PREFACE TO CHAPTERS 3 AND 4

Chapter 3 provides an overview of resources found within the Upper McKenzie Watershed. Chapter 4 provides additional, more detailed analysis on some of the resources, and the information is presented by Landform Block. The Landform Blocks were created to aid in presenting and integrating data within specific areas. Stratification considered geological processes as well as vegetation patterns, fire behavior, valley segment types, and fish and wildlife habitat. Chapter 3 uses the Landform Blocks as a basis for comparison of resources within the watershed.

CHAPTER 3

PAST & CURRENT CONDITIONS AND RANGE OF HISTORIC VARIABILITY

OVERVIEW OF GEOLOGICAL RESOURCES

Introduction

The Cascade Range is a north-south trending line of volcanoes associated with the Cascadia subduction zone off the Oregon coast. As the Pacific plate is pushed under the North American plate in this zone, melting of the rock occurs with increased depth. The molten rock is then forced to the surface as volcanic eruptions, which is the mountain-building process of the Cascades.

The Upper McKenzie Watershed is located in the Cascades where two physiographic provinces meet: older Western Cascades (9 - 40 million years old) and younger High Cascades (9 million years old to the present). The stratigraphic and time sequence proposed by Priest, Woller, and Black (Priest and Vogt 1983) is used in this analysis, except that the early High Cascade ridge-capping basalts (9-4 million years B.P.) including Avarmenko's (1981) Browder-Bunchgrass and Iron Mountain units, and Flaherty's (1981) Frissel-Ollallie units are included as part of the Western Cascade province for simplification. Figure 3-1 displays geological areas of interest and the Landform Block stratification referred to throughout Chapters 3 and 4.

WESTERN CASCADES

The Western Cascades represent the oldest rocks found on the Forest. They are generally found west of the McKenzie and Smith Rivers and north of Belknap Springs. The Western Cascades were derived from episodic volcanic vent and fissure eruptions between 9 and 40 million years ago (late Eocene to early

Figure 3-1. Major Geological Features and Landform Blocks 1-6

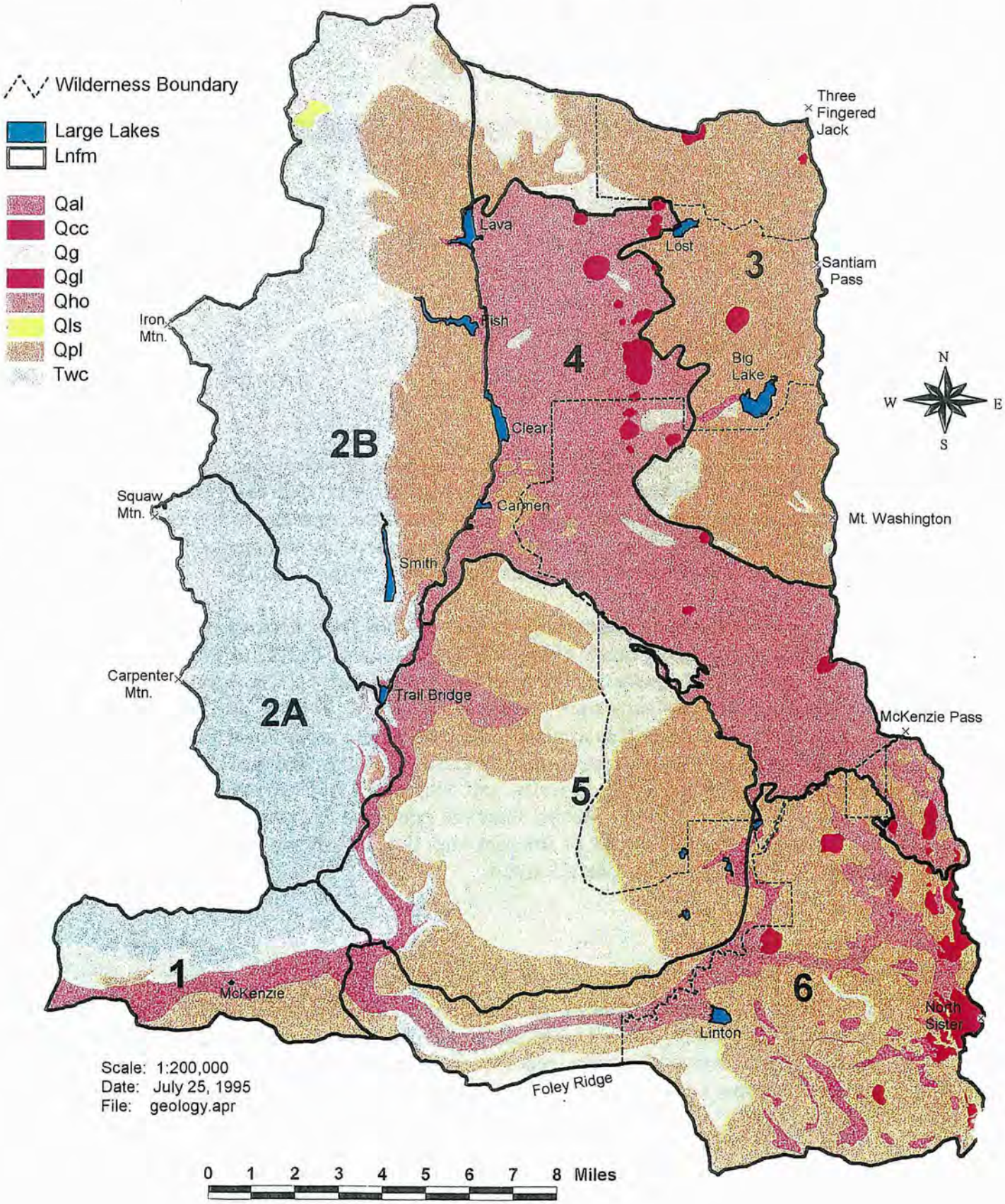


Figure 3-1. Major Geological Features and Landform Blocks 1-6

Block 1 - McKenzie Bridge Glacial Valley
Block 2a - Deer Creek Cirque-Ridge
Block 2b - Western-High Cascade Transition Zone
Block 3 - Early High Cascade Platform
Block 4 - Recent High Cascades Lava
Block 5 - Scott Mtn. Glacial Plateau & Valleys
Block 6 - Lost Creek Glacial Trough

Wilderness Boundary

Large Lakes

Landform Blocks 1-6

Qal...Alluvial Deposits
Qcc...Volcanic Cinder Cones & Composite Volcanoes
Qg....Glacial Deposits
Qgl ...Active Glacier
Qho...Recent High Cascade Lava <12,000 Yrs. Old
Qls...Ancient Landslide Deposits
Qpl...Late High Cascade Lavas Plio/Pleistocene 12,000-4 Million Yrs. Old
Twc...Western Cascades & Early High Cascade Ridge Capping Basalts 4-40 Million Yrs. Old

Pliocene). These eruptions consisted predominantly of basalt, however rhyodacite and welded tuffs are abundant as well as some minor intrusions of diorite and scattered andisitic lava flows. This accumulation of volcanic material reached a thickness of over 5,000 feet, yet did not result in enough relief to produce the orographic effect on the prevailing westerly winds of windward rainfall and leeward desert until the Pliocene (Priest and Vogt 1983).

Uplift and Incision

In the mid to early Pliocene [3 to 5 million years before present (my bp)] regional uplift began taking place at a rate of approximately 20 centimeters per 1,000 years, which produced an increase in elevation of approximately 400 meters (Sherrod 1986). This increase in elevation was associated with an increase in stream gradient, some of which was more than twice its norm. The increased stream gradients produced deeply dissected valleys, increased relief, and produced drainage patterns now present in the western portion of the watershed. Pleistocene glacial floods and lower mean sea levels resulted in additional valley scouring. However, subsequent outwash, still water, and landslide deposition to depths of over 100 feet refilled the valleys to a base stream level that matches the existing sea level. Valley fills have been drilled to 146 ft in the Blue River area, 175 feet in the McKenzie Bridge area (Williamson 1961), and over 280 feet below the bottom of the Columbia river at the Bonneville Dam east of Portland (U.S. Army Corps of Engineers 1984). Areas within the Western Cascades contain the majority of past and present landslide activity due to the age of the rocks and their composition, hydrothermal alteration, previous uplift and faulting, and valley incision. These all produce a net decrease in resisting forces and material shear strength.

Northwest Trend Faulting and the High Cascade Graben

During the last 8 to 10 and 4 to 5 my B.P., major northwest-trending fault systems developed, especially near the present boundary of the Western and High Cascade physiographic provinces. This fault system controls the north-south direction of flow of many of the upper reaches of Cascade rivers including the McKenzie, S. Fork of the McKenzie, Smith, N. Santiam, Horse Creek, N. Fork of the Willamette, and the Metolius Rivers. The earlier faulting events between 8 and 10 my B.P. occurred along the axis of the S. Fork of the McKenzie River (Cougar reservoir). Later events (4 to 5 my B.P.) occurred along the present Horse Creek, McKenzie, and Smith River alignments on the west-side of the Cascades; and the Metolius River (Green Ridge) on the east-side. The latter event is thought to have produced at least 3,000 feet of vertical offset as a block of the central Cascades dropped between the McKenzie River and the Metolius River as a result of an extension of the Earth's crust (Priest et.al 1983).

HIGH CASCADES

Early High Cascade Shield Volcanoes

The earlier major faulting event was accompanied by tremendous eruptions of basalt and basaltic andesite from the now-forming High Cascade shield volcanoes. Over the following 2 million years, this event filled the down-thrown block, now referred to as the High Cascade Graben. [Note: the word "graben" is from German referring to the depression made in a grave-site as a wooden coffin collapses due to the weight of the overlying soil] Due to its own weight, it is believed that the High Cascades have subsided and now dip approximately 5 degrees to the east.

Evidence for this now-filled "graben" is mostly indirect and not without differences of opinion among scientists as to its existence. However, gravimetric anomalies (differences in rock densities), river and hot spring alignment, north-south alignment of the major volcanic peaks, and a number of exposed fault scarps on the west and east side of the crest suggest that this model is plausible. One of the most important features of this model is the highly fluid lavas that eventually breached the western fault scarp and filled the ancient McKenzie valley. Those flows are now recognized as Foley Ridge. The Ridge's inverted topography is common to "intracanyon" flows, where surrounding rocks are eroded away, leaving the lava flows perched above the valley floor (Flaherty 1981).

Late High Cascade Composite Volcanoes

Between 2 million and about 12,000 years ago, the High Cascade composite volcanoes were actively building on the shield volcano platform. Volcanic peaks of the Three Sisters, Mt. Washington, and Three Fingered Jack fill the present horizon in the area. Basalt flows reached as far west as Smith River.

At least three periods of major alpine glacial advance and retreat interacted with this volcanic activity to scour the valleys and peaks leaving deposits of till and glacial outwash. One of the early Oregon Geologists, Edwin T. Hodge (1925) theorized the Three Sisters were a remnant of a single ancient volcano that reached over 20,000 feet high, which he named Mt. Multnomah. Hodge's theory stood for many years until the science of geochemistry and igneous petrology were developed. It was then determined that each volcano was significantly different in chemistry and origin.

Recent High Cascade Volcanic Eruptions

After the ice recession of the last major glacial episode (around 12,000 years ago), eruptions from smaller composite volcanoes and cinder cones produced more recent lava flows down the ancient valley of the McKenzie River and Lost Creek which dammed the rivers and formed lakes and waterfalls. Lava flows from the

Sand Mountain and Lost Lake chain of cinder cones, Belknap Crater, Simms Butte, Collier Cone and Scott Mtn. now cover over 50% of the Late High Cascade platform topography.

Areas that lie within the High Cascades are less prone to slope instability due to the more resistant younger rocks, relatively little faulting, and lower valley incision rates. The exception is in areas such as Lost Creek, where recent volcanic flows have been deposited over former valley side slopes and glacial deposits. Here, differential weathering takes place as the less resistant material erodes at a faster rate below the young flows. Overhangs then develop which eventually fail as debris avalanches.

Alpine Glacial Processes

During the Pleistocene (1.6 my bp to 12,000 yrs bp) at least three major changes of climate (perhaps more than a dozen) produced a High Cascade ice field that completely covered all but the highest of the Cascade volcanoes (Birchfield et.al. 1981). The ice sheet eventually moved down the valleys on both sides of the Cascades. In the Mckenzie valley it moved as far as the community of Blue River (Scott 1977, VanDusen 1962). These advances were followed by retreats of the ice. The cycles may have taken as long as 100,000 years each. Many theories have been advanced as to a general reason for major changes in the Earth's climate, but the one most often held now is a periodicity in the Earth's orbit that takes it further from the sun on about a 100,000 year cycle (Shackelton and Opdyke 1973).

Much of the volcanic hazard during the eruption of a composite volcano is the rapid ice melt from the side slope glaciers. The Three Sisters now contain approximately 5.6 billion cubic feet of ice in 5 major glaciers covering 3.2 square miles. However, two of the largest glaciers remaining in the High Cascades (Jefferson and Collier) have reduced in size by 50% over the last 50 years (Allen 1985).

The most recent glacial episode in the watershed is represented by fresh moraine and outwash between 7,000 and 9,000 feet elevation on high peaks. Radiocarbon ages indicate that these moraines were formed less than 2,500 years ago. The next oldest glacial stage ended 10,000 to 12,000 years ago (latest Wisconsin). During this time a broad ice field accumulated in the High Cascades which fed many valley glaciers, however none of these extended beyond the High Cascade platform and very few below 3,600 feet elevation. The oldest glacial advances have been obliterated in the area by the more recent ones, but evidence can be seen of them in deeply weathered and poorly preserved lateral and ground moraines, far removed from the Cascade Crest (Taylor 1968).

Glacial Advance

During times of extreme ice accumulation on the continent, and in the higher elevations of the Cascades, several processes interact to produce accelerated geomorphic change. As ice accumulates, the world ocean levels are lowered due to a lack of return moisture (that becomes entrapped in the ice) to the hydrologic cycle. Sea levels are estimated to have been at least 200 feet lower during the Pleistocene than today (Flint 1971). This means that in addition to the ice scour that took place in the valleys during glacial advance, the stream gradients were drastically increased This caused stream velocities and erosive capabilities to increase.

As a glacier advances down a valley, compressional stress is applied to the valley sidewalls, which causes a temporary elastic strain, or deformation, to accumulate within the rock masses. Glaciers accumulate material from the valley bottom and sidewalls as they advance. These deposits are transported down valley in front of the glacier as terminal moraine. The material transported along the bottom of the glacier is called lodgement till and is often found in a very compacted and dense state that can be seen in the road cut slopes on the east side of Deer Creek. The material transported and deposited along the sides is called lateral moraine, and the upper glacial debris left as the ice melts in place is called ablation till (Flint 1971). These deposits all have a common aspect in that they are composed of unsorted material of varying sizes and lithologies.

Geomorphic features in the higher elevations produced by glacial scour and morainal blockage of streams include most of the high elevation lakes. Other features produced include cirques (depressions left by ice), cols (saddles between ridges formed coalescing glaciers) and tarns (peaked spires). The Middle and South Sister were active during the late Pleistocene and are much less glaciated that the other older composite cones.

Glacial Retreat

Valley side-slope instability is a result of glacial processes. The stress applied to the valley sideslopes during glacial advance may be removed by glacial recession rather quickly (geologically speaking, thousands of years). When this occurs, the temporary elastic strain that accumulated in the valley sidewall rock mass during 100,00-200,000 years of ice loading, elastically "rebounds" as the load is released. This causes rupture in the rock mass, and valley side slope collapse which results in large landslide deposits and talus slopes (Ferguson et.al. 1981, Long 1994a,). Earthquakes and seismic loads associated with volcanic eruptions are also a source of major landslide and debris avalanche initiation (Keefer 1993, Long 1994b).

During glacial retreat, deposition occurs along valley sidewalls from material that has fallen on top of the ice mass at the lateral margins. This material may

then may become stranded on the valley side-slopes after ice melt occurs. The material may remain in a marginal state of slope equilibrium as latent landslides, and may be susceptible to failure with very little geometric modification such as road construction or stream scour.

Ice dams may have formed at valley constrictions behind terminal moraines. Proglacial lakes then form, and still-water sediments of clay and silt accumulate in seasonal varves, or thin layers. A good example is in the road cut on the south side of US 126 about 1 mile north of Trail Bridge reservoir. This deposit is very important to geologists who can interpret the time, sequence, and climate during this period in Earth history. Ice dams are susceptible to breaching and cause massive down valley flooding, scour and deposition, and may cause major rivers to change course. A good example of this type of process is the major gravel deposits found at Pleasant Hill southeast of Eugene. Here, massive glacial flood deposits are thought to have re-routed the Willamette River around the east side of Mount Pisgah. An anecdotal account of the 1933 failure of the Skinner glacier terminal moraine on South Sister was reported in the Eugene Register Guard (Tims 1958). An unusually warm summer accelerated the melting rate of the glacier, causing the melt water to overtop the debris dam at its front. The resulting failure sent "millions of cubic feet of water" down Separation and Horse Creeks to the McKenzie, scouring out the soil and bedrock.

MCKENZIE RIVER CORRIDOR

The upper McKenzie River flows out of Clear Lake through a narrow gorge in volcanic rock. The river between Clear Lake and Carmen Reservoir is crossed by several relatively recent lava flows which formed Sahalie and Koosah falls. The McKenzie is one of the few rivers in the region that is closely associated with recent vulcanism, and these volcanic features are a unique scenic attraction. As the McKenzie flows beyond Koosah Falls, it is intercepted by the Carmen-Smith hydroelectric diversion project completed in 1963. The project consists of Carmen reservoir which diverts the upper McKenzie westward through a two-mile tunnel constructed through Smith Ridge into Smith Reservoir. From there, the water flows south and then east through two additional tunnels and out through hydroelectric turbines at Trail Bridge reservoir.

Prior to the diversion project, the river flowed in its natural channel through Beaver Marsh and into Tamolitch Valley. There the volcanic features become less dominant, and incised mountain slopes rising along the valley's edges

become the dominant landforms. Much of the river's previous course in this area was underground through porous basalt. Eventually, it resurfaces over Tamolitch falls. Some water still flows through the underground passages in the lava, emerging at Tamolitch Pool from various natural springs. The water spills over the lip of the pool, then runs as a freeflowing river until it converges downstream with Trail Bridge reservoir.

Tree casts can be found in Tamolitch Valley within the lava flows. These hollow areas were formed when lava cooled around the trunks of standing trees before the wood could be completely burned away. The casts are relatively unusual because the lava must have the right consistency and temperature to be fluid enough to mold around the tree, but stiff enough to hold its shape after the tree burns.

Below Trail Bridge Reservoir, the river winds it way along the North Santiam Fault Zone which controls the North-South direction of the river. The lava flows are much older through this section and now vegetated by forest. Some of these older lava flows have been modified by hydrothermal alteration associated with geothermal activity. The river corridor within this section is within the 178,000-acre Belknap-Foley Geothermal Area. Two hot springs are the only surface expressions of geothermal activity near the river. A small hot spring emerges next to the River near Deer Creek and a second at Belknap Hot Springs.

Just south of Belknap, the river changes its course to a westerly direction as it breaches the ancient High Cascade escarpment and flows into the McKenzie Bridge-Blue River glacial valley. Through this area, the valley is wider due to glacial scouring, but still constrained by Foley and Lookout Ridges.

