are more prevalent because of high pore pressure.

Figure 5 Unstable Soils Map



Unstable soil types identified by Washington DNR Soil Types and USDA USFS Soil Resource Inventory.

NOTE: Unstable soil types are NOT the same as unstable slopes. This map does not include the slope of the terrain nor the water table information necessary for identifying unstable hillslopes. Unstable slopes (and therefore Riparian Reserves associated with them) will be identified on the ground in the event that any ground-disturbing projects are analyzed through the NEPA process for this area.

Figure 6 Road 12 at MP 7.7: Road failure and subsequent debris torrent

Natural Sedimentation

Mt. Baker, and to lesser extent, the north face of Twin Sisters Mountain are flanked with large active glaciers as well as numerous smaller glaciers and perennial snowfields. Within the South Fork and Middle Fork watersheds, the alpine zone comprises a large percent of the area. Varying amounts of unconsolidated, un-vegetated material, derived from the glaciers, occur in the headwaters of many of the streams within the Middle Fork Watershed. This material is stored in moraines and in deposits from debris flows, mudflows, and floods that have scoured the moraine material. Erosion and mass wasting of these deposits constitute an important source of coarse and fine sediment to both the Middle Fork and South Fork Nooksack Rivers. Runoff from melting glaciers provides an additional source of fine sediment to the Middle Fork. Portions of the lower watershed are also strongly influenced by deep deposits of glacial sediments, especially in the South Fork below Bell Creek and in the Middle Fork below Warm Creek.

Landslides and Mass Wasting

Landslide activity has been identified as a concern within the watershed because of water quality concerns. Glacial lake sediment deposits have significant influence on the turbidity of and erosion processes within the South Fork Nooksack River. Remnant deposits of this material occur in the valley walls. This material can be subject to spontaneous liquefaction. Liquefaction occurs when saturated sand or silt is shaken violently and undergoes a sudden loss of shear strength. Vibrations generated by idling track dozers, rock blasting, or a passing train can be enough to trigger the subsequent landslide (Noson et al., 1988). Puget Sound earthquakes generated 20 landslides as far as 112 miles from the epicenter of the 1949 Olympia earthquake, magnitude 7.1, and 21 landslides were generated as far as 62 miles from the epicenter of the 1965 Seattle-Tacoma earthquake, magnitude 6.5 (Keefer, 1983; 1984).

Keefer (1983) noted that geologic environments in the Puget Sound Region have high susceptibilities to ground failure including areas of postglacial stream, and lake sediments, river deltas, and areas having slopes steeper than 35 degrees. Types of ground failures to expect include landslides, soil liquefaction, and differential compaction. Both of the above Puget Sound earthquakes occurred within the Puget Trough. A seismic event of this nature could trigger a massive landslide similar to the one ran down the Middle Fork Valley and reached Bellingham Bay.

Road related landslides have been fairly isolated to Road 12 Milepost (MP) 7.0 to MP 9.0 where shallow outwash material is overlaying bedrock on slopes greater than 30 percent. The combination of these shallow soils over bedrock, poor road construction techniques of the 1960s, and insufficient drainage has resulted in fill slope failures with sediment delivery to Wanlick Creek. In the Middle Fork, the only notable road failure was the Rankin stream crossing of the now-decommissioned Road 3830. The road crossed an in-filled fault trace with too small a drainage structure, which plugged and failed. This failure led to the channel flushing out large wood debris below this point.

Infiltrating water can generate unstable conditions on hill slopes by increasing the weight of the soil and increasing the pore water pressure. Rain infiltrating the ground surface easily penetrates the underlying sand, but the relatively impermeable silt or clay layer impedes further downward movement of the water. A zone of saturation at the top of the impermeable layer causes slumps in the overlaying sand. When disturbed, the saturated sand oozes over the steep slope as a mudflow.

Landslides also occur where bedrock is close to the surface (Heller, 1978, Hale, 1992). Heller suggests the bedrock is not only trapping water percolating from above, but may also direct ground water flow to the slide site along the bedrock surface.

The level of the groundwater table rises in wet periods. This results in increased pore pressure (pressure in saturated soils due to presence of interstitial water) in the coarser layers of the varves (layered glacial lake sediment). The increased pore pressure force soil particles apart and thus reduces shear strength (friction surfaces between particles) of the fine sediments. When pore pressure increases high enough to exceed sheer strength this brings about instantaneous slope failure. This is relevant in light of the possibility that reductions in evapotranspiration due to logging may result in increased rates of landslides due to the associated rise in the height of the water table along South Fork Nooksack River margins. Hale (1992) reported that 43 percent of the landslides measured were natural, 11 percent timber harvest related, 17 percent by road fill and culverts, and 6 percent from road cut-banks.

Soils that have had the highest frequency of landslides are glacial outwash and meta-sedimentary rock (20% and 26% respectively). A good example, and one of the few failures related to Forest Service roads in the Middle Fork watershed, occurred on Road 3830 at the Rankin Creek crossing (which is now decommissioned and no longer a threat). The road crossed an in-filled gully consisting of glacial outwash on a fault contact. The ground slope was greater than 30 percent, and underlain with broken meta-sedimentary rock. Another place where the same conditions existed, and the same result happened but on nearby private timberlands, was above the end of Warm Creek Road to the west of the Warm Creek. When the area was logged by private industry, multiple slope failures occurred with delivery to Warm Creek.

Channel Processes and Large Instream Wood

The Middle Fork and its tributaries naturally carry high levels of suspended sediment and bedload. In particular the headwater tributaries of the Middle Fork are steep and prone to erosion of post-glacial debris and mobilization of glacial moraine deposits. A conservative estimate of the sediment load from glacier and pro glacial environment is 83,980 tons/year (Westbrook 1988).

Between RM 17 and Rankin Creek the Middle Fork channel exits in a confined narrow ravine-like valley where gradient drops to approximately three to four percent. Due to the reduced gradient, a lower transport capacity for carrying bedload and debris exists. With the reduction in transport capacity, bedload and debris are deposited and the channel naturally shifts back and forth across the valley bottom depositing boulder and cobble bedload; as deposited sediment fills up one channel it pushes the main flow into another channel.

Several tributaries feed the right bank of this river section. These tributaries are important because they provide clear and relatively cool water year-round. It's likely that these tributaries had beaver presence due to the vegetation communities that exist. Beaver activity is known to influence channel morphology through the damming and diversion of stream flow. This slows the water velocity, promotes sediment deposition and channel infilling, and often causes the main channel to shift to a new location. The abandoned channels are eventually stabilized by vegetation, providing areas of sediment storage until remobilized by high flows.

In streams, large wood strongly benefits the formation and maintenance of physical features of channels such as gravel bars, pool formation, side channel development, and bank protection (Nelson, 1998; Beechie, 1998). Large wood in the channel is recruited from landslides in mature timber stands and from channel bank scour, undercutting trees in the riparian area. For the portions not federally owned of both forks of the Nooksack River, much of the riparian area has been disturbed by timber harvest. Recruitment of large wood from these areas is dependent on what is remaining in proximity to the channels. During timber harvests on federal lands, all trees in the riparian areas at the bottom of units were removed, and large wood was cut out of stream channels in the following areas--right bank tributaries of the Middle Fork Nooksack River, middle reaches of Clearwater Creek, Wanlick Creek, and middle reaches of Bell Creek riparian areas.

Wanlick Creek was identified as a stream where wood removal had an adverse impact (increased fine sediment levels and elevated stream temperatures). These channel conditions resulted from natural landslides, snow avalanches, sediment inputs from road failures, and past practices of wood removal from streams. Washington Monument's periodic snow avalanches and landslides temporarily dammed Wanlick Creek in 1990, 1995, and 2003 resulting in surge flows down the channel. In response to the above impacts to Wanlick Creek, a cooperative channel project was conducted between 1990 and 1996 increased large wood channel content to 300 pieces per mile, but flooding since then has reduced large wood to less than 154 pieces per mile (Table 5, Page 39).

Stream surveys and wood inventories in the South Fork have documented that wood recently fallen into the river is neither embedded in the channel nor extensive enough to form valley wall jams for sediment storage. Both of these characteristics are necessary to provide sediment retention and improve channel stability.

In either 1977 or 1978 there was an extensive channel clearing project in the South Fork Nooksack River using D-8 caterpillers, pushing the logjams and LWD to the channel edges on from the confluence with Bell Creek (RM 37.3) down to the 1260 bridge (RM 35.8) (pers comm Ned Currence, Nooksack Tribe, 2005 reiterating his pers comm with Mike Janicki 2005). The upper part of the reach was accessed by what is now the trail that leads toward Elbow Lake. This was channel clearing was in response to two debris flows that initiated in old growth during a major rain on snow flood event in 1976. Both debris flows traveled all the way to the river, depositing huge volumes of wood and sediment, creating very large logjams. One of these debris flows came down Bell Creek, depositing substantial accumulations of wood and sediment into the lower gradient river. The second debris flow came down a tributary draining Loomis Mountain that enters the river between Bell Creek and the bridge. This debris flow went through at least one younger reproduction stand, bringing in more material as it did so. Between the two events, major river channel changes occurred, in places completely changing the channel location. For example part of the river flowed east of the 1260 bridge, instead of going under it. Very large logjams stored large amounts of sediment. In the river reaches downstream from this, between the 1260 bridge and Larsons Bridge (off-Forest), LWD was lacking and there wasn't much spawning gravel. According to Janicki, the premise for the project was that if the sediment that was trapped by the wood between Bell Creek and the 1260 bridge was released to move down river, it would increase the available spawning gravel for fish downstream.

Below the analysis area, the lower South Fork historically had full spanning log jams and forested islands, and has experienced diminished LWD loads since at least the early 1930's (NNR in prep.), and the higher LWD densities within the analysis area will likely provide LWD to the low gradient lower South Fork. The lower South Fork has no high LWD recruitment potential areas (Coe 2001)

Flooding

Historically, flooding in the Nooksack basin has been severe and frequent, averaging one major flood every five years (Kunzler, 1991). Floods over the past two decades have been some of the most damaging on record, causing millions of dollars in property damage.

Ketcheson (1992, 1998) conducted a review of the most recent flood events in Western Washington which included the following findings:

- Flooding primarily occurs from October through February, when winter storms produce 75 percent of the annual precipitation in western Washington.
- During the winter season, precipitation builds up groundwater reserves and saturates the soil.
- Strong, two-to-five-day storms with heavy rainfall will result in high runoff and flooding.

Figure 7 Photo #1 Wanlick Creek

Pictured above is the lower one mile of Wanlick Creek. Timber, including Douglas-fir stands located one-quarter mile up from mouth has been clear-cut. Few pieces of instream wood were greater than 4' diameter. Douglas fir stand density is high, and the likelihood of large diameter growth is poor for long-term large wood recruitment into the stream channel.

Figure 8 Photo #2 Wanlick Creek

Note the large landslide pictured above.

Figure 9 Photos of Bell Creek Crossing

Bell Creek Road Crossing: a 9’x15’ arch culvert partially interrupts bedload transport and blocks upstream fish passage of an isolated and fragmented population of Dolly Varden. Removal or replacement with a 50- 60’ bridge is recommended to provide a 30’ channel cross section.

- The largest and most damaging storms are often rain-on-snow events, when warm wind on snow causes snowmelt runoff in addition to that from rain.
- Occasionally local flooding may occur during spring runoff, but it is not usually damaging.

Recent years have seen some of the larger floods on record.The Middle Fork drains an area of 100 square miles; the river gradient averages 279 feet per mile (Williams et al. 1975). Precipitation is quite heavy. Snow and ice fields act as natural surface storage in the upper river basin. The water is highly discolored most of the year due to glacial flour.

The Middle Fork snow and ice fields act as natural surface storage in the upper river basin. The South Fork lacks the precipitation storage provided by snow and ice fields and as a result, responds to high intensity rainstorms rapidly. The South Fork is more likely to respond to rain-on-snow events (melting of snow between 1,500-3,500 feet elevation) and high elevation rainfall.

Fahnestock (1963) found that major storms produced 1,000 cubic feet per second (cfs) of runoff per square mile of glacier. The Middle Fork is also subject to outburst floods that result from glacier melts, water channels damming and then bursting which send a wall of water (surge flow) and ice, downstream. In 1927, Bill Bennecke, a former Forest Service employee, reported blocks of ice the size of houses in the Middle Fork below Ridley Creek.

USDA Natural Resource Conservation Service and Whatcom County established the Elbow Lake SnoTel Station in 1995 at 3200' elevation on Road 12 at MP 17.1 as part of a national flood prediction program. This site, as well as the Wells Creek site on the North Fork Nooksack River, is used by Whatcom County as part of their early warning flood system. The Elbow Lake Station and the Wells Creek Station have been used for the last ten years to forecast flood events for the Nooksack River and Whatcom County. The stations are important in early warning flood forecasting for the Nooksack River where floods affect Whatcom County, Washington as well as the Sumas area of Canada (Paula Cooper, Whatcom County River and Flood Engineer, personal communication). Whatcom County closely monitors snow water content during a high precipitation event and concern rises as water content in snow approaches 50 percent. Before that time the snow pack has a sponging aspect, which absorbs the rainfall and modifies the storm effect.

Water Quality

Water quality is commonly thought of as the chemical standards which water must meet for certain designated beneficial uses such as drinking water, swimming, or supporting aquatic life. Water quality is in fact a more holistic concept. The objective of the 1972 Clean Water Act is "to restore and maintain the physical, chemical and biological integrity of the nation's waters." The chemical and physical components of the act have been written into state and federal standards for such parameters as temperature, dissolved oxygen, sediment, fecal coliform, etc. These measures, while important indicators do not represent the full range of values necessary to assure a functional aquatic ecosystem. Current understanding of what is required to support the beneficial uses (e.g. fisheries, potable water, etc.) of water has broadened to include parameters such as flow regime, biotic factors, energy source, and habitat structure (Bauer and Ralph, 1999).

The State classifies the South and Middle Forks of the Nooksack River as Class AA (extraordinary) within the analysis area. The highest standards of water quality criteria apply to these waters. Chemical water quality parameters collected from 1977-1993 indicate the Nooksack River is meeting these criteria (WDOE, 1998). Overall water quality in the upper forks of the Nooksack system is high and fully supports designated beneficial uses (USGS, 1992).

The Middle Fork Nooksack River and several tributary streams are fed by melting glaciers. They have a cooling influence and naturally carry high loads of suspended sediment from glacial erosion, primarily silt-sized glacial flour. Further, the headwater tributaries of the Middle Fork are steep and prone to erosion of postglacial debris or mobilization of glacial outwash deposits. The Middle Fork Nooksack River is a municipal watershed providing drinking water for the City of

Bellingham, WA. Water has been diverted to the Whatcom Creek drainage from the Middle Fork Nooksack River since 1960 when a dam was constructed across the Middle Fork, blocking fish migration, at RM 7.2. Water diverted from the Middle Fork runs through a tunnel, then pipe, to Mirror Lake in the upper watershed of Lake Whatcom where glacial flour and other fine sediment settles out. Water is then routed from Mirror Lake into Anderson Creek, which flows into Lake Whatcom.

The South Fork is clear relative to historic conditions, but it is subject to elevated temperatures. The river basin receives approximately 100 inches of precipitation annually. Low flows occur in late summer to early fall. Because of the lack of augmentation from melting glaciers or snow packs, the South Fork experiences extremely low flows compared to Middle Fork. In mid-winter the low flow is less pronounced when precipitation is stored as snow. In the analysis area, the South Fork frequently reaches water temperatures in the high 60s in summer, and the temperature rises rapidly downstream of Wanlick Creek to even higher temperatures. High water temperatures (>70 degrees Fahrenheit) can stress salmonids and increase their susceptibility to disease, and if temperatures reach the mid-70s F, can even result in mortality. Historic data presented in the U.S. Fish and Wildlife Service, Lummi and Nooksack Tribal Report showed there were ten days between August 7 and August 27, 1986 when the maximum daily water temperature was equal to or exceeded 60 degrees Fahrenheit.

Particularly downstream of the National Forest, forest management has also affected temperatures - through removal of river and tributary riparian vegetation, initiation of debris flows in tributaries, increased sediment production, routing and channel widening in low gradient storage reaches, and potentially through loss of logjams and increased unvegetated gravel bars, and through hydrologic changes associated with clearcurtting and forest roads (USFWS 2004).

Watershed Restoration

Storm data and data about the rates of channel recovery indicate that the channel system in the South Fork drainage was already highly unstable prior to road building, logging and mining in the drainage (Hale1992). Recognizing that treating roads was the most cost effective way to reduce sediment delivery into streams in managed forested areas (Harr and Nichols 1993), the Forest Service began correcting the backlog of drainage insufficiencies for mainline roads starting in 1992.

This effort was financed in the 1990s by funding with multiple partners including the Lummi Nation, Nooksack Tribe, and the Washington Department of Fish and Wildlife. Current drainage correction efforts are financed by grants from Washington State's Salmon Recovery Funding Board through a sponsor, the Nooksack Salmon Enhancement Association. The restoration focus and primary objective has been to improve water quality and fish habitat for salmon recovery.

The current effort has turned from correcting a backlog of drainage insufficiencies to replacing fish passage and bedload obstructions.

Currently, three such structures are being replaced in the Middle Fork Nooksack watershed. In the South Fork Nooksack watershed, one stream crossing has been identified as insufficient for bedload and fish passage at Bell Creek. This crossing also provides access to the Elbow Lake SnoTel station. As a result, the future of this crossing and road segment are being evaluated. A decision will be made either to replace the crossing or to remove the crossing and decommission several miles of road. This decision will take into account costs of replacement and maintenance, the level of need for maintaining the SnoTel station at that particular site, the benefit of providing recreational access, and impacts to wilderness fostered by easy access.

Since the mid 1800s, there have been reports of several large mass movements of land of undetermined cause. A debris avalanche traveled 6.8 miles beyond the Rainbow Glacier terminus sometime around 1860. A number of debris avalanches or debris flows have occurred: 3.1 miles below the Easton Glacier in 1911, 5.6 miles from the Deming Glacier in 1927, and repeated, unspecified distances down valley from Mazama, Roosevelt, and Thunder Glaciers.

Fisheries and Aquatic Habitat

Instream Habitat

This section provides information on existing aquatic habitat conditions within the Middle Fork and South Fork Nooksack Rivers and some of their tributaries. Most physical habitat parameters for this analysis, unless otherwise stated, were collected by USFS field crews using the Pacific Northwest Region Level 2 Stream Survey Protocol (USDA FS 2005).

In order to make judgments about the quality of habitat indicators in the analysis area, forest-wide data were broken into five percentile ranges to represent reference conditions of very low to very high levels of those habitat indicators (Table 3). In other words, the lowest 20 percent of values for stream reaches of an indicator, e.g. pools per mile, were used to create the range of values considered very low. The next 20 percent were considered low; the following 20 percent were considered median, and so on so that the top 20 percent of values were considered very high. Deep pool, all pools, and large wood frequencies were extracted from the Mount Baker Snoqualmie National Forest stream survey data in the "SMART" database on the "Stream Bank 2 CD", 2005. Only the most recent data were used from streams where those streams were resurveyed (in order to eliminate pseudoreplication). All streams surveyed on the forest were included regardless of channel type or stream size because streams surveyed throughout the forest included a similar range of channel types and stream sizes as those in the analysis area.

Conductivity percentiles were not derived from forest-wide data, but rather they were extracted from a more limited dataset from tributaries and the mainstem of the North, Middle, and South Forks of the Nooksack River, the tributaries to Baker Lake, and the tributaries and mainstem of Bacon Creek.

Table 3 Broadscale summary analysis of pool frequencies, wood frequency, and conductivity.

Rank	Percentile Range	Pools per mile	Deep pools (>3') per mile	Large wood per mile	Conductivity (µS/ml)
Very Low	0 - 20	0.6 – 6.4	0.6 – 3.5	0 - 30.7	10 – 32.4
Low	20 – 40	6.4 – 12.1	3.5 – 6.1	30.7 - 62.1	32.4 – 48.0
Median	40 – 60	12.1 – 19.6	6.1 – 9.0	62.1 - 103.8	48.0 – 63.0
High	60 – 80	19.6 – 32.2	9.0 – 14.3	103.8 - 165.8	63.0 – 96.8
Very High	80 – 100	32.2 – 222.3	14.3 – 65.3	165.8 – 884.5	96.8 – 193.0

In-channel Large Wood and Pool Habitat

In the Middle Fork Nooksack River and its tributaries, large wood occurs at low to very low frequencies (Table 4). Trees were harvested in the 1970's along many of the tributaries north of the Middle Fork, and large wood was actually removed from these streams most likely to reduce the risk of road damage from large wood during floods. Large wood recruitment is considered moderate to low in the mainstem of the Middle Fork Nooksack River, but moderate to high in the upper tributary streams (Salmon Recovery Board 2005). Given the high and very high frequencies of pools and deep pools, large wood may not be that much of a concern for creating fish habitat; however since stream clearing of large wood did occur, it may be possible to create even more pools with large wood augmentation projects.

In the South Fork Nooksack River, high frequencies of large wood appear to have contributed to high frequencies of pools and deep pools except in one small tributary, Elbow Creek. Large wood structures have been placed throughout Wanlick Creek since the early 1990s to increase frequencies to levels similar to the South Fork Nooksack River mainstem, Elbow Creek, and Bell Creek.

Conductivity

Conductivity is a nonspecific chemical measure, but it is commonly used as a surrogate for dissolved solids and alkalinity, and because higher levels of these chemicals represent higher levels of nutrients for the primary production of algae and bacteria, it has proven to be a good indicator of aquatic habitat quality (May et al. 1996). Higher levels of algae and bacteria provide more food to aquatic insects and allow aquatic insects to be more abundant. As the next step in the food chain, fish populations can be more abundant in streams with high levels of aquatic insects because aquatic insects are an important food source for juvenile and adult trout and juvenile salmon. Of course high levels of nutrients or aquatic insects won't benefit fish populations if another habitat measure, like pool frequency or the quality of spawning habitat, is limiting the population.

In the Middle Fork Nooksack River, conductivity measurements in late Spring prior to glacial influence were generally low, but they were moderate to high in some locations. This seems to indicate significant areas of abundant aquatic insects only likely exist in the mainstem above Green Creek and in Warm Creek relative to other rivers and streams measured in the Nooksack and Skagit river basins.

Conductivity measurements made in a few locations within the South Fork Nooksack River watershed were moderate.

Barriers

In the Middle Fork Nooksack River, the City of Bellingham Diversion Dam, at RM 7.2, is a complete migration barrier. Currently, only native char, cutthroat trout, and rainbow trout use the habitat available above the dam. Clare Fogelsong, representing the City of Bellingham at the Nooksack Salmon Summit in 2005, stated that the removal of the dam would likely occur in 2007 (pers. comm. Ned Currence, Nooksack Tribe, 1/2006).

In the South Fork Nooksack River, a culvert at the crossing of Bell Creek along Forest Service Road 12 is a complete barrier (Figure 9) and fragments the population of Dolly Varden isolated above a natural barrier lower in Bell Creek (Figure 10).

Table 4 Summary of Middle Fork Nooksack Stream Surveys 2005

Stream Name	Survey Reach	Survey beginning + Miles surveyed	Avg BF Width/ Avg BF Depth Ratio	Pool Habitat	Pools per Mile	Deep pools (>3') per mile	Wood per Mile	(µS/ml)
Mainstem	1	Wallace Cr + 0.31	15	7	9.6 L	9.6 H	26 VL	47.4 L
	2	Green Cr + 0.25	23	23	24 H	24 VH	29 VL	94.7 H
	3	Rankin Cr + 0.19	9	15	21 H	21 VH	27 VL	61 M
Green Cr		Mouth + 0.25	24	38	40 VH	24 VH	58 L	32 VL
Rankin Cr		FS Rd 38 + 0.125	15	30	32 H	8 H	8 VL	19 VL
Ridley Cr		Mouth + 0.25	24	25	24 H	12 H	42 L	47 L
Wallace Cr		Mouth + 0.31 (barrier)	12	26	26 H	22 VH	22 VL	44 L
Warm Cr		FS boundary + 0.125	22	80	32 H	16 VH	16 VL	60 M

Table Notes: Short stream surveys performed in 2005 in the Middle Fork Nooksack watershed. Superscripts correspond to the very low to very high ratings in Table 3.