FOSSILS AND AREAS OF UNIQUE GEOLOGIC RESEARCH INTEREST

According to Dr. William Orr (personal communication), professor of paleontology and, curator of the University of Oregon paleontological museum, there are no known sites in the watershed of fossil-bering strata. However, the tree casts in Tamolitch Valley and a pro-glacial lake deposit one mile north of Trail Bridge Reservoir on the east side of the highway are two areas which should be protected for further research. Other well-know areas of geologic research interest are well within the Wilderness boundaries or in Special Interest Areas such as Sand Mountain.

SLOPE STABILITY AND DISTURBANCE HISTORY

Mass Wasting

Mass wasting, or slope instability, is initiated when the sum of the driving forces on a slope (gravity, earthquake loads, construction loads, valley stress relief, pore water pressures, changes in geometry) exceed the resisting forces (soil and rock shear strength, root cohesion, tree surcharge). Natural events such as fire, precipitation, and earthquakes and human-caused disturbances such as road construction and tree harvesting can cause rapid changes in slope equilibrium (Koler 1994).

In general, the highest number of incidents of mass wasting have occurred in the UPMAKWA in Landform Blocks 1, 2A, and 2B. This is due to the nature of the landforms being located in Western Cascade and Early High Cascade ridge-capping volcanics which consist of much older and hydrothermally altered basalts and pyroclastic rocks which are more susceptible to weathering and decomposition. The valleys are much more incised than those of the High Cascades, exhibiting sideslopes in most cases greater than 70%. The majority of mass movements have occurred in elevation bands of 2800-3200 feet and 3800-4200 feet, which may represent glacial valley stages, or elevations of glacial equilibrium on the valley sideslopes where kame terraces developed. Similar elevation bands of valley benches were observed by Van Dusen (1962) and Williamson (1987) in west-side central Cascade valleys. To some extent, Landform Block 6 is prone to debris avalanche failures due to differential weathering at the base of the intracanyon basalt flows that are located on the valley side slopes.

Valley Stress Relief

Valley sideslope collapse and resulting talus and deep colluvial toe slopes can be the result of valley stress relief and elastic rebound (Matheson and Thomson 1973). Valley stress relief and the resulting rebound is a function of the elastic modulus of the rock, deviator stress, and cyclic intervals. Stress application to valley sidewalls and floors can result from alpine glaciation or outwash sediment accumulation. In alpine glacial environments, these events are usually recompression cycles, as a function of glacial advance and retreat in response to global warming and cooling trends. This cyclic deviator stress tends to have a more adverse effect on rock slope stability than single valley-stage alluvial development by erosion and deposition. These conditions conducive to mass wasting are prevalent in Landform Blocks 1, 2a, 2B, and 6, and in the steeper areas of Landform Blocks 3, 4, and 5.

In alpine glacial sequences, lateral and vertical compression is applied to the valley during glacial advance. Stress removal takes place during glacial retreat, which causes buckling in the side slopes, defined as zones of extension or tension, and arching in the valley floors, defined as zones of compression

(Ferguson and Hamel 1981). Young and Shakoor (1987) completed a study of valley stress-relief-induced slope failures along the Ohio River in West Virginia and Ohio. They found that the most prominent joint sets in this area were those paralleling the river and were a result of release of residual stress, normal to the valley, caused by river downcutting.

In their study of valleys in western Canada, Matheson and Thomson (1973) recognized that upwarping of the valley floor influences the dip of bedding in sedimentary rocks and may produce interbed slip and gouge zones that influence slope stability when they are located at the toe of slopes. They also concluded that valley rebound (strain) may be up to 10 percent of the valley's depth, but more typically is found in the range of 3 to 5 percent.

Minor structural features may be an indication that valley sidewalls are in tension. Features such as minor anticlinal structures in valley floors, inflated or "diced" rock masses caused by cooling joints in igneous extrusive rocks being intersected by stress relief joints, near-vertical stress relief joints parallel to the valley, tension cracks, and overhangs are all indicators of stress relief or differential weathering. Natural processes which can accelerate the rates of failures in these terrains include freeze-thaw cycles, wind-levering of trees, root-wedging, elevated pore water pressures in discontinuities, and rapid drawdown of reservoirs.

Differential weathering occurs in rock masses that are layered with sequences of alternating rock of different strength, such as sandstone and shale sequences, basalt flows over glacial till (such as in Landform Block 6), or andesite flows with pyroclastic interbeds. In these situations, the lower-strength material weathers at a faster rate than the overlying material, resulting in an overhang. This force imbalance eventually results in failure of the overhang, which may precipitate mass failure of the slope (Arambarri and Long 1993).

Fire Impacts on Slope Stability

Wildfire, especially in high intensity burns where tree mortality is greater than 70%, has four direct impacts on slope stability: root strength is removed from the soil as root systems are burned underground; macropores are opened in stump holes leaving large cavities for water infiltration; evapotranspiration ceases; and tree surcharge, which adds a stability component to the slope, is removed. In addition to mass movement, overland erosion is also accelerated. In 1981, 50% of all post-fire slope failures on the Boise N.F. occurred as debris avalanches in soil less than 3 feet deep on slopes greater than 73% (Gray and Megahan 1981). Unlike high intensity wildfire, prescribed burns are normally low intensity in which the stumps and roots do not burn out. Historically, the highest intensity fires in areas of steep slopes and low shear strength soils have burned in Landblock 1, and Landblock 2B.

Disease

Insects and disease that lead to tree mortality has similar effects on slope stability as clear cutting and fire through loss of root cohesion and wind levering, though to a much less extent. Areas in Landform Blocks 2A and 2B have been affected in some cases to as much a 20 acres of dead and dying trees on steep slopes (Gene Skrine, personal communication), and are mapped annually.

Precipitation

Local storm events that depart from normal precipitation can be a triggering mechanism for slope failures, especially if the prior rainfall has been above average, and the soil is already near saturation such as the 1964, 100-year event and the 1973, 7-year event. If other compounding factors such as a recent high intensity fire, roads under construction, or clearcut units that are over one year old are present, the probability of failure is greater.

Earthquakes

Earthquakes are a daily occurrence in the Pacific Northwest, and they have triggered many of the ancient landslides in the watershed, especially slopes that contain loose glacial deposits. The majority are below 3.0 magnitude, but due to our proximity to the Cascadia Subduction Zone off the Pacific Coast, magnitudes of 8 to 9 have been recorded in the geologic record (Heaton and Hartzell 1987).

On the Oakridge Ranger District a 2 million cubic yard earthquake-induced landslide that displaced the North Fork of the Middle Fork of the Willamette River has been dated at 4,700 years before present (Long, unpublished report). Anecdotal reports include blockage of the Columbia River for several days after a major earthquake struck western Washington in 1872 and triggered a landslide dam (Oregon Geology 1994); and the great Bonneville landslide which blocked the Columbia 700 years ago (Palmer 1977). The 5.6 magnitude Scotts Mills earthquake in March of 1993, and the Klamath Falls 6.0 earthquake in September of 1993 are just two examples of recent seismic events that are becoming more frequent. Darienzo and Peterson (1995) have dated at least six occurrences of great earthquakes along the Pacific Northwest coast with and average magnitude of 8.0 and an average recurrence interval of 400 years with some as low as 200 years.

The proximity of the watershed to the probable focal point of a subduction earthquake is over 75 miles. This distance provides a certain amount of attenuation for primary and secondary shock waves. An expected peak velocity of 6-19 cm/s and a duration of shaking of less than 9 seconds reduces the risk of damage considerably (Weldon 1994), however does not eliminate the risk. The Corps of Engineers determined that the Tumalo Fault was capable of producing of magnitude 7.2 earthquake in the area; a local fault system in the Three Sisters

area a 6.0; and North Santiam Fault Zone, which runs along the McKenzie and Smith Rivers south to Belknap Springs a 5.1.

The Federal Energy Regulatory Commission (FERC) requires that dam licensees perform periodic safety inspections of all critical facilities for structural integrity and adequate stability including expected earthquake loads. Such studies have been completed for the Carmen-Smith and Trail Bridge dams in 1995.

Road Construction

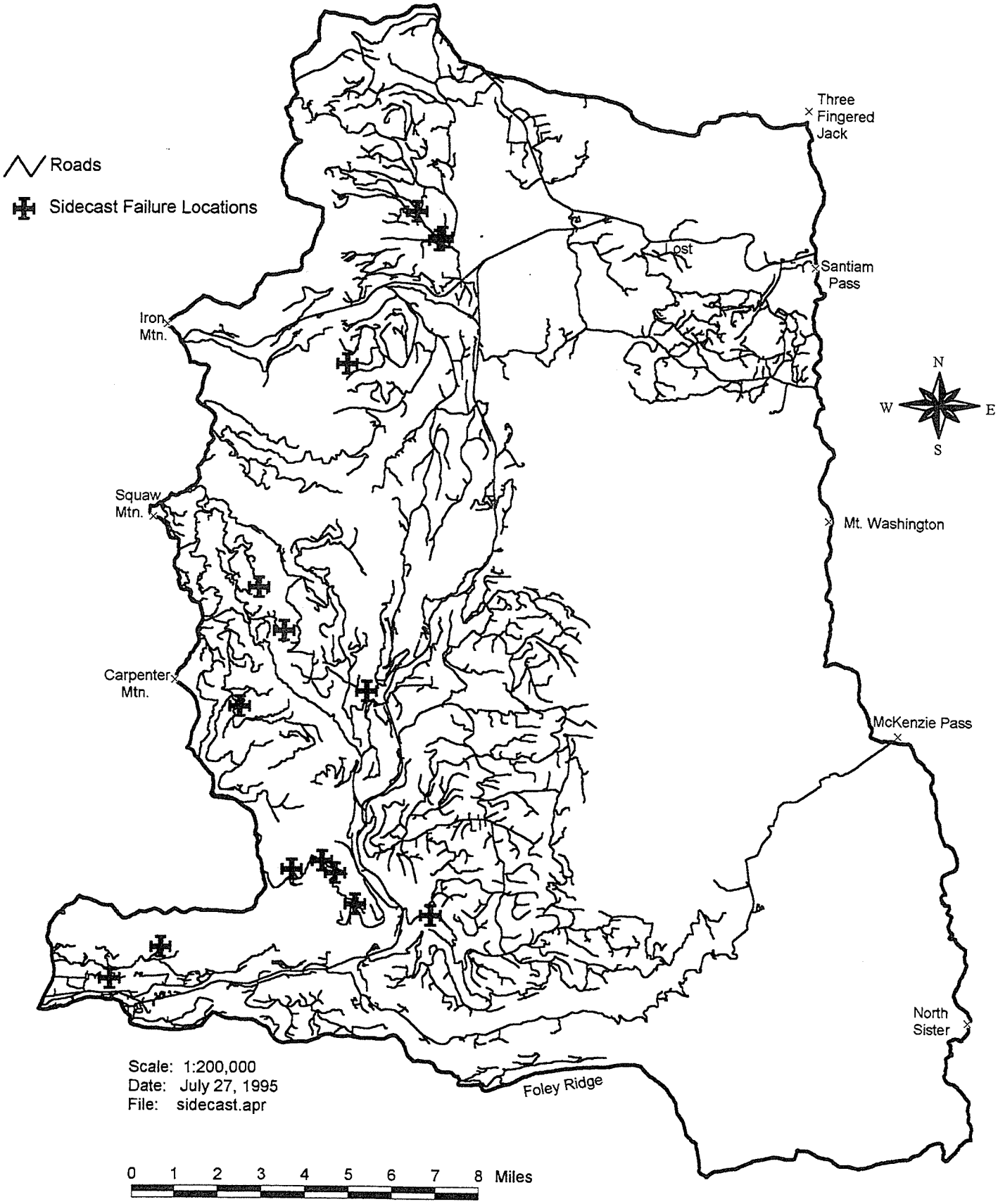
The watershed contains approximately 900 miles of roads. A review of the geotechnical engineering project files, interviews with district personnel (Larry Wilson, Pat Hutchins, and Gene Carver) concluded that there have only been 19 road related failures with historical significance (Geology Appendix). Seventy-five percent of these failures occurred in Landform Blocks 2A and 2B as a result of sidecast failures over Western Cascade volcanics (Figure 3-2). Rock aggregate for road surfacing has been of high quality in the watershed, which has kept road surface sediment contributions to a minimum. However, in the Budworm and County Creek drainages in Landform Block 2A, continual ravel from road cutslopes require yearly ditch cleaning.

Clearcut Harvest

The practice of clearcutting for timber harvest in itself is not detrimental to slope stability. Root strength tends to remain in place for up to 5 years, and the soil biomass remains in place. However, clearcutting does remove the tree surcharge from the slope, and the major portion of the evapotranspiration system is removed until re-growth can occur. If a major storm event occurs, a net decrease in slope stability could lead to failure.

Unlike intense wildfire where root cohesion loss is 100%, after clear cutting the root cohesion loss for Douglas-fir is approximately 50% by the end of the 1st year and 75% after 5 years (Gray and Megahan 1991). Ziemer (1981) also noted that "Removal of slope vegetation tends to decrease root cohesion, increase piezometric levels and decrease slope surcharge...and about 50% of the original root reinforcement is lost within 2 years after clearcutting and 90% is gone within 9 years." He also pointed out that "It may take about 15 years until the new forest provides 50% of the root reinforcement supplied by the original forest before cutting and 26 years until the soil in the harvested area returns to the strength of that in the uncut forest." Post-harvest debris avalanche initiation has occurred in the County and Conroy Creek drainages in Landform Block 2A.

Figure 3-2. Sidecast Failures



SOIL RESOURCES

The original 1973 Forest Soils Resource Inventory (S.R.I.) was updated in 1990 and placed in the Forest Geographic Information System (G.I.S.) as a Forest-wide layer. Areas newly designated as unstable, or potentially unstable were verified with aerial photos and on-the-ground where possible.

The 1990 S.R.I. was found to be reliable, and generally useful for planning purposes. Each polygon contains the following attributes: type, area, timber suitability, if unsuited why, stability classification, erosion potential, sediment yield potential, water yield, and site classification. Frequency distribution queries were made of the database to determine the areas of unstable soil types.

Frequency distribution for soils that are classified as stable, but where mass movement could be increased by management activities, were spatially identified from the database by intersection queries with slope polygons greater than 70%. These areas include those with shallow soils on sidslopes >70%; valley headwalls that have a potential for debris avalanche; areas with potential for high intensity fires or clearcutting; and areas associated with large storm events.

Probability Analysis

Similar frequency and distribution analyses were made for potentially unstable soil types. A probability analysis was made in these areas using the Level I Stability Analysis program, LISA (1991). Developed by the Intermountain Research Station, this program statistically analyzes the probability of failure within polygons under conditions of normal and extreme precipitation events, clearcut, 50% partial cut, and high intensity wildfire. Further information on the analysis process is found in the Geology Appendix.

The probability of failure for natural slopes that are classified as potentially unstable, or potentially unstable slopes greater than 70%, is about 4% (Table 3-1). This may be close to a "range of natural variability" for slopes in the Western Cascades. In the same area, under an extreme storm event, with 50% partial harvest or clearcut logging, the probability of failure increases above the range of natural variability by 1% and 6% respectively. These percentages will vary when applied to individual soil units within individual landform blocks. High intensity wildfire will have the greatest effect on slope stability in these areas. The probability of failure may increase to over 50% in most areas identified as potentially unstable (Table 3-1). Similar results were obtained in areas of western and eastern Washington and southwest Oregon in validity studies by Ristau (1988), McHugh (1991), and Wooten (1988).

Table 3-1: Summary of designated soil units and LISA percent probability of failure within the Upper McKenzie Watershed.

Potentially Unstable Areas:

SRI UNIT	NATURAL	50% CLEARCUT	CLEARCUT	WILDFIRE
Talus slopes and debris avalanche chutes <3 ft. deep				
SRI 3 (GW/GM)	24.5			63.4
Cohesive soils 6-20 ft. deep				
SRI 233/235 (MH/CL)	3.2	10.2	21.4	33.8

Potentially Unstable Areas on slopes >70%:

SRI UNIT	NATURAL	50% CLEARCUT	CLEARCUT	WILDFIRE
Granular soils <3 ft. deep				
SRI 71 (SM)	5.7	14.3	23.9	78.3
Granular soils 3-6 ft. deep				
SRI 13/61/64/610 610U/614(GW /GM)	18.8	24.8	50.0	93.8
Cohesive soils <3 ft. deep				
SRI 21/31/301/310U (ML/MH)	8.0	11.3	86.6	86.6
Cohesive soils 3-6 ft. deep				
SRI 16 (GMu)	16.0	22.4	32.1	48.6

S.R.I. Landtype and Stability Classification Conditions

The following describes soil types found within the Upper McKenzie Watershed.

Unstable: Areas which are prone to mass failure under natural conditions (unroaded, unharvested), and where human activities such as road construction and timber harvest are likely to increase landslide distribution in time and space to the point where this change is likely to modify natural geomorphic and hydrologic processes. (FSEIS glossary p. 18) and classified by the Forest S.R.I. as moderately (several failures observed within a polygon) to very unstable (entire polygon shows evidence of recent and past failures).

LANDTYPE	DESCRIPTION
25	Cohesive residual and colluvial soil, Sandy Silt with some Clay and rock fragments overlying pyroclastic bedrock on 20 to 40% slopes

Landtypes were identified through frequency analysis for SRI types and air photo interpretation.

Potentially Unstable: Areas which contain conditions of steep geometry, high ground water potential, and soil with low shear strength characteristics that "...considers the probability of landslide-triggering storms within the period of minimum root strength and elevated ground water (as well as slope adjustment to piping changes); the probability of channel adjustments that trigger streambank and toeslope failures (FEMAT IX-38); and classified by the Forest S.R.I. as stable or moderately stable to locally unstable. These conditions include high intensity fire and clearcut harvesting.

LANDTYPE	DESCRIPTION
3	Rock outcrops of basalt, andesite and pyroclastic material which are prone to differential weathering and stress relief from glacial unloading which produce talus slopes and debris avalanches
233 and 235	Clayey Silts to Silty Clays overlying pyroclastic bedrock on steep slopes up to 70 %

Landtypes were identified using aerial photo interpretation, a frequency query for SRI types, intersections with slope layer, and probability analysis using LISA for high intensity fire and clearcut scenarios.

Potentially Unstable on slopes >70%: Shallow soils in steep sideslope or valley headwall areas that have a potential for debris avalanche failure. Classified by the Forest S.R.I. as stable.

LANDTYPE	DESCRIPTION
13	Glacial deposits
16	Toe slopes glacial/fluvial deposits
61, 64, 610 610U, 614	Glacial till overlying basalt and adesite soil depth 3-6 feet
71	Ridges and cirque headwalls w/less than 3′ of granular soil
301, 310U, 21	Sandy Silt to Clayey Silt overlying Tuffs and Breccias with less than 3 feet of slightly plastic soil.

Landtypes were identified using a frequency query for SRI types and intersections with slopes >70%.

OVERVIEW OF HUMAN USE

PREHISTORIC RESOURCES

Prehistoric heritage resources in the UPMKWA are not well-understood at this time in terms of the activities of native peoples which lead to the deposits of those artifacts. Some activities have left patterns of artifacts, which in conjunction with environmental data are straightforward and functionally clear. Debris from quarrying and preparing obsidian for toolmaking at Obsidian Cliffs is one example. Other patterns are less obvious. For instance, we know that resource processing must have taken place at many locations, yet the obsidian tools left at those sites yield little specific information about which plants or which animals were involved. Most documentation is in the form of Region Six Site Forms. Earlier years of recording (1979-86) are rather sketchy, though improvements in data occurred in recent years. In addition to this data, several contract archeological evaluations and data recovery projects (mitigations) have resulted in some furtherance of our understanding.

Prehistoric resources include chipped obsidian lithic scatters and obsidian lithic isolates, representing tool use, modification, or manufacture related to hunting and gathering. Ongoing stone tool analysis, both by agency archeologists and contractors, suggests that this portion of the Cascades was occupied primarily by people indigenous to the Cascades. Those people were probably ancestral to the Molalla people that were involved in early (but unratified) treaties of the 1850's. Some of their descendants are members of the Grande Ronde tribe. There appears to be a long period, the Middle Archaic (about 8,000-2,000 years ago) where there was marked stability in adaptation as it relates to stone tool use. Analysis of obsidian from archeological sites outside the UPMKWA area indicates that Obsidian Cliffs glass has a widespread distribution in the Northwest, demonstrating that other native people came and got obsidian or obtained it through trade with resident people.

Because much of the area is covered by recent volcanism, we can assume that there are many prehistoric resources deeply buried under those deposits. At this time, there are hundreds of prehistoric resources documented in the three Ranger Districts of the UPMKWA area. Many of these sites probably represent warm season occupation of the high elevation reaches of an ethnic group's territory, or they may be areas of probable travel route branching (such as the Parks Creek area on Sweethome District). The large number and high density of prehistoric sites at lower elevations along the main stem of the McKenzie are likely temporally-overlapping winter villages or encampments.

HISTORIC RESOURCES: MAJOR SITES AND COMPLEXES

Historic Resources are more well-documented in the watershed. They include the following major sites and complexes:

Santiam Lodge: The lodge was originally constructed by the Civilian Conservation Corps in 1939-1940. It is one of two surviving ski facilities constructed on the Willamette. It was operated under a Special User permit held by the Presbetery of the Cascades until 1987 or 1988. Then it reverted to the government, and it has been boarded up and slowly deteriorating ever since. The building complex consists of the main lodge, a garage, and pump house. The lodge is eligible for the National Register. Formal nomination has not been prepared, but a future use determination is being prepared by the District. If the existing trend continues, this historic building will be lost to vandals and the ravages of time.

Santiam Wagon Road: The SWR began as a commercial toll road, constructed in the 1860's. It reverted to Linn County ownership around the World War I era. Since then, portions of the road have been abandoned and other portions have become Forest Service roads. Its condition has been assessed along its 27 mile length across the Willamette NF. Within the UPMKWA area, its heritage integrity is classified as fair. The SWR was one of the first trans-Cascade roads, and it served to connect the Willamette Valley to eastern Oregon. Large quantities of freight and stock were driven over the road in its heyday. A skirmish in the Paiute Campaigns or the Bannock Wars (1878) may have been fought along the road in the vicinity of Sand Mountain. There is reputed to be a mass grave at the site. The SWR is eligible for the National Register. A formal nomination to the NR has not been completed. Personnel at Sweet Home RD are preparing a management plan and a Special Interest Area implementation guide for the SWR, which will prescribe protection of this resource.

Hogg Railroad: Hogg Railroad is a well-known historic cultural resource (District Number 07300h). It is located along the North Santiam River and east to the summit of Santiam Pass, about 22 air mails northeast of McKenzie Bridge. The old railroad grade forms part of the administrative boundary between McKenzie and Detroit Ranger Districts. The railroad grade continues east and beyond the Willamette-Deschutes Forest boundary.

Hog Railroad, as it is locally known, was the brainchild and scheme of a 19th century entrepreneur, T. Egenton Hogg. Hogg and others worked to develop a railroad running from Yaquina Bay on the Oregon coast to Boise, Idaho. This venture at various times was known as the "Corvallis and Yaquina Bay Railroad Company," the "Willamette Valley and Coast Railroad Company," the

Oregon Pacific Railroad," the "Oregon Central and Eastern Railroad Company," and finally as the "Corvallis and Eastern Railroad." The only operational portion of the railroad ran between Yaquina Bay to as far east as Idanha near Detroit in the western Cascades.

At the crest of the Cascades, a small amount of track was laid and a boxcar was hauled in (via the Santiam Wagon Road) and rolled along the track in a futile effort to secure financing for the failing enterprise. The Santiam Pass segment of Hogg Railroad, at Hogg Rock, was reputedly built by Chinese laborers, although no direct evidence for this has been found so far. Construction took place in 1888, 106 years ago. After bankruptcy, the Santiam Pass segment and all associated camps, construction, and most equipment was abandoned. To date, we have documented construction laborer camps, tool caches, construction dump cart parts, and of course the grade itself.

HISTORIC RESOURCES: GENERAL TRENDS AND LANDMARK EVENTS

While transportation was the dominant historic "theme" in the UPMKWA area, early recreational and extractive ventures also occurred, as well as agricultural settlement. The following lists landmark events in order of occurrence. Where several dates are shown, i.e., 1863/1869, the events are certain but sources conflict on actual date.

All sources note the first presence of Euroamericans in the early 1800s. Fur trappers and explorers from John Jacob Astor's Pacific Fur Company and the Hudson Bay Company were present in the Willamette Valley just after the turn of the century. The McKenzie River itself was "discovered" and named by a member of Astor's enterprise. Donald Mackenzie (note spelling), leading a party of trappers, may have explored the river in 1812 (Williams 1988:7).

The next 5-6 decades were characterized by migration into the Willamette Valley and settlement in present-day Eugene, Springfield, Pleasant Hill, and Thurston. As in-migration occurred in these areas, exploration pushed further up the McKenzie Valley, foreshadowing settlement to come.

1859. The so-called McBride Party, composed of George Millican, John Templeton Craig, James Storment, and Joseph Carter were "first to seek for the headwaters of the McKenzie." A hot springs, later named Belknap Springs, is "discovered" by the McBride Party. It is possible that the McBride Party also "discovered" Clear Lake on this expedition (Walling 1884).

1860. J.H. McClung, with a party of seven from Eugene, makes a trip to the Cascade summit via an old Indian trail, later named Scott Trail.

1862/1863. Felix Scott Jr. makes crossing of the Cascades with 900 head of cattle, nine heavily laden wagons, and about 50 men. To do so, his party of 50-60 men routed and cut trail starting about 4 miles east of present-day Vida and crossing the Cascade summit several miles south of the present highway. John Templeton Craig was a member of this party.

Before the 1870's most of the activity in the McKenzie Valley was exploratory and/or extractive. From the beginning of that decade, homesteading, transportation and settlement became more emphasized. Settlement spread from Eugene/Springfield into the lower valley in the mid-1840's and '50's. From there, settlers moved gradually into the upper valley in the late '60's and afterward.

1870. Rollin Simeon Belknap begins development of Belknap Springs as a resort. The Belknap Springs resort was being served by stagecoach, run by John West Sr. from Eugene. Philander Renfrew and "Uncle" George and "Auntie" Frissell settled at Craig's Prairie (Strawberry Prairie) at about this time, which roughly corresponds with the building of the first bridge at a location now known as McKenzie Bridge.

As the nineteenth century drew to a close, use patterns in the upper McKenzie Valley shifted to reflect a stabilizing settlement situation and changes in the quality of life. Values were emerging that would shape modern land management and use of the McKenzie.

As settlers transitioned from the demands, rigors and uncertainty of frontier homesteading, they had time for activities beyond those needed to survive. And, for those who had come to the area because of its beauty and/or its bounty, the increasing population meant increased pressure on natural resources. With a de-emphasis on subsistence, settlers' values gradually began to shift to economic development, improving infrastructures, and recreational activities in the upper McKenzie Valley.

Several events occurred within a very short time that would set the stage for the future of the McKenzie.

1889. John B. Waldo proposes, to the Legislative Assembly of Oregon, forest reserves to "protect wilderness values, scenery, forests, waterflow and wildlife" along the crest of the Cascades.

1891. Congress passes Forest Reserve Act to set aside public lands covered with timber or undergrowth, whether of commercial value or not. Reserves are to "protect city watersheds, to protect salmon spawning grounds, to preserve irrigation water and amenity values."

1893. Cascade Range Forest Reserve is designated.

The next 40 years saw the transition from a land of isolated frontier habitations to a series of forest communities, including those nearest the McKenzie. Travelways were being improved to expedite the flow of commerce across the Cascades. Upper valley settlers were responding to the influx of recreational users and commercial traffic with entrepreneurial spirit. Logging became a substantial economic concern in the McKenzie Valley. In 1891, 17 million board feet of timber came down the McKenzie in the largest drive ever made. Clearcutting was the common practice.

1908. According to Manena Schwering, long-time resident of Blue River, the establishment of the McKenzie Ranger District had a significant and lasting impact on community development. The first Ranger, Smith L. Taylor, served the area for 27 years and came to be regarded as an unofficial spokesman for community projects, school and highway improvement, and later, fought for rural electrification.

1908. The Cascade Forest is one of four forests carved from the Cascade Crest Reserve.

1905. First automobile crosses Santiam Pass, and hydroelectric power comes to the lower Valley.

1911. Eugene Water Board (later to become EWEB) is created.

1915. Forest Examiner Robert S. Wallace submitted and Clyde Seitz, Forest Supervisor of the Cascade National Forest from 1908-1919, approved a significant report detailing needs for construction of what would become the McKenzie Highway. Timber is listed as the number one principal resource of Lane County, with an inventory of some "60,000,000,000 feet of high grade standing merchantable timber." Wallace also predicted that "With the completion of the State highway system and its tributaries through Lane County, this beautiful country will be a veritable paradise for sportsmen, motorists, fishers, campers, and all lovers of out-door life." Referring specifically to the "McKenzie Highway," Wallace stated: "From a County, State and National point of view, this is by far the most important portion of road needing improvement in Lane County at present." (Wallace 1915).

1919-1921. The upper valley road is improved. Highway 242, built on the old wagon road begun in the 1860's by John Craig, is completed in 1925.

During the period **1933-1945**, the lumber industry made a major shift from private to public lands as a source of timber; many lumber companies went

under and others changed ownership; "sustained yield" became a goal of Forest Service management; railroad logging and river drives gave way to tractor logging and truck transportation, and cutting practices changed. Growing timber was now an industrial business.

The 1930's brought a new interest in winter sports, especially skiing, and recreation became a year-round proposition. CCC labor built a two-story lodge, cabins, water and sanitation systems, and a ski run at White Branch, off the McKenzie Highway. Unfortunately, at 3000' elevation, sufficient snow depths to support a long winter season were unlikely.

The 1950's were years of confidence and growth. However, a near tragic fire and some alleged favoritism in timber sales had created a rift between the residents of the McKenzie Valley near Blue River and the Forest Service in the late Fifties. Then district ranger Edward Anderson initiated what might be recognized as the first Natural Resource Education program ever undertaken in an effort to restore confidence in the Forest Service.

1963. Carmen-Smith hydroelectric complex is dedicated.

1964. Clear Lake Cutoff opens as modern day Highway 126. Three Sisters designated "wilderness."

Between the early 50's and the mid-'60', recreation use (primarily camping and fishing) had grown by over 300% across the Forest. Developed recreation facilities were being built both to handle the increase in use and to minimize impacts to "dispersed" sites.

In 1962, the Forest initiated a fee system at Paradise Campground, charging $1 per day, to help fund recreation facility development, maintenance and improvement. And, in 1965, the Land and Water Conservation Fund (LWCF) was established, formalizing payment of a national fee for use of campgrounds.

By 1970, only three persons out of ten were rural dwellers nationally. But the character of the McKenzie Valley remained largely rural and agrarian until the following decade. In the mid-80's, the collapse of the timber industry in the valley forced many residents to seek employment elsewhere. Comparatively inexpensive property coupled with scenic values and recreational opportunities of the middle and upper valley appealed to retirees and seasonal visitors looking for summer homes.

Through the 1980s and into the present, development in the lower McKenzie Valley has turned many of those communities into "bedroom" communities for relatively affluent commuters from Eugene/Springfield.

1988. Upper McKenzie River, from Scott Creek to Clear Lake, designated Wild and Scenic River.

1993. The McKenzie Watershed Council forms to coordinate and integrate resource planning for the entire McKenzie basin.

CURRENT AND FUTURE HUMAN USE

People use the Upper McKenzie Watershed in several distinct ways: as an area to visit and recreate, as a workplace destination, and some use this area as their home.

Access to the Upper McKenzie Watershed is provided by three highways: US Highway 20, State Highway 126, and State Highway 242. From these highways, Forest roads branch out to provide access to the area. Visitors from many Oregon counties, other states, even other nations are attracted to this area of the Cascades Range.

The 1994 Recreation Resource Inventory System (RRIS) tracked different activities such as camping, hiking, and sightseeing. Over one and a half million separate activity-days were tabulated. This may be one person counted several times as they hiked, rode, or camped overnight during their stay on the McKenzie Ranger District within the Watershed. The Upper McKenzie Watershed contains the entire range of recreational activities found across the Willamette National Forest. Virtually all McKenzie District's campgrounds, boat launches, recreation residences, picnic areas, viewpoints, resorts, youth camps, ski areas and the vast majority of hiking trails are contained in this watershed. Activities range from white water rafting, downhill skiing, water skiing, hiking, off-road vehicle riding, wilderness travel, hot spring use, mountain biking, etc across the spectrum of recreation offerings. In the Sweethome District, an interesting anomaly occurs: recreation use patterns exist without the influence of major water ways. Here, use is focused more on a few small creeks and the trail systems accessing the major ridgeline peaks. (See Appendix ? for recreation focus on Sweet Home RD). Detroit Ranger District administers the portion of the Mt. Jefferson Wilderness that is within the watershed. This portion contains several trails including a major access point of the Pacific Crest National Scenic Trail.

According to the 1992 McKenzie Pass/Santiam Pass Scenic Byway Management Strategy :

> Future recreation use within the byway (watershed) will likely be affected by changes in various socio-economic indicators (e.g., population growth,

> disposable income, leisure time), the availability of opportunities, technology, weather conditions, and other variables. Due to uncertainties about the variables affecting future use, estimates become less reliable as they are extended into the future. Studies which have predicted future growth for recreation cannot anticipate fluctuations in microclimatic weather patterns nor predict regional energy shortages or economic recession. Therefore, estimates of future use generally assume an underlying demand is present and will increase with a growing population that has an ever-increasing awareness and appreciation of recreation values.
>
> Based on these factors, general trends in past use in both the Willamette and Deschutes National Forests and current efforts to diversify local economies with an emphasis toward tourism and recreation, it seems **appropriate to assume that future participation in all activities within the area of the Scenic Byway (all of the McKenzie portion is in the watershed analysis area) will increase as long as opportunities are provided.**

A 1993 report conducted for the McKenzie Pass/Santiam Pass National Scenic Byway Interpretive Plan gives useful insight into a wide scope of the visitors to the watershed. Dean Rynyan Associates conducted the research entitled "Interpretive Audience Analysis, The Central Cascades, Oregon." It used data from a study on 1989 travel and tourism in Oregon conducted for the Oregon Tourism Division. For that analysis, respondents who traveled in and through Central Oregon and the southern Willamette Valley were polled. The sample consisted of 636 Oregon residents and 890 out-of-state visitors. According to the Interpretive Plan:

> Two basic groups could be defined, with 65% being visitors from Oregon, Washington, and California. The remainder were visitors from other states and foreign countries. Most residents and out-of-state visitors traveled by private auto, with a significant portion of both groups using RVs. Most visitors (80-83%) to the area were traveling primarily for pleasure and/or were to visit friends and relatives. Accommodations of choice by residents equal between the use of campgrounds and commercial lodging, however out-of-state visitors choose commercial lodging twice as often as they do public campgrounds.
>
> Residents stay in the area about four days as compared to about ten days for out-of-state travelers, who choose locations to visit based on information gathered during their trip. Most travelers are a mix of families with two children, and older couples traveling without children who earn moderate annual incomes, and who are an average age of 50

years. Travelers to this area are relatively well-educated, with most having some education beyond high school and a majority of this group having bachelors or graduate degrees. Most visitors to the area engage in a variety of travel related activities, including: relaxing and sightseeing (94%), hiking (65%), small town shopping (64%), visiting a museum or historic site (62%), wildlife viewing (60%), picnicking (52%), and visiting friends and relatives (49%).

A January 1995 report titled "Initial Social Assessment of Proximate Communities for the Central Cascades Adaptive Management Area" (Shindler, List, Smith, and Steel) produced Tables 3-2 and 3-2. These university researchers conducted a random sample survey of 931 Lane and Linn County residents in the spring of 1994 regarding uses and management preferences for the Willamette National Forest. Fortunately for this watershed analysis, the AMA requirements for a survey closely paralleled our needs. From the initial 931 contacted, 744 residents of Eugene, South Santiam River drainage, and the McKenzie River drainage responded. This survey lacks residents from the rest of Oregon and out of state visitors. However, the survey provides useful insight into a large percent of the users of this watershed.

There are 107,635 acres of privately-owned land within the watershed. Of this area, only 812 acres (0.7%) are used for residential purposes. There are 2,178 acres of industrial classified private land near McKenzie Ranger District, primarily located near McKenzie Bridge off of Highway 126 or Highway 242. One large section is also located along the Eno Road. Therefore, 97% of the privately held acres in the watershed are located in the north part of the watershed, most adjacent to Sweet Home RD, less than 500 acres near Detroit District's boundary.

Table 3-2: Recreational Uses by people in Eugene, S. Santiam River drainage, and the McKenzie River drainage.

Forest Use	Total	Eugene	Santiam	McKenzie
Visit any forest for recreation:				
Never	3%	1%	5%	1%
Occasional (few times a year or less)	64%	57%	67%	65%
Frequent (at least monthly)	33%	42%	28%	34%
Visit the Willamette National Forest:				
Never	4%	1%	4%	5%
Occasional (few times a year or less)	76%	76%	80%	69%
Frequent (at least monthly)	20%	23%	16%	26%

Table 3-2 (continued)

Forest Use	Total	Eugene	Santiam	McKenzie
Use of Willamette National Forest:				
Day hiking	77%	70%	79%	81%
Camping in developed sites	77%	77%	79%	74%
View/photo wildlife	72%	73%	74%	68%
Fishing	66%	52%	76%	64%
Hunting	48%	28%	62%	45%
Mushroom/berry picking	40%	33%	42%	43%
Overnight backpacking	37%	40%	37%	32%
Bicycling	36%	44%	29%	40%
Power boating	36%	27%	45%	30%
Woodcutting	32%	21%	35%	39%
River rafting	31%	37%	26%	34%
Downhill skiing	27%	36%	22%	25%
Cross country skiing	20%	29%	17%	16%
Motor cycling/ATV	20%	14%	24%	18%
Horseback riding	15%	15%	17%	11%
Snowmobiling	9%	6%	10%	9%

Table 3-3 shows that the average age, income, and education level for these communities tends to compare well to other populations surveyed (i.e. Oregon and national samples) (Shindler, List, Smith and Steel 1995). The surveyors also noted that older, more educated people with higher incomes tend to respond to natural resource surveys, as they tend to be more interested, have more time for questionnaires, and may have more at stake in forest management decisions. The other items the surveyors found noteworthy were the length of residence of 28 to 34 years, with relatively few individuals having moved into Lane or Linn county in the last five years. This suggests to the researchers that the public has a good sense of the landscape around them and may have a strong interest in how it is allocated and managed. Another item of note is the economic sector data. There seems to be a relatively high number of retirees in the sample, which may or may not be representative of the state as a whole. The 36% figure compares well with their statewide survey (35%), but is substantially higher than they found in an interest group membership (25%). The high number of timber dependence (33%), is not unexpected, with Eugene's figure of 22% closer to the statewide level of 21%.