Table 5 Summary of South Fork Nooksack Level II Stream Surveys

Stream Nam	Year	Survey Reach	Survey beginning + Miles surveyed	Avg BF Width/Avg BF Depth Ratio	% Pool Habitat	Pools per Mile	Deep pools (>3') per mile	Large Wood per Mile	Conductivity (µS/ml)
Mainstem	1990		FS boundary + 4.4 miles		16	12 L	10 H	116 H	56 M
Bell Cr	1990		Mouth + 3 miles		11	22 H	17 VH	167 VH	61 M
Elbow Cr	1990		Mouth + 1 miles		1	7 L	4 L	106 H	
Wanlick Cr	2002	1	Mouth + 1.1 miles	22	17	16 M	10 H	154 H	62 M
	2002	2	River mile 1.1 + 1.5 miles	29	13	16 M	9 H	129 H	
Upper Wanlick + Loomis Creek	2002	3	River mile 2.6 + 2.8 miles	23	19	30 H	5 L	140 H	

Table Notes: Obtained from SMART database information contained on "StreamBank 2" CD (USDA FS 2005). Superscripts correspond to the very low to very high ratings in Table 3.

Timing of Anadromous Fish Use of Streams

In order to minimize impacts from forest projects, especially those that are near streams, the timing of anadromous fish use is frequently used to limit the time of year that projects are implemented so that they won't affect fish, particularly during the spawning time period. Table 6 shows the generally accepted timing of fish for the Nooksack Basin. Due to the location of the analysis area high in the watershed, fish are probably not using these streams as much during the early part of the displayed period of use.

Table 6 Timing of Salmon, Sea-run Trout and Char Freshwater Life Phases within the Nooksack River Subbasin (Anchor Environmental, LLC. 2003).

Spring Chinook	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River Entry												
Upstream Migration / Holding												
Spawning												
Intragravel Development												
Age-0 rearing												
Age-0 outmigration												
Age-1+ rearing												
Age-1+ outmigration									????	????	?	????
hinook	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct.	Nov.	Dec
River Entry						??					?	
Upstream Migration / Holding						????						????
Spawning												????
Intragravel Development												
Fry <~55mm												
Juvenile Rearing												
Outmigration												
Coho	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River Entry		????										
Upstream Migration / Holding												
Spawning		????										
Intragravel Development												
Fry <~55mm												
Juvenile Rearing												
Outmigration												
Ch	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River Entry												
Upstream Migration / Holding												
Spawning												
Intragravel Development												
Fry												
Juvenile Rearing (not applicable)												
Outmigration												
Pink	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River Entry						????						
Upstream Migration / Holding						????						
Spawning												
Intragravel Development												
Fry												
Juvenile Rearing (N/A)												
Outmigration												

Table note: ???? indicates possible use.

Sockeye	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
River Entry				■	■	■	■	■	■	■		
Upstream Migration / Holding				■	■	■	■	■	■	■	■	
Spawning								■	■	■	■	
Intragravel Development	■	■	■	■				■	■	■	■	■
Fry and Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Outmigration			■	■	■	■	■					
Summer Steelhead	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Upstream Migration				■	■	■	■	■	■	■		
Holding	■	■	■	■	■	■	■	■	■	■	■	■
Spawning		■	■	■								
Adult Outmigration		■	■	■	■							
Intragravel Development		■	■	■	■	■						
Fry <~55mm	■			■	■	■	■	■	■	■	■	■
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Outmigration		■	■	■	■	■	■	■				
Coastal Cutthroat (anad.)	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Upstream Migration	■	■	■	■	■	■	■	■	■	■	■	■
Holding	■	■	■	■	■	■	■	■	■	■	■	■
Spawning	■	■	■	■	■	■	■					
Adult Outmigration	■	■	■	■	■	■						
Intragravel Development	■	■	■	■	■	■	■	■	■			
Fry <~55mm	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Outmigration		■	■	■	■	■	■	■				
(anad.)	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Upstream Migration					■	■	■	■	■	■	■	
Subadult Upstream Migration								■	■	■	■	
Subadult Overwinter Holding	■	■	■	■	■			■	■	■	■	■
Holding	■	■	■	■	■	■	■	■	■	■	■	■
Spawning								■	■	■	■	■
Adult Outmigration	■	■	■	■	■	■	■					
Intragravel Development	■	■	■	■				■	■	■	■	■
Fry <~55mm		■	■	■	■	■	■	■				
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Outmigration			■	■	■	■	■	????				

Table note: ???? indicates possible use.

Fish Species of Interest

Fish species known to occupy streams within the analysis area are listed in Table 7. Fish distribution within the analysis area was divided into "zones" based on the location of full or partial migration barriers resulting in different species assemblages (Figure 10). The zones are: Lower Forks, Middle Fork above Dam, Warm and Green Creeks, Upper South Fork, and Bell and Pine Creeks. Fish species distributions were mapped by Washington Department of Fish and Wildlife (for salmon and steelhead) and the Northwest Indian Fisheries Commision (for all species).

Table 7 Fish Species in the Middle Fork and South Fork Nooksack Watersheds

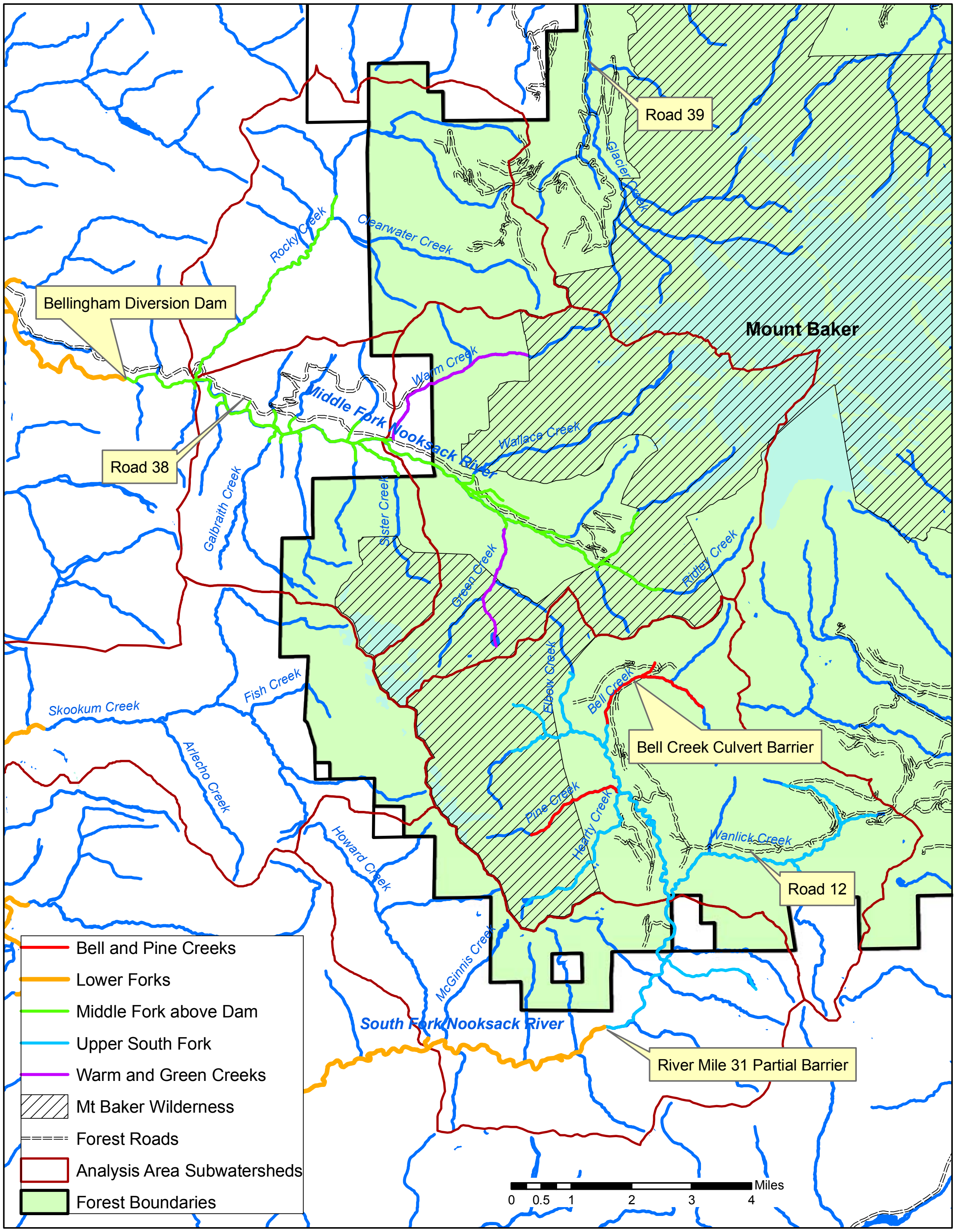
Name	Scientif Na
Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Pink Salmon	*Oncorhynchus gorbuscha*
Chum Salmon	*Oncorhynchus keta*
Sockeye Salmon	*Oncorhynchus nerka*
Bull Trout/Dolly Varden	*Salvelinus confluentus/ Salvelinus malma*
Steelhead/Rainbow Trout	*Oncorhynchus gairdneri*
Coastal Cutthroat Trout	*Oncorhynchus clarki clarki*

Chinook salmon and native char (bull tout/Dolly Varden) populations within the analysis area are listed as Threatened under the Endangered Species Act (ESA). Coastal cutthroat trout populations, within the analysis area, are considered Sensitive by the Pacific Northwest Region Regional Forester and are to be managed to avoid future listing under the ESA.

North Fork (includes Middle Fork spawners) and South Fork Nooksack Chinook populations are considered depressed based on 1993 to 2004 escapement figures (Salmon Recovery Board 2005). Nooksack native char spawner abundance has not been estimated due to insufficient field survey data (USFWS 2004). Past timber management and associated road building likely contributed to the decline of these local fish populations within the analysis area.

Coastal cutthroat trout populations are well distributed within the analysis area. However, quantitative data on abundance or survival related to population status are lacking. Smolt trap outmigration data from the lower South Fork indicate that anadromous cutthroat smolts are not abundant (NNR unpublished smolt trap data).

Figure 10 Fish Distribution



Lower Forks

The "Lower Forks" portion of the analysis area is described as those reaches of the Middle Fork and South Fork Nooksack Rivers that are below partial or full anadromous migration barriers. This zone extends up the Middle Fork Nooksack River to the City of Bellingham Diversion Dam at RM 7.2 and up to RM 31.0 in the South Fork Nooksack River (Figure 10). Salmonid species present within this zone are Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), pink salmon (*Oncorhynchus gorbuscha*), chum salmon(*Oncorhynchus keta*), sockeye salmon (*Oncorhynchus nerka*), steelhead/rainbow trout (*Oncorhynchus gairdneri)*, coastal cutthroat trout(*Oncorhynchus clarki clarki*), and bull trout (*Salvelinus confluentus*).

Middle Fork above Dam

The "Middle Fork above Dam" portion of the analysis area is described as those reaches of the Middle Fork Nooksack River above the City of Bellingham Diversion Dam, excluding Warm and Green Creeks. This zone extends from the Diversion Dam (RM 7.2) up to RM 17.7 on the mainstem, up to RM 3.5 on Clearwater Creek, up to RM 0.8 on Ridley Creek, and in the lower reaches of several unnamed tributary streams (Figure 10).

If the City of Bellingham Diversion Dam were removed, Chinook salmon, coho salmon, steelhead, and anadromous bull trout have the potential to inhabit the mainstem up to approximately RM 17.2, Clearwater Creek up to approximately RM 1.0, and Sisters Creek up to the Forest boundary.

Native char, in low numbers, are known to use the mainstem up to RM 17.7, Ridley Creek up to RM 0.8, Clearwater Creek up to RM 4.5, and the lower reaches of several other tributary streams.

Rainbow and cutthroat trout are known to utilize all accessible portions of this zone, and rainbow trout are the most abundant species.

Warm and Green Creeks

The "Warm and Green Creeks" portion of the analysis area is described as those reaches containing isolated populations of introduced rainbow trout upstream of natural upstream migration barriers. The Warm Creek population was stocked directly with rainbow trout, and they now utilize this creek from a barrier near the mouth up to the Forest boundary. The Green Creek population has dispersed from populations stocked in Wiseman Lake. The population now extends from the lake downstream to a migration barrier near the creek mouth. Fish from these introductions are likely the sources of the abundant rainbow trout population present in the "Middle Fork above Dam" zone.

Upper South Fork

The "Upper South Fork" portion of the analysis area is described as those reaches known to be utilized by salmonids above the partial migration barrier at RM 31.0 (i.e. the upper extent of Chinook salmon), excluding Bell (above RM 0.3) and Pine Creeks. This zone extends up to RM 40.0 on the mainstem, up to RM 1.7 on Elbow Creek, up to Heart Lake in Hearty Creek, and up to Springsteen Lake in an unnamed creek. In Wanlick Creek, the zone extends up to RM 4.5, and in its tributaries: Monument Creek upstream 0.5 mi (0.8 km) to a natural barrier; and Loomis Creek upstream 1.0 mile to its headwaters.

Steelhead are known to utilize the mainstem up to approximately RM 37.5 and Wanlick Creek up to approximately RM 1.3. Because habitat conditions should permit them to use upstream areas, they are presumed to utilize the mainstem up to RM 39.0, Wanlick Creek up to RM 4.5, Bell Creek up to RM 0.3 and Elbow Creek up to Doreen Lake.

Native char are known to use the mainstem up to RM 40.0, Wanlick Creek up to RM, Loomis Creek up to RM 1.0, Bell Creek up to RM 0.3, Elbow Creek up to Elbow Lake, and recent surveys (Ecotrust unpublished data) also found native char up in Monument Creek up to RM 0.5.

Cutthroat trout are known to use the mainstem up to the mouth of Bell Creek, Wanlick Creek up to RM 2.0, Hearty Creek up to Heart Lake, and the unnamed creek up to Springsteen Lake. They are presumed to use the mainstem up to the mouth of Elbow Creek, Wanlick Creek up to RM 2.7, and Bell Creek up to RM 0.3.

Rainbow trout or steelhead are known to use Monument Creek from the mouth up to a barrier at RM 0.5.

Bell and Pine Creeks

The "Bell and Pine Creeks" portion of the analysis area is described as those reaches containing isolated populations (above natural barriers) of Dolly Varden in the upper South Fork Nooksack River. Microsattelite DNA analysis of native char from the South Fork near the USFS 12 Road crossing were determined to be bull trout, while those in "Pine" Creek were Dolly Varden trout (Young, WDFW pers. comm.). Snorkel surveys in Wanlick Creek recorded multiple age classes of juvenile bull trout as well as an adult approximately 30 inches (Ecotrust unpublished data). This zone extends up Bell Creek from RM 0.3 up to approximately RM 2.2 as well as .25 miles up a major tributary from the North upstream of the culvert (pers observation Scott Lentz, USDA Forest Service fisheries biologist 2005), and up Pine Creek from the mouth up to RM 1.7.

Critical Habitat

Chinook Salmon

The final rule designating critical habitat for Chinook salmon in the Puget Sound Ecologically Significant Unit (ESU), including the South Fork Nooksack, was printed in the Federal Register on September 2, 2005 (50 CFR 226). Critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). In areas where ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge which generally has a recurrence interval of one to two years on the annual flood series.

Within the analysis area, Chinook Critical Habitat was designated for the Middle Fork Nooksack River up to the confluence with Ridley Creek, and in the South Fork Nooksack River up to the falls at river mile 31 (50 CFR 226, 2005). The designation requires Section 7 compliance through consultation with NOAA fisheries regarding potential affects to Chinook Critical Habitat from federal actions.

Bull Trout

On September 26, 2005, the U.S. Fish and Wildlife Service designated "…critical habitat for the Klamath River, Columbia River, Jarbidge River, Coastal- Puget Sound, and Saint Mary-Belly River populations of bull trout (Salvelinus confluentus) in the coterminous United States pursuant to the Endangered Species Act of 1973, as amended (Act). This final designation totals approximately 3,828 miles (mi) (6,161 kilometers (km) of streams, 143,218 acres (ac) (57,958 hectares (ha) of lakes in Idaho, Montana, Oregon, and Washington, and 985 mi (1,585 km) of shoreline paralleling marine habitat in Washington.

The FWS determined that PACFISH, INFISH, the Interior Columbia Basin Ecosystem Management Project (ICBMP) strategy, and the Northwest Forest Plan (NWFP) Aquatic Conservation Strategy (ACS) provide a level of conservation and adequate protection and special management for the PCEs essential to the conservation of bull trout at least comparable to that achieved by designating critical habitat.

As a result, the Forest Service administered lands within the analysis area are not being designated critical habitat as they do not meet the statutory definition. In many specific ways these plans are superior to a designation in that they require enhancement and restoration of habitat, acts not required by the designation (Department of the Interior 2005).

Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) requires federal fishery management plans to describe the habitat essential to the fish being managed and describe threats to that habitat from both fishing and non-fishing activities. In addition, in order to protect this Essential Fish Habitat (EFH), federal agencies are required to consult with the National Marine Fisheries Service (NMFS) on activities that may adversely affect EFH.

Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). The EFH guidelines under 50 CFR 600.10 further interpret the EFH definition as follows:

"Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) established a new mandate for the National Marine Fisheries Service (NMFS), regional fishery management councils (FMC), and other Federal agencies to identify and protect important marine and anadromous fish habitat.

Chinook Salmon

Essential Fish Habitat exists for Chinook salmon in those locations documented as proposed critical habitat by Department of Commerce (2005[a]). This habitat designation exists in all reaches currently accessible to Chinook salmon within the analysis area (i.e. up to RM 7.2 in the MF and up to RM 31.0 in the SF).

Coho Salmon

Coho salmon utilize the South Fork Nooksack River and accessible tributaries up to RM 25, and are presumed to use it to that cascade at mile 31 (NWIFC 2004).These occupied areas are considered Essential Fish Habitat for coho salmon. In the Middle Fork Nooksack River, coho salmon are present up to the City of Bellingham Diversion Dam at river mile (RM) 7.2. They could inhabit the river up to approximately RM 17 if the dam were removed. At that time, this would also be considered Essential Fish Habitat.

Pink Salmon

Pink salmon use the Middle Fork Nooksack River up to the City of Bellingham Diversion Dam at RM 7.2. They are not presumed nor have potential to use the river above RM 7.6. Pink salmon use the South Fork Nooksack River up to RM 25, and due to the steepness of the river, they are not expected to use habitat upstream (WDFW 2004). For these reasons, no Essential Fish Habitat for pink salmon currently exists in streams on National Forest System Lands.

Trends in Aquatic Habitat and Fish Species of Interest

In the Middle Fork Nooksack River Watershed, the proposed removal of the City of Bellingham Diversion Dam below the National Forest will restore fish passage by anadromous salmonids to several miles of habitat on the National Forest. With the removal of the dam, Chinook and coho salmon as well as steelhead and anadromous bull trout will likely expand into these habitats and benefit accordingly. Resident bull trout will also benefit with increased prey availability of juvenile salmon. With the return of marine derived nutrients from anadromous fish carcasses, all fish species will benefit.

The South Fork Nooksack River has been impacted by past timber management activities (e.g. timber harvest and associated road building) and floods. Wanlick Creek has received significant restoration treatment since the early 1990s, but it still shows evidence of channel instability (e.g. bank erosion, channel aggradation/degradation, and siltation).

Riparian Reserves

Riparian reserves include the land surrounding streams, wetlands, and landslide prone areas to varying amounts based on site specific conditions, e.g. perennial vs intermittent stream channels. Riparian reserves are managed to protect stream bank stability from erosion, provide shade to prevent excessive stream temperatures, and to act as a source of large wood which is important in forming pools for fish habitat. Riparian reserves also include landslide prone areas which are managed to prevent catastrophic inputs of fine sediments into streams. Unstable soils have been identified, but specific landslide prone areas were not mapped due to lack of site specific information. Often riparian reserves are approximated on a map, but in the analysis area, mapping was completed at two different spatial scales leading to very different predictions for different parts of the analysis areas, and therefore it was not included here. Regardless, riparian reserves are always identified on the ground depending on very site specific conditions.

As mentioned in the Geology, Soils, and Hydrology section, large wood has been reduced in much of the analysis area, and high stream temperatures are a problem in the South Fork Nooksack River as a result of reduced stream shading, particularly downstream of the National Forest. Historic harvests in parts of the analysis areas cut trees down to the stream, and has resulted in densely-stocked young stands. Although the fish habitat analysis suggests that large wood is not lacking for pool creation, in tributaries to the Middle Fork Nooksack River, they do represent important sources of large wood for the lower mainstem., and in the South Fork Nooksack River, ongoing contributions of large wood are necessary for maintaining pool frequencies. Large wood in Wanlick Creek is only at its current levels due to extensive large wood augmentation.

Terrestrial Ecosystem

Vegetation Zones and Ecozones

The following discussion is based largely on a classification of the vegetation that was completed on the Mt. Baker-Snoqualmie National Forest as a part of the Pacific Northwest Region Ecology Program (Henderson et al., 1992).

Ecozones are areas of land with similar environments, and are defined by the elevation of the lower limit of the Pacific Silver Fir Zone. An Ecozone map can be used to interpret broad moisture related environmental patterns. Correlated with Ecozones are many of the plant associations, fire history, wind disturbance history, and timber productivity. Ecozones are numbered from 5 to 13, with 13 being the driest. In the analysis area, the range is from Ecozone 7 to 10, with neither extremely wet nor extremely dry areas found. Most of the analysis area is in Ecozone 9, which includes a lot of non-National Forest System (NFS) land. The clouds from in-coming weather systems arrive first at Twin Sisters Mountain, and this is the wettest area. The microclimate becomes increasingly dry moving north from the Twin Sisters Mountain.

Henderson et al. (1992) defines Vegetation Zones as "taxonomic units, which are aggregates of Plant Associations with the same climax indicator tree species". Table 8 shows the distribution of Vegetation Zones within the South and Middle Forks Nooksack River analysis area, within the limits of available data. Seral stages were defined in the Subregional Ecological Assessment for the Mt. Baker Snoqualmie National Forest (USDA Forest Service 1993).

Table 8 Vegetation Zones in the South and Middle Fork Nooksack Watersheds

Vegetation Zone	National Forest acreage	acreage		Percent of total
Western Hemlock	3,079	11,763	14,842	16
Pacific Silver Fir	19,211	20,070	39,281	41
Mountain Hemlock	22,298	9,646	31,944	33
Subalpine Fir	44	0	44	<1
Parkland	7,498	8	7,506	8
Alpine	1,989	0	1,989	2
Total analysis area acreage	54,119	41,487	95,606	100

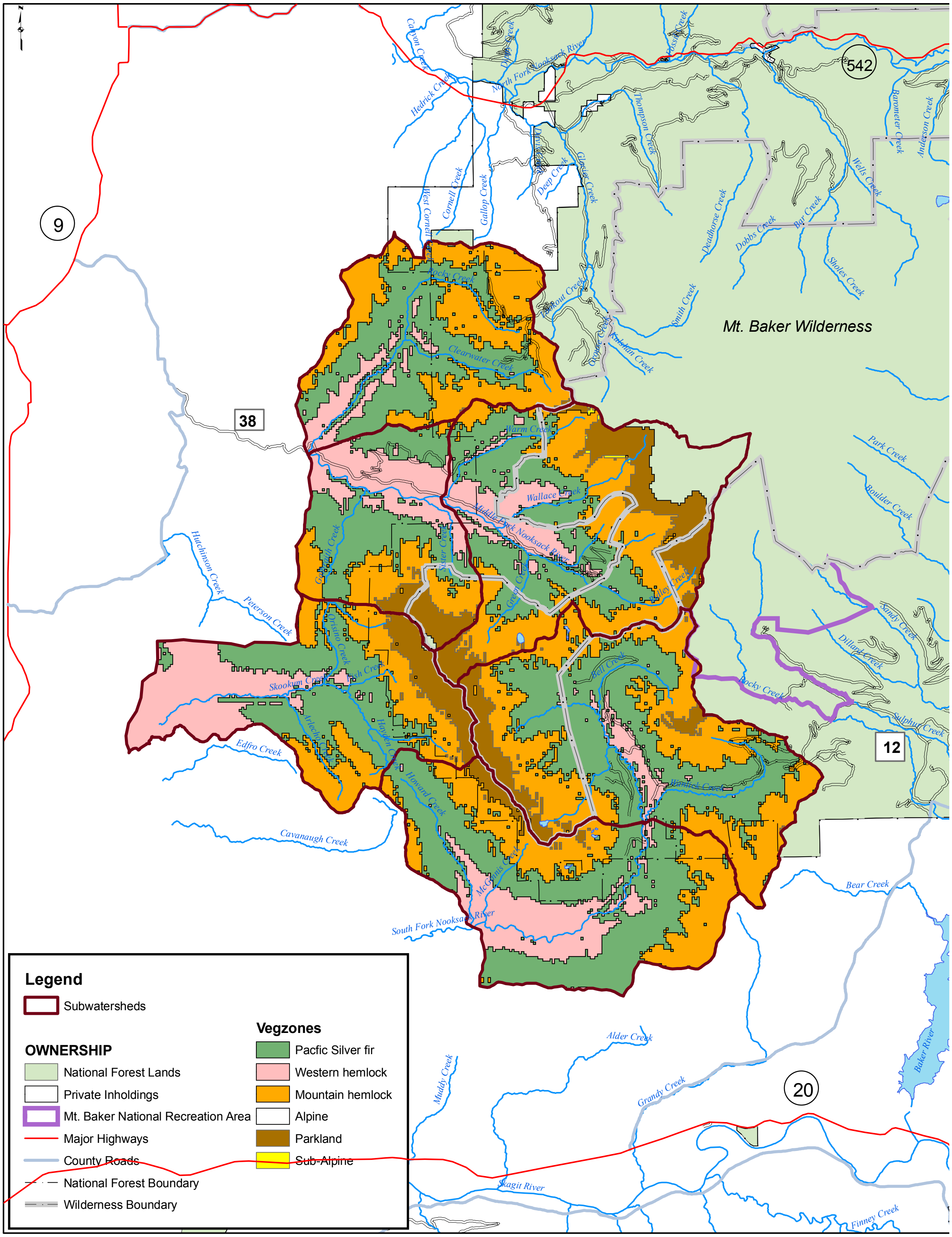
The South and Middle Fork Nooksack watersheds are typical of the fairly wet and cool areas found on the north half of the Forest. The subalpine fir zone is much more common on the southern end of the Forest, where it is relatively drier, but in the Nooksack watershed the total acreage in that zone is a very small percent of the total. There are no noteworthy differences in vegetation zone patterns between the South and Middle Forks.

Western Hemlock Zone

Approximately 14,842 acres (16%) of the analysis area are in the Western Hemlock Zone. This Zone occupies the lowest elevations typically along river bottoms up to approximately 2,500 to 3,000 feet elevation. This Zone is continuous along the Middle Fork and Skookum Creek, and along the South Fork to near the Forest boundary where it begins to become patchy. It is also patchy along Clearwater Creek.

The climate in the Western Hemlock Zone portion of the watershed is characterized as warm temperate to maritime, receiving most of its precipitation in the form of rain. The Western Hemlock Zone occurs on some of the most productive growing sites in the analysis area.

Figure 11 Potential Vegetation Zones



Pacific Silver Fir Zone

Approximately 39,281 acres (41%) of the analysis area are in the Pacific Silver Fir Zone. This is the largest zone in the analysis area, and on non-NFS lands, although not the largest zone on the National Forest. This reflects the large amount of mid-elevation forest in the analysis area, much of which is on private land. This Zone lies at a higher elevation than the Western Hemlock Zone and extends further into the major drainages including the headwaters of some creeks.

The climate in the Pacific Silver Fir Zone is characterized as cool temperate, receiving much of its annual precipitation in the form of snow. This Zone occurs on low to moderately productive sites in the watershed. Cold temperatures and soil types can limit stand growth potential in this series. Western hemlock is present in significant amounts in this zone and may in fact be the dominant species in many stands at the lower elevation limit of Pacific silver fir.

Mountain Hemlock Zone

Approximately 31,944 acres (33%) of the analysis area are in the Mountain Hemlock Zone. This is the largest Vegetation Zone on NFS lands and the second largest in the analysis area which reflects the fact that the upper elevations are primarily on the National Forest. It occupies the area between the upper Pacific Silver Fir boundary and the upper limits of closed forests with a more or less continuous canopy cover. Many of the trailed recreation destinations in the analysis area are in this zone.

The climate in this Zone is characterized as cold temperate, receiving much of its annual precipitation in the form of snow. Site productivity in this Zone is generally low, primarily due to soil types, long periods of cold temperatures, and a heavy, persistent snowpack.

Subalpine Fir Zone

Within the analysis area are approximately 44 acres (less than 1%) of Subalpine Fir type. This Zone occupies upper elevation slopes, mostly above 5,500 feet on drier parts of the Forest, but may occur at lower elevations if on talus or recent lava flows. This vegetation type is typically found in the driest Ecozones and is not common on the north half of the Forest due to the greater precipitation levels here. In this part of the Forest, it is typically replaced by the Mountain Hemlock Zone. In the analysis area, the Subalpine Fir Zone is found at high elevations, on or near Heliotrope Ridge.

Parkland Zone

Above approximately 4,500 feet, the forest becomes increasingly discontinuous and the landscape appears as a mosaic of tree patches and meadows. There are approximately 7,506 acres (8% of the area) of Parkland Zone in the analysis area, almost all of which are on NFS land. Temperature, topography, and aspect affect the location of late-melting snow patches that are important in determining the vegetation patterns in this Zone. At the upper limit of the Parkland Zone, trees lose their erect growth habit and eventually disappear from the community altogether. In the analysis area this Zone occurs on Twin Sisters Mountain, Loomis Mountain, and the flanks of Mount Baker.

Alpine Zone

In this Zone trees are absent, and the upper limits of plant life are reached. This Zone occurs downslope from glaciers and snowfields, generally above 5,500 feet. There are approximately 1,989 acres of Alpine Zone in the analysis area, representing two percent of the total area. It is also found on the flanks of Mt. Baker, and on the summit of South Twin Sister Mountain, at the highest elevations supporting plant life.

Plant Association Groups

Vegetation is the major component of the ecosystem, and one way to describe vegetation is through a classification based on potential vegetation, using the plant association as the basic unit (Henderson et al. 1992). Potential vegetation is the projected climax plant community that will occupy a site, given current climate and site conditions in the absence of disturbance that would reset the community to an earlier seral state. Plant associations groups (PAG) are useful for indicating the growing potential of an area’s vegetation, for getting a sense of appropriate management activities in a given area, and for identifying potential rare plant habitat. It should be noted the PAG model continues to undergo refinement, and the information used in this analysis is based on the model as it existed at the time of writing (2005).

The PAG model groups together plant associations, which have similar floristic characteristics. Forest Ecologists developed the model using moisture, temperature, and topography variables. The results have been field-checked and show a high degree of accuracy, however, care should be used in interpreting any point on the ground because the model interprets broad vegetation patterns across the landscape and may be misleading at the microsite scale. Most of the plant associations groups in each PAG are described in the Plant Association Guide for the Mt. Baker-Snoqualmie National Forest (Henderson et al. 1992).

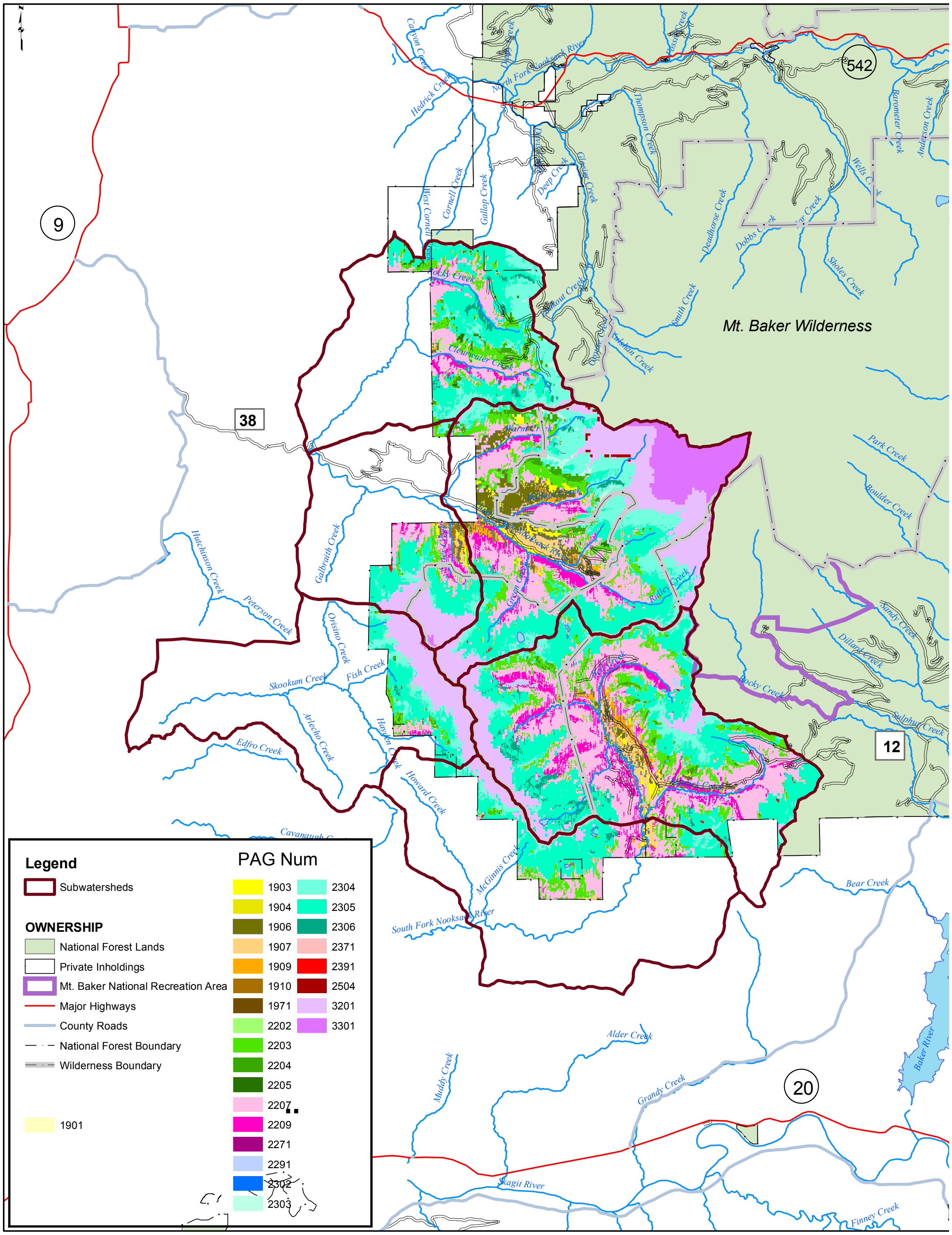
On NFS land, the mountain hemlock zone/Alaska huckleberry is the most abundant PAG. This is a common, widespread PAG on the Forest. Another common PAG in the analysis area and on the Forest is silver fir zone/wet Alaska huckleberry. This is found primarily on north slopes or similar aspects. All other PAGS represent a small percentage of the total acreage.

Table 9 Plant Association Groups

Plant Association Group	PAG Number	National acres	Non-Forest acres	Total acres	NF percent	Non-NF total
Western Hemlock Zone						
Big huckleberry-Queen's cup	1901	7	0	7	<1	0
Dry salal	1903	727	16	743	<1	<1
Alaska huckleberry-bunchberry	1904	9	0	9	<1	0
Mesic salal-oregongrape	1906	1308	3	1311	1	<1
Wild ginger-oakfern	1907	829	62	891	<1	<1
Alaska huckleberry-oxalis	1909	505	0	505	<1	0
Dry non-forest	1971	15	0	15	<1	0
Undetermined	1910	158	6	164	<1	0
Pacific Silver Fir Zone						
Salal-oregongrape	2202	104	0	104	<1	0
Dry Alaska huckleberry	2203	4541	215	4756	5	<1
Big huckleberry-beargrass	2204	799	6	805	<1	<1
Big huckleberry-white rhododendron	2205	73	24	97	<1	<1
Wet Alaska huckleberry	2207	11866	295	12161	12	<1
Devil's club	2209	2756	29	2785	3	<1
Dry non-forest	2271	6	0	6	<1	0
Wet non-forest	2291	217	5	222	<1	<1
Mountain Hemlock Zone						
Grouse huckleberry-big huckleberry	2302	<1	0	<1	<1	0
Big huckleberry-fool's huckleberry	2303	221	0	221	<1	0
Mesic big huckleberry	2304	6017	159	6176	6	<1
Alaska huckleberry	2305	14024	695	14719	15	<1
Wet devil's club	2306	680	3	683	<1	<1
Dry non-forest	2371	27	0	27	<1	0
Wet non-forest	2391	38	<1	38	<1	<1
Subalpine Fir Zone						
White rhododendron-beargrass	2504	56	0	56	<1	0
Parkland Zone (no particular PAG)	3201	7167	2	7169	7	<1
Alpine Zone (no particular PAG)	3301	1970	0	1970	2	0
Unknown		0	39968	39968	0	42

Note: the PAG names are uniform for the entire Pacific Northwest Region, and may not accurately reflect the particular species found in the analysis area

Figure 12 Plant Association Groups



See Table 9 Plant Association Groups for the PAG Number

Plant Species of Concern or Interest

Sensitive Species

This section discusses the species on the Regional Forester's Sensitive Species List (USDA Forest Service, 2004), Sensitive species listed by the Washington Natural Heritage Program (2005), and species regulated by law. Less than one percent of the analysis area has had systematic botanical surveys, and additional sightings of Sensitive species are expected due to the abundance of suitable habitat.

As of the time of writing, there are six known occurrences of Sensitive plant species in the two watersheds, from seven sites. The species documented and their general locations are listed below:

- Arctic aster (*Aster sibiricus var. meritus*) (Forest Service and State Sensitive) – Grouse Butte
- Treelike clubmoss (*Lycopodium dendroideum*) (Forest Service and State Sensitive) – Elbow Lake Trail
- Thompson's chaenactis (*Chaenactis thompsonii*) (Forest Service and State Sensitive) – South Twin Sister
- Boreal bedstraw (*Galium kamtschaticum*) (Forest Service Sensitive) – Bell Pass Trail and Elbow Lake Trail
- Indian rice lily (*Fritillaria camschatcensis*) (Forest Service and State Sensitive) – Bell Pass Trail
- Russet sedge (*Carex saxatilis var. major*) (Forest Service Sensitive) – Southeast of Three Lakes

Noxious Weeds

Systematic surveys for noxious weeds have not occurred in either watershed, and no noxious weeds are documented. There are documented noxious weeds just north of the analysis area, along Roads 36 and 39. For this reason, it is highly likely that noxious weeds occur in one or both watersheds.

Plant Habitat Characteristics and Trends

Unique habitats

Two situations within the analysis area are noteworthy. First is the Twin Sisters Mountain area, which is a massive deposit of a rock type, called dunite. Dunite, a constituent of the earth's mantle, was brought to the surface as a result of volcanism. It is a rock high in magnesium and iron, very low in calcium, and high in trace minerals such as nickel and chromium, producing very infertile soils. This type of rock is referred to as ferromagnesium, or ultramafic. Many plants are unable to tolerate ultramafic soils. As a result, the flora of the Twin Sisters is highly unusual:

- Plant cover and species richness is low,
- The treeline is depressed,
- The alpine and subalpine zones are not well distinguished,

- Lodgepole pine is wide ranging and occurs as krummholz near timberline, and
- Plant species known to show high fidelity to ultramafics are present (Samson, undated; Kruckeberg, 1974).
- The Twin Sisters area is also the only known site on the Forest of the Sensitive plant Thompson's chaenactis, also an ultramafic endemic.

The second noteworthy site is the Sulphur Creek Botanical Area, although only a few acres are included in this analysis area. A thorough discussion of this area was completed for the Baker River Watershed Analysis (USDA Forest Service, 2002).

Seral Stages

Seral stages by vegetation zone for the Middle and South Fork Nooksack watersheds were determined using the definitions shown in Table 10 **.** Seral stages were defined in the Subregional Ecological Assessment for the Mt. Baker Snoqualmie National Forest (USDA Forest Service 1993). They are different for different Vegetation Zones because natural regeneration times and growing conditions vary from low to high elevations, and the time needed to reach a certain stage generally becomes longer with increasing elevation. Seral stages also differ by plant association group, but have been reduced to averages for this analysis.

Table 10 Seral Stage Definitions by Vegetation Zone (numbers are stand ages in years)

Vegetation Zone	Early seral	Mid seral	Late seral single- story	multi-story
Western Hemlock	0-30	30-80	80-200	>200
Pacific Silver Fir	0-30	30-80	80-300	>300
Mountain Hemlock	0-80	80-200	200-300	>300

Seral stages are not reported for the Parkland and Subalpine Fir Zone because the total acreage is small and they are not significantly forested. Seral stage is also not reported for the Alpine Zone because it does not support trees. The totals are for the National Forest only, because insufficient data exist for the private lands.

Figure 13 Seral Stage

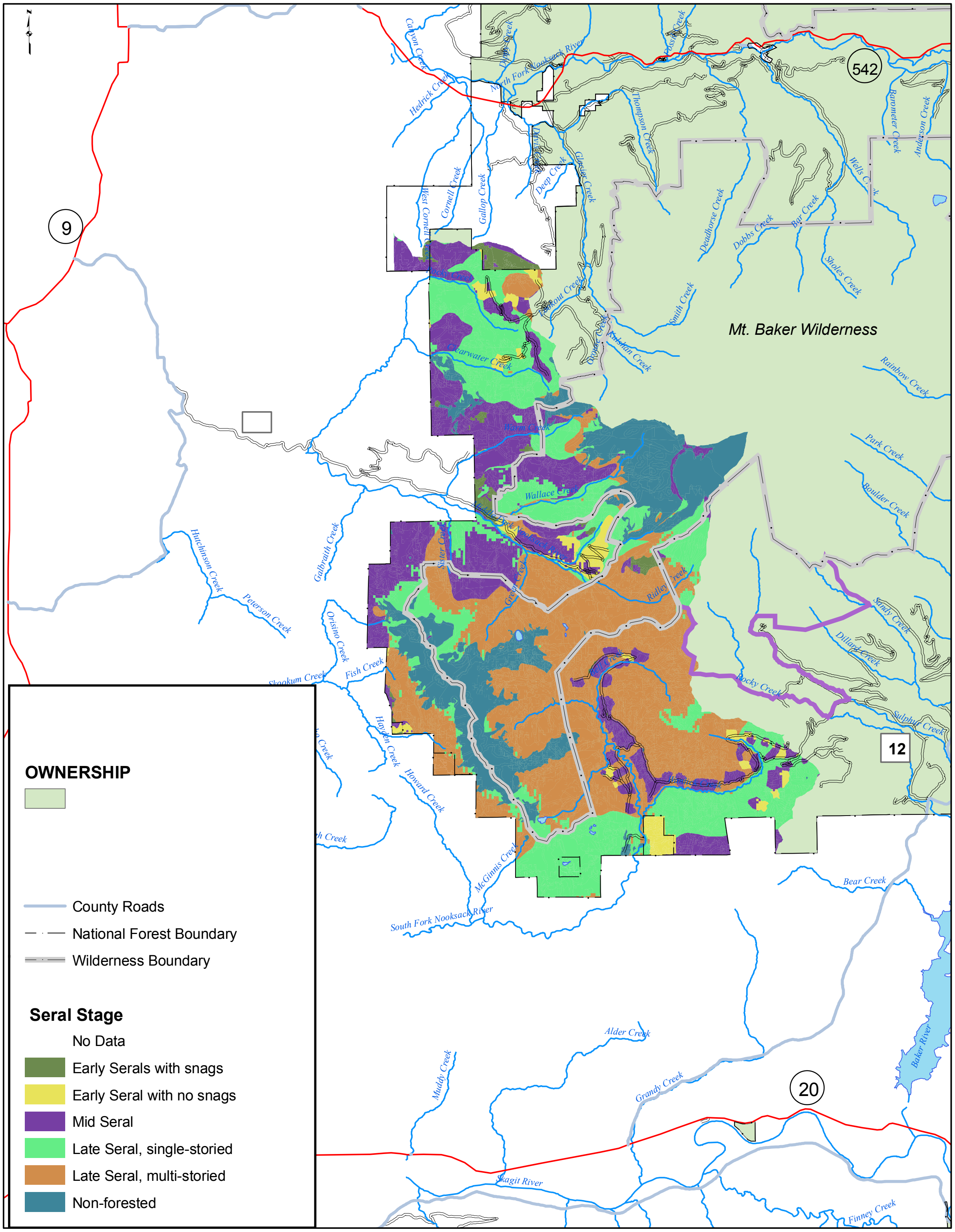


Table 11 Current Seral Stages in the MF Nooksack Watershed

Note: Numbers are percent of total acreage in each vegetation zone.

Vegetation Zone	Early seral	Mid seral	Late seral single-story	Late seral multi-story	Unknown
Western Hemlock	12	29	46	12	1
Pacific Silver Fir	7	44	24	23	2
Mountain Hemlock	4	25	29	31	11

Table 12 Current Seral Stages in the SF Nooksack Watershed

Note: Numbers are percent of total acreage in each vegetation zone.

Vegetation Zone	Early seral	Mid seral	Late seral single-story	Late seral multi-story	Unknown
Western Hemlock	0	50	0	46	4
Pacific Silver Fir	2	12	24	56	6
Mountain Hemlock	2	7	20	63	8

Range of Natural Variability

The concept of the range of natural variability (RNV) acknowledges that ecosystems are not static and that they vary over time and space. Native species have evolved within a context of natural disturbance regimes and habitats that result from those regimes. A key assumption of this concept is that when systems are outside their spatial and temporal range of natural variability, there is increased risk that species survival may be compromised and that biological diversity and ecological function may be adversely affected. The dynamic nature of ecosystems presents the need for us to consider ranges of conditions under natural disturbance regimes, rather than conditions at a single point in time in order to provide the context for ecologically justifiable management decisions. Comparisons of the current condition to a single year in the past can be misleading because that particular year may be atypical, and because other conditions may be equally appropriate and better meet natural resource demands.

Rather than analyze RNV data within the Middle and South Fork basins only, the team compared the situation in the analysis area with RNV data from three other watersheds, following the methods found in Hessburg, et al (1999) (Table 13). The natural variation in a single watershed is subject to extremes that can be purely random, and there are long intervals in the natural disturbance regime. Observing the variation among multiple, similar watersheds effectively increases sample size and gives greater confidence in the results. The Upper Skagit, Sauk, and Skykomish watersheds were chosen for comparison because they are comparable to the Nooksack Forks in terms of climate, all are on the north half of the Forest, and they have available historical data for the last 400 hundred years. All are primarily within Ecozones 8 through 11.