Table 3-3: Community Profile within the Upper McKenzie Watershed.

Residents	Total	Eugene	Santiam	McKenzie
Age (mean)	54	52	55	56
Female	52%	55%	52%	46%
Male	48%	45%	48%	54%
Income (annual Mean)	$21,900	$22,200	$21,300	$22,700
Level of education:				
High School	26%	16%	35%	21%
Some College	48%	54%	45%	48%
college degree	16%	18%	14%	18%
Advanced degree	10%	12%	6%	13%
Years residing in Lane/Linn Co.	32	28	34	30
Less than 5 years	6%	8%	3%	8%
Economic Sector:				
Private or self-employed	44%	47%	43%	44%
Government	11%	13%	10%	11%
Retired	36%	29%	40%	38%
Unemployed	3%	5%	2%	2%
Other	5%	5%	5%	5%
Members of immediate family dependent on timber industry for economic livelihood.	33%	22%	37%	39%
Self-described ideology:				
Liberal	10%	18%	7%	6%
Moderate	71%	63%	76%	70%
Conservative	19%	19%	17%	24%
N	744	198	363	183

OVERVIEW OF UPLAND VEGETATION AND WILDLIFE HABITAT

The following section discuses existing and historical conditions and trends of the vegetative systems within the Upper McKenzie watershed. The following will include answers to questions such as "What is there now, and how did it get that way? "What was there in historical times?" and "What processes will continue regardless of human intervention?"

DISTURBANCE

Disturbances are events that may result in change to vegetative or topographical characteristics within the landscape. They can be described in terms of their type, intensity, frequency, duration, and effect. The prominent disturbance phenomena influencing the current landscape patterns in the Western Cascades include fire (human-caused and lightning starts), wind, insects and disease, and landslides (Diaz and Apostol 1992). These disturbance phenomena can be thought of as a complex that may increase or decrease the biotic diversity on the landscape. Their interactions are dynamic, and unique combinations may exist at a forest, community, or microsite level. Because these factors are interdependent, removing or altering one disturbance factor may influence the role of the others. Glaciation and volcanism are also disturbance factors on this landscape. They created the topographical features and heavily influenced the subsequent development of vegetation.

Fire

Fire is a significant environmental process. Fire affects the environment because it:

- influences vegetative succession;
- influences age structure and species composition of vegetation;
- produces a vegetation mosaic on the landscape;
- influences population dynamics of insects and plant diseases;
- influences nutrient cycles and energy flows;
- influences productivity, diversity, and stability of ecosystem;
- and determines availability of habitats for wildlife over space and time (Heinselman 1990).

Portions of the Upper McKenzie forests appear to have a closer, more frequent relationship with fire than usually observed on the west side of the Cascades. Factors such as lightning frequency and seasonal east winds that result from the areas' position on the Cascade crest significantly affect the fire regimes within the area.

Periodic fire has been a normal and reoccurring component of the Upper McKenzie area since the retreat of the last glacier, playing an important, often dominant, role in shaping and maintaining the vegetative communities. These forests have periodically experienced both large and small disturbances that altered vegetation on areas ranging from less than an acre to thousands of acres at a time. Fire is essential to the functioning of this natural system.

The relationship between fire and this landscape has been greatly influenced by the presence of humans. Fire suppression efforts that began about 1900 altered the historical fire regimes. Prior to fire suppression activity, there is a history of human use in this area that also influenced the fire regime. White settlers engaged in road building, travel, railroad building, hunting, and recreation. These activities greatly increased the fire frequency within this area during the late 1800's.

There is little quantitative evidence that Native Americans used fire to manage the environment in the Upper McKenzie prior to European settlement. However, the area is known to have been a key east to west travelway, and the wetter more productive sites within the Pass would likely have been good candidates for semi-permanent huckleberry propagation. It is likely that Native American's also influenced the fire regime in this area, but the extent is unknown.

The result of these combined historical factors is reflected in the composition and distribution of the vegetation that we see today. The fire regimes of watershed can be best characterized by looking at the plant associations that have developed within this area. A detailed analysis of the fire regimes by plant series in the watershed will be discussed later in this chapter. Fire regimes by plant association are shown in Table 3-4. Figure 3-3 displays the different fire regimes found within the watershed.

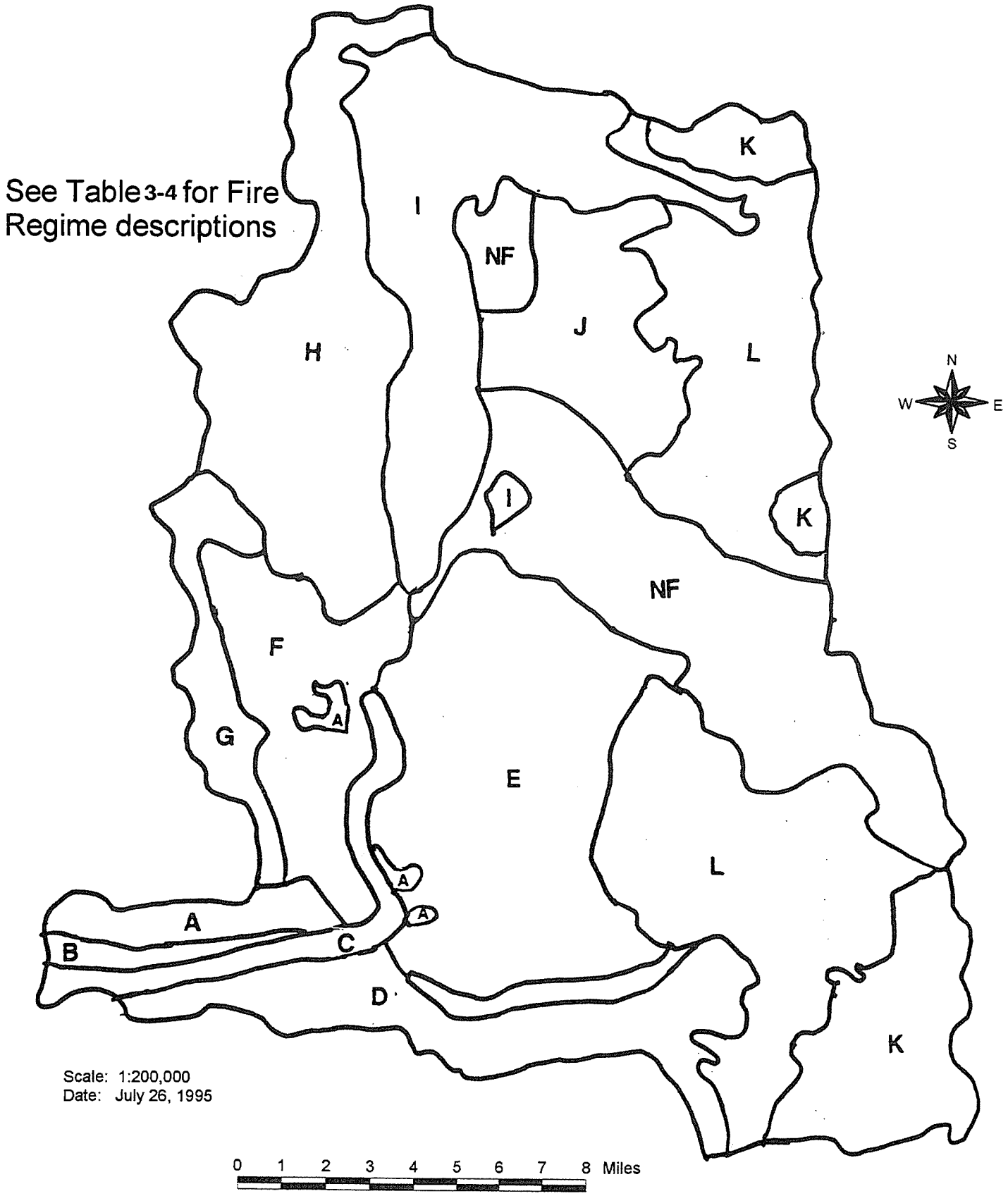
For those plant associations dominant in wilderness areas, the role of natural fire must be allowed to function naturally to maintain and restore biological and physical processes as required by the Wilderness Act of 1964.

Table 3-4: Typical fire regimes in the Upper McKenzie watershed. The first line for each regime represents a stand-replacement fire. The lower line is a typical underburning type fire.

Regime	Frequency	Intensity	Size	MFRI
A	Frequent Frequent	High Moderate	Large Medium	50-75 yrs 40 yrs
B	Intermediate Frequent	Moderate-High Low-moderate	Medium Small	100-130 yrs 60 yrs
C	Intermediate Intermediate	Moderate Low	Small Small	200-300 yrs 100-150 yrs
D	Intermediate Intermediate	Moderate Low	Medium Small	150-200 yrs 100 yrs
E	Frequent-Inter Frequent	High Low-Moderate	Large+ Small	90-130 yrs 60 yrs
F	Intermediate Frequent	Moderate-High Low	Small-medium Small	130-190 yrs 80 yrs
G	Intermediate Frequent	Low-Moderate Low	Small Small	100-200 yrs 80 yrs
H	Intermediate Frequent	High Low	Medium-Large Small	100-150 yrs 80 yrs
I	Intermediate Frequent	High Low-Moderate	Large Small	100-150 yrs 60 yrs
J	Intermediate Frequent	High Low	Medium Small	100-200 yrs 18-75 yrs
K	Frequent	Low-Moderate	Small	75 yrs
L	Intermediate	High	Large	58-206 yrs

Frequency	Size	Intensity
Infrequent - >300 year MFRI	Small - <300 acres	Low - 0-30% mortality
Intermediate - 100-300 year	Medium - 350-700 acres	Moderate - 30-70% mortality
Frequent - <100 year MFRI	Large - > 700 acres	High - >70% mortality

Figure 3-3. Historic Fire Regimes



Wind

Wind flow in and around the Upper McKenzie watershed predominately occurs from two directions: southwest and east. The majority of the time, wind blows from either direction with little to no noticeable effect. Depending on the time of year and atmospheric condition, both of these wind directions can occur on a daily basis in the area. Wind flow can change the pattern of vegetation on the landscape in two ways: by blowing over trees and influencing the behavior of fire.

Large wind events have occurred in the area, causing significant changes to the landscape through the creation of openings or gaps that increase the horizontal diversity of stands, and by increasing large woody debris. Windthrow hazard is partially based on the probability of trees being uprooted by wind as a result of insufficient soil depth and inadequate soil strength to provide anchoring of tree roots. Other site characteristics may also influence this hazard seasonally (i.e., soil moisture content and depth to water table). During the spring when soils are saturated by snowmelt and rainfall, windthrow hazard is increased. Coarse textured (sandy) soils such as those common in the watershed are less likely to be affected by seasonal moisture content because they lack the ability to hold moisture in the soil profile. Excess moisture is quickly drained.

The topography influences the effect of wind in several ways. One effect occurs on the lee-side (away from the wind) of ridges, extending for some distance down the slope. This is an area where windthrow often occurs during a storm. Several timber sales in the near Santiam Pass (Spud and Search), along Smith Ridge (Tattoo, End, and Raven), and in the Robinson Lake area (Taffy and FDR) all experienced windthrow during the winter storm of 1990. North and east edges of several units were also affected from the strong influence of the southwest wind that came through the area during that time.

In the watershed, wind is a dominant factor in fire's influence on the landscape. This is evident by examining fire sizes and shapes in the area over the last 90 years. Hundreds of lightning fires have been recorded over time in the watershed. With the advent of fire protection, the majority of these fires have remained very small, usually never exceeding 1/4 acre in size. These fires have had very little influence at a landscape level, though they have strongly influenced the within stand diversity of every plant association group through the creation of gaps. Fires that did grow to a significant size were driven by a strong east wind. East wind is the biggest factor influencing the spread, size and intensity of most of the larger fires within the watershed.

Topography combined with wind patterns also play an important role in fire's influence on the landscape. The summer of 1967 proved to be an active lightning period, with numerous lightning starts in the area. Most of the fires

that stayed small were protected from the influence of the east wind by topographic features. Only those fires influenced by east wind grew to significantly affect the landscape through stand replacement. Figures 3-4 and 3-5 display typical wind patterns in the watershed.

Lightning

Lightning is the primary source of fire ignition within the watershed, typically occurring in the summer months. During the period from 1970 to 1989, no lightning fires were recorded before June or after September in the watershed. Nearly two-thirds of documented fires occurred from mid-July to mid-August (Simon 1991).

There is a wide variance in the number and severity of lightning caused ignitions. They ranged from 0 to 29 fires per year between 1970 and 1989. Many go unnoticed because of their very small size. The average frequency of lightning storms per year is influenced by climate. Climatic variations affect the potential for thunder storms and the fuel flammability. The variation in the annual number of lightning-caused fires is great with a few lightning storms dominating the record. Records show that 1967 produced numerous fires with the majority of them occurring between August 10 and August 28. These included the Airstrip, Cupola, Peggy Creek, Squaw, and Lava Flow fires that burned approximately 6400 acres within the watershed.

There is a strong correlation between summer drought (monthly precipitation) and fire frequency in this area. When average monthly precipitation is compared to monthly lightning fire frequency, the highest occurrence of lightning fires coincides with the lowest average monthly precipitation. This is typical during the months of July and August. Under these conditions, small lightning-caused fires have the potential of becoming large stand-replacement fires.

Fire records documenting lightning fires are based on reported fires. Prior to 1949 (the start of aerial detection) it is very unlikely that all fires were reported. Lightning storms with many ground strikes probably ignited many small unrecorded small fires. Fire detection and suppression improved over time because of improved access, suppression methods, and staffing. Figure 3-6 displays lightning-caused fires per 1000 acres by plant series. The S-TSME is the subalpine portion of the mountain hemlock forests. This series has the most fires because the crest of the Cascades receives significantly more lightning strikes than the lower portions of the watershed.