Data for the present analysis came from the Subregional Ecological Assessment for the Mt. Baker-Snoqualmie National Forest (USDA Forest Service 1993). The numbers reported are by watershed, for NFS lands only.

Table 13 Range of Natural Variability and Current Seral Stages for the MF Nooksack

Numbers are percent of total acreage by vegetation zone.

Vegetation Zone:	Pe Seral: RNV/Current	Mid-Seral: RNV /Current	Late Seral Single-Story: RNV /Current	Late Seral Multi-Story: RNV /Current
Western Hemlock	0-75/12	0-80/29	0-80/46	20-70/12
Pacific Silver Fir	0-35/7	10-40/44	0-20/24	40-90/23
Mountain Hemlock	0-30/4	5-35/25	0-15/29	65-80/31

The western hemlock zone is within the historical range, except for late-seral single-story. This is likely the result of the amount of western hemlock zone in private ownership and the amount harvested on NFS lands in the past.

The Pacific silver fir zone is within the range for early-seral. It is above the range for mid-seral and late-seral single-story, and below the range for late-seral multi-story. This is largely a function of harvest history and fire history. As the stands grow older, the amount in each category will fall within the historical range.

The mountain hemlock zone is within the natural range for early and mid-seral, above the range for late-seral single-story, and below the range for late-seral multi-story. This is also likely a function of the fire history.

Table 14 Range of Natural Variability and Current Seral Stages for the SF Nooksack.

Numbers are percent of total acreage by vegetation zone.

Vegetation Zone:	Percent Early Seral: RNV/Current	Percent Mid-Seral: RNV /Current	Percent Late Seral Single-Story: RNV /Current	Percent Late Seral Multi-Story: RNV /Current
Western Hemlock	0-75/0	0-80/50	0-80/0	20-70/46
Pacific Silver Fir	0-35/2	10-40/12	0-20/24	40-90/56
Mountain Hemlock	0-30/2	5-35/7	0-15/20	65-80/63

In the western hemlock zone, the amount of early-seral reflects the fact that there is little of this zone in the South Fork watershed on NFS land, and many of the old clearcuts in it are over 30 years of age. What wasn't cut is still late-seral multi-story.

In the Pacific silver fir zone, there was a large amount of clearcutting in the Wanlick Pass area that have now grown into the mid-seral stage.

In the mountain hemlock zone, all seral stages are at or near the natural range except for late-seral single story, which reflects the fire history and the relative lack of harvest in this zone.

Habitat Trends

Given that the amount of late-seral habitat in the watersheds is currently high, and that most of this habitat occurs in forest land management allocation areas that reduce or preclude commercial timber harvest (such as wilderness), the outlook for plant species dependent on late-successional forest is good.

The ultramafic habitat is almost entirely on NFS land, and most of that is within the Mt. Baker Wilderness. Any habitat changes in this area would be the result of natural processes.

Habitat connectivity is the ability of seeds or spores to disperse across the landscape to areas suitable for germination and plant growth. Habitat connectivity is often a concern for late successional species due to past harvesting or other large-scale disturbance. Connectivity between the Middle and South Fork watersheds is via the Elbow Lake area, and the forest stands there are approximately 700 years old. Because it is also within the Mt. Baker Wilderness, that connectivity is expected to persist.

Connectivity to the east is poor due to the height of Mt. Baker. A dispersal corridor exists between the South Fork and the Baker Lake watershed via Wanlick Pass, but this connectivity was fragmented by clearcutting that began in earnest in the 1960s. Over time, these stands will mature and better connectivity will be re-established. Pre-commercial or commercial thinning in these stands may help hasten old-forest structure. Connectivity between the Middle Fork and the North Fork is via the Grouse Butte area, where clearcutting began in the 1940s. These stands will also mature over time, and may be helped with stand treatment such as thinning.

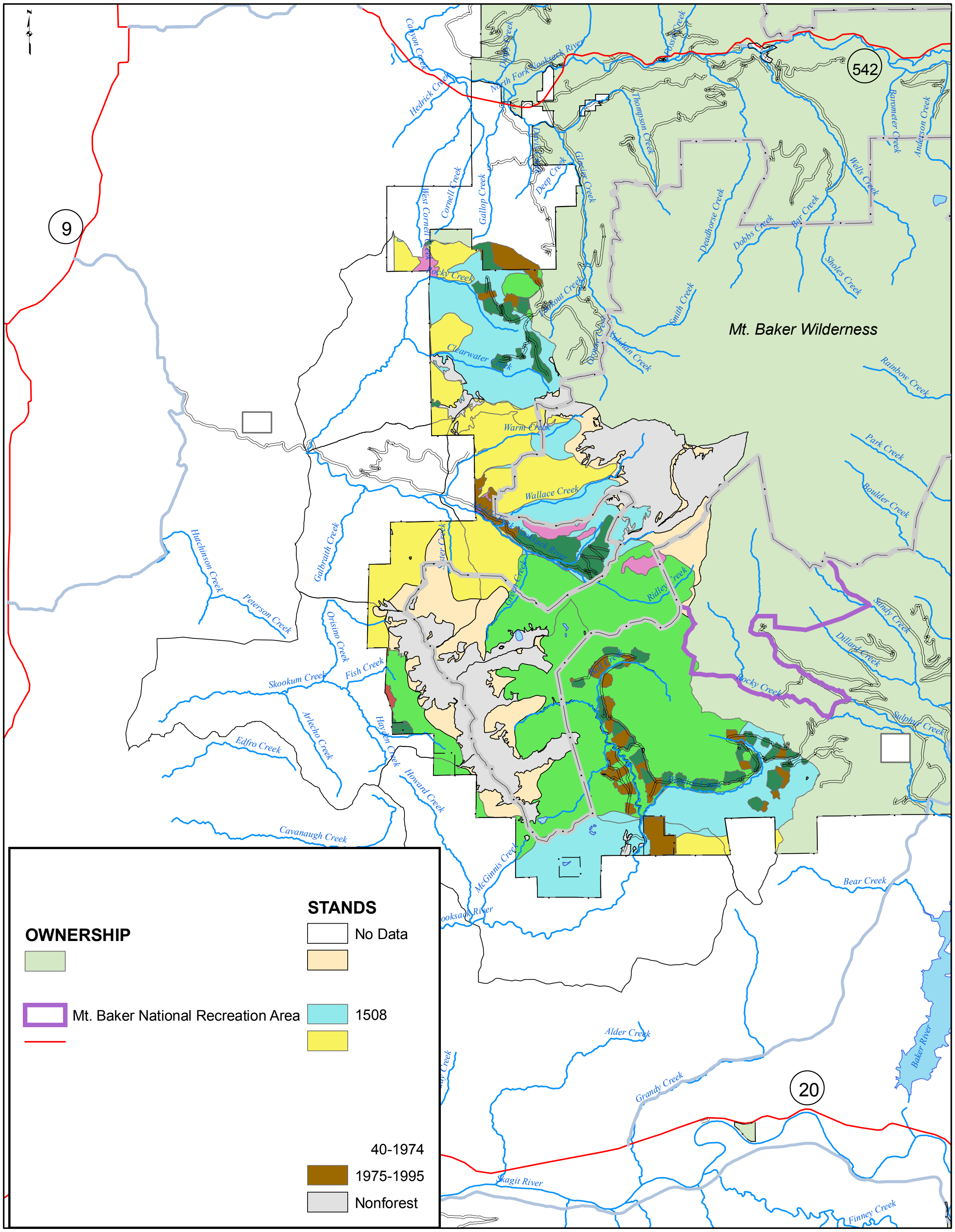
Fire and Other Disturbances

Fire History

Stand age and composition within the analysis area is a function of fire history and timber harvestsFigure 14). Large fire events have been the principle driver shaping vegetation in western Washington for the last 1000 years. Douglas-fir and western red cedar can live for over 1000 years. A detailed representation of fire history across the landscape has been constructed through the study of these older living trees by determining stand age of younger stands and through analysis of the historical record. In most large fire events, burning conditions vary across the landscape and thus, variations in age within a given stand are to be expected.

Climate is the major contributing factor to large fires in the region and within the analysis area. Western Washington was warmer and drier during the Medieval Optimum (900-1300 AD) than in the recent past. The relative lack of trees older than this period is evidence of frequent or large scale fire events. Remnants of stands originating during this period (circa 1000 AD) are relatively small due to subsequent periods of high fire activity and are now principally found at higher elevations along the flanks of Mt. Baker and the Twin Sisters (Figure 14).

Figure 14 Stand Year of Origin



Large landscape scale fires in western Washington are also evident in three distinct periods during the Little Ice Age (1300-1750 AD). The first of these large scale events occurred in about 1308.

During this fire event, or series of fires, most of the analysis area burned and much of this fire area has subsequently burned again. Remnants of stands generated by the 1308 burn can be found: on the north aspect of the Middle Fork drainage east of Green Creek and throughout the Ridley Creek drainage; in the headwaters of the South Fork above the confluence of Wanlick Creek; and lastly, on the southwest aspect of the Twin Sisters above Hayden and Howard Creeks.

The second major burning episode in western Washington during the Little Ice Age occurred around 1500 with the largest event occurring in about 1508. Again, not all of the stands generated by this event are in evidence within the analysis area due to subsequent fires. The major remaining stands originating during this period occur: in the headwaters of Rocky and Clearwater Creeks; on northwest aspects of Warm and Wallace Creek drainages; north of the Middle Fork between Wallace and Ridley Creeks; and finally south of the Twin Sisters between McGinnis Creek and the South Fork continuing northeast through to the north west aspect of the Wanlick Creek drainage.

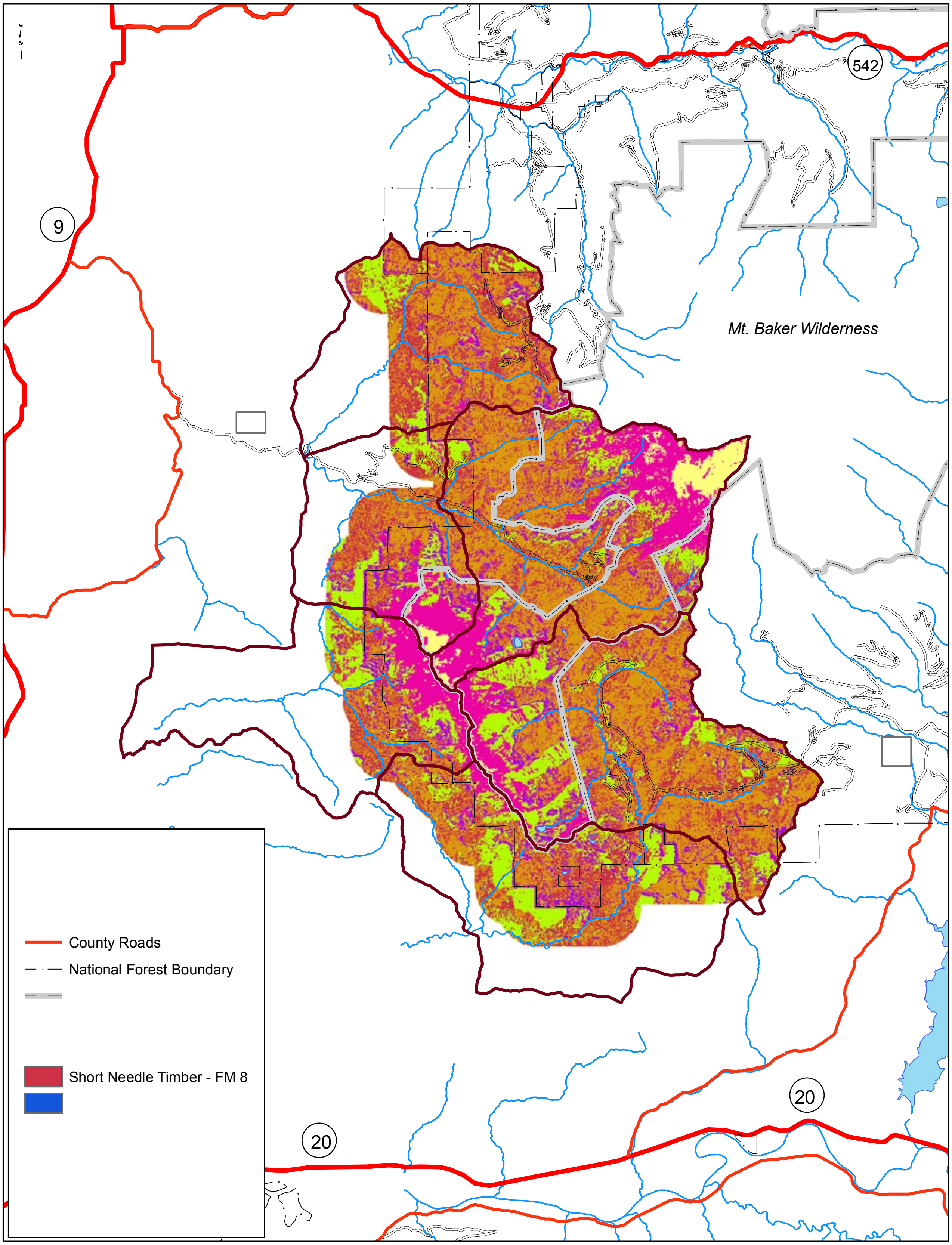
The final great fire episode during the Little Ice Age occurred around 1700 with the last large fire occurring in about 1701. Although this too was a large landscape scale fire, evidence of this fire can primarily be found at lower elevations and is predominantly outside of the Forest boundary. However, evidence of the 1701 burn may be found throughout the analysis area including: the south aspects of Rocky, Clearwater, Warm and Wallace Creeks; on the north aspect of the Middle Fork between the Forest boundary and Green Creek; the northwest flank of the North Twin; and lastly, in a small area east of the South Fork along the Forest boundary.

Fires in the recent past are also evident within the analysis area. These fires occurred in 1923 and 1924. The mid-1920s was a notable time period for wildfire throughout the western United States and within the analysis area. In 1923, a small fire (about 73 acres) occurred in the headwaters of Rocky Creek. The following year, a large fire (about 1800 acres) occurred along the Middle Fork and was primarily located between Warm and Wallace Creeks on the south aspect of the Middle Fork. This fire likely resulted from railroad or logging activity in the area. Other smaller fires including fuels treatment burns (prescribed fire) have also played a small part in vegetation patterns in the area.

Fire and Fuels Current Conditions and Trends

Current fuel conditions can be considered based on the fuel types identified within the analysis area. Fire behavior predictions are currently based on thirteen standard fire prediction fuel models (FM). The Fire Behavior Prediction System (FBPS) is a system designed to provide short term, site specific predictions to estimate fire behavior. FBPS utilizes thirteen surface fuel models to make fire behavior predictions. A fuel model is a set of attributes for a fuel bed that provides inputs to fire behavior prediction equations. The surface fuel models are classified into four types based on the fuel bed or the primary carrier of the fire: grass (fuel models 1,2,3), brush (fuel models 4,5,6,7), timber litter (fuel models 8,9,10) and slash (fuel models 11,12,13). The models can be used to predict range of fire behavior parameters from rates of

Figure 15 Fuel Types



spread to fire intensity. A Forest fuel model data base was constructed through use of satellite imagery from 30 meter surface reflectivity pixels. Each pixel was then assigned a representative fuel model. Based on this analysis, fuel models were assigned to all of the vegetation types within the analysis area. While other models are represented within the analysis area, the principle fuel models within the area are: FM 5 Brush, FM 8 Timber and FM 10 Mature Timber (Figure 15).

Fuel Model 5 is one of the brush models and is used to predict fire behavior in plant communities typical of early seral conditions, in avalanche chutes or in reproduction units. These fuels do not typically display rapid rates of spread or fire line intensity and do not generally result in large fires. Potential fire behavior in reproduction units not burned prior to reforestation is likely underrepresented by the designated FM 5. The slash in these untreated units would be more accurately represented by one of the relatively more volatile slash models (FM 11 or FM 12). The slash models exhibit higher rates of spread and fire line intensity than FM 5. These fuel conditions will likely persist in the near term until the overstory has completely developed. Much of the fuels in the adjacent ownership would also be represented by one of the slash models. Fires originating from untreated slash, adjacent to the Forest Boundary, could also impact the analysis area.

Forested areas within the analysis area are represented by timber fuel models FM 8 and FM 10. FM 8 models fuel conditions in stands of generally younger short needle species such as Douglas-fir, western hemlock and western red cedar. Fires generally spread along the surface through compact needle litter. Larger woody material, grass and brush are usually sparse resulting in slow rates of fire spread and flame lengths too low to cause serious threat of fire moving into the forest canopy. While torching and short crown runs are possible in FM 8, typical fire movement is on the ground with relatively low resistance to suppression efforts. Also, natural barriers such as breaks in topography and riparian areas are often sufficient to substantially slow fire spread in FM 8, indicative of the relatively small fire sizes in these fuel types. Steep slopes like those found throughout the analysis area can increase fire movement both up and down slope and make safe suppression efforts challenging in FM 8. The most prevalent fuel type identified in the analysis area is FM 10 Mature Timber. Fire behavior in this fuel type is generally driven by an abundance of accumulated surface fuels. Given appropriate weather conditions, crown fire, torching and spotting are common to this fuel type. FM 10 is very resistant to control efforts particularly on steep slopes. Large stand replacement fires are likely in this fuel type given dry conditions.

Insects and Disease

Insects and disease exist in the watersheds at all times. Levels are usually low and do not cause significant problems. Diseases, such as root rots, usually occur in small patches and are scattered throughout the area, slowly killing a few weakened trees. Dwarf mistletoe usually occurs on individual western hemlock trees, but it can also affect patches of trees covering several acres. Insects are also present in low numbers, but usually causing little damage. However, when conditions permit, insect numbers can increase to the point that many trees are killed. The recent outbreak of hemlock looper in the adjacent Baker Lake area is an example of such an outbreak. In the recent past, there have been no major insect or disease problems identified within these two watersheds.

Wildlife

Late Successional Reserves

The Northwest Forest Plan established a system of Late Successional Reserves (LSR) to provide habitat capable of supporting viable populations of species associated with late and old successional (LOS) forest. The key to this strategy is providing large LSRs capable of supporting 20 or more pairs of nesting spotted owls. A Forest-wide Late Successional Reserve Assessment (USDA 2001) was written to guide management within Late Successional Reserves.

The Middle and South Forks of the Nooksack River are at the northern extent of the range of the northern spotted owl, which extends slightly into southern British Columbia. In the North Cascades portion of the range, habitat is generally fragmented into relatively small areas by high ridges.

The Baker LSR 112 is approximately 82,100 acres. It is located in the Baker River and South Fork Nooksack watersheds. The Mt. Baker Wilderness and the Mt. Baker National Recreation Area provide additional habitat that contributes to the conservation of late-successional and old-growth (LOS) forest species. These areas provide an additional 29,750 acres of habitat that were not incorporated in the Baker LSR, but are a part of Designated Conservation Area (DCA) WD-21 established for northern spotted owl (USDI 1992). This DCA also includes a portion of the Nooksack LSR in the mainstem Middle Fork Nooksack River and Warm Creek watersheds. This DCA is projected to support 28 pairs of nesting spotted owls.

The Nooksack LSR 111 is 75,053 acres and is located in the Middle (MF) and North Fork (NF) Nooksack Rivers, and Canyon Creek. This LSR incorporates a small portion of DCA WD-21 as noted above. The Clearwater Creek portion of the MF Nooksack watershed does not overlap a DCA. Because these two LSRs overlap one DCA, habitat conditions are similar, and habitat is contiguous between them, they will be addressed as one unit designed to conserve northern spotted owl at the northern extent of its range.

Because of its size and expected contribution to spotted owl production, the Baker LSR is important to the success of the LOS conservation strategy adopted by the Northwest Forest Plan. The LSR is expected to be a source of owls dispersing north to the Nooksack LSR, southeast to the Cascade LSR, South to the Finney LSR, and east into the North Cascades National Park. The Baker LSR may be critically important to owl occupancy of potential habitat in the North Cascades National Park because habitat in the Park is limited and owl populations appear low (Kuntz and Christopherson 1996). Immigration of owls into the park from the east is likely limited by high elevation, glaciated ridges.

LSR Habitat Quality

Approximately 65 percent of the Baker and Nooksack LSR/DCAs is in the western hemlock and Pacific silver fir forest zones, which is suitable habitat for the northern spotted owl and marbled murrelet. The remaining 35 percent is mountain hemlock forest or non-forest area, which does not provide habitat for northern spotted owl (USDA 1992, Forsman and Giese 1997) or many other species associated with LOS forest.

In forest zones that are suitable habitat for northern spotted owl and marbled murrelet, approximately 75 percent of the LSR/DCAs is late seral or old forest and 57 percent is old forest. Late-Successional Reserves are fully functioning when these forest stages comprise 80 percent or more as defined in the Forest-wide Late Successional Reserve Assessment (USDA 2001). Therefore the Baker and Nooksack LSRs are very close to being fully functional.

Of the LOS forest in these LSR/DCAs, approximately 20 percent is late seral and 80 percent is old forest. However, in the SF and MF Nooksack watersheds, there is very little late seral forest (Table 14). Roughly one third of the old forest is greater than 450 years old and provides optimum habitat for LOS forest species. Old forest stands in the South Fork Nooksack are approximately 700 years-old, while old forest stands in the Middle Fork Nooksack are approximately 300 years-old. Old forest patch size is generally larger than 620 acres. Old forest patches of this size or larger have a high probability of being suitable as spotted owl nesting areas (Meyer et al. 1998). Early and mid-seral forest patches created by timber harvest are concentrated along roads in both river forks.

Habitat connectivity in potential spotted owl habitat is nearly contiguous between the Middle and South Fork Nooksack Rivers near Elbow Lake. Also, a narrow band of continuous owl habitat connects the Baker and South Fork Nooksack watersheds at Wanlick Pass. There is a considerable amount of edge between LOS forest in this area. A large amount of forest in earlier seral stages on both sides of Wanlick pass may limit movement of some species associated with late successional forest habitat between the Baker River and South Fork Nooksack watersheds.

The Nooksack and Baker LSRs meet the desired condition of 50 percent or more old forest in the western hemlock and Pacific silver fir vegetation zones. For late successional and old forest combined, the current condition of 75 percent of the forest zone in these habitat classes is less than the desired condition of 80 percent or more. This condition will persist for roughly 30 years when a sufficient area of mid-seral stands become late seral stands (greater than 80 years-old). Barring a large stand loss such as from wildfire, both LSRs are expected to be within desired habitat conditions, and fully functioning within 30 years.

Late Successional Reserve Trends

The trend of reductions in the amount of old-growth forest stopped in the early 1990s. Mid-seral stands are developing into late seral stands. In the absence of large wildfires in the western hemlock and Pacific silver fir forest zones, the amount of late seral and old-growth forest will continue to increase. Within the next 30 years, habitat conditions are expected to be fully functional for species closely associated with late successional and old-growth forest.

North Cascades (Nooksack) Elk Herd

The Nooksack elk herd inhabits portions of both watersheds. In 1984 the population was estimated to include 1,700 animals, but is currently believed to include only 300 animals (Davison 2002). The population objective for this herd is 1,450 animals (Davison 2002).

Elk Habitat Quality

Based on recent local research, two efforts have been made to model elk habitat in portions of the Nooksack herd range (Davis et al. 2003, Tressler and Davis 2003). Davis et al. (2003) estimated that only 13 percent of the land area considered provides foraging habitat of good or marginal value for elk. The remaining 87 percent of the landscape provides limited to no food value for elk. This model did not include areas in the parkland vegetation zone, or naturally occurring, non-forested areas.