Figure 3-4. Upper McKenzie Watershed
Normal Westerlies

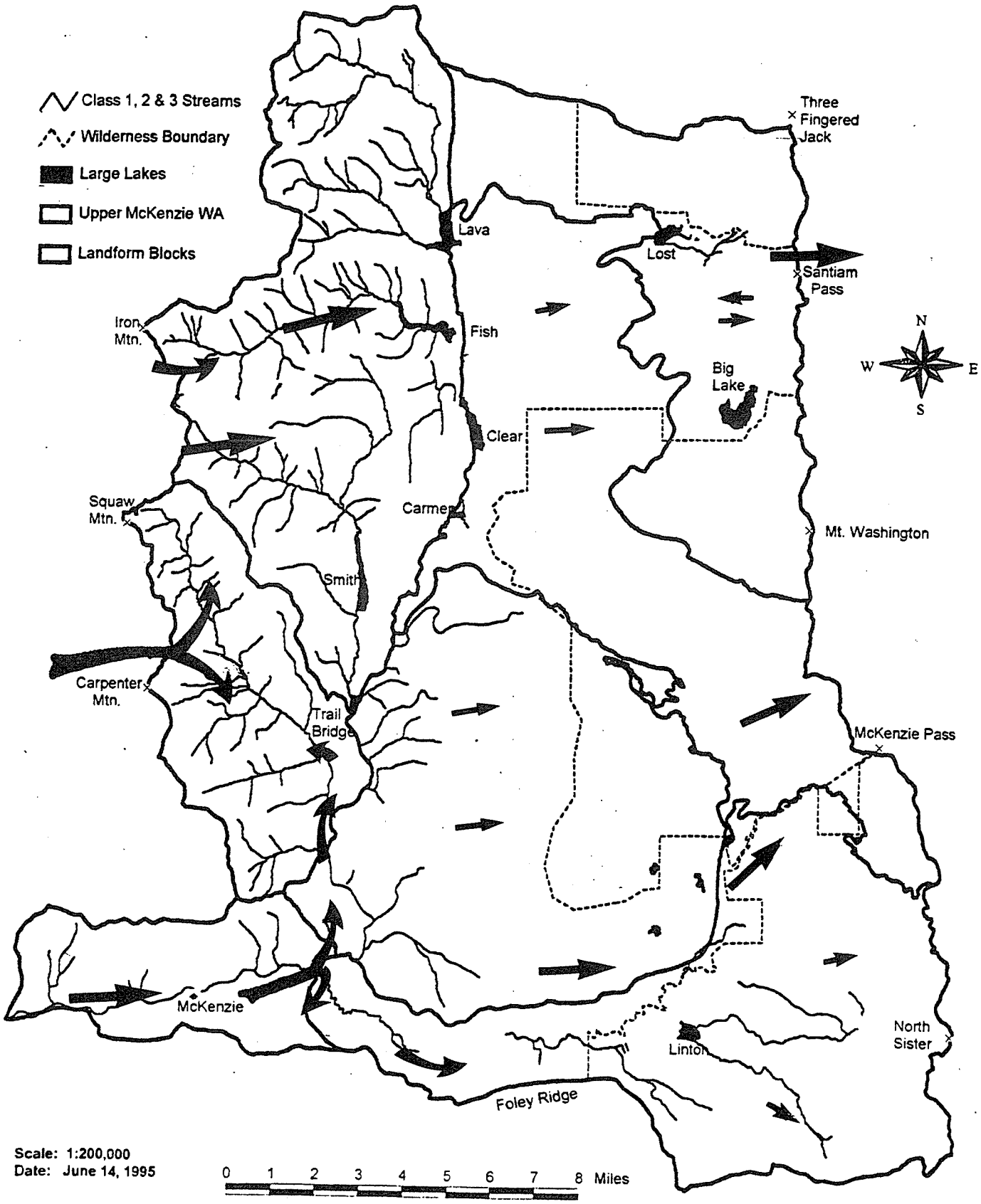


Figure 3-5. Upper McKenzie Watershed
An East Wind Event

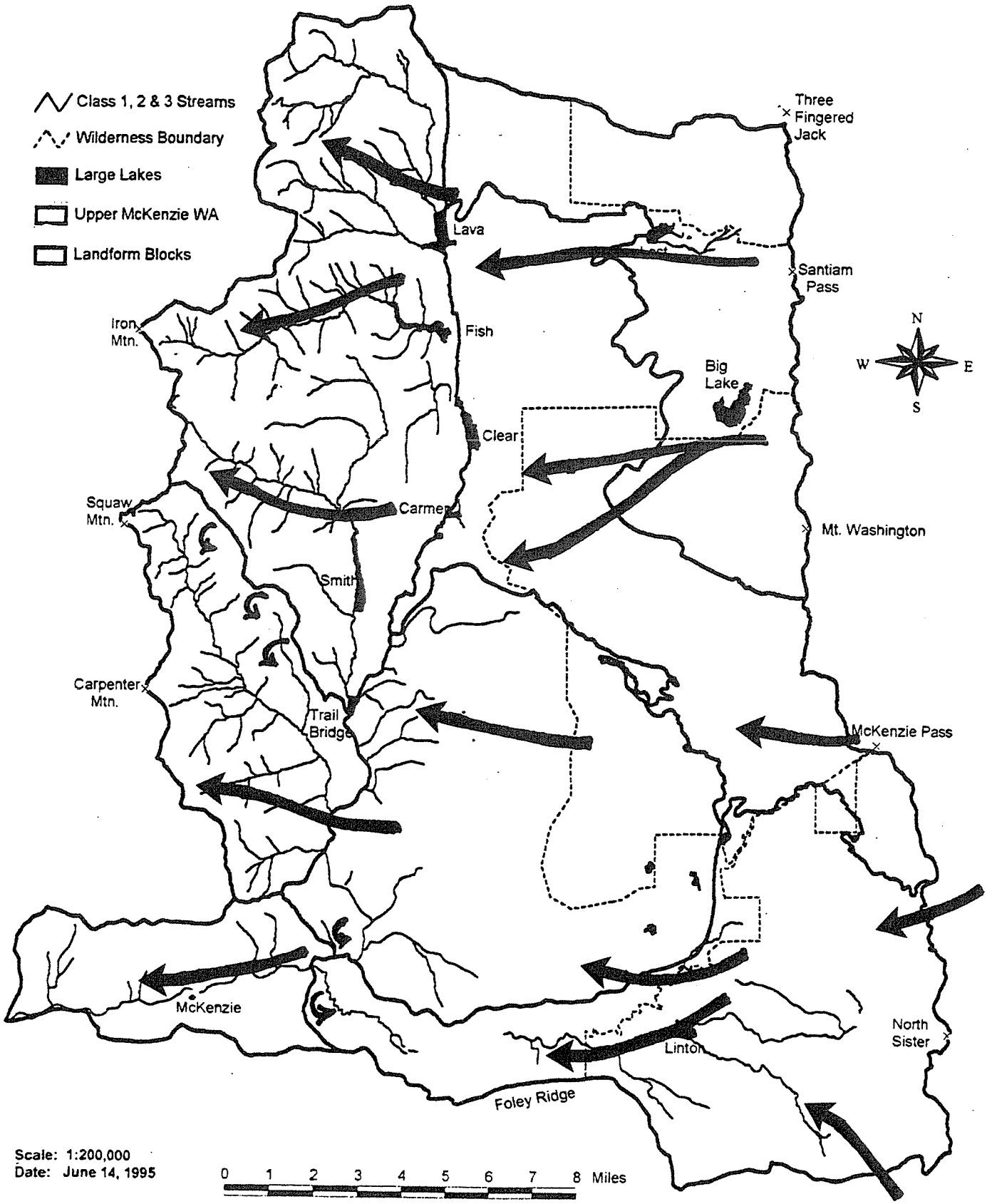
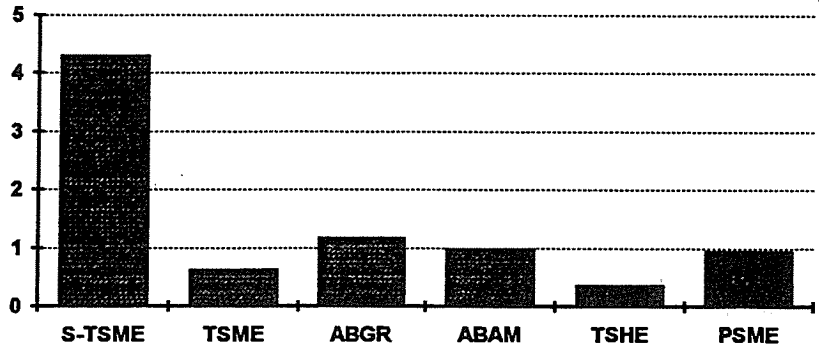


Figure 3-6: Number of Lightning Fires per 1000 acres in the UPMAKWA.



Insects And Disease

The role of insects and disease as a disturbance factor has increased within the watershed because of the increase in fire suppression since the turn of the century. There is evidence to suspect that the cycle of western spruce budworm (*Choristoneura occidentalis*) outbreaks that occur within the watershed is becoming shorter than the historical average.

The two most recently recorded budworm outbreaks are 1949-1953 and 1986-1993. There is also evidence to suspect that the fire suppression of the last 80+ years within the watershed has resulted in larger scale outbreaks than previously recorded. In the absence of fire, the western spruce budworm can play a similar role in the forest, killing tree species and age classes that would have burned if wildfire ignitions had not been successfully suppressed. Because larger outbreaks increase the number of dead and weakened trees, they also influence the magnitude of subsequent fire events.

The development of damaging budworm outbreaks at Santiam Pass depends ultimately on the availability of suitable forest habitat and favorable climate. The availability of suitable budworm habitat is directly related to fire exclusion and the development of multi-storied stands of fire susceptible true fir.

Douglas-fir beetle (*Dendroctonus pseudotsugae*) is the primary insect attacking Douglas-fir trees within the watershed. Douglas-fir beetle population increases are strongly associated with areas of fresh blowdown or dead standing timber. Once Douglas-fir beetle populations become elevated, they infest and are highly destructive to live green Douglas-fir trees. They often infest live trees that are weakened by drought, disease, or competition stress. Douglas-fir beetles can fly many miles over the landscape to find patches of weakened or stressed trees.

Root disease is a factor that affects the vegetative composition and health of the forests in the watershed. The two root diseases that have the most impact are

Armillaria root rot (*Armillaria ostoyae*) and laminated root rot (*Phellinus weirii*). Both of these diseases are widespread within the watershed and are capable of causing considerable tree mortality.

White pine blister rust (*Cronartium ribicola*) has significantly reduced the population of Western white pine within the watershed over the last thirty years. White pine blister rust is a fungus that attacks and kills all five-needle pines. It was inadvertently imported from France in the early 1900's, and it continues to kill and injure many trees. Affected trees in the watershed include western white pine (*Pinus monticola*), whitebark pine (*Pinus albicaulis*), and sugar pine (*Pinus lambertiana*). Rust-resistant strains do occur in nature, and rust-resistant Western white pine planting stock is available for reforestation.

STAND DYNAMICS AND SUCCESSION

Because of the close relationship between disturbance, particularly fire, and the development of vegetation within the watershed, an "initial floristics" model of stand development is most appropriate for this area (with the probable exception of high elevation mountain hemlock). General stages of this model are as follows: early seral, stand initiation, stem exclusion, understory reinitiation, and late-successional old growth.

The early seral stage begins after a disturbance to the preexisting plant community. During this period, seeds present in the seed bank, pioneer invader species, and regrowth from vegetative sprouts dominant the area. In the second stage, stand initiation, conifers regenerate, and shrubs and herbaceous species that were present in the preexisting plant community are usually reestablished in abundance. The next stage is stem exclusion. As saplings grow, a dense canopy develops, limiting the sunlight available to shade-intolerant species and preventing further regeneration. During this period, the natural thinning of the conifers can create openings in the canopy. Shade-tolerant trees, shrubs, herbaceous plants, and cryptogams are established in the understory. Eventually, large trees in the overstory die, creating gaps; younger trees in the lower canopy layers are released; and the stand develops into an old-growth stage with an irregular canopy (Oliver and Larson 1990).

Forest development does not typically proceed in chronological uniformity. It will vary depending on the type of disturbance and intensity, soil composition, macro and micro-environmental conditions and the preexisting plant communities. A seral stage can occupy or overlap in various sequences for an indefinite period of time until site conditions initiate change.

In the watershed, the plant associations present have evolved over time with fire as a frequent natural disturbance influencing successional changes. The effect of

fire (intensity and frequency) has created plant communities with great complexity of species and structural diversity. Many of the plant communities follow a single regeneration pattern under "normal" fire periods. However, succession patterns can change following a disturbance of very short or long fire intervals. The macro- and micro-environment of the watershed, and the dominant role fire has had in the area, have created a landscape of multiple successional pathways. One example of a common succession pattern is the post-fire seral invader species, lodgepole pine. Lodgepole pine is able to invade and dominate following a fire disturbance if it was present in the pre-fire plant community or if a seed source exists for regeneration.

PAST MANAGEMENT ACTIVITIES

Historical grazing for profit was focused on the upper parts of the watershed. Grazing in the lower part was mostly for personal use by homesteaders. Sheepmen of the late 1900's wintered their flocks in eastern Oregon and drove them into the Cascades in May and June to reach the alpine meadows by August. The areas around Mt. Jefferson and the Three Sisters were popular grazing areas and in continual use from the 1880's.

The period of Federal management of the watershed began in September of 1893 when President Grover Cleveland created the Cascade Range Forest Reserve under the jurisdiction of the General Land Office. Grazing was excluded after creation of the forest reserve. However, there were instances of trespass. In 1896, at least 16,000 head of sheep were known to be grazing illegally in the area of the watershed. In 1898, the reserve was reopened to legal grazing using a permit system to regulate the size and range of the sheep herds. The area supported 6 herds of 2000 head each. The grazing agreement required the sheep owners to suppress human-caused fires. In addition, an area of huckleberry patches near the headwaters of the McKenzie River was excluded from grazing.

From 1898 to 1905, management in the forest reserve became more active. Activities included small timber sales, grazing, special product collection, settlement, trail building, and fire suppression. After initial fire suppression efforts in 1898, fire management increased in efficiency as other management activities increased.

Control and management of the forest reserves were transferred to the Secretary of Agriculture in February of 1905. In 1908, the bulk of the watershed was part of the Cascade National Forest; the northern part of the watershed was part of the Oregon National Forest. In 1911, portions of the Oregon National Forest were renamed Santiam National Forest. That Forest included all portions of the watershed north of the Linn County border.

Automobiles first crossed the Santiam Wagon road in 1905. The Santiam Wagon road was built by paying for the construction with alternating sections of land. Some of those sections were later sold to timber companies. Most of this land was later exchanged for property closer to the valley. However, several of the sections of private land in the watershed are holdovers from the original transaction. Grazing reached its legal peak in this area in 1909 and 1910; the grazing tapered-off as old burns and cutover areas were reforested, thereby reducing the available forage. In addition, this was a time of general decline for the grazing industry. Partly in response to grazing competition from sheep, a game refuge was created in the 1920's around the Three Sisters big game summer range where grazing and hunting were forbidden.

In 1933, the Willamette National Forest was created from the Santiam and the Cascade forests. This marked the joining of the watershed under a single administrative unit. After World War II, timber management became an active part of the Upper McKenzie area. Forest Service records indicate that less than 500 acres of federal land in the watershed were harvested before 1950. About 2,800 acres were harvested during the 1950's. This amount is relatively low when compared to the neighboring watersheds.

In the 1960's, timber management in the watershed began in earnest. Between 1960 and 1969, a total of 9,886 acres of timber were harvested. The 1960's figure includes portions of the 5,400 acres that burned in the Airstrip fire of 1967. The harvest amount dropped in the 1970's to 7,400 acres harvested during the decade, as harvests in the Willamette National Forest were focused in other areas. Harvests in the watershed peaked in the 1980's at 14,227 acres total. Acres harvested in the 1980's were concentrated in the later half of the decade because timber sales that defaulted in the early 1980's were re-offered. In addition, market conditions encouraged the timber purchasers to accelerate harvest of sales already under contract. Timber harvest in the first half of the 1990's was 3,453 acre. This is a reduction by more than half from the previous decade because of the new Willamette Forest Plan, various litigation, and the ROD for the President's Plan.

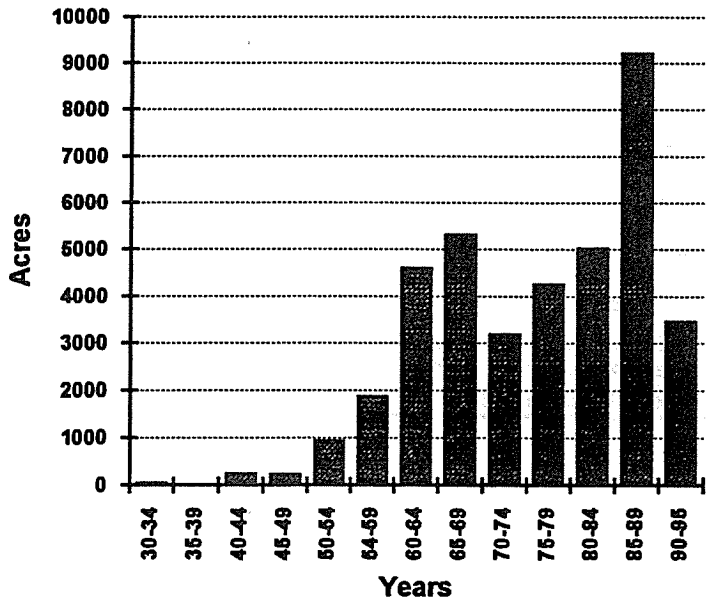
Cumulatively, 38,257 acres of Federal timber have been harvested within the Upper McKenzie area to date. This is about 17% of the total federal watershed area. With private land included, harvested acres in the watershed are about 19.5%. If wilderness areas and non-forest areas are excluded, about 33.6% of the watershed has been harvested, including private lands. Almost all of the harvested acres have been replanted and are currently fully stocked with conifer trees.

The majority of the past timber harvest units have been clearcut. However, differing forest practices have left a varied legacy. Harvests in the early 1960's and before did not remove material that was considered unmerchanable. The

result is the "cull" logs left behind provide a significant source of large woody debris. Timber harvests in the late-60's, 70's, and early 80's were "clean" logging; the purchaser was required to yard most of the down material. Units from the late 1980's to the present have had requirements to leave large woody debris and snags.

Most of units that were treated with a shelterwood harvest were later treated with an overstory removal. The result is much the same as a plantation created by clearcutting. However, about 3300 acres in the watershed received a shelterwood harvest and the overstory trees were not removed. About 60% of these units are in Landblock 5 and about 20% are in Landblock 2B. Plantations that develop under an overstory will grow more slowly and the stand will eventually develop a two-layered canopy. Approximately 37% of the watershed is currently in a late successional condition.

Figure 3-7: Acres harvested in the Upper McKenzie Watershed by Half-decade



FUTURE TIMBER MANAGEMENT

The Upper McKenzie Watershed contains 230,000 acres. After subtracting areas set aside by Congress, areas set aside by the Willamette Forest Plan, and areas set aside by the President's Forest Plan (including riparian reserves), the watershed contains approximately 85,453 acres of suitable and available land that could potentially be harvested. This amount is approximately 37% of the watershed.

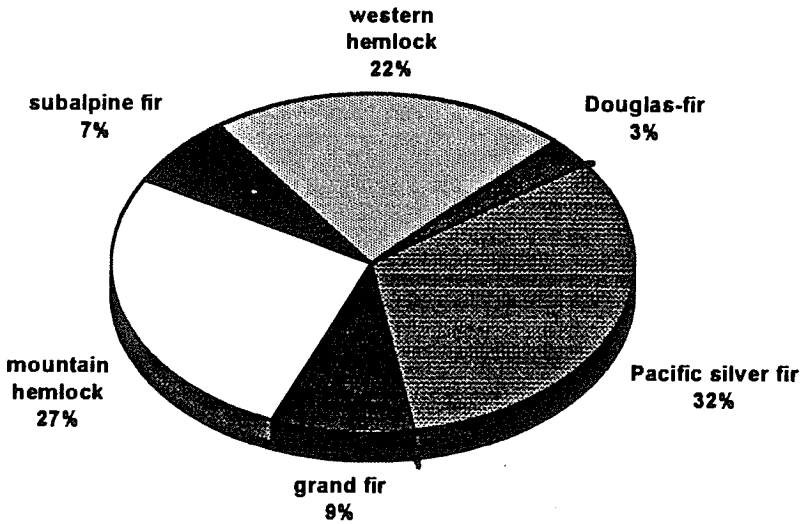
STRATIFICATION BY PLANT ASSOCIATION

The current forested vegetation of this watershed can be best understood by stratifying and discussing the "plant associations" that have developed within this area. Plant associations are the plant communities that have developed or could develop on specific forest sites, given relatively stable environmental conditions and no disturbance. Plant associations can be used as indicators of specific environments. The following summary (Table 3-4a) displays Upper McKenzie plant associations and fire regimes. It was produced from recent stand exam data and a review of literature available on fire and natural disturbance in similar forest types. Figure 3-8 displays the percentage of each plant association within the watershed, and Figure 3-9 displays their location.

Table 3-4a. Upper McKenzie plant series with associated fire return intervals (FRI) and fire intensity regimes.

Upper McKenzie Watershed Plant Series	Site Characteristics	Characteristic Fire Regime
Douglas-fir	Hot, dry sites, on droughty, south-facing slopes. Elev. 3200′ to 4400′	High Intensity FRI 52 - 76 yr. Low Intensity 20-40 yr.
Grand fir	Cool, dry sites, on relatively flat/gentle slopes Elev. 3200′ to 4400′	High Intensity FRI 100 - 200 yr. Low Intensity 18-75 yr.
Western hemlock	Warm, moist sites on a wide variety of slopes & aspects, valley bottoms Elev. 1200′ to 3800′	Medium to High Intensity FRI 130-150 yr. Frequent low intensity under-burns with patchy flair-up
Pacific silver fir	Cool, moist sites, on a variety of slopes and aspects. moderate winter snowpak. Elev. 3600′ to 4600′	Mod & High Intensity FRI 58-206 yr. Low intensity 43-108 years
Mountain hemlock	Cold, dry sites, on flat upper slopes. Deep snowpak. Elev. 4400′ to 5600′	Mod & High Intensity FRI 87-248 yr.