Tressler and Davis (2003) modeled habitat only in the Baker River watershed, but included the parkland vegetation zone and non-forested areas. They also evaluated elk forage value by season. The results of this modeling exercise also found that most (54.6 percent) of the landscape provide poor to no forage value for elk (Table 15).

Table 15 Percent of Seasonal Elk Ranges In Forage Habitat Classes In The Baker River Watershed (Tressler and Davis 2003).

	Foraging Habitat			
Range	Good	Marginal	Poor	No Habitat
Winter/Transition	28%	12%	60%	
Spring and Fall	12%	26%	61%	1%
Summer	32%	18%	29%	20%
All Ranges	28.5%	16.9%	42.4%	12.2%

For the entire North Cascades elk range, Table 15 probably overestimates forage quality. In the Baker River watershed, most good forage habitat is found at higher elevations, but higher elevation areas comprise a much smaller percentage of the entire herd range. Furthermore, the high-elevation parkland vegetation zone, which provides good quality forage, occurs at lower elevations in the Baker River watershed than other watersheds due to cold air drainage that pools in the Baker Lake basin (MBS 2002). Finally, forest canopy closure, which has the greatest influence on elk forage, was modeled using data from 1996. At least on National Forest System (NFS) land, some of the areas modeled as good or marginal foraging habitat were created by timber harvest and canopy closure is likely higher than represented in the 1996 data. Some of these areas have likely increased canopy closure to the point where forage value is now less than represented by the model.

In the South and Middle Forks of the Nooksack River forage habitat values likely lie between the 13 percent good and marginal foraging habitat reported by Davis et al. (2003) and the 45 percent good and marginal foraging habitat reported by Tressler and Davis (2003). With more than 65 percent of the landscape likely having poor to no forage value for elk, forage is likely limiting the population size of the elk herd. Although factors such as predation and roads can affect how elk use landscapes, the basic determinant of any landscape to support herbivores, including elk, is the quality of the foraging environment (Tressler and Davis 2003, Davis et al. 2003).

Forested areas with canopy closures in excess of 40 percent provide poor forage habitat for elk. Management objectives for Late-Successional Reserves preclude managing large areas for low canopy closures. As a result, elk range quality on NFS land will be determined by natural disturbance events that are not likely to affect much of the landscape, and managing roads and trails near naturally occurring areas of low forest canopy closure. Because elk use areas less near roads open to motor vehicles and high-use trails, unneeded roads that pass near high quality foraging habitats could be closed (at least seasonally) to improve use of these limiting habitats. New trail construction can also be designed to avoid reducing the value of these foraging habitats.

Although NFS land provides a considerable amount of good and marginal foraging habitat in areas with naturally low forest canopy closure, land management objectives for high-canopy closure late successional and old forests will not increase the quality of elk foraging habitat on NFS land. Elk foraging habitat on NFS land is expected to decline as the forest canopy closes in foraging habitat created by timber harvest in the late 1980s and early 1990s. Significant improvements in foraging habitat on non-federal lands will likely be necessary to meet the herd management goal of 1,450 elk.

Opportunities to increase elk forage through timber harvest are almost exclusively limited to non-federal ownerships within the watersheds. Although timber harvest commonly occurs on industrial forest land and lands managed by the Washington Department of Natural Resources, the value of forage habitat for elk is reduced through the use of herbicides which kills forage plants and indirectly reduces forage by facilitating coniferous tree forest crown closure.

Probably the best opportunity to improve elk foraging habitat in the watersheds is to manipulate vegetation on a 4,000 acre parcel of land owned by Seattle City Light (SCL) that abuts NFS land in the South Fork Nooksack watershed. This parcel was acquired as wildlife mitigation land as a part of the license renewal of their dams on the upper Skagit River. This parcel was specifically acquired to benefit elk, but there are currently no plans for habitat improvement. Much of this parcel is modeled as poor quality foraging habitat (Davis et al. 2003).

Additional land acquisition or conservation easements to improve elk foraging habitat on approximately 1,700 acres is expected to occur as a part of the license renewal of the Baker River Hydroelectric Project operated by Puget Sound Energy. These parcels may or may not be within the analysis area. If forage improvements are made on these parcels, they would significantly increase elk habitat in the herd's range and would likely contribute to a noticeable increase in the elk population.

Additional improvements to summer elk habitat could occur on NFS land through the development of fire management plans that would allow for natural fires to burn in wilderness, and suitable sites in other land allocations. Although the Mt. Baker-Snoqualmie Land and Resource Management Plan as amended (Forest Plan) directs natural fire in wilderness to be managed this way, plans to identify conditions under which such fires could be allowed to burn for resource benefit have yet to be developed. As a result, all natural fires must be suppressed unless there is a concern for firefighter safety. Development of fire management plans for wilderness areas could result in improved elk habitat in the watersheds and is the only remaining opportunity to improve elk habitat on NFS land in this area.

Elk Herd Trends

The North Cascade elk herd has greatly decreased since the mid 1980s. Elk forage on National Forest System Lands (NFSL) has decreased during this time period due to reductions in timber sales. Road closures on NFSL have been implemented to improve elk forage value in naturally occurring, low canopy closure areas.

Mountain Goat

The area around Mt. Baker probably has the largest mountain goat population on the Mt. Baker-Snoqualmie National Forest, and it is one of the largest in Washington State. According to Washington State Department of Fish and Wildlife (WDFW), mountain goat populations in Washington have declined for many decades despite reductions, or cessation, of hunting (WDFW 2001). State-wide, the number of mountain goats is estimated to have declined by 60 percent since 1961 (WDFW 2001).

In the South and Middle Forks of the Nooksack River, mountain goats historically occurred on Washington Monument and Twin Sisters Mountain, but no longer are present in these areas. A small population of 15-20 animals is present on Loomis Mountain in the South Fork Nooksack watershed. Within these two watersheds, mountain goats in the Mt. Baker population are limited to the Middle Fork Nooksack River watershed. Although individual animals are occasionally seen as far south as Cathedral Crag, mountain goats mostly occur from Deming Glacier north along the sides of Mt. Baker, and on Marmot and Grouse Ridges.

Goat Population Status

Wadkins (1962) estimated the goat population in the Mt. Baker Area at 650 animals, however Figure 3 of that report shows this area included Hunt Units 23 and 24. These Hunt Units include areas east of Swift Creek (Mount Shuksan), Twin Sisters Mountain west of Mt. Baker, and on Loomis Mountain and Washington Monument south of Mt. Baker. These other populations were not surveyed as a part of the Mt. Baker population in more recent years, and in the case of the latter three areas, probably had limited exchange of individuals with the population on Mt. Baker.

Methods pertaining to population estimation in Wadkins (1962) are not explicit, but do indicate that the population estimates are a compilation of observational data. Johnson (1983, p. 69) provided more information on Wadkins' methodology. Johnson indicated that surveys were conducted by Washington State Game Department (now the Washington Department of Fish and Wildlife) personnel and subsequently combined with Forest Service information. Johnson further states that Wadkins doubled the number of goats determined by the compiled records to estimate the population.

To develop a population estimate for 1961, but restricted to Mt. Baker, goat numbers were used from file maps that were likely used in the 1961 population estimation. The number of goats indicated on this map in surveys of the Mt. Baker population since 1985 total 192 animals. Doubling this, as was done for the published estimate, yields an estimate of 384 animals on Mt. Baker in 1961.

The file maps indicate two groups of mountain goats along the Swift Creek trail, just east of the creek totaling 35 animals. The precision of these two locations is not known and could represent the spot where the animals were observed from or the location of the animals. Therefore the animals could represent goats in, or out, of the area currently identified as the Mt. Baker population. If it is assumed that half of these animals were actually west of Swift Creek, including 35 additional goats, this would result in an initial population size of 419 animals. The best estimate of a 1960 mountain goat population estimate on Mt. Baker (the area bounded by the North Fork Nooksack River, Swift Creek, Baker River, Rocky Creek, Bell Creek, the Middle Fork Nooksack River, Clearwater Creek, and Glacier Creek) is between 384 and 419 animals.

Nearly 25 years later, in 1985, an intensive ground-based effort to count mountain goats in Whatcom and Skagit counties found 155 animals in the Mt. Baker area. Assuming only 50-percent of the goats present were seen, as was done for the 1961 estimate, there were 310 animals in 1985.

A two-day helicopter survey of the Mt. Baker area in 1995 observed only 39 animals. In Olympic National Park, helicopter surveys sighted 66 percent of the population (Houston, et al 1994). Applying this correction factor, the 1995 survey population estimate is 59 goats. As a result of the few animals observed, the Washington Department of Fish and Wildlife (WDFW) stopped issuing permits for hunting mountain goats on Mt. Baker.

Mountain goat inventories occurred in September 2000 and October 2001. A helicopter inventory on September 21, 2000 replicated 80 percent of the area surveyed in 1995 and occurred at the same time of year. The remaining 20 percent of the 1995 survey route (Rainbow, Park, and Boulder Creeks) could not be surveyed due to insufficient helicopter fuel. Using the correction factors for helicopter surveys, the 2000 population estimate is 139 animals, plus any animals that were in the unsurveyed area. In 1995, this area accounted for 20 percent of the goats seen. Had this area been surveyed and contained 20 percent of the animals on Mt. Baker, the 2000 estimate would have likely been 172 goats. The October 2, 2001 inventory personnel surveyed the entire area around Mt. Baker. This survey yielded a count of 121 goats for a population estimate of 183 goats. The similar numbers observed in 2000 and 2001 indicate that helicopter surveys can be valuable in tracking trends in the goat population.

As a part of an on-going study to develop a correction factor that accounts for mountain goats present but not observed during helicopter surveys, some animals have been marked with collars that are tracked via a global positioning system (GPS). Surveyors in July 2004 observed 229 individual goats. Corrected for environmental factors affecting marked mountain goats that were seen, and not seen during the survey, and for group size, the estimated population of mountain goats on Mt. Baker is currently 300 animals.

Inventories indicate a downward trend in the goat population from the early 1960s to the mid 1990s. The 1995 population estimate is 85 percent lower than the 1961 estimate. The small number of animals seen in these surveys suggests large decline in the goat population through the mid -1990s that resulted in the closure of goat hunting in the Mt. Baker area. Since hunting stopped, the goat population on Mt. Baker appears to have increased sharply to the current estimate of 300 animals.

Factors Affecting Goat Population Dynamics

Mountain goat populations have been reported as declining for decades in western Washington. Some areas formerly occupied by mountain goats currently support no animals (Twin Sisters Mountain and Washington Monument) or greatly reduced populations. Several possible causes of these declines include: habitat degradation due to fire suppression and timber harvest on mountain goat winter range, increased recreational use resulting in displacing goats from preferred habitat, over-harvest, predation, disease, and parasites. On a statewide basis, the WDFW suggests that wildfire suppression and disturbance from recreational activities are the two greatest factors negatively affecting mountain goat habitat (WDFW 2001).

Goat Hunting

Data to evaluate most of the factors potentially affecting mountain goat populations are lacking, however records of sport harvest maintained by the WDFW are detailed and cover a long time span. Although many factors may be contributing to mountain goat population dynamics, determining the magnitude of the impact for one or more potential causal factors can help focus research and restoration actions. To evaluate the possible effects of sport harvest on mountain goats, a deterministic population model was developed that incorporates known harvest and estimates of mountain goat population sizes in the Mt. Baker and Goat Mountain area (Appendix A). Model results indicate that hunting mortality largely explains the population change at Mount Baker and that hunting was an important factor affecting the Goat Mountain population as well.

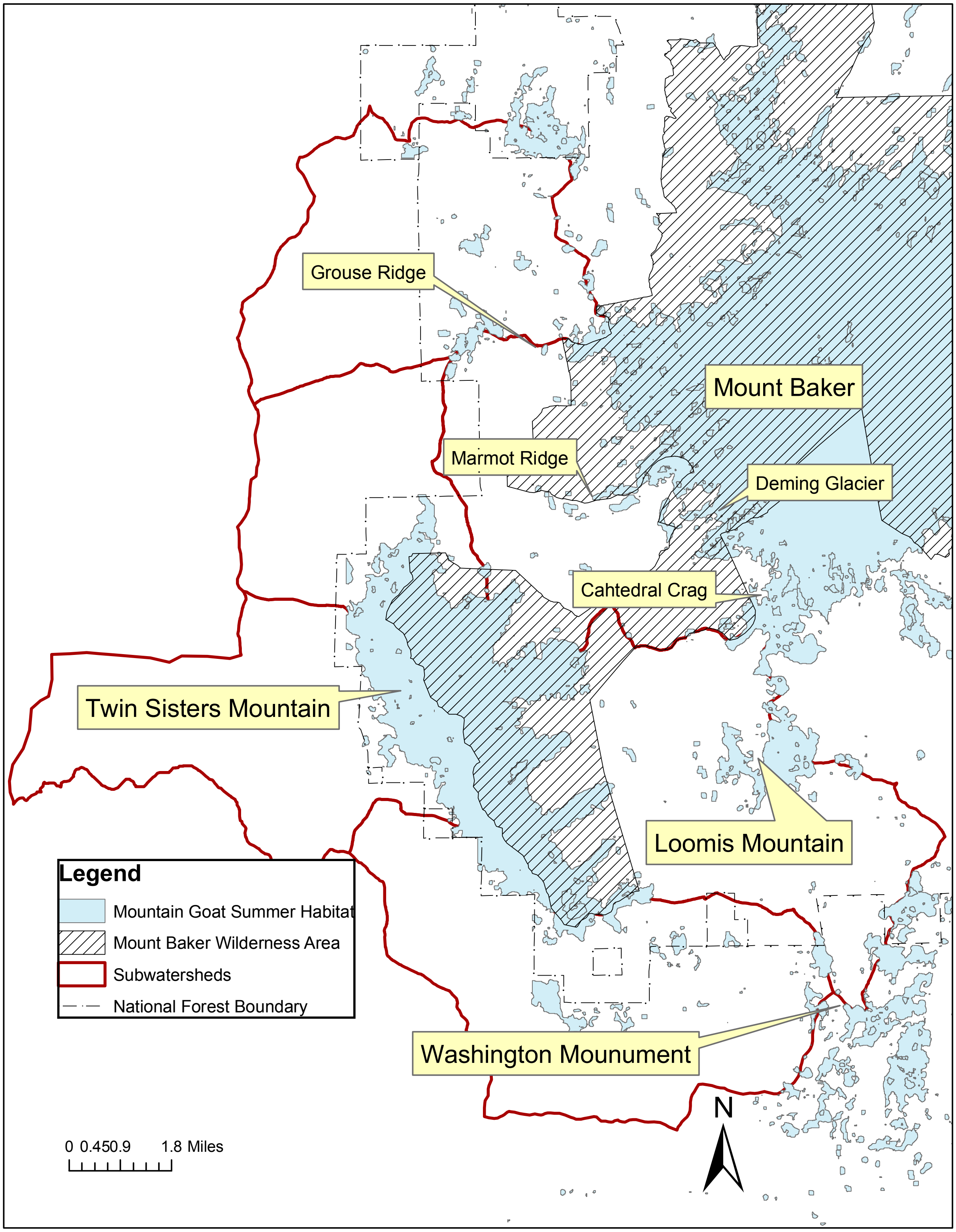
Impact of Fire Suppression on Goat Habitat

The WDFW (2001) suggests that fire suppression has degraded mountain goat foraging habitat through increased forest cover. This is unlikely to be a significant factor in explaining the large reduction in mountain goat populations west of the Cascade Crest where mountain goat habitat occurs primarily in the mountain hemlock, parkland and alpine vegetation zones. Fire return intervals in this vegetation zone are estimated to be 1,500 years or more (Agee 1993). This suggests that fires are either infrequent or do not burn large areas in this vegetation zone.

East of the Cascade Crest, where subalpine fir vegetation zone is used by mountain goats, fire return intervals range from 109 to 250 years. Because fire is either more common and/or burns more area east of the Cascades, fire suppression may have had a more significant impact on mountain goat populations and habitat quality than west of the Cascade Crest.

Development of forests in the mountain hemlock zone is slow due to very low productivity created by deep and long-lasting snowpack (Henderson et al. 1992). Forest establishment in the mountain hemlock forest zone may not occur for up to 100 years (Agee 1993). Because of the limited ability of forests to develop in this vegetation zone, and because new mountain goat habitat has been created as glaciers have receded, it is unlikely that the drastic reduction in mountain goat numbers has been influenced by either fire suppression or forest establishment in meadows, or other important goat foraging areas.

Figure 16 Mountain Goat Summer Habitat



Disturbance of Goats from Recreation Activities

Increased recreational use of goat habitat is believed to be another factor negatively impacting mountain goats (WDFW 2001). Hikers on trails did not appear to displace goats near Mt. Baker, but off-trail hikers did result in goats fleeing (Wright 1977). Female/kid groups seemed most vulnerable to disturbance. Wintering goats on Barometer Mountain fled from nearby skiers (Raedeke Associates 1990). Mountain goats are disturbed by a variety of activities and range abandonment may occur (Foster and Rahs 1983). Camps in goat habitat can temporarily displace goats from regular feeding areas (Foster and Rahs 1983).

Summer goat use is most common near ridgetops (Fox 1977, Hjeljord 1973). Trailed and untrailed hiking activity also tends to occur in these locations. In early summer, nanny/kid groups are further restricted to areas near escape terrain (McFetridge 1977). Mountain goat populations can have very low reproductive rates (Festa-Bianchet et al. 1994, Bailey 1991). The availability of forage may be the most important factor influencing reproductive success (Bailey 1991). Frequent interactions of hikers and goats during the summer months may be resulting in reduced foraging by nannies and kids, and lower reproductive rates. Furthermore, the energetic cost of fleeing disturbance is high for mountain goats compared to other ungulates (Dailey and Hobbs 1989). Because mountain goats and hikers frequent the same areas and goats can be displaced from preferred feeding areas, the potential exists that recreational activities can limit the size of mountain goat populations.

Mountain Goat Trends and Conclusions

Mountain goat populations have declined greatly since the early 1960s, but the population on Mount Baker has increased considerably over the past 10 years in the absence of hunting. The population on Goat Mountain now also appears to be experiencing a large increase.

Although fire suppression, displacement due to recreational activities, predation, and other factors have undoubtedly had some impact on mountain goat populations, hunting appears to have had the largest role in the area-wide declines in mountain goat populations. Declines of 60-90 percent are predicted to have occurred in the two largest populations in the area due to the impact of hunting. The Mt. Baker population appears to be rapidly growing since hunting ceased in 1996, further suggesting that mountain goat numbers were decreasing due to that factor. The Goat Mountain population appears to be increasing in the absence of hunting, although the response in this population was much slower than the response at Mount Baker, possibly due to the very low residual population. It is possible that goat harvest was also a factor contributing to the disappearance of goats from Washington Monument and Twin Sisters Mountain.

Although fire suppression is not likely a significant causative factor in explaining the magnitude of the decline in mountain goat populations, there are opportunities to allow for mountain goat habitat improvement. Because early-seral habitats are preferred by mountain goats (Schoen and Kirchoff 1982, Smith 1986[b], Singer and Doherty 1985), converting conifer forest to early seral habitats can improve the amount and quality of mountain goat habitat. Olmsted (1978) documented the value of fire in improving mountain goat habitat throughout the state, including in the Mt. Baker area. Creating early seral habitats near escape terrain has been proposed as an enhancement measure for habitat and population losses (Foster and Rahs 1985).

Development of fire management plans that would allow fires to create additional mountain goat habitat would be desirable. Wildfires that have been allowed to burn due to firefighter safety concerns have created or improved mountain goat habitat in the Cascade River in 2003 and Swift Creek in 2004. However, other fires that could have had benefits to mountain goats have been suppressed. In 2004, a fire in mountain goat winter habitat in Blum Creek just inside the national park boundary was suppressed because of the lack of a fire management plan on adjacent NFS land.

As discussed above, some recreational activities can reduce the quality of mountain goat habitat. However, on the Ptarmigan Ridge Trail, goats appear to be unaffected by hikers remaining on trails (Wright 1977). Conversely, it appears that one of the mountain goats outfitted with a tracking collar on Church Mountain consistently avoids areas near the Church Mountain Trail despite there being no apparent difference in habitat between its use area and areas near the trail. At Kool Aid Lake, along the Ptarmigan Traverse in a remote, untrailed area in the headwaters of the West Fork Cascade River, hikers have reported mountain goats feeding among tents at campsites. It appears that mountain goat reaction to recreational activities is dependent on the type of activity and potentially by past experience. Because of their remote location, goats at Kool Aid Lake unlikely received any hunting pressure and, like goats in Glacier National Park, may be very tolerant of human presence.

Data collected in the on-going WDFW research project on mountain goats may yield some valuable information to assist in determining how many mountain goats are displaced from habitat as a result of recreational activity and to what extent displacement occurs. Until there is greater certainty about this impact, trail construction and reconstruction activities should be designed to minimize displacement of mountain goats.

Grizzly Bear

The South Fork and Middle Fork Nooksack Watersheds are at the western edge of the North Cascades Grizzly Bear Recovery Area. The watersheds are a part of the Sisters Bear Management Unit (BMU), which is likely not occupied by grizzly bear. Habitats in this BMU have high core area on federal land and could become occupied if the population recovers. There has been no detectable increase in the grizzly bear population in the recovery area over the past 40 years despite there being no known grizzly bear deaths. Because the population has not increased during a time of no known mortality, the population appears unlikely to recover without augmentation from other grizzly bear populations. Augmentation is unlikely to occur anytime in the foreseeable future.

Other Threatened and Endangered Species

There is no known habitat for wolves, lynx or bald eagle in the watersheds. Northern spotted owls and marbled murrelets are discussed in the Late-Successional Reserve section on page 65.

Regional Forester's Sensitive Species

There is no known habitat for Oregon spotted frog, common loon, peregrine falcon, and great gray owl in the watersheds. Townsend's big-eared bat may occur in the watersheds. Individuals have been documented in the adjacent North Fork Nooksack and Baker River watersheds (Perkins 1988). This bat is associated with caves or mine shafts for maternal colonies and hibernacula (Johnson and Cassidy 1997). There are no caves in either watershed known to be used by Townsend's big-eared bat, but there is a cave in the vicinity of Washington Monument and others likely in limestone formations near the town of Concrete. Perkins (1988) identified a cave near Chuckanut Creek, south of Bellingham that may be used by this species. Use of the watersheds by big-eared bat is likely limited to foraging activity.

A wolverine was killed by a vehicle west of the analysis area in the South Fork Nooksack watershed on SR 9 near Acme in the late 1990s. Because of this confirmed presence, the watersheds are likely occupied by wolverine. Wolverines occur at low density and are believed to be dependent on deer and elk as primary food sources (Banci 1994). Because of the low deer and elk densities in the watersheds, wolverine may occur at even lower densities in the analysis area compared with other areas.

Other Management Indicator Species

In addition to the other MIS species which have been discussed above, American marten and woodpeckers are management indicator species (MIS) for the MBS Forest Plan as amended. These species were identified as MIS because they are indicators of old growth forest habitat and dead wood habitat. At the time the Forest Plan (prior to amendments) was written, timber harvest was a common activity affecting hundreds of acres each year. Because timber harvest reduced old growth and snag habitat, American marten and woodpeckers were considered good indicators to determine if the levels of timber harvest were consistent with projected impacts on these species, and others that used similar habitats.

With the amendment to the Forest Plan in 1994, timber harvest has become a minor activity. All resident woodpeckers are expected to have a 100 percent likelihood of being well distributed on National Forest System land in western California, western Oregon, and western Washington (USDA, USDI 1993). As a result, woodpeckers are expected to be common and no longer valuable as indicator species.

Marten are predicted to have a 67 percent likelihood of being well distributed, but this is due to very low populations in the Olympic Peninsula and Oregon coast (USDA, USDI 1993). Marten are common in the North Cascades, including the South Fork and Middle Fork Nooksack watersheds. Marten reach highest densities in subalpine areas which were little affected by past timber harvest and are well represented in wilderness areas. As a result, American marten are expected to be common and no longer valuable as indicator species.

Air Quality

The Nooksack Forks watershed is within 70 miles of nearly 3 million people from the Puget Sound metropolitan area to the south to the greater Vancouver BC area to the north. In addition the watershed is in relatively close proximity to large oil refineries in Anacortes, Ferndale, and Blaine. The vehicles and industries associated with urbanization plus the sulfur dioxide and other pollutants emitted by the refineries contribute to the existing air quality within the Nooksack Forks watershed.

Air quality in the area has not been monitored to any great extent, but given what is known about the sources, the topography, and the meteorology of the area, a few assumptions can be made. Wind patterns during the winter (October through March) would tend to bring pollutants primarily from sources to the southwest or Puget Sound area. In summer, prevailing winds patterns would bring pollutants from the northwest or greater Vancouver, BC area. Periods of stagnation would result in the buildup of pollutants from the local area.

Ambient air monitoring in the vicinity (Anacortes, Marysville, and Bellingham) does not indicate that the area is at risk for exceedences of National Ambient Air Quality standards (NAAQS) set by EPA to protect human health, although ecosystems are often more sensitive than humans to air pollution. Ecosystem monitoring for air pollution effects is very difficult, but possible impacts to ecosystems within the Nooksack Forks watershed include excess deposition of sulfur and nitrogen which can cause acidification and/or unnatural fertilization of soils and surface waters. In addition, ozone formation could cause injury to vegetation. Ozone is formed when volatile organic compounds (VOC's) combine with nitrous oxides (NOx) in the presence of heat and sunlight. The area around the Nooksack Forks watershed is probably rich with ozone precursors although the hot, stagnant conditions needed for excess ozone formation do not occur all that frequently. Average ozone concentration is known to increase with elevation so sensitive ecosystems could be experiencing ozone concentrations at levels high enough to cause impacts. This is an area that needs further study.

Emissions from larger point sources in the vicinity (Skagit and Whatcom counties) are shown in Table 16.

A significant portion of the upper reaches of the Nooksack Forks watershed is within Mt. Baker wilderness. Mt. Baker wilderness is considered a Class II area for air quality protection so does not receive all of the protections provided by a Class I designation although the Washington State Department of Ecology does give the Mt. Baker wilderness extra attention and protection from air quality impacts when possible. The Clean Air Act amendments of 1977 gives Federal Land Managers, including the Forest Service, "…an affirmative responsibility to protect the air quality related values (including visibility)…within a class I area." The Mt. Baker-Snoqualmie National Forest works to protect Mt. Baker wilderness air quality related values as if it were a Class I area even though the legal designation is not there. Glacier Peak wilderness and North Cascades National Park are Class I areas in the vicinity of Nooksack Forks watershed.

Table 16 Significant stationary emission sources in Skagit and Whatcom counties.

Facility Name	County	Facility Type	NH3 t/yr	NH3 %WA total	NOx t/yr	NOx %WA total	PM2.5 t/yr	PM2.5 %WA total	SO2 t/yr	SO2 %WA total	VOC t/yr	VOC %WA total
Tesoro Northwest Company	Skagit	Petroleum Refining	0		2,217		454		4,809		1,313	
Puget Sound Refining Compa	Skagit	Petroleum Refining			9		105					
General Chemical Corp.	Skagit	Industrial Inorganic Chemicals			14				105			
Tecnal Corp		Cyclic Crudes And			1		1					
March Point Cogeneration	Skagit	Elec & Other Services Combined	0		233		6		25		20	
Northwest Pipeline Mt Vernon		Natural Gas Transmission			4		3					
Pse Fredonia	Skagit	Elec & Other Services Combined			207		10		1		4	
Alcoa Primary Metals Intalco W	Whatcom	Primary in			9		555					
Tosco Refining Company	Whatcom	Petroleum Refining	0		776		103		2,437		919	
Arco Cherry Point Refinery		Petroleum Refining			2 3		106					
Georgia Pacific West Inc	Whatcom	Pulp Mills	0		174		77		39		69	
Tenaska Ferndale Cogeneratio	Whatcom	Elec & Other Services			9		7					
Pse Whitehorn	Whatcom	Electric Services			120		5		10		2	
Northwest Pipeline Corp Suma	Whatcom	Natural Gas Transmission	0		2		10					
Sumas Cogeneration Calpine	Whatcom	Electric Services	9		45		6		6		6	
Encogen Nw Cogeneration Pla	Whatcom	Electric Services			1		11				1	
1999 Annual Total (Small facilities not shown so columns do not add to totals.)			646	16%	8,704	16%	1,569	11%	17,164	14%	4,901	26%

Visibility Protection in and near Nooksack Forks Watershed

Visibility is a value that is protected primarily within the boundaries of a Class I area. The MBS seeks to protect Mt. Baker wilderness as if it were Class I so visibility is an important value with in the portion of the watershed that is within the wilderness.

- NH3 (Ammonia): primarily from livestock waste, fertilizer production and agriculture. Combines with SO2 and NOx to form fine particulate matter that impairs visibility. Also causes nitrification and eutrophication of aquatic systems.
- NOx (Nitrous oxides): primarily from high temperature combustion processing including motor vehicles and power plants. NOx plays a major role in ozone formation and causes acidification and/or eutrophication of aquatic systems.
- PM2.5 (fine particulate matter): primarily from fuel combustion. Other pollutants can form fine particles (SO2, NOx, and VOC's) through atmospheric chemical reactions. Causes visibility impairment.
- SO2 (Sulfur dioxide): primarily from the combustion of fossil fuels, metal smelting, and other industrial processes. Causes acidification of surface waters and terrestrial systems. Forms secondary particles that impair visibility.
- VOC's (Volatile organic compounds): from volatilization of carbon containing compounds such as gasoline, benzene, toluene, and other solvents. Combines with NOx to form ozone. Can react to form fine particulates which impair visibility.

Glacier Peak wilderness and North Cascades National Park visibility is officially monitored at an IMPROVE (Interagency Monitoring of Protected Visual Environments) site located at Ross Lake. The Ross Lake location is much farther east than the Nooksack Forks watershed and probably measures air quality that is much cleaner than conditions in the Nooksack Forks watershed. Another IMPROVE site is located at Snoqualmie Pass for Alpine Lakes wilderness Class I area and has some applicability since this site is closer to urbanization. Visibility at Mt. Baker wilderness probably falls somewhere in between what is measured at the two sites.

Figure 17 shows average seasonal and annual standard visual range in miles as measured in 2001 (the most recent year with complete data). Standard visual range is simply how far someone can expect to see through the atmosphere. Theoretical maximum visual range with nothing in the air except natural components of the atmosphere is about 240-miles, but even without the influence of human-caused air pollution, visibility would not always reach this limit. Naturally occurring particles of dust, smoke, pollen, and gaseous hydrocarbons contribute to visibility impairment. Average natural visibility in the western US is estimated to be about 110-115 miles. The annual average standard visual range measured at Ross Lake is very close to this showing that generally, visibility is excellent at this location. Visibility at Snoqualmie Pass is rather more impaired. The general sources of visibility impairment at both sites are shown in

Figure 18.

Identifying exactly what and who is causing visibility impairment can be challenging. Common sources of the pollutants measured by the IMPROVE monitors include:

- Nitrates: Automobiles, any combustion source.
- Sulfates: Coal/Oil fired power plants, refining and smelting.
- Coarse Mass: Smoke, pollen.
- Elemental Carbon: Diesel, oil, and coal combustion.
- Organic Carbon: Biogenics, industrial solvents, smoke.
- Soil Dust: Unpaved roads, agriculture.

In addition to visibility, other Air-Quality-Related-Values (AQRV's) of particular interest in the Nooksack Forks watershed include surface waters, and flora. Surface waters can become acidified through atmospheric deposition of pollutants; and sensitive flora (lichens especially) can be injured or killed from pollutant deposition or airborne concentrations of pollutants such as ozone.

The Forest has been sampling lakes for chemistry and looking for signs of acid deposition, but no lakes within the Nooksack Forks watershed have been sampled. Lakes further south in the Cascade Range, especially in the Alpine Lakes Wilderness, have in general been found to become more acidic more readily than lakes in Mt. Baker or Glacier Peak wilderness due to geology and soils.

Figure 17 Standard Visual Range in miles measured at two sites near Mt. Baker Wilderness.

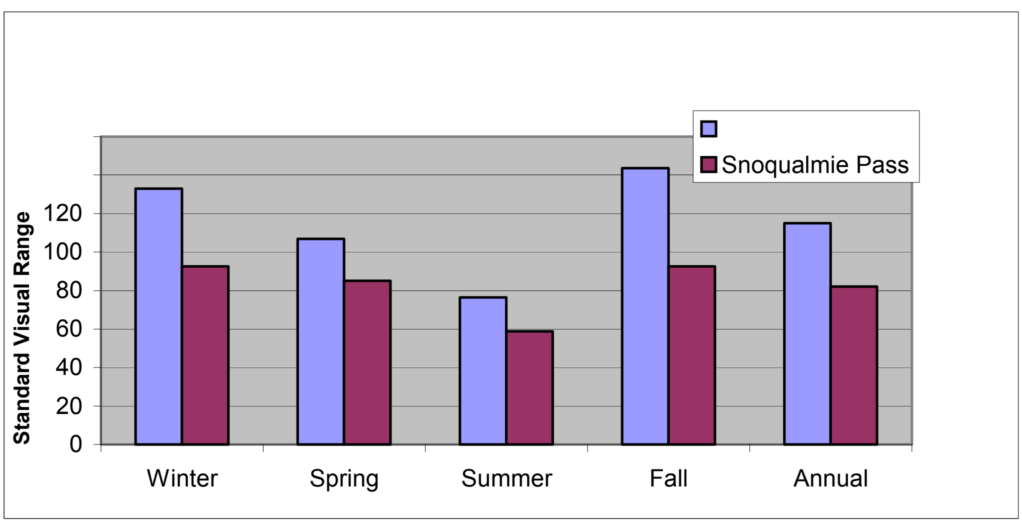
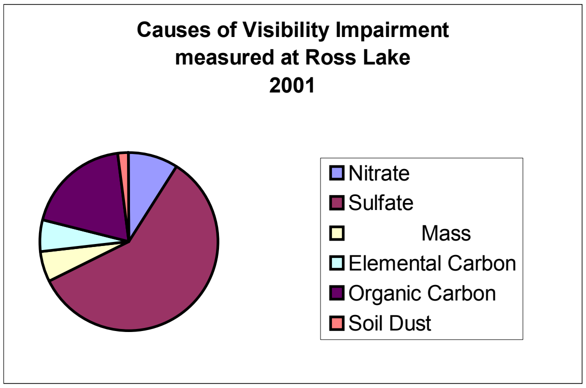
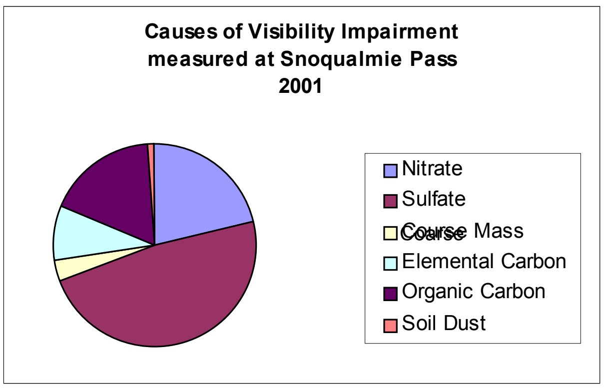


Figure 18 Sources of visibility impairment at monitoring sites near Mt. Baker Wilderness.





Human Use

Timber Harvesting

Even-aged timber management – clearcutting - was the main timber management practice from about 1910 through the 1980s. In the late 1970s and early 1980s, clearcut harvest was accompanied by yarding of the unmerchantable timber to the landings to provide for better utilization of cut material and to provide for planting spots by removing the created slash. Harvest units were normally burned to dispose of the remaining slash which was considered a fire hazard. Units were usually reforested by natural seeding and by planting desired species of trees.

As in many other watersheds, timber harvesting started slowly in the analysis area (see Figure 14 and Table 17 for the decades described below). Within the South Fork, harvesting started about 1910 with a clearcut of about 50 acres along the western edge of the watershed. It was not until the 1920s that the harvesting started in the Middle Fork. In the 1930s and 1940s there was no harvesting in either watershed. In the 1950s harvesting started up again in both watersheds. It was not until the 1960s and 1970s that timber harvesting peaked in the two watersheds. The 1980s saw a slow-down of activities and there were no timber harvesting activities in the 1990s in the

Middle Fork, and only minor amounts in the South Fork. The last timber harvesting in the Middle Fork was the Headwaters Resale Timber Sale of about 43 acres cut in 1988. The last sale in the South Fork was the Sissy Sale cut in 1987. Both of these last timber sales were clearcuts, as usual for that time.

Table 17 Acres Harvested by Decade on National Forest System Land

Decade	1910	1920	1930	1940	1950	1960	1970	1980	1990	Total Acres
Middle Fork	0	550	0	0	180	1250	470	160	0	2610
South Fork	50	0	0	0	10	700	1070	290	30	2150
Total	50	550	0	0	190	1950	1540	450	30	4760

Timber harvesting within the private land holdings within the analysis area has been less than on public lands. Within the Middle Fork, 570 acres have been harvested since the 1920s, and 350 acres within the South Fork. These non-public lands are usually located on the boundary of the two watersheds.

In 1990, the Mt. Baker-Snoqualmie National Forest Land and Resource Management Plan was adopted. This plan de-emphasized timber production where conflicting resource needs were recognized. In 1994, an amendment to the forest plan established (among others) Matrix and Late-Successional Reserve (LSR) as land allocations. A small portion of the western edge of the Middle Fork is Matrix land where scheduled timber harvest is allowed, but it should be noted that the underlying Forest Plan Management Area is 23A – Other Municipal Watershed, which affects the harvest prescriptions. In the past there has been no timber harvesting in this area, and none is planned.

The objectives of the LSR are to maintain a functional, interactive, late-successional and old-growth forest ecosystem. The location of past timber harvesting is within these LSR land designations.

Over the past decade or two, younger stands within these two watersheds have been pre-commercially thinned to improve growing conditions for the residual trees. Prior to 1994 the objectives for the pre-commercial thinning were to meet timber management objectives. However, since 1994 the non-commercial thinnings have been accomplished to meet LSR objectives.

Special Forest Products

Special Forest Products (SFP) are divided into two categories: those that are converted from logs to smaller useable specialized form such as fence posts, poles, cedar shakes, and firewood, among others; and those products that are not converted from logs, such as mushrooms, berries, seedling transplants, floral greens, Christmas trees, tree boughs, seed cones, etc. Currently, most of the SFPs are collected by the public for personal use only, both on the Forest generally and in these two watersheds. There are three exceptions to this personal use only policy. In the recent past, seed cone collection permits have been sold to local buyers, and conifer tree boughs have been sold for commercial use. Certain conifers and hardwood seedling transplants have also been sold commercially in the past.

The public demand for SFPs has been increasing in the past decade as the public demand increases. This trend is expected to remain constant or increase in the future. Illegal harvesting of SFPs has been a concern throughout the accessible portion of this watershed. This illegal harvesting is expected to continue or increase as the values of certain products increase, such as western red cedar blocks used for shakes and shingles.

Minerals

The main mineral feature of the Middle and South Fork Nooksack watershed is the Twin Sisters Olivine formation. It is one of the largest bodies of olivine in the world, and the largest commercial grade body in the United States. Olivine's scientific name is magnesium iron silicate, also known as peridot in its crystalline form.

Olivine is relatively chemically inert, has a very high melting point, and does not release silicone when ground into fine particles, which can be toxic if absorbed by the lungs. These characteristics allow its use in industrial applications such as metal casting, lining highly corrosive pipes, and sandblasting. In geologic processes, olivine usually settles out from other minerals due to its higher specific gravity, forming layers.

Olivine is rarely present at the earth's surface without having been altered into serpentine, a mineral that has different physical and chemical properties than olivine. The Twin Sisters deposit is unique in the fact that the deposit is unaltered, and heavy metals like chromite are disseminated throughout the body rather than being layered.

Olivine from a deposit in the Twin Sisters in the Middle Fork watershed is currently the only olivine originating from the western United States, and it is shipped all over the country. It has produced an average of 40,000 tons per year for the last several years, making it the largest producing olivine mine in Washington and Oregon. Norway is the main competitor for olivine production worldwide, and commercial operations there are government subsidized.

A previously active olivine mine operated by International Minerals & Chemicals Corporation and later purchased by Applied Industrial Materials Corporation (AIMCOR) in the South Fork Nooksack River drainage resulted in negative impacts to the riparian system. This operation was not a hardrock quarry, but instead used water to wash reject material out of moraine deposits. Compared to the olivine found in the Twin Sisters deposit, a hardrock source with approximately 10 percent reject material, the moraine deposits hold 50-60 percent reject material, which was flushed into the river during the time the AIMCOR mine was in operation.

Reclamation work required by the Forest Service in 1988 prior to releasing AIMCOR from a bond and futher liability included recontouring of the site, construction of water channels with erosion control dams and deflectors, establishment of seeded grass cover, willow staking and installation of check dams in live streams, and tree planting.

Natural alder seeding was found to be more successful than two attempts at tree planting. In 1990 the company requested that “due to the extensive reclamation efforts put forth by AIMCOR, the environmental sensitivity, and the close proximity to the south fork of the Nooksack River,” the Forest Service “remove this entire site from any and all future mining activities.”

Geothermal energy resources are also known to exist in the Middle and South Fork Nooksack watershed. Heat from magma, which is found everywhere in the earth at great depth, is in some places close enough to the surface to be economically recoverable for use as an energy source. Drilling into geologic formations that contain underground water heated by magma close to the surface allows the hot water to be pumped to the surface for direct use in supplying heat, or to drive turbines for electrical production if the temperature is high enough (over 300 degrees Fahrenheit). In Washington State the Cascade Range is considered to hold the best potential for high temperature geothermal resources (Bloomquist, undated). Thermal activity at Mt. Baker increased dramatically in 1975 with the venting of large amounts of steam from fumaroles in the summit crater. In 1981 the US Geological Survey estimated energy flux at an electrical equivalent of 80 megawatts, about 15 times greater than pre-1975 levels (WDNR, 1981).

Because there is a limited number of high quality olivine deposits worldwide and demand is steady, the Twin Sisters Olivine deposit will continue to be developed for extraction of olivine. There are a number of active mining claims for olivine and gold in the Middle and South Fork Nooksack watershed, although at this time only one out of two groups of olivine claims is under development.

Applications for leases for geothermal exploration and development, issued by the Bureau of Land Management, currently include 65,398 acres in the Mt. Baker vicinity from applications dating back to 1989. At this time no leasing decisions have been made on these applications, and no surface disturbance for exploration has occurred.

Minerals Trends

Olivine extraction is likely to stay at current levels or increase. Interest in geothermal energy development is dependent on energy market conditions, and may fluctuate over time.

Road Infrastructure

Road construction to access both the Middle and South Forks of the Nooksack River began in the 1960s. Roads were first constructed through both State and Private lands to access the Mt Baker-Snoqualmie National Forest for timber harvests. Harvesting continued into the 1980s. By the late 1970s the removal of timber began to decline and the need for new roads declined as well. In the mid-1980s new road construction was all but halted and the focus was to use existing roads to access timber removal areas. Roads were identified for continued maintenance to allow public access for recreation purposes, private land in-holding access, as well as for forest and fire management access.

Reducing the amount of roads in inventories was started in 1990's due to declining road maintenance budgets. Existing roads that were located in areas where timber would not be harvested again were nominated for storage or decommissioning. Decommissioning in most cases only requires removal of culverts and allowing natural revegetation which is very rapid in this area. Decommissioning also removes the road from the Forest Road System. Storage removes culverts but leaves the road in the Forest Road System for potential future use. The method of choice is based on whether the road might be needed again or not. The final decision made through an access and travel management environmental assessment. An environmental assessment for the South Fork Nooksack portion of the analysis area is currently underway.

Road management within these drainages focuses on keeping and maintaining only select roads that provide safe access to recreational areas and are able to be maintained within the yearly road maintenance budget. The roads now serve multiple forest management access objectives, including: dispersed camping, winter snow play activities, hunting, fishing, wildlife and scenic viewing, berry picking, trailhead access for equestrian, hiking, backpacking, and rock climbing opportunities, and mine claim access. Road management continues to require attention and focus to maintain an adequate and safe route to the popular destinations within the two drainages.

The biggest challenge to maintaining roads is not only the required annual maintenance but also the replacement of aging drainage structures. Fortunately, most of the structures on Forest Service roads within the analysis area have already been reviewed and upgraded to standard. Roads identified as low-use or as unneeded are treated by decommissioning or put into storage. One final concern is surface rock conditions. The application of a well-graded surface rock is vital to maintaining a drivable road surface and preventing rutting and erosion which lead to resource damage. Unfortunately, low budgets have required the Forest to decide to maintain road drivability at a lower standard due to the cost of surface rock replacement. This will affect the recreational user's experience and could affect water quality.

Road 38 is the main access road into the Middle Fork of the Nooksack drainage. Road 12 is the main access road into the South Fork of the Nooksack drainage. The total road miles for the South and Middle Forks drainages are 44.18 miles. The current Forest Service INFRA Travel Routes database divides the roads into the following Maintenance Levels (Table 18).

Table 18 Middle and South Fork Forest Road Miles by Maintenance Levels

Road Maintenance Level	Operational Level Miles
Level 1 (Closed – In Storage)	6.25
Level 2 (Open – Maintained For High Clearance Vehicles)	12.15
Level 3 – 5 (Open – Maintained for passenger cars)	25.78

The Forest completed a forest-wide roads analysis in 2002 as per direction in Forest Service Manual (FSM) 7712.15 and Interim Directive 7710-2001-1 dated May 31, 2001.. During this review, impacts and benefits to each resource area (including fish habitat, wildlife habitat, and water quality) were analyzed. Values for the aquatic risk rating for the Middle Fork roads were updated in 2005 to reflect road improvement work done in 2002–2005.