Figure 3-8: Percent of each plant series represented within the watershed



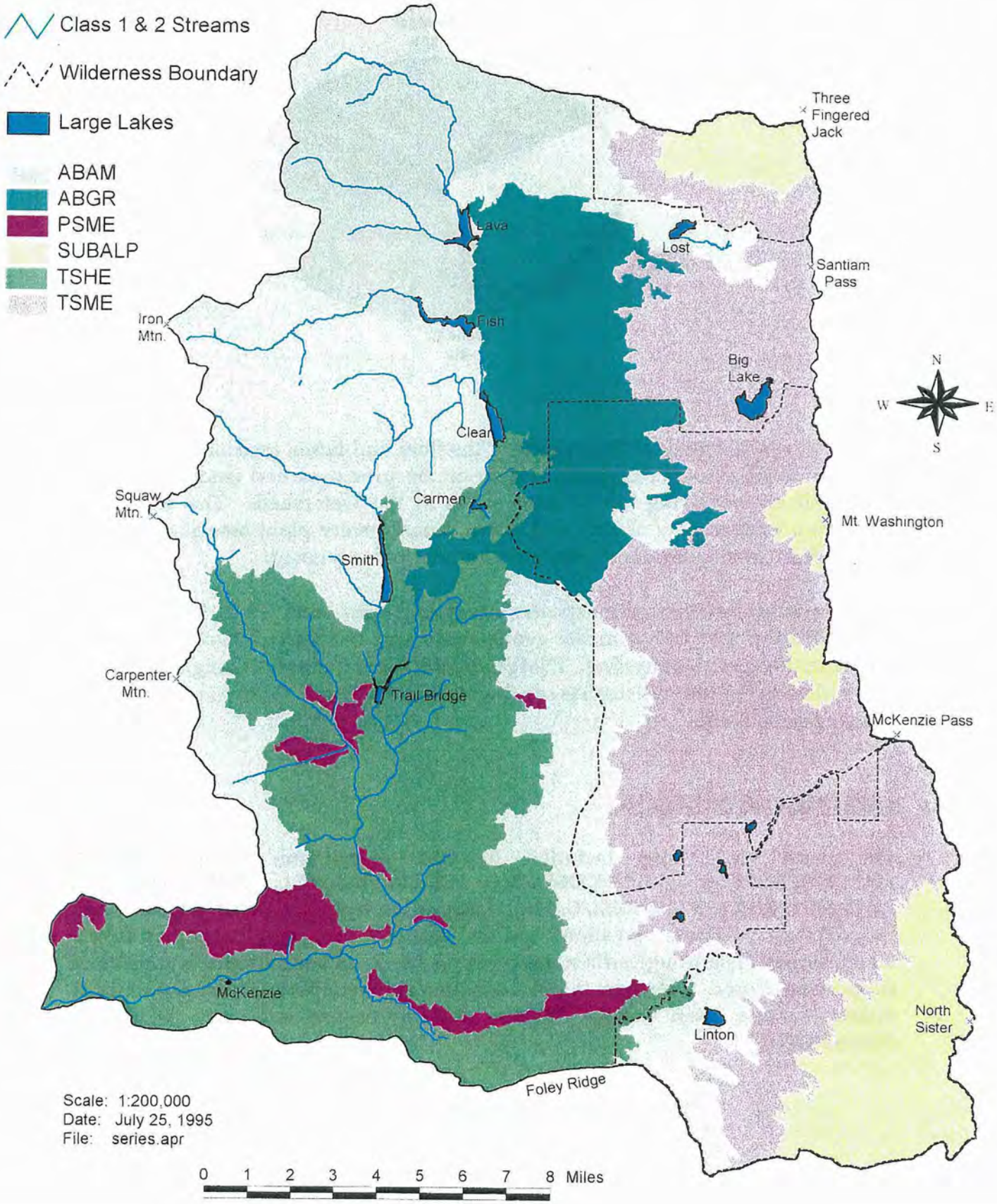
What follows is a general description of the flora and fauna associated with each vegetation series and a characterization of the processes and interactions that have and are occurring within each series in the watershed. The watershed contains a wide variety of site conditions. Nearly every plant association found on the Willamette Forest is represented within this watershed.

For shorthand notation, plant species are given a four letter code. The first two letters are the first letters in the genus name and the second two are the first letters in the species name (e.g., PSME= *Pseudotsuga menziesii* = Douglas-fir). For a complete list of the code names see the Willamette Forest Plant Association and Management Guide.

DOUGLAS-FIR (PSME) SERIES

The plant associations included in this group are: PSME/HODI-BENE, PSME/HODI/GRASS, PSME/HODI-WHMO, PSME/SYMO-WILL, PSME-TSHE/BENE, PSME-TSHE/RHMA, PSME-TSHE/GASH. These sites typically occur on relatively hot, dry sites at lower elevations and on relatively steep south and southwest facing slopes. The Douglas-fir series occupies the driest environments capable of supporting closed forest on the Willamette National Forest. Predawn plant moisture stress often exceeds 15 bars during August and early September (Means 1980).

Figure 3-9. Vegetation Series



Fire Disturbance - Douglas-fir

The growth and development of the Douglas-fir forests within the watershed have been dictated to a large degree by fire. The fire regime for Douglas-fir forests is characterized by moderate to high fire intensity, which generally results in partial or total stand replacement fires.

Lightning is common in these forests and the fire return interval is relatively low. Agee et. al 1990 found a 52 - 76 year mean fire return interval for these forests.

The effect of fire on Douglas-fir forests depends on the species composition and the structure of the vegetation at the time of the fire (Agee 1993). Douglas-fir is moderately resistant to fire, especially at mid to late age. Douglas-fir has thick bark that insulates the cambium against damage. In mature stands its height helps it to avoid crown scorch (Agee 1993). Low intensity fires generally only kill the thinner barked, less fire resistant trees and shrubs.

Woody Debris/Fuel Loading - Douglas-fir

Because of the frequent fire return intervals, levels of woody debris and fuel loadings do not get very high. Most of the woody debris is large Douglas-fir logs that are capable of surviving low intensity fires. Although the Logs are large, the average tonnage per acre is not great. Fuel loadings less than 20 tons per acre are common.

Comparison of Historic Versus Existing Landscape Vegetation - Douglas-fir

Using old timber inventory maps and past fire history information, we were able to develop an approximation of the vegetation within the watershed area in the year 1900. Figures 3-10 and 3-11 displays the change in vegetation from the years 1900 to 1995 within the Douglas-fir.

Figure 3-12 graphically displays a shift of the overall vegetation from a predominance of early seral (1900) to a dominance of mid to late seral condition (1995). This shift in dominance to mid to late seral corresponds to our era of fire suppression, approximately 1910 to the present. Historic information on the composition and distribution of vegetation was not compiled specifically for Douglas-fir forests during the Regional Ecosystem Assessment Project (REAP). forests. Early seral stages include grass/forb, open sapling/pole, shelterwood, and shrub conditions; Mid-1 includes closed sapling/pole, Mid-2 includes open small saw and closed small saw conditions; Late includes large saw and old growth.

Figure 3-10. Existing Vegetation Current Structural Stage

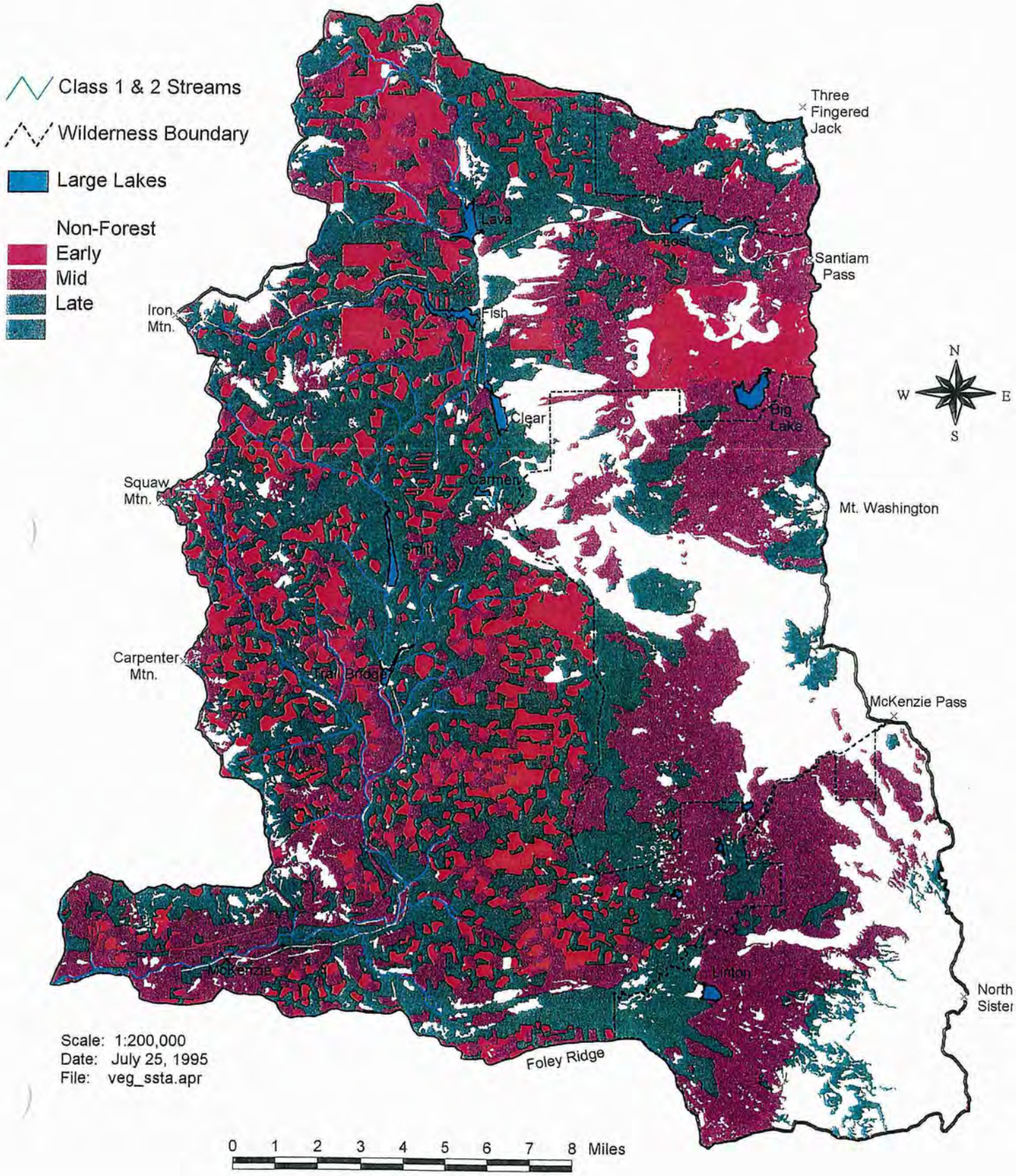


Figure 3-11. Historic Vegetation Historical Structural Stage

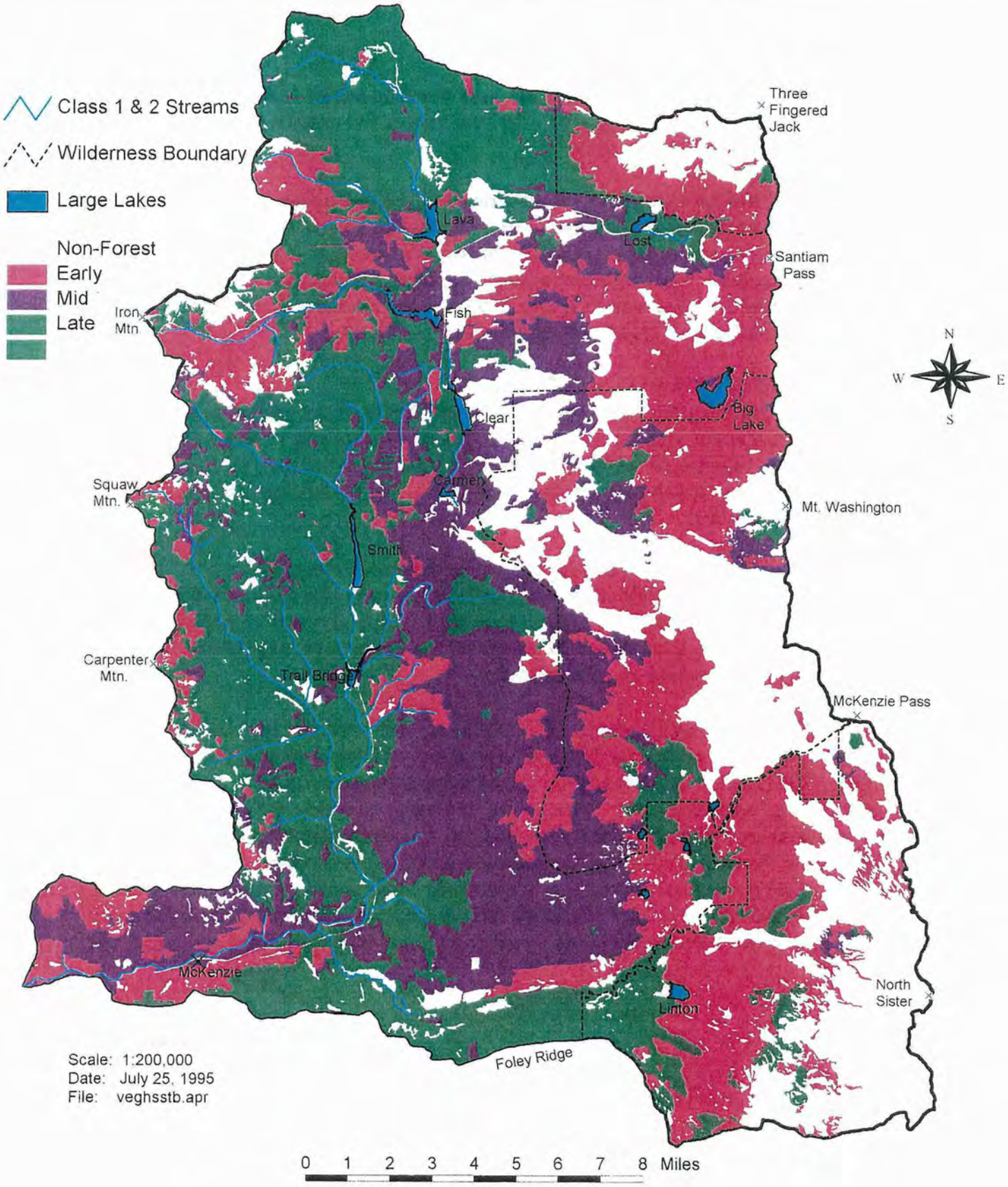
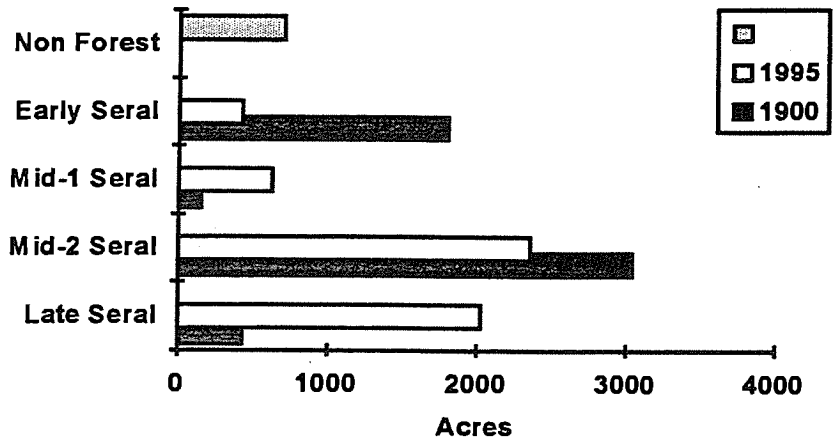


Figure 3-12: Acres of Current and Historic Douglas-fir Seral Stages



Wildlife Use - Douglas-fir

These forests only comprise 3% of this watershed. Their contribution to wildlife habitat is limited. Therefore, the discussion on these forests will be limited. Douglas-fir forest habitat in this watershed consists of 6 small, mature to late seral islands on harsh slopes. Patches range from 50-900 acres in size. These areas were frequently burned over, providing intermittent early-seral habitat. They are slow to regenerate because of the harsh conditions, so an open habitat was prolonged. Frequent fire return intervals probably restricted their ability to develop into late-successional habitat. Because of the prolonged open stage, these areas may have functioned as reservoirs for early seral species. There is no available data on snag or down woody debris levels for these stands. Snag levels are probably low because of the high falldown rates on the steep slopes. Large woody debris levels are probably higher than historical levels since fire exclusion has allowed build-ups in these areas.

Management of these patches has not included clearcut harvesting. Difficulty in regeneration will heavily influence future management. These are areas where future influence of fire should be allowed to maintain their health.

Botanical Resources - Douglas Fir

Four Douglas-fir associations found Landform Blocks 1,2A, 2B, 4 and 4 are more commonly found in forest communities and environmental conditions typical of the Cascade range to the south. The distribution and occurrence of these and other uncommon forested plant associations contribute to the biological and ecological diversity of the watershed. One documented occurrence of *Allotropa virgata,* a species listed in Table C-3 occurs in the Douglas-fir-western hemlock/Oregon grape plant association. *Allotropa virgata* is discussed in more detail in the Botanical Overview Section in this chapter.

GRAND FIR FIR (ABGR) SERIES

The plant associations included in this group are: ABGR/BENE, ABGR/CHUM, and ABGR/ARUV. These sites typically have more moisture than Douglas-fir plant associations, less moisture than Pacific silver fir sites, and they are warmer than mountain hemlock sites.

Grand fir forests on the west side of the Cascades are relatively uncommon, but do exist in several other areas of the Willamette National Forest, particularly areas of the Rigdon Ranger District. Grand fir forests are typically associated with the drier, colder environment on the east side of the Cascade Crest. West-side grand fir sites occupy relatively cool, dry, well-drained, rocky, or ashy soils in Eastside to Westside transition areas. The topography of the grand fir forests in the watershed is relatively flat to gently sloping, with an elevation ranging from 3200 to 4400 feet. These grand fir forests are fairly contiguous and uniform in age and structure.

Fire Disturbance - Grand Fir

The growth and development of the grand fir forests within the watershed have been largely influenced by natural fire. Fire events within the grand fir forest, identified through tree age data, old inventory maps and literature review occurred in: 1950, 1925, 1905-1915, 1880-1885, 1860, 1775-1780, 1745, 1705.

The fire regime for grand fir forests is characterized by low to moderate fire intensity, which generally results in ground fires or partial stand-replacement fires. The fire regime can be characterized as relatively frequent low intensity burns (18-75 years) and less frequent moderate to high intensity stand replacement events (100-200 years).

The effect of fire on grand fir forests depends on the species composition and the structure of the vegetation at the time of the fire (Agee 1993). Grand fir is moderately susceptible to fire. Its low branching habit, flammable foliage, heavy lichen growth, relatively shallow roots, and high stocking density, all tend to increase its susceptibility to fire damage. High intensity fires kill grand fir and favor the regeneration of shrubs and lodgepole pine by creating a hot, dry, mineral-soil seed bed. Fires of moderate intensity often kill grand fir and increase the dominance of Douglas-fir relative to lodgepole pine or grand fir. Douglas-fir has thick bark that insulates the cambium against damage. In mature stands its height helps it to avoid crown scorch (Agee 1993). Low intensity fires generally only kill the thinner barked, less fire resistant grand fir (especially young grand fir seedling and saplings).

Historically, low intensity burns that remove the stands' understory layer, have been common in these grand fir forests. Several years following low intensity burns, a new cohort of regeneration will develop. Depending on the intensity of

the fire, this new cohort generally develops as shade-tolerant grand fir (Larson 1982) beneath an overstory of older, residual Douglas-fir that had survived the fire.

Substantial understory development, whether it occurs because of low severity fire or after the breakup of early seral lodgepole pine in the canopy, will encourage an "understory reinitiation" stage in stand development (Oliver 1981). Because of the "fire ladder" nature of this understory structure, it is closely associated with increased crown fire potential (Agee 1993). A long interval between underburns promotes the development of a tall understory, which has a higher probability of crowning (Davis et al. 1980), especially under severe burning conditions. Severe conditions often occur in late summer or early fall, and are associated with east winds.

The majority of the grand fir sites within the watershed are in this "understory re-initiation" phase of stand development. Eighty years of fire suppression has allowed a moderately high level of fuel and understory to develop in the grand fir stands in the watershed. This condition was historically transitory as a precursor to large, stand replacement fire events.