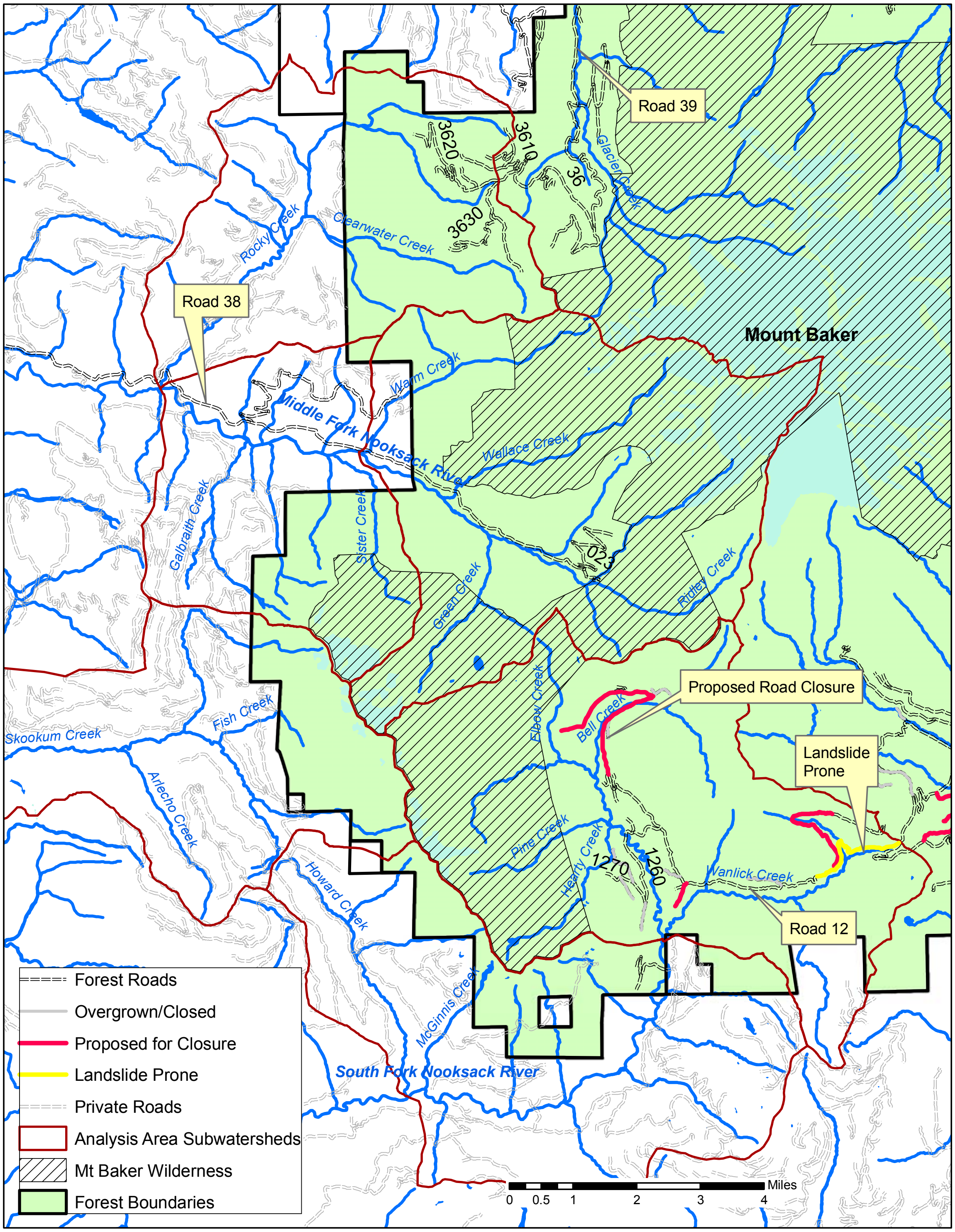
The roads analysis identified high risk roads which may require upgrading or decommissioning. Segments that were to be kept open for continuous access by either high clearance vehicles (Management Level (ML) 2) or passenger car vehicles (ML 3, 4, 5), were identified. These roads access trailheads, dispersed recreational areas, mining areas, and areas needed for administrative uses such as fire fighting. The final decisions to close open roads require further analysis. Those decisions will include impacts on fish and wildlife, the overall condition of the watershed, road maintenance budget levels, and the public's use of the area. Decisions will be documented, and arrived at, through the appropriate NEPA analyses.

Middle Fork Nooksack

FS Road 38 is the main access into the Middle Fork Nooksack drainage. A small portion of the northern edge of the Middle Fork is accessed via FS Road 36. The end of the FS Road 36 system has seven roads located in the Middle Fork drainage. There are a few lateral roads that were constructed off FS Road 38. Table 19 describes each road in the Middle Fork system, its Aquatic Risk Level, mileage, Operational Maintenance Level, and ownership or manager.

FS Road 36 at MP 2.9 to MP 4.5, Road 3630 for 1.5 miles, and Road 38 for 12.30 miles are moderate risk to aquatic concerns and are concerns for possible resource damage in the future. These roads were upgraded to standard between 2000 and 2004. Routine maintenance is advised to maintain current stability and risk rating. The other Forest Service roads in the analysis area vary from Level 2 roads that are stabilized (with low risks to aquatic resources) to Level 1 roads

Figure 19 Roads



that are currently in storage. FS Road 36 was upgraded to standard in 2000. Road 38 was upgraded in 2004.

Table 19 Middle Fork Nooksack Road System

Road Number	Road Name	Total Miles	Operational Management Level	Aquatic Risk Rating	Owner/ Manager
3600000	Grouse Butte	1.65	2	M	FS
3600000	Grouse Butte	0.40	1	L	FS
3610011	Coal Creek	0.70	1	L	FS
3610012	Outlook	0.15	1	L	FS
3620000	Rocky Creek	2.70	2	L	FS
3620014	Rocky Pt.	0.50	1	L	FS
3620020	Brenda Spur	0.40	1	L	FS
3630000	Elk Horn	1.50	2	M	FS
3630000	Elk Horn	0.50	1	L	FS
3800000	Mid Fork Nooksack	9.20	3	M	DNR/FS
3800000	Mid Fork Nooksack	2.33	3	M	FS
3800000	Mid Fork Nooksack	1.30	3	M	FS
3800000	Mid Fork Nooksack	1.90	2	L	FS
3800023	Ridley Creek	0.20	3	L	FS
	TOTAL	23.43			

South Fork Nooksack

FS Road 12 is the main access to the South Fork of the Nooksack drainage. There are a few lateral roads that were constructed off of FS Road 12. Table 20 below describes each road in the South Fork system, its Aquatics Risk Level, mileage, Operational Maintenance Level, and ownership or manager.

Road 12 at milepost (MP) 7.0 to MP 9.0 has a high risk assessment. Inadequate construction techniques in the mid 1960s have contributed to slope instability through this area. In 1994 and 1999 an effort to improve drainage items in this section was implemented. The improved work to upgrade the drainage structures brought these items to then current forest standards and practices for those items. However, unstable slopes through this section continue to need attention and improvement.

Table 20 South Fork Nooksack Road System

Road Number	Road Name	Total Miles	Operational Mgt. Level	Aquatic Risk Rating	Owner / Manager
1200000	Loomis Nooksack	1.00	3	H	FS
1200000	Loomis Nooksack	4.95	3	M	FS
1200000	Loomis Nooksack	4.60	3	M	FS
1200013	Big Bull	0.70	1	L	FS
1200015	Picnic Table	0.30	2	M	FS
1200017	Bell Creek	0.30	1	L	FS
1200018	Ding Dong	0.20	1	L	FS
1200020	Trail Head	0.40	2	L	FS
1200021	Bates-Jones Elk	0.50	1	L	FS
1200022	Bell Incline	0.30	1	L	FS
1230000	Blue Lake	1.40	3	M	FS
1240000	Loomis Creek	1.40	2	L	FS
1260000	Sisters Mtn	0.80	3	M	FS
1260000	Sisters Mtn	1.40	2	L	FS
1260000	Sisters Mtn	0.70	1	L	FS
1260011	Miner	0.50	1	L	FS
1270000	Three Lakes	0.60	2	L	FS
1270000	Three Lakes	0.30	2	L	FS
1270013	Camprobber	0.40	1	L	FS
	TOTAL	20.75			

Road 12 from MP 13.63 to MP 17.2 was upgraded in 1999, 2000, and 2002. In this section, the Bell Creek crossing at MP 15.02 needs upgrading. Currently, this section is stable.

Road 1200015 has a moderate risk rating. This road is steep, and the proximity to the South Fork Nooksack is a concern. Another problem is that it has narrow and tight radius turns for horse trailers.

Road 1230 has a moderate risk rating for the 1.4 miles of road that is located within the Nooksack watershed. Current conditions are stable; however there is the possibility of erosion under the right conditions at some embankment locations due to questionable drainage installations and steep cut-banks.

Road 1260 has a moderate risk rating for the first section of 0.8 miles. This section has one minor area of road prism slumping. This road was upgraded to standard in 2000 with the addition of drivable waterbars from MP 0.8 to MP 2.9. Proximity to the South Fork Nooksack is of concern for Road 1260 from MP 0.8 to MP 2. 0 if maintenance is compromised. The remaining 0.9 miles of this road from MP 2.0 has been categorized as low risk.

Roads 1200013, 1200017, 1200018, 1200020, 1200021, 1200022, 1240000, 1270, and 1270013 are low risk roads. These roads have had decommissioning or storage treatments done to them. These roads have been reconstructed and left in a condition to minimize any erosion and therefore to cause little or no effect upon the South Fork Nooksack.

Summary

The Middle Fork and South Fork road systems have one mile in the high risk category, 32.3 miles in the medium risk category, and 21.05 miles in the low risk category.

Road Infrastructure Trends

With declining budgets to maintain roads, it is unlikely that all roads can be maintained to standard.

Communities and Settlements

The historic uses of the analysis area left tangible remains: heritage resources. In the Middle and South Fork Nooksack watersheds, these resources include historic trails, railroad logging remains, structural remains from buildings (e.g. mining cabins), and archaeological remains (e.g. flakes from stone tool use and manufacture). Surveys to identify and locate heritage resources are usually conducted as a requirement of a proposed project, such as timber harvest or trail construction (Section 106 of the National Historic Preservation Act (NHPA)).

Section 110 of the National Historic Preservation Act requires federal agencies to have preservation programs for the identification, evaluation and nomination to the National Register, as well as for the protection of significant heritage resources. The Middle and South Forks Nooksack watershed have not been surveyed systematically for the identification of heritage resources, and several known resources have not been documented and evaluated for significance.

The Park Butte Fire Lookout Cabin is listed on the National Register of Historic Places, and on the National Historic Lookout Register. The Lookout is being cared for (light maintenance) by volunteers associated with the Skagit Alpine Club. Major maintenance is being completed by the Forest Service, as resources are available.

Traditional cultural places and Indian sacred sites may not be identifiable by physical remnants. These are places important in the beliefs and customs of a living community that have passed down through generations. The Nooksack Indian Tribe has identified such locations within the Middle and South Fork Nooksack watershed. Such locations may be eligible for the National Register of Historic Places, or require consideration under E.O. 13007.

Prehistory

Archaeologists have constructed two chronological sequences of land use that may be applied to the northern Puget Sound and Cascade foothills area (Mierendorf et al. 1998; Blukis and Astrida 1987). There is evidence that human presence in these areas may date from 10,000 to 12,000 years before present (B.P.) (Hollenbeck and Carter 1986).

It has been suggested that the earliest period (10,000-12,000 B.P.) was characterized by a relatively uniform cultural adaptation to a post glacial environment, with small, nomadic populations which focused on large game hunting. The archaeological record is limited and evidence of other resources that may have been present has little chance of being preserved.

The period that followed (ca. 4,000-10,000 B.P.) saw a more intensive use of the North Cascades than either earlier or later time periods (Mierendorf et al*.,* 1998). This period is believed to reflect economies based on utilization of a variety of plants and animals including fish, plants and smaller mammals.

Around 4,000 years ago, changes in prehistoric adaptations began to occur. This seems to have been the result of a complex interplay among an increased regional population, changing climatic conditions, and new technology (Miss and Burns, 1989; Miss and Nelson, 1995). Late Holocene adaptations (200-4,000 B.P.) included semi-permanent or permanent village sites with satellite camps and resource use areas that were temporarily occupied for specialized subsistence and ceremonial pursuits. Food preservation and storage permitted the accumulation of surplus food for use during the winter. Most of the archaeological sites found in the interior of the Cascades reflect these more specialized activities.

The prehistoric period draws to a close with the first written accounts by non-Indian explorers of their experiences and observations. Cultural changes, however, began almost a hundred years earlier, when a way of life that evolved over 10,000 years or more was disrupted by the introduction of diseases to which the native populations had no immunities.

In summary, a gradual, progressive model of evolutionary change from generalized mobile foragers to highly organized specialists is proposed. Ethnographically observed patterns are thought to be a result of increasing economic specialization and population fluctuation.

Indian Uses and Treaty Reserved Rights

Current uses of the watershed by Indian tribal members include the exercise of treaty rights and practices of ceremonial and religious significance. Today, Indian spirit power religion is composed of many varying animistic religions, centering on beliefs in guardian spirits and supernaturals (Snyder, 1981). Individuals can undertake a quest to obtain a guardian spirit. Some kinds of spirit powers require the use of the forest and its products. Many of the materials are gathered in a ritualistic manner: wrong timing or setting may have significant adverse consequences to the individual. In addition, some practices require that materials be returned to the forest and hidden, undisturbed. The privacy and purity issues surrounding these practices are of concern to the Indian community.

In 1981, the Mt. Baker-Snoqualmie National Forest completed a study of Indian religious use, sites, localities and resources in the Forest (Blukis Onat and Hollenbeck, 1981). According to the study, members of the Lummi, Nooksack and Samish Tribes use the watersheds, as well as Indian persons that are not identified as members of a federally recognized tribe.

Treaty reserved rights include the rights to hunt and gather on open and unclaimed lands, and to fish at usual and accustomed grounds and stations. The court case United States vs. State of Washington (384 F. Supp. 312 459 F. Supp. 10020, 476 F. Supp. 1101 and 626 F. Supp. 1405) adjudicated usual and accustomed fishing rights for western Washington Tribes. The analysis area is within the lands encompassed by the Lummi and Nooksack Indain Tribes' usual and accustomed fishing places (USDI BIA, 1977).

Data on the extent to which hunting and gathering rights are exercised are not available. A number of species were traditionally important and continue to be important to the tribal communities including deer, elk, bear and mountain goat.

The Nooksack elk herd represents an important resource to local tribal cultures. As noted in the Washington State Elk Herd Plan for the North Cascade (Nooksack) elk herd (WDFW 2002):

The elk has been an intrinsic part of tribal culture for thousands of years. It has helped Northwest Indian people survive throughout the centuries by providing a continual source of meat and marrow for sustenance and vitamins. This animal is used for religious purposes, clothing, and drum making. To this day, the elk can still be found at traditional ceremonies and is essential for maintaining tribal culture. Ceremonial and subsistence needs are met by hunting deer and elk.

Gathering activities are also poorly documented, perhaps more so because harvest information is not compiled for most species. No attempt is made here to list the plant species of importance, as the inventory is quite large, and it is not known which plants are important from the watershed, and which are gathered or used elsewhere. Gathering is a right reserved by tribes from land cessions, but it is important to note that it is, in some cases, a private, ceremonial practice, which cannot be freely discussed. Perhaps the most significant plant resources, at least with respect to quantity, are the abundant huckleberries found on the slopes of Mt. Baker. There are, however, over 40 species of plants found in the analysis area that are used for food, medicine and ceremonial purposes (Nooksack Indian Tribe, 2001).

Information concerning current Indian uses is important in understanding the possible conflicts between potential federal actions and treaty rights, as well as in fulfilling federal responsibilities under the National Historic Preservation Act, the National Environmental Policy Act, and the American Indian Religious Freedom Act. Currently, information is gathered on a project-by-project basis through NEPA scoping and Government-to-Government consultation with Tribes potentially affected by the project proposal. Depending on the scope of the project, consultation for a project in the analysis area may include all of the Point Elliott Treaty tribes based on the potential for hunting and resource gathering to be affected.

Economy/Economic Environment

The Puget Sound area economy has become relatively diversified. Major manufacturing sectors include aerospace (primarily Boeing), defense, and timber industries. The agriculture, forestry and fisheries sector is another major employer in the region. The Puget Sound area has experienced rapid growth in its high technology sector, led by the Microsoft Company. Increases in employment in the trade, services, and finance/insurance/real estate sectors are indicators of the maturation of the regional economy into a Northwest and international commercial center. Recreation and tourism are also major contributors to the Puget Sound economy.

The Puget Sound economy of the next 10-20 years is expected to continue its maturation and diversification process. Strong growth is expected in the retail and service sectors and slower growth in the goods producing sectors. Recreation and tourism in the service sector is likely to remain relatively strong through 2020. The high quality living environment of the Puget Sound region will continue to attract business and industry (and their employees).

Greater Whatcom County's traditional economy has been based on agriculture, commercial fishing, logging, and mining. Logging and agriculture were the employment mainstays. The county's current economy is based on agriculture/food processing, fishing/fish processing, timber/wood processing, manufacturing, retail trade, and tourism. Approximately 64% of Whatcom County is managed by either the USDA Forest Service or USDI Park Service. Federal management of these lands has direct impacts upon the local economies.

Mining, logging, and recreation were the primary economic benefits of the upper Middle and South Forks of the Nooksack River. Mining for olivine continues and is likely to continue into the foreseeable future. Timber production from this small area in the Middle Fork and South Fork watershed has been reduced. Recreational use is likely stable or increasing as the Puget Sound population increases.

Recreation

Recreation Participation Demographics

Results from the National Survey on Recreation in the United States show that 94.5 percent of Americans participated in at least one of the surveyed forms of outdoor recreation in 1994-95. That percentage translates into 189 million participants nationwide.

Since 1982-83, the population of the nation has increased by 13.4 percent and the proportion of people participating in at least one activity has risen from 89 to 94.5 percent. As a result, numbers of participants have increased for almost all activities. The fastest growing recreation activities included bird watching (155%), hiking (94%), backpacking (73%) and primitive area camping

(58%). These activities grew at a much faster rate then the population growth during this period. Activities that showed a decline included hunting (-12%), horseback riding (-10%), and fishing (-4%) (Table 21).

In addition, the survey recognized new activities because of their growing popularity. These activities included orienteering (finding your way by map and compass cross-country), mountain climbing, rock climbing, and specific kinds of nature viewing.

Participation is growing for people of all ages. Participation in activities requiring vigorous exercise is considerably higher for young and middle-aged people than for those over 60, although people over 60 are also participants. Many older people have more time to recreate because they are retired and are interested in maintaining physical fitness.

For most activities, participation is low for people with family incomes below $25,000 per year. Interestingly, it often is also low for people with incomes above $100,000. Participation is highest for people with family incomes between $25,000 and $75,000 per year.

For many across all groups, camping is a traditional family activity, and participation increases as family size increases.

Table 21 Recreation Participation in the Pacific Region and Change in United States Recreation, 1982 to 1994 (USDA Forest Service, 1997a)

Recreation Activity	Percent Of Participants 16 Yrs. And Older In Pacific Region	Number Of Participants 16 Yrs. And Older (Millions) In Pacific Region	Percent Change In Recreation Participation From 1982-1994 Nationwide
Walking	67%	21	+43%
Sightseeing	59%	19	+40%
Picnicking	50%	16	+16%
Hiking	35%	11	+94%
Bird Watching	24%	7	+155%
Fishing	24%	8	-4%
Primitive Area Camping	18%	6	+58%
Backpacking	12%	4	+73%
Horseback Riding	8%	3	-10%
Hunting	6%	2	-12%
Cross-Country Skiing	4%	1	+23%
Snowmobiling	2%	1	+34%

Recreation surveys from a variety of sources which include Washington State were summarized in Hall (2005) and indicate that activities within including wildlife viewing, ORV riding and sightseeing will continue to increase in the foreseeable future. Further, participation in snowmobiling, primitive camping and rock climbing use will remain fairly stable and hunting and backpacking may be declining. However, participation in freshwater fishing, mountain biking, day hiking, horseback riding, picnicking, and driving for pleasure may fluctuate or surveys indicate no clear direction in future use.

Recreation use on the Mt. Baker- Snoqualmie National Forest (MBS) for calendar year 2000 was 5,006,932 National Forest visits +/-14.9 percent. A National Forest visit is the entry of one person upon a National Forest to participate in a recreation activity for an unspecified period of time. A National Forest visit can be composed of multiple site visits. A site visit is the entry of one person onto a National Forest site or area to participate in recreation activities for an unspecified period of time. There were 5,379,362 site visits, an average of 1.1 site visits per National Forest visit. Included in the site visit estimate are 700,814 wilderness visits. The MBS has the highest number of forest visits and some of the highest trailed and wilderness recreation use in the region. MBS users report a high satisfaction with recreation facilities and opportunities compared with other Forest's within Region 6 and also compared with other Forests at the national level.

Recreational Road Use

For road 12, historical traffic count information indicated that in 1993 an average of 90 cars per day were recorded (83 of which were for recreation), for an average monthly recreation traffic of 2,504 visitors, and average annual recreation traffic of 22,135 visitors. Similar road use figures were recorded for Road 38 from 1988 to 1993: with a high of 19,740 recreation visitors and a low of 6,332 recreation visitors estimated from vehicle counts. In 2001 and 2002, Puget Sound Energy as part of the Baker River Reliscensing Project, sampled vehicle traffic north and south of the Road 12 junction on Road 11 (Baker Lake Highway). Study results indicate that approximately 15% or 43 recreational vehicles per day on average, and 150 vehicles per day on peak periods (104 visitors per day on average and 304 visitors per day on peak days) of the traffic on the Baker Lake Highway turns off onto the Road 12 road system which eventually accesses the South Fork Nooksack Watershed but also accesses the Mt Baker National Recreation Area which is the likely destination for the majority of the visitors (Huckell/Weinman Associates 2003).

Recreation Opportunity Spectrum

The Recreation Opportunity Spectrum (ROS) provides a framework for defining the types of outdoor recreation opportunities that the public desires, and it identifies that portion of the spectrum that an area of the Forest can provide. The ROS classes are combinations of physical, social and managerial attributes representing a range of activities and visitor experiences in a variety of physical settings. The ROS classifications serve as a component of recreation planning in the analysis area.

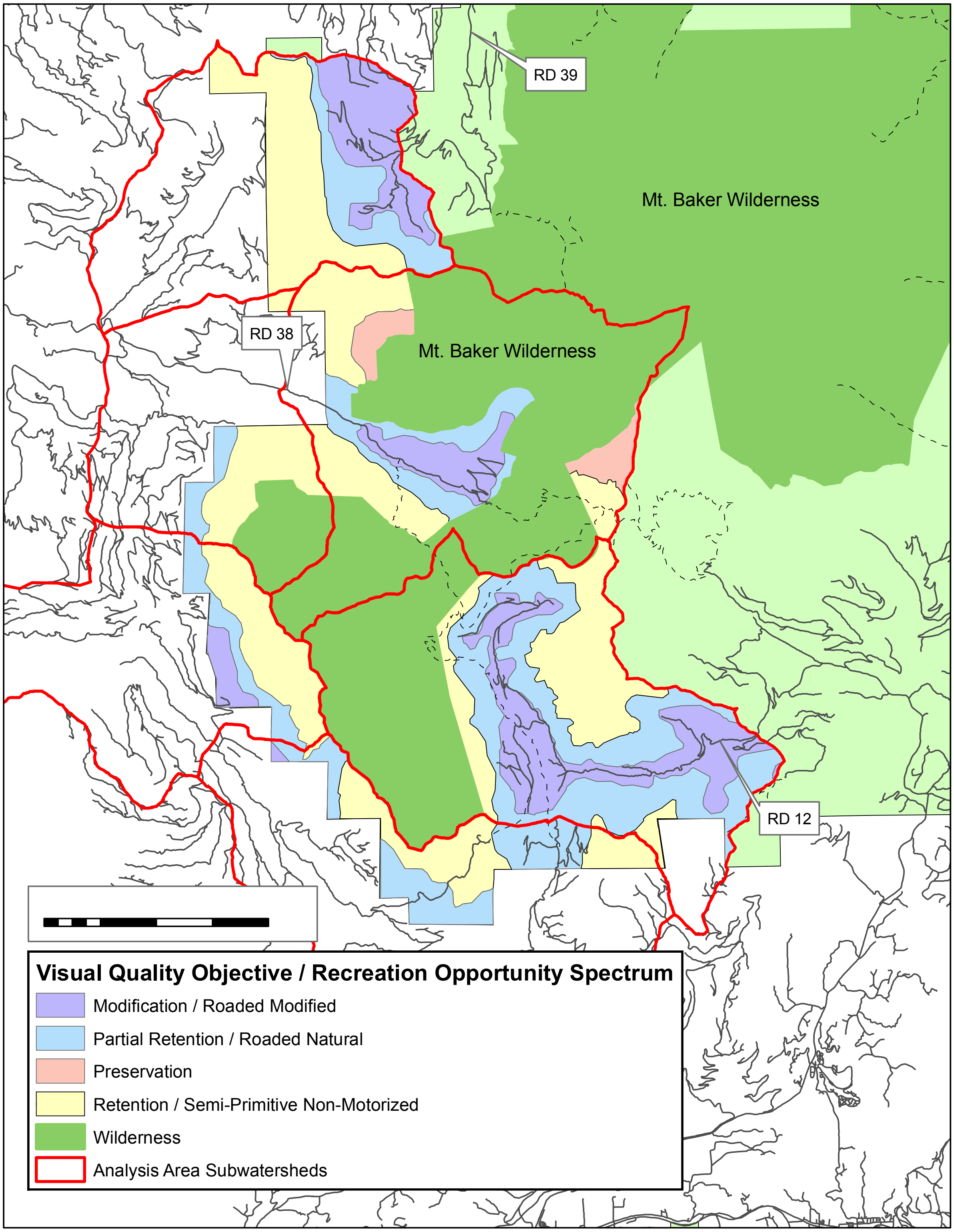
Recreation Opportunity Spectrum Classes within the Analysis Area:

1. Primitive – Area is characterized by essentially unmodified natural environment of fairly large size. Interaction between users is relatively low and evidence of other users is minimal. The area is essentially free from evidence of human-induced restrictions and controls. Motorized use is not permitted.
2. Semi-primitive Non-motorized – Area is characterized by predominantly natural or naturally appearing environment of moderate to large size. Interaction between users is low, but there is often evidence of other users. Management would subtly employ the use of minimal onsite controls and restrictions. Motorized recreation use is not permitted.
3. Roaded Modified – Area is similar to Roaded Natural but activities take place on less frequently used roads where there is an opportunity to get away from others. The environment can be substantially modified except for campsites. Moderate evidence of others on roads but little evidence of others or interaction at campsites. Facilities are not provided. Conventional motorized use is allowed.
4. Roaded Natural – Area is characterized by predominantly natural-appearing environment with moderate evidence of the sights and sounds of man. Such evidence usually harmonizes with the natural environment. Interaction between users may be moderate to high, with evidence of other users prevalent. Resource modification and utilization practices are evident, but harmonize with the natural environment. Conventional motorized use is allowed and incorporated into construction standards and design facilities.

The analysis area provides a range of recreational opportunities at the less developed end of the recreation spectrum including dispersed camps in wilderness and roaded areas and developed trailheads and trails. The analysis area lacks the developed campgrounds or larger trailhead developments of other adjacent watersheds. As budgets limit the amount of road that can be maintained, the future could bring less area accessed by roads and more land area which becomes essentially roaded natural ROS.

The acres of each ROS class are displayed in Table 22. The Roaded Natural class dominates, and includes the area accessed by the primary road system. Roaded Modified areas are found encompassing the primary roads into the analysis area including Road 38 the Glacier Creek road system from the North Fork Nooksack area, Road 38 the Middle Fork road system from the Middle Fork Nooksack Area, and Road 12 the Loomis Nooksack Road system from the South Fork Nooksack area and Baker Lake. Semi-Primitive Non-Motorized and Primitive areas are those areas of the analysis area that are primarily unroaded and often adjacent to, but outside of,

Figure 20 Visual Quality Objectives and Recreational Opportunity Spectrums



wilderness. Wilderness areas are not included in the ROS classifications, nor are water bodies. Refer to Figure 20 for the location of the ROS classes on NFS Lands within the analysis area.

Table 22 Acres within Recreation Opportunity Spectrum Classes

Recreation Opportunity Spectrum Class:	Roaded Natural	Roaded Modified	Semi-Primitive Non-Motorized	Primitive
Watershed Acres	67,821	11,914	22,427	3,238

Aesthetics and Scenery Management

Visual resources throughout the Forest have been inventoried, and the management direction is reflected in terms of Visual Quality Objectives (VQOs). The VQOs represent a composite rating of the visual variety of the landscape, combined with a sensitivity level rating that reflects the number and relative concern of viewers for the scenic quality of the landscape.

The following is the description for the VQO's found within the Analysis Area (USFS 1974):

1. Preservation (P): Allow ecological changes only.
2. Retention (R): This VQO provides for management activities that are not visually evident. Under Retention, activities may only repeat form, line, color, and texture that are frequently found in the characteristic landscape. Changes in their qualities of size, amount, intensity, direction, pattern, etc. should not be evident.
3. Partial Retention (PR): Management activities remain visually subordinate to the characteristic landscape when managed according to the Partial Retention VOQ. Activities may repeat form, line, color, or texture common to the characteristic landscape, but changes in their qualities of size, amount, intensity, direction, pattern, etc. remain visually subordinate to the characteristic landscape. Activities may also introduce form, line, color, or texture which are found infrequently or not at all in the characteristic landscape, but they should remain visually subordinate to the visual strength of the characteristic landscape.
4. Modification (M): Activities may visually dominate the original characteristic landscape. However, activities of vegetative and land form alternation must borrow from naturally established form, line, color, or texture so completely and at such a scale that its visual characteristics are those of natural occurrences.

There are three levels of visual sensitivity – Level 1 (VSL 1) represents the highest viewer sensitivity, Level 2 (VSL 2) represents average viewer sensitivity, and Level 3 (VSL 3) represents the lowest viewer sensitivity. Travel routes within the watershed are primarily roads to secondary trailheads are classified as Visual Sensitivity Level 2 including FR 12 and FR 38. Trails are given similar visual sensitivity classifications based on level of use. The Elbow Lake Trail-South Fork Nooksack section (Trail 697), Bell Pass Trail (Trail 603.3) and Blue Lake/Dock Butte (Trail 604) are classified Visual Sensitivity Level 1, Elbow Lake Trail-Middle Fork Nooksack section (Trail 697), Elbow Lake Trail-Pioneer Camp section (Trail 697), Ridley Creek Trail (Trail 696) and South Fork Nooksack trails are classified as Visual Sensitivity Level 2. All other roads and trails are classified Visual Sensitivity Level 3.

Landscape variety and sensitivity levels are combined with distance zones to help develop the (VQOs). Distance zones identify the distance from which viewers typically experience the landscape: foreground = 0 to ¼ mile from the viewer, middleground = ¼ mile to 5 miles, and background = greater than 5 miles.

NFS lands within roaded and harvested areas have been designated with a VQO of Modification (M). Areas outside major roaded corridors but are still affected by roads, were classified as Partial Retention and areas furthers from roads and adjacent to wilderness areas were classified as Retention (R) or Preservation (P). Along primary trail corridors (VSL 1), proposed projects on NFS lands need to meet a Forest Plan Standard and Guide VQO of Retention in the foreground and Partial Retention in the middleground. Along secondary road corridors and trails (VSL 2), proposed projects are required to meet a VQO of Partial Retention in the foreground and middleground.

As shown in Table 23 and Figure 20, NFS lands within the watershed area have been assigned four VQOs: Preservation, Retention, Partial Retention, or Modification.

Table 23 Acres within Visual Quality Objective Classes

Visual Quality Objective	Preservation	Retention	Partial Retention	Modification	(Other, Wilderness)
Watershed Acres	3,238	22,427	67,821	11,914	1119,129

Existing Visual Condition (EVC) for the Middle Fork Nooksack River (Road 38) and the Loomis Mountain (FR 12) viewsheds is Heavily Altered and Glacier Creek viewshed is Slightly Altered. Under the Forest Plan all viewsheds were to become Moderately Altered if visual management direction where applied. Under the current Forest Plan objectives for the maintenance of LSR and Riparian Reserves conditions, past harvest units will likely continue to grow and blend with the surrounding stands without the addition intrusion of new clear cut harvest units. The application of timber management techniques such as thinnings to encourage the development of old growth stand conditions would likely further improve the EVC. The regrowth of previously harvested stands reflects a positive change in visual quality compared to the current condition and the lack of additional clear cut timber harvest units could allow the viewshed to attain a EVC of Slightly Altered over time.

Scenic views could also be affected by the lack of stand treatments. Panoramic views of Twin Sisters Mountain are limited to the end of Road 12 and the Pioneer Camp trail head at the end of Road 1200.015. These views were created by forest management and will be obscured by forest growth within the next decade unless access is maintained and the vegetation is managed to retain the views. Management actions to benefit visual condition and aesthetics are desirable.

Wilderness Resources

The Mount Baker Wilderness is a congressionally designated wilderness area and comprises 21 percent of the Middle Fork and South Fork Nooksack River analysis area. The Mount Baker-Snoqualmie Land and Resource Management Plan (LRMP) allocates most of the Mount Baker Wilderness to management area 10C, or general trail-less wilderness. However, transition areas (management area 10A) occur within 500 feet of the Elbow Lake, Ridley Creek and the Bell Pass trails. Both transition and trailed wilderness allocations allow for higher levels of human use and resource impacts. The Twin Sisters Range is well known to climbers for its quality rock climbing; however there are no Forest Service system trails to the climbing area. Primary access is cross-country from private land holdings to the west of the range.

Transition Wilderness

Current use of transition wilderness areas is well below the LRMP standard for human use (an average of eight or fewer parties encountered/day). Estimates of use, indicate Elbow Lake and Bell Pass Trails have an average of 1.7 parties/day combined. Ridley Creek Trail is in poor condition and averages less than 1 party per week. Current conditions are within the Forest Plan's (as amended) standard for resource damage (Vegetative loss at campsites shall not exceed 1,000 square feet, trees felled or with scarring shall not exceed 10 trees, or 50% of trees on site) with a few exceptions. At Elbow Lake 25 percent of the sites exceed 1,000 square feet of vegetative loss and 50 percent of the sites exceed ten trees felled or scarred. To date, no management action has occurred to address this non-compliance with the LRMP. Wilderness rangers patrol the area an average 0-1 times per season.

The Elbow Lake and Bell Pass Trails provide access into the Mt. Baker Wilderness for a multitude of users including hikers and equestrians. Use season is generally from mid-May to October for hikers and August 1 to October 31 for stock. The majority of visitors are from the Puget Sound area with a smaller number from other states or nearby communities. The following table displays the average number of users per year by trailhead. This information comes from the trailhead registration sheets and field observations, adjusted for an estimated 61 percent based on a compliance rate found at five trails in the Baker Lake Basin in 1993 as documented in the Baker Lake Basin Visitor Use Estimate Sample Plan.

Table 24 Wilderness Trail Use Averages

Trailhead	Number of Users Per Year	Average # Parties Per
Elbow Lake Trail	438	1.5
Bell Pass Trail	40	0.2
Ridley Creek Trail	20	<1

Primary wilderness use was at the Elbow Lake Trail. Use begins in spring and steadily increases, as upper elevations become snow free.

Trail users on these trails utilize a few remote campsites primarily located at Elbow Lake. Group size within the Mt. Baker Wilderness is limited to 12 “beating hearts”— which includes stock animals.

Trails

The Ridley Creek Trail (Trail 696) is all that remains of the historical Deming Trail, circa 1890s. The Deming Trail was a historical pack and saddle trail used by early climbers to access the western slopes of Mt. Baker and terminated at a cabin located in Mazama Park. The trail was also one of several routes that were used in the infamous Mt. Baker Marathons in the early 1900s. Although some of the trail on state and private land was lost to a railroad grade for logging that area between 1900 – 1930, most of the original Deming Trail has been lost to road construction and logging operations that occurred since the end of World War II. The remaining miles of the Deming Trail were renamed the Ridley Creek Trail, after Joe Ridley, a turn-of-the-century Forest Ranger and Mt. Baker Marathon racer.

The Elbow Lake (Trail 697) and Bell Pass (Trail 603.3) trails were built in the 1920s and 1930s. Trail crews first built the trails primarily for access to the backcountry for the purpose of administration and firefighting. Trail construction allowed for stock access and the ability to transport crews and supplies for fire suppression as well as materials and tools needed to construct lookouts.

Timber sales and road construction obliterated a large portion of the Middle Fork and South Fork Nooksack drainage trail system. Road 38 is built on what was once a portion of the Deming Trail (now the Ridley and Elbow Trails), and Road 12 removed a portion of the Bell Pass, Elbow Lake,.and Nooksack Flat trails in the South Fork Drainage. Road 1230 significantly shortened the trail to Blue Lake. The history of the Three Lakes Trail is unknown but it receives very little use.

Figure 21 Photo #1 Erosion on Ridley Creek Trail (.25 MP)

The Elbow Lake Trail from the Middle Fork and South Fork Nooksack drainages was reconstructed in the early 1990s for a combined cost of approximately $200,000. A new pack and saddle bridge over Bell Creek on the Elbow Lake Trail was constructed in 2003 for $45,000. The Bell Pass Trail has had various reconstruction efforts over the past five years for approximately $15,000. The Ridley Creek Trail was scheduled for reconstruction in the late 1990s but was postponed.

Flooding in October 2003 destroyed the Elbow Lake Trail's pack and saddle bridge over Middle Fork Nooksack, reducing access from the west side to Elbow Lake, and removed a natural log crossing accessing the Ridley Creek Trail. The estimated cost for replacing the Middle Fork Nooksack Bridge for the Elbow Lake Trail is $300,000 to $400,000, and the estimated cost of placing a bridge to access the Ridley Creek Trail is $200,00 to $300,000 or more. For the Elbow Lake Trail, a 300-foot suspension bridge would be required to span the channel. No evaluation of bridge size for the Ridley Trail has been done. Construction of either bridge is cost prohibitive at this time. Both Elbow Lake and Ridley Creek trails require fording the glacier-fed Middle Fork Nooksack River, which is hazardous during glacier snow melt and maritime storm cycles. Future trail use on these trails is expected to decline because of the loss of the bridge and natural log crossing.

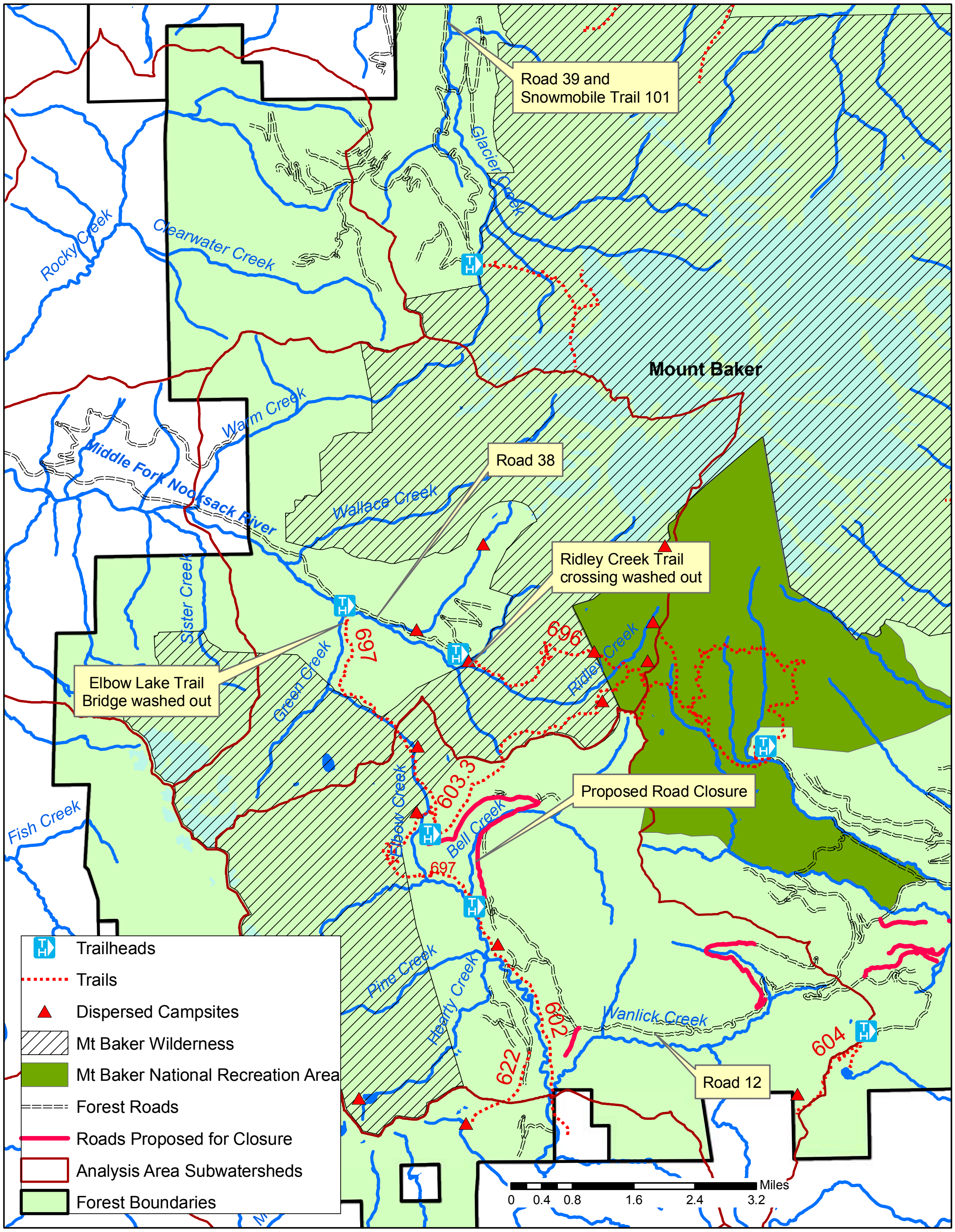
This portion of the trail system receives annual to bi-annual maintenance with larger reconstruction projects completed as funding is found. Funds for both maintenance and reconstruction come from a variety of sources including Federal and State Grants, the Forest Service Trails Capital Investment Program, Northwest Forest Pass Program, and private donations. Work is completed by contractors, youth work programs, Forest Service crews, and various volunteers groups.

Table 25 Trail Designations

Tr	Trail Name	Primary Objective	Difficulty Level	Use Level	Area	Miles	Maintained to Standard?
604	Blue Lake/Dock Butte	Hiker	Easy to More Difficult	Heavy	Non-wilderness	2.2	Blue Lake:Yes/ Dock Butte: No
697	Elbow Lake Trail – South Fork Nooksack	Pack and Saddle	More Difficult	Medium	Wilderness and Non-wilderness	3	Yes
697	Elbow Lake Trail – Middle Fork Nooksack	Pack and Saddle	More Difficult	Medium	Wilderness and Non-wilderness	3	No
603.3	Bell Pass Trail	Pack and Saddle	More Difficult	Low	Wilderness and Non-wilderness	6	Yes
602	Nooksack Flat	Hiker	More Difficult	Low	Non-wilderness	7	No
622	Three Lakes	Hiker	More Difficult	Low	Non-wilderness	3	No
696	Ridley Creek	Pack and Saddle	More Difficult	Low	Wilderness	6	No
101	Glacier Creek Snowmobile Trails	Snowmobiles	More Difficult	Medium	Non-wilderness	6	Yes

Use Levels:
Extra Heavy Use = 5000 plus users per year.
Heavy Use = 2501 – 5000 users per year.
Medium Use = 501 – 2500 users per year.
Low Use = 0 – 500 users per year

Figure 22 Recreation – trailheads, dispersed sites, trails



Dispersed Recreation

Recreational use in the analysis area includes lake fishing, hunting, berry picking, mushrooming, cross-country skiing, scenic driving, camping, hiking, climbing, backpacking, horseback riding and snowmobiling. Data collected for the INFRA inventory indicate there are approximately 31 dispersed camp sites at 13 locations and 54 climber camps within the analysis area (see Figure 22 and Table 26 Dispersed Campsites). Dispersed campers use spur roads and old skid trails for dispersed camping sites along the South Fork Nooksack River, designated campsites within the Mt. Baker National Recreation Area, and various trail end lakes and view points within the analysis area. Climbers have traditionally used two areas on Mt Baker (Climber and Sandy Camps) for overnight and base camps for climbing and climbing instruction.

Estimated use of general dispersed recreation opportunities is relatively low compared to the use that the Mt. Baker National Recreation Area receives. Both the South Fork and Middle Fork Nooksack drainages have Forest Service patrols to a much lesser extent than other high use areas on the District, limiting user data collection.

The portion of the road system in the analysis area accessed by the Glacier Creek Road (Road 39) is included within the Washington State SnoPark Program. These roads provide groomed snowmobile trails and receive moderate use. Funds for grooming are provided through a grant from Washington State Winter Recreation Commission.

Table 26 Dispersed Campsites

Campsite Location	# of Campsites	Amenities	Area
High Camp	7	Tent Pads, Box toilet	NRA
Climber & Sandy Camps	54 approx.	Box toilet	NRA
Cathedral Camp	4	Tent Pads, Box toilet	NRA
Mazama	1	Shelter	NRA
Park Butte Lookout	1	Box toilet	Wilderness
RD 3800.023	2		Non-wilderness
Ridley Cr Trailhead	1		Non-wilderness
Ridley Shelter	1	Shelter	Wilderness
Elbow Lake	3	Mt Toilet	Wilderness
Elbow Lake Trail	1		Non-wilderness
Road 1260	3		Non-wilderness
Heart Lake	3	Mt Toilet	Wilderness
Three Lakes	3		Non-wilderness
Dock Butte	1		Non-wilderness

Developed Recreation

Within the analysis area there are five developed trailheads: Elbow Lake (Rd 38 and Rd 12), Ridley Creek, Pioneer Camp, and Dock Butte/ Blue Lake Trailheads. Typical features at these trailheads include gravel parking areas, bulletin boards, and trailhead registers. At Pioneer camp there is additional parking for horse trailers. As of 2005, the Blue Lake/ Dock Butte and NRA trailhead which serve the Bell Pass Trail are in the Northwest Forest Pass Program under the "Federal Lands Recreation Enhancement Act". With this program, funding is available for trail and trailhead maintenance and patrol. Trailheads not within this program receive occasional maintenance and patrol. As a result of less frequent patrols, vandalism of signs and the limited facilities is often a problem and repairs are slow to be made. The Park Butte Lookout is an historic structure on the eastern edge of the analysis area. The lookout is maintained by volunteers and receives the occasional overnight visitor. There are no other developed recreation sites (campgrounds, picnic areas, etc.) within the analysis area.

Outfitter and Guides

There is one land-based outfitter and guide who operates in the Middle Fork and South Fork drainages within the Mt. Baker Wilderness. National Outdoor Leadership School (mountaineering course) operates 70 days per year.

Since 1999, the Mt. Baker-Snoqualmie National Forest has implemented a moratorium on permitting further commercial use until an outfitter guide and resource needs analysis is conducted. That is not to say that this moratorium has prevented other non-permitted companies and individuals from guiding. Decreased wilderness patrols have made it difficult to monitor illegal guiding activity.

Recreation Trends

There will be continuing pressure to provide a range of recreation opportunities within the analysis area due to the increasing number of participants and increasing demand for the recreational pursuits that are found within the analysis area, including primitive (dispersed) camping, hiking and backpacking, sightseeing and driving for pleasure, and wildlife viewing including bird watching. There may be somewhat decreased pressure to provide some recreational activities if recreation users follow regional trends in horseback riding, hunting, and fishing. Demand will likely remain high for winter sports including cross-country skiing and snowmobiling, primarily in the NRA.

Wilderness use will continue to present challenges to protect resources while providing for increased demand due to decreasing funds for wilderness management. There will be a continued need for use of helicopter for trail repairs, search and rescues, and fire.

The Forest trail budget continues to decline while other revenue sources for trail maintenance and reconstruction, such as the Northwest Forest Pass, state, federal, and private grants, seem to be increasing. The existing level of trail maintenance is expected to continue. The current trail system is not adequate to meet future recreational needs.

Damage from the October 2003 floods will require expensive bridge replacements and trail reconstruction. The Elbow Lake Trail from Road 38 will be difficult to cross during summer glacial melt due to high water and strong currents.

Funding is expected to be inadequate for proper maintenance and monitoring of trail use and dispersed recreation.