Woody Debris / Fuel Loading - Grand Fir

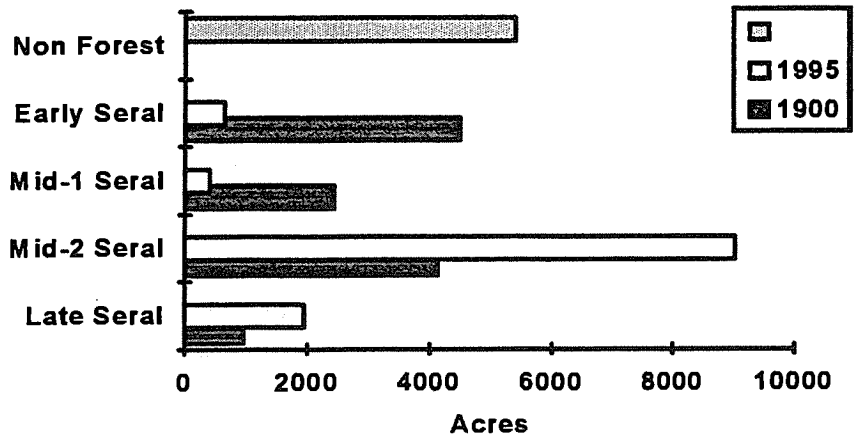
Site specific, quantitative descriptions of woody debris levels on grand fir sites are scarce. Downed, woody fuel on similar habitat types inventoried by Fischer (1981) in Western Montana ranged between about 13 and 38 tons per acre. The heavier levels tended to occur in very moist stream-side locations. Drier upland sites varied between 13 and 20 tons per acre. Natural debris loadings taken from limited field exams in the Upper McKenzie area show fuel loadings of 25 to 45 tons per acre. These loading are relatively high for this type. Much of this fuel is lodgepole pine mortality that occurs naturally during the "understory reinitiation" phase of stand development.

Comparison of Historic Versus Existing Landscape Vegetation - Grand Fir

Using old timber inventory maps and past fire history information, we were able to develop an approximation of the vegetation within the Upper McKenzie area in the year 1900. Figures 3-10 and 3-11 display the changes in vegetation from the years 1900 to 1995 within the grand fir forests.

Figure 3-13 graphically displays the shift of the overall vegetation from a predominance of early seral (1900) to a dominance of mid and late seral condition (1995). This shift in dominance to mid and late seral corresponds to our era of fire suppression, approximately 1910 to the present. Historical information on the composition and distribution of vegetation was not compiled specifically for Grand fir forests during the Regional Ecosystem Assessment Project (REAP).

Figure 3-13: Acres of Current and Historic Grand fir Seral Stages



Wildlife Use - Grand Fir

Two hundred and seventeen species use the grand fir zone for breeding and foraging. Uncommon, non-TES species documented in the area include the N. Goshawk. Potential habitat for TES such as the Townsend's big-eared bat, wolverine, and spotted owl occurs in the area. ROD species of concern that may occur in the area include the black-backed woodpecker, great gray owl, and red tree vole. Underlined species have been documented in the area.

Habitat - Grand Fir

These forests are at a moderate elevation sandwiched between Pacific silver and Mt. Hemlock forests. The species that occur in this area vary by forest developmental stage. Species such as mountain quail, white crowned sparrow, and western pocket gopher are associated with early seral conditions, while three-toed and black-backed woodpeckers are associated with mid to the late seral conditions with large diameter Douglas-fir and grand fir overstory.

Early Seral - Grand Fir

Historically, large patches of early seral habitat were periodically created by stand-replacement fires. Patches created from incidental mortality associated with ground fires were more common. These patches were often small and transient. Post-fire conditions included abundant dead material in the form of snags and down, large woody material. Grand fir are moderately susceptible to fire, and most do not survive stand replacing events. Large diameter Douglas-fir, often present in these stands, survive fires to provide residual green tree structure in the developing stand. The fire disturbances resulted in a mosaic of age classes and structures.

Large patches were a major landscape component around the turn of the century because of settler activity. Reburns were probably common, resulting in a

diminished density of snag and down woody debris components. With the advent of fire suppression activity in the early 1900's, the availability of large or small patches of early seral habitat was dramatically reduced.

In the last 30 years, very little early seral habitat has been created in this forest type through clearcutting. These stands are often on unsuited soils. The clearcut patches that do exist are small and lacking in important structural components typically found after a fire event. Snags, down woody material, and residual green trees were not retained in these units.

Table 3-5 displays a comparison of the distribution and availability of this habitat during 1900 and 1994. Early seral habitat has become significantly less abundant. The number of patches has increased, but they are significantly smaller with less variability than the 1900 condition. The 1900 data indicates moderately sized patches with higher edge densities, which reflects the variable effects of fire activity. These trends can be attributed to the decrease in fire activity associated with increased fire suppression efforts. Figures 3-10 and 3-11 show the change in distribution of this habitat type on this landscape.

Table 3-5: Characteristics of early seral grand fir habitat in 1900 and 1995.

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
4505	25	180	2.1	654	33	20	.5
SD		390				54	

There is no data available for historic range of variability (RNV) in grand fir forests. However, the significant reduction in early-seral may indicates a trend outside of the RNV. The habitat that does exist is of extremely low quality. Very little LWD or snags were retained in the harvested areas. There are no wildlife species that are solely dependent on the early seral stage of grand fir habitat, though could be used by 216 species for breeding. It is important that this habitat type continue to exist on the landscape to maintain the distribution of early seral species. These mid-elevation forests are an important link between lower and higher elevation bands of forest. It is important that future management retain snags, LWD, and large-diameter, live residual trees, such as Douglas-fir.

Mid and Late Seral - Grand Fir

The availability of this habitat type has not fluctuated greatly over time. Mid and late seral habitat has dominated this landscape for over 100 years. The abundance has increased over this century with increased fire protection efforts. Protection efforts have also changed the structure of these stands, increasing the

vertical diversity. Table 3-6 displays data comparing the landscapes from these two time periods. Figures 3-10 and 3-11 display their change in distribution.

Table 3-6: Characteristics of mid and late seral grand fir habitat in 1900 and 1995.

Mid-seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
6155	34	180	2.5	7017	31	227	3.3
SD		417				670	

Late seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
1405	14	101	0.7	4394	34	`128	2.1
SD		91				192	

Fire suppression efforts have resulted and will continue to result in a trend of increased availability of mid and late-seral grand fir habitat. This is beneficial to species that are associated with this habitat type.

The quality of this habitat type has been degraded by spruce budworm. Simplification of structure, reduction in diameter growth, and mortality has occurred. Spruce budworm is an important agent in creating biodiversity on a landscape, and it is also an important food source for many forest-dwelling birds, mammals, and insects. At epidemic levels, it can seriously reduce the quality of habitat for species dependent on large diameter trees and multi-storied canopies. At epidemic levels, local populations of wildlife have little impact on spruce budworm populations. It is critical that in stands susceptible to spruce budworm, habitat components important to spruce budworm predators be available at 100% levels. This includes abundant snags for birds such as the pileated woodpecker and abundant down woody debris that provides habitat for ants and voles.

Douglas-fir beetle is killing many of the large diameter firs in areas with high levels of standing and down dead material. Within the grand fir forests, Douglas-fir is an important structural component, exhibiting larger diameters than the grand firs. It is also important because of its tenacity through fire events, described above. With the loss of these trees, the availability of large diameter, high quality snags will increase in the short term. Snags are generally

not limiting in this area, and this surge in abundance is not expected to result in increased populations of snag-dependent species.

Snags and Large Woody Material - Grand fir

Forests in the grand fir zone are considered habitat for the three-toed woodpecker, black-backed woodpecker, and williamson's sapsucker. Forested stands in the grand fir zone can produce trees large enough to sustain snag habitat > 18" dbh. The unmanaged grand fir stands on average contain 0.5 snags/acre ≥ 18" dbh (Table 3-7). The snags are primarily lodgepole pine. Each tree is only counted as 1/2 a snag because of the short period of time they function as standing habitat. They typically fall over quickly, and even as standing stags, they do not display heart rots important for many PCE's. There are 4.5 snags/acre ≥ 12" dbh available. Smaller diameter trees will be used by black-backed and 3-toed woodpeckers and Williamson's sapsucker (Goggans et. al. 1987, Marshall 1992, Thomas et. al. 1979). Existing harvest units are contributing no snag habitat on this landscape. These areas will continue to be devoid of snags > 12" until late in their successional development (75+ years). Species that depend on snags in this zone include 2 species of amphibians, 28 birds, and 21 mammals.

Table 3-7: Snags by species and size class in unmanaged late seral grand fir stands. (SAF=subalpine fir, GF=grand fir, DF=Douglas-fir, LP=lodgepole pine, MH=mountain hemlock, WP=white pine, WH=western hemlock)

SIZE CLASS	SAF	GF	DF	LP	MH	WP	WH
11-12.9				12			
13-14.9							
15-16.9			2	2			
17-18.9				2			
19-20.9							
21-22.9				1			
23-24.9							
25-26.9							

Avg number of snags/acre for all size classes (0-25+") = 10

Because of the abundance of insect and diseases in the forests of this zone, levels of small diameter snags (<12" dbh) and large woody material are high.

Botanical Resources - Grand Fir

Two rare grand fir plant association are located in the portion of the watershed on the Sweet Home Ranger District. The sensitive plant *Botrychium montanum* is found within one of these: the grand fir/Oregon grape plant association. The grand fir/prince's pine plant association occurs frequently on the McKenzie RD,

its distribution is considered rare in the Sweet Home RD. *Allotropa virgata* is documented in the grand fir/bearberry plant association in landform blocks 3 and 4.

MOUNTAIN HEMLOCK (TSME) SERIES

The plant associations included in this group are: TSME/VAME/XETE, TSME/VASC, TSME/RHMA, and TSME/LUZULA.

The climate of mountain hemlock forests is characterized by relatively cold winter temperatures, substantial winter snowpack, and short growing seasons. Mountain hemlock sites are colder and less productive than lower elevation grand fir sites. Despite substantial rainfall, mountain hemlock sites tend to retain less moisture than Pacific silver fir sites in the Upper McKenzie area. The elevation of these forests ranges from 4400 to 5600 feet.

Franklin and Dryness (1973) divide the mountain hemlock forest into two major subzones, a lower subzone of closed forest and an upper parkland subzone. In the lower subzone, there is essentially continuous forest cover of mountain hemlock and it main associates, lodgepole pine and subalpine fir. The upper subzone (high elevation area surrounding Mt. Washington, Three Finger Jack, Belknap Crater, and the Three Sisters) is a mosaic of forest patches and tree groups interspersed with shrubby or herbaceous subalpine communities.

Fire Disturbance - Mountain Hemlock

The growth and development of the mountain hemlock forests within the watershed have been dictated to a large degree by natural fire. Fire events within the mountain hemlock forest, identified through tree age data, old inventory maps and literature review occurred in: 1968, 1945-1950, 1925-1930, 1900-1915, 1880-1885, 1860, 1835-1840, 1825.

Mountain hemlocks are not well adapted to survive fire: they are fire avoiders (Agee 1993). Most fires within the mountain hemlock zone are stand replacement fires. Because of the lack of fire resistance of the species, within-stand individual tree and small group disturbance is more likely to be related to insect and disease mortality.

Mountain hemlock forests display very complicated fire behavior. The fires within the mountain hemlock forests are often weather-driven, resulting in erratic behavior. Fire behavior estimates based on natural fuel loads generally underestimate the fire potential of these mountain hemlock forests (Agee 1993). This is evident in the mountain hemlock zone in and around Santiam Pass. The fuel loadings do not indicate a significant fire hazard, but mountain hemlock has low-hanging branches, highly flammable foliage, and a tendency to grow in

dense groups that make it very susceptible to fire injury. Mountain hemlock is easily killed by fire from root charring and crown scorching.

According to the scientific literature, the fire return interval of mountain hemlock forests is highly variable. Because dense subalpine forests transition into parkland and alpine areas, a clear delineation of zones is difficult, and estimates of fire-return intervals are often not possible (Agee 1993).

The results of a fire study on the Mt. Jefferson Wilderness indicate the fire regime of mountain hemlock forests tends to include moderate to high intensity stand replacement fires on a moderate to long fire return interval. The fire return interval for stand replacement fires from nearby east-side sites on the Mt. Jefferson Wilderness range from 87 to 248 years (Simon 1991). Considering tree age class data gathered during stand examination on the area directly around Santiam Pass, the return intervals between stand replacement events range from 28 to 48 years.

Clearly the Santiam Pass area of the watershed has burned more frequently than anticipated through the literature and probably more frequently that the higher elevation areas away from this historical travelway. This area has a history of road building, railroad building, and travel starting in the mid 1800's. This period of intense settler activity and the relatively short time period actually viewed through existing tree age class data probably does not represent a long-term historical view of the fire regime for mountain hemlock forests. Simon's (1991) estimate of a 87-248 year fire return interval for partial or complete stand replacement is probably our best approximation of historical fire activity throughout the entire zone.

Lodgepole pine is the major pioneer species in the high cascades portion of the mountain hemlock zone. Mountain hemlock does not regenerate quickly or easily following intense fire, often taking decades to reestablish. Post-stand replacement fire communities are usually dominated by shrubs, such as *Ceanothus* or *Vaccinium*, and lodgepole pine. Mountain hemlock and subalpine fir often regenerate in the partial shade of the lodgepole pine overstory. As the lodgepole pine stands grow older and lose their dominance (approximately 80 years), gaps are created, and the mountain hemlock understory responds to the additional sunlight and available resources. Mountain hemlock will then retain dominance at the site until a stand replacement fire resets this cycle. Subalpine fir, Engelmann spruce, and western white pine will form an uneven understory with a forest floor composed of shrubs and herbaceous species.

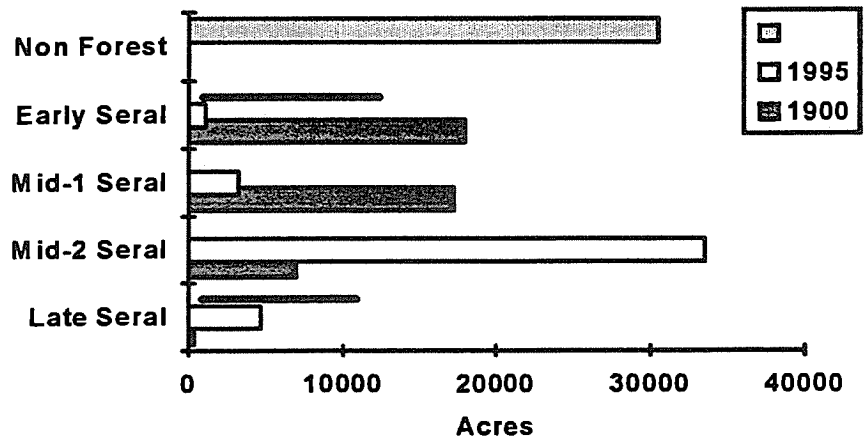
Fuel Loading - Mountain Hemlock

Eighty years of fire suppression has allowed a moderate level of fuel to develop for this forest type. Natural fuel loads taken from field exams produced 10 to 30 tons per acre.

Comparison of Historic Versus Existing Landscape Vegetation - Mountain Hemlock

The following information is patterned after the Regional Ecological Assessment Project, which used a course filter approach to investigate the range of natural historical conditions by plant series and seral stage in the region. The REAP process stratified the landscape into 3 age groups: early (1-20 years), mid (20-50 years), and late (200+ years). The age class between 50 and 199 was not analyzed during the REAP process. Figure 3-14 displays the acres of the mountain hemlock forest in each seral stage at 2 points in time. The dark solid line represents a historical range of variability from 1600 to 1850. We are displaying that information for the years 1900 and 1995 as "Mid-2" to compare the change in the landscape within this century. The overall vegetation shifted from a predominance of early seral (1900) to a dominance of mid to late seral condition (1995). This shift in dominance to mid to late seral corresponds to our era of fire suppression, approximately 1910 to the present. The dark solid line represents a historical range of variability from 1600 to 1850.

Figure 3-14: Acres of Current and Historic Mountain hemlock seral stages.



Wildlife Use - Mountain Hemlock

One hundred and fifty-six wildlife species use mountain hemlock forest for breeding and foraging. Uncommon, non-TES species documented in these forests include the N. goshawk, golden eagle, mountain bluebird, three-toed woodpecker, badger, pika, yellow-bellied marmot, and short-horned lizard.

Potential habitat for TES species such as peregrine falcon, bald eagle, wolverine, and Townsend's big-eared bat occurs here. Habitat for ROD species of concern includes the black-backed woodpecker and great gray owl. Surveys have documented the species underlined.

Habitat - Mountain Hemlock

The mountain. hemlock forests fall within an ecotone between eastside and westside forest systems, resulting in high species' richness. The occurrence of species varies by forest structural stage. For example, the golden-mantled ground squirrel and short-horned lizard are associated with early seral conditions or open forest conditions, while three-toed woodpeckers and pine marten are associated with mid or late seral conditions.

Early Seral - Mountain Hemlock

In Mt. hemlock forests, early seral habitat historically resulted from catastrophic fire events. Post-fire conditions included abundant standing and down woody material. Mountain hemlocks are very susceptible to fire, resulting in few residual green trees on the landscape following stand-replacing fire events. Partial stand-replacement events occasionally create a mosaic of live patches of varying sizes. Areas protected by topography also provided patches of green tree remnants.

Historically, early-seral habitat was a major component of this landscape. Patches were generally large with irregular edges. As white settlers began to use this landscape, the increased frequency of fires in the late 1800's resulted in an extended availability of early seral habitat. Reburns were common, resulting in a diminished density of snag and down woody debris components. Fire suppression activity from 1900 on may have resulted in a decreased availability of early seral habitat in these forests. The Big Lake Burn in 1967 created a 9000 acre patch of early seral habitat. The burn area was heavily salvaged, and the majority of dead and alive woody material was removed. Snag and down woody material levels are currently low, reducing habitat quality. The majority of the burn is still in an early seral condition. Thinning prescribed for these stands were designed to increase horizontal diversity. Patches of dense lodgepole thickets were retained to provide cover and pockets of insects.

Table 3-8 displays a comparison of the distribution and availability of this habitat in 1900 and 1995. Very little early seral habitat has been created in this forest type in the past 30 years. Nineteen percent of the landscape was in early seral mountain hemlock forests at the turn of the century. Now only 2% is in this condition, and important structural components typically found after a fire event were not retained in these areas. The average patch size created through clearcutting is also very dissimilar to what was historically present. Mean patch sizes are now 209 acres, versus 886 acres in 1900. The number of patches has decreased, and they tend to have regular edges compared to the highly variable edges created by fire. The patches have also become more variable in size, which is indicated in the larger standard deviation.

Table 3-8: Characteristics of early seral Mountain Hemlock habitat in 1900 and 1995.

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
34651	39	886	7.4	3989	19	209	1.1
SD		2820				7577	

The abundance of this habitat is currently trending outside of the historic range of variability. Habitat that does occur is very low in quality because they lack structural elements. There are no wildlife species that are solely dependent on the early seral stage of Mt. hemlock forests, though 106 species may use it for breeding. These are some of the highest elevation early seral patches, and they are important to maintain species' distribution in the watershed.

Whether early seral habitat is created through a future stand replacement fire or regeneration harvest, it is important that future management retains habitat components such as snags and down woody material to provide a quality early seral stage condition. Thirty-two percent of the species that use early seral habitat in Mt. hemlock forests require snags for breeding. Thirty-eight percent require large down woody material.

It is important to mention that during post-fire rehabilitation efforts following the Big Lake Burn, wheat laced with 1080 strychnine was dropped at 6 pounds to the acre to reduce the rodent population. This rodent-control activity occurred for several years. The long-term effects to this environment is unknown. Impacts to the food chain, particularly predators of the rodent population that may have absorbed this chemical, is unknown.

Mid and Late Seral - Mountain hemlock

Little mid and late seral habitat was available in the late 1800's and 1900's because of human caused fires and no suppression of natural fires. Over the past 70 years, fire suppression has allowed stands to succeed, and the abundance and distribution of mid and late seral habitat has changed. Table 3-9 displays data comparing the landscapes from these two time periods. Larger blocks of mid seral stands with irregular edges are now available throughout the area. Variability in patch size has also increased, which is indicated by the larger standard deviation. Average patch size of late seral stands has not significantly changed, though there are more of them. Figures 3-10 and 3-11 display their change in distribution.

Table 3-9: Characteristics of mid and late seral mountain hemlock habitat in 1900 and 1995.

Mid Seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
4162	33	126	1.8	32559	50	649	3.3
SD		304				2306	

Late Seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
3742	24	156	1.6	6007	41	146	1.7
SD		333				301	

The abundance of late seral habitat is currently within the range of natural conditions. Fire suppression efforts will result in a trend of increased availability of mid and late seral mountain hemlock habitat. This is beneficial to species that are associated with these high elevation forests, such as pine marten, black-backed and three-toed woodpeckers. This habitat is currently well distributed, and patches are large enough to provide high quality habitat. Mid seral stands created from historic fires general have important structural components. Those that succeeded from previous clearcuts are not as high a quality.

In the absence of fire, insects and diseases will have the greatest effect on this habitat. At a stand level, insects and disease can simplify stand structures, resulting in reduced vertical diversity and loss of niches for wildlife. However, they also result in an abundance of snags and large woody material, which are important breeding habitat for more than 51 species in this area. At the landscape level, these diseases increase horizontal diversity as they create pockets of mortality. Mistletoe is used by several species for food, nesting structures, and cover. It can also create spike tops, which provide mini-snag habitat used by wildlife. Mistletoe infections rarely reduce habitat quality for wildlife species. In general, these diseases are not expected to reduce the overall quality of Mountain hemlock habitat on this landscape.

Snags and Large Woody Material - Mountain Hemlock

Forests in the mountain hemlock zone are considered key habitat for the three-toed woodpecker, black-backed woodpecker, and williamson's sapsucker

All three species are on the state sensitive list because of loss of mature and old growth stands within their range.

These forested stands can produce trees large enough for snags > 18" dbh, but they are not abundant. This is due to the short growing season, harsh conditions, and natural fire disturbance. The unmanaged mountain hemlock stands on average contain only 2 snags/acre ≥ 18" dbh. Lodgepole pine snags are counted as 1/2 a snag because of the short period of time they function as standing habitat. They fall over quickly, and even as standing stags, they do not display heart rots important for many PCE's. There are 12.5 snags/acre ≥ 12" dbh available (Table 3-10) Smaller diameter trees will be used by black-backed and 3-toed woodpeckers and Williamson's sapsucker (Goggans et. al. 1987, Marshall 1992, Thomas et. al. 1979). No snag habitat is being contributed from existing harvest units. These areas will continue to be devoid of snags > 12" until late in their successional development (75+ years). Species that depend on snags in this zone include 2 species of amphibians, 28 birds, and 21 mammals.

Table 3-10: Snags by species and size class in unmanaged mountain hemlock stands. (SAF=subalpine fir, GF=grand fir, DF=douglas-fir, LP=lodgepole pine, MH=Mt. hemlock, WP=white pine, WH=w.hemlock.

SIZE CLASS	SAF	GF	DF	LP	MH	WP	WH
11-12.9	9						
13-14.9	8						
15-16.9							
17-18.9				5			
19-20.9							
21-22.9				1			
23-24.9							
25-26.9		2					

Avg number of snags/acre of all size classes (0-25+") = 50

The ROD requires retention of habitat for 100% population levels of the black-backed woodpecker. Additionally, 40% habitat levels are required for other primary cavity excavators (PCE). This would require at least 1.8 snags/acre >12" dbh in treated areas. Stand exams indicate this level of snag habitat (on average) does occur in this area. However, managing the entire primary cavity excavator guild at 100% habitat levels is critical since the majority of the PCE species feed on insects that contribute to forest health "problems" in these forests. Managing habitat at this level would require 4.2 snags/acre. Stand exams indicate that this level of snags is currently available in unmanaged stands.

The Big Lake Burn is an area of concern. Heavy cutting for firewood and salvage activities that occurred after the fire dramatically reduced the availability of snag habitat typically available after stand replacement events. The 26 year old lodgepole pine regeneration is currently < 12" dbh. This area is currently void of any snags of suitable dbh for cavity excavators, and it has low structural diversity. Large diameter snag habitat will not be available for 100+ years.

Down woody debris levels in this zone are very low in the managed stands and the Big Lake burn area. Natural stands have not been salvaged, and they are providing moderate levels of material. The abundance of down woody material is not a concern in this area.

Botanical Resources - Mountain Hemlock

One uncommon mountain hemlock plant associations occur in landform block 5. Both of these plant associations indicate very cold, high elevation sites.

Wildlife Use - SUBALPINE

One hundred and twenty-nine wildlife species use the Subalpine zone primarily for breeding and foraging. Uncommon, non-TES uncommon species documented here include the prairie falcon, rosy finch, water pipit, and yellow bellied marmot. Potential habitat for TES species such as the peregrine falcon and wolverine occurs here. Surveys have not been conducted for either species. There are no ROD species of concern in this area.

Habitat - Subalpine

Subalpine forests are a subzone of the Mountain hemlock zone. These high elevations areas surrounding Mt. Washington, Three Finger Jack, the Sisters, and Mt. Jefferson are a mosaic of forest patches and tree groups interspersed with shrubby or herbaceous subalpine communities. Because these areas are covered with snowpack until late in the summer, their use by wildlife species is limited. Most of the species that occur here also can be found in the lower Mountain hemlock forests.

Fire suppression of lightning starts probably has had the greatest impact on habitat alteration over time in this area. Fire is considered an important factor in creation and maintenance of subalpine meadows. Fire exclusion has resulted in conifer invasion, which can threaten the maintenance of these systems.

With the current policy of extinguishing fires in these wilderness areas, this system will trend outside the historic range. Meadows will continue to be encroached by conifers, and the dynamic tension that occurs in these ecotones

between tree and treeless regions will diminish. Comparing statistics on vegetation from 1900 to existing vegetation displays the dramatic changes that have occurred (Table 3-11). Between 1900 and 1994, the statistics indicate that total acres of meadow/early seral habitat has been significantly reduced, and patch size has decreased in size and variability. This is a reflection of the increased fire suppression efforts. The availability of mid and late seral habitat has increased substantially as the forest has succeeded without disturbance.

Table 3-11: Characteristics of subalpine habitat in 1900 and 1995

Early Seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
4878	50	97	2.6	348	15	22	0.3
SD		338				35	

Mid and Late Seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
484	11	44	0.4	5028	46	109	0.5
SD		62				333	

We know very little about the dynamics of wildlife populations in these complex, high elevation areas. Because of their limited and disjunct location on the landscape, maintaining the processes that occur within these systems appears critical for their sustainability through time. Surveys of the botanical communities and their associated wildlife are needed for their preservation. Though data is not available to show the historic range of variability, it appears that significant shifts in the proportion of open areas to forested areas has occurred. Fire suppression in the high elevation areas is contributing to this situation. Loss of open habitat in these areas may be critically reducing the availability of habitat for species such as the wolverine. Allowing fire to function within this system will be critical in the future.

Snags and Large Woody Material - Subalpine

Snag and large woody material levels may have increased in these areas because of fire suppression. Species that potentially breed in snags in this zone include 4 species of amphibians, 20 birds, and 17 mammals.

PACIFIC SILVER FIR (ABAM) SERIES

The plant associations included in this group are: ABAM/TITR, ABAM/VAAL/COCA, ABAM/OPHO, ABAM/RHMA/XETE, ABAM/RHMA-BENE, ABAM/VAME/CLUN, ABAM/ACCI/TITR, ABAM-ABGR/SMST, ABAM/BENE, ABAM/VAME/XETE.

The cool, temperate climate of Pacific silver fir forests is characterized by moderate winter temperatures, substantial winter snowpack, and relatively limited summer drought (Packee et al. 1981). Pacific silver fir forests are wetter and cooler than the adjacent, lower elevation western hemlock forests (Franklin and Dyrness 1973) and the adjacent grand fir forests, and they are warmer and more productive than mountain hemlock sites. The elevation of these forests ranges from 3200 to 5000 feet.

Fire Disturbance - Pacific Silver fir

The growth and development of the Pacific silver fir forest in the watershed have been strongly influenced but not dominated by fire. Of all the plant series in the watershed, the Pacific silver fir series has historically had the least distinguish- able fire activity. Distinguishable fire events within the Pacific silver fir forest, identified through tree age data, old inventory maps and literature review occurred in: 1950, 1930-1935, 1910-1915, 1875-1885, 1835-1840, 1800-1805, 1775-1785, 1715.

Pacific silver fir seldom survives fire because of its thin bark and shallow roots. Pacific silver fir is a fire avoiding species throughout all stages of its life (Agee 1991). It is extremely fire sensitive and its foliage is highly flammable. Underburning tends to cause complete mortality, except in stands with a high component of large size Douglas-fir.

The fire regime for Pacific silver fir forest is characterized by infrequent fires of high severity (100-300 yr., Agee 1993) (58-206 yr., Simon 1991). Based on tree age class data gathered during stand examination, the fire return intervals between fire events in these Pacific silver fir forests within the Santiam Pass range from 43 to 108 years.

The fire return intervals reported in Simon and Agee refer to stand replacement events. The intervals calculated through stand exam data are based on a limited sample taken along the route of the Hogg railroad grade. These intervals are lower than reported in the literature. However, the events that were recorded within these stands are not necessarily the type of stand replacement events that would be picked up within a fire analysis. The events recorded through tree age analysis are indicative of disturbance, and some of these events may be markers of other disturbances (i.e., pockets of wind, disease, insect, etc.).). Also, The pacific silver fir area in the Santiam area is a relatively narrow peninsula

surrounded by mountain hemlock and grand fir types. These types have more frequent fire events that may contribute to repeated ignitions by spotting in the adjacent Pacific silver fir area.

When fires do occur in the Pacific silver fir forest, it is usually associated with summer drought and east winds (Agee and Flewelling 1983). These fires tend to be of high intensity and kill most or all of the trees on site (Agee 1993).

When Pacific silver fir forests are surrounded by drier forest types, as is the situation at Santiam Pass, longer burning fires in the adjacent drier forests may result in repeated ignitions and low intensity fire spread in the Pacific silver fir type (Agee 1993). These low intensity fires would tend to create a very diverse, patchy pattern of forests of varying ages, almost as if the fire "meandered" across the landscape. Patches come in many sizes and shapes, have curvilinear edges and offer a high degree of internal structural diversity (snags, islands of residual trees, etc.)

Fuel Loading - Pacific Silver Fir

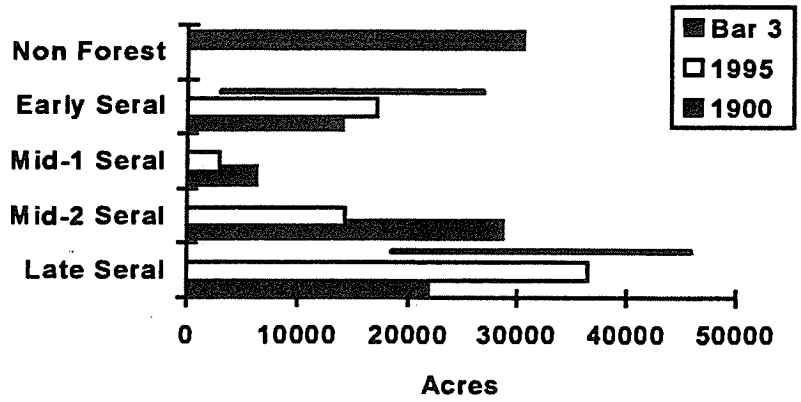
Eighty years of fire suppression has allowed a relatively high level of fuel to develop in the Pacific silver fir stands in the Upper McKenzie area. The stand-replacing nature of most forest fires in the Pacific silver forests results in course woody debris patterns resembling a U-shaped curve over time (Agee 1993). Post-fire created snags slowly decay as the stand ages to a point where the firs start to die, then course woody debris loadings slowly increase again. This is basically the present condition that we see up in the Watershed. Field inventories show an average of 45-65 tons per acre of natural fuel loadings with some stands exceeding 70 tons per acre. One of the few studies showing course woody debris in Pacific silver forests documented 80 tons per acre in a 180 year-old stand. (Grier et al. 1981).

Comparison of Historic Versus Existing Landscape Vegetation - Pacific Silver Fir

The following information is patterned after the Regional Ecological Assessment Project. With this data, a comparison can be made between a range of "historical landscape conditions" pre-settlement conditions and a current state.

The REAP process stratified the landscape into 3 age groups: early (1-15), mid (16-50), and late (200+). The age class between 50 and 199 was not analyzed during the REAP process. We are displaying that information for the years 1900 and 1995 to compare the change in the landscape within this century (Figure 3-15).

Figure 3-15: Acres of Current and Historic Pacific Silver fir seral stages



The overall vegetation shifted from a predominance of early seral (1900) to a dominance of mid to late seral condition (1995). This shift in dominance to mid to late seral corresponds to our era of fire suppression, approximately 1910 to the present. The dark solid line represents a historical range of variability from 1600 to 1850.

Wildlife Use - Pacific Silver Fir

One hundred and seventy-three species use the Pacific Silver fir zone for breeding and foraging. Uncommon, non-TES species documented here include the N. Goshawk, three-toed woodpecker, Cascade frog, and yellow-bellied marmot. Potential habitat for TES species such as the bald eagle, wolverine, spotted owl, red-legged frogs, sandhill crane, peregrine falcon, and Townsend's big-Eared bat occurs here. Species underlined have been documented in the area. Habitat for ROD species of concern includes the great gray owl, red tree vole, and black-backed woodpecker. All but the vole have been documented in these forests.

Habitat - Pacific Silver Fir

This is the most abundant forested habitat in the watershed. Species occurrence in these forests varies by structural stage. Species such as black-tailed deer, mountain quail and brush rabbits are associated with early seral conditions containing beargrass, fireweed, and huckleberry. The spotted owl and goshawk are associated with mid to the late seral conditions, which provide multi-storied forests with a large diameter Douglas-fir and Pacific silver fir overstory

Early Seral - Pacific Silver Fir

In the Pacific silver fir zone, early seral habitat has historically been created by large, stand replacement events, or small, spot fires. Post-fire conditions included abundant dead material in the form of snags and large woody material

on the forest floor. Pacific silver fir is very susceptible to fire, whereas the co-dominant Douglas-fir is well adapted to fire events. The larger diameter Douglas-fir survived fires to provide residual green trees in the developing stand. Because of the high flammability of the Pacific silver fir foliage, PSF snags present in the post-fire stand may have been shortened from incineration, reducing their longevity and use on the landscape. Spot fires created small gaps, providing small patches of early seral habitat within an otherwise contiguous stand of mid or late seral habitat. The early seral patches were generally small to moderately sized, depending on the wind conditions that drove the flames. Small open patches were typically within stands between periods of stand replacement fires. Large patches of early seral have not been created in this zone since the fires in the 1800's.

Over the past 30 years, early seral habitat has been created through clearcutting. These patches do not resemble the complexity that occurred after natural fire or insect disturbances. Critical biological components, such as snags and large woody debris, are limited in treated areas. Table 3-12 displays a comparison of the distribution and availability of this habitat during 1900 and 1994. More early seral habitat is on the landscape at this time. The average patch size is dissimilar to what would be found after a fire event. Patches now average 69 acres, which is smaller than landscape-level disturbances that historically created this habitat type, but probably larger than patches created by fire spotting or insects/disease. Patches are also less variable in size.

Table 3-12: Characteristics of early seral Pacific Silver fir habitat in 1900 and 1995.

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
13990	95	148	5.4	17156	248	69	9.5
SD		408				229	

This habitat is well within the historic range of variability. There are no wildlife species that are solely dependent on the early seral stage of Pacific silver fir. Through harvest activity (and the inevitable future catastrophic fire), this habitat condition will continue to occur on the landscape. It is important that future management post-disturbance retain snags, down woody material, and live, large diameter Douglas-fir trees.

Mid and Late Seral - Pacific Silver Fir

The distribution of this habitat has fluctuated since the late 1800's, but not to a great degree. Table 3-13 displays data comparing the landscapes from 1900 and 1994. These seral stages have dominated the Pacific silver fir zone for over 100

years. Mid seral habitat has decreased over time as stands succeeded into late seral forest or were harvested. Their patch size is now smaller and less varied. Late seral forests have increased slightly, but their patch size has been reduced by half and they have more edge. This habitat has become more fragmented through clearcutting.

Table 3-13: Characteristics of Mid and Late seral Pacific Silver fir habitat in 1900 and 1995.

Mid Seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
17345	81	215	5.8	11658	165	72	6.5
SD		736				172	

Late seral

YEAR 1900				YEAR 1995			
ACRES	# PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# PATCHES	MEAN PATCH SIZE	EDGE DENSITY
39517	51	773	8.7	41878	85	491	15.6
SD		2938				2220	

Harvest activity will be the greatest landscape altering disturbance in this zone in the future. Efforts to minimize fragmentation will be important in maintaining the contiguity of the patches left. This habitat is currently high quality and well distributed. It is the only plant association group in the northern portion of the watershed that can sustain multi-storied structure for long periods of time. It supports many of the known spotted owl and goshawk nest sites.

The abundance of this habitat is currently well within the range of historic variability. The level of fragmentation may be outside of the historic range of variability, since the pattern created by clearcutting has not mimicked the effect of historical fires. Fires may have created gaps in these stands historically, but they were typically small (1-10 acres) and highly scattered.

In the future, changes to this habitat will also occur from insects and diseases. Western spruce budworm (WSBW) populations have risen above endemic levels in recent years, causing a simplification of structure, reduction in diameter growth, and high levels of mortality. Spruce budworm is an important agent in creating biodiversity on a landscape, and it is also an important food source for many forest-dwelling birds, mammals, and insects. However, at epidemic levels, it can seriously reduce the quality of habitat for species dependent on

large diameter trees and multi-storied canopies. The understory trees provide structure in these stands, making them more valuable to species such as the spotted owl.

At epidemic levels, local populations of wildlife have little impact on WSBW populations. Changes in climate and/or stand structure are the only factors that will reduce the populations back to endemic levels. It is critical that in stands susceptible to spruce budworm, habitat components important to spruce budworm predators be available at 100% levels. This includes abundant snags for birds such as the pileated woodpecker and abundant down woody debris that provides habitat for ants and voles.

The Douglas-fir beetle is also affecting habitat. Where high levels of standing and down dead material occur, many of the large diameter Douglas-fir trees are being killed. Douglas-fir is an important structural component within these forests. Their large diameters provide important residual habitat following fire. In some areas, these trees appear to have survived multiple fires in their life time. The death of these trees will increase the availability of large diameter, high quality snags. Snags are generally not limiting in this area, and this surge in abundance is not expected to result in increased populations of snag-dependent species.

Other insects and diseases are not threatening to decrease habitat quality for wildlife. Their presence increases horizontal and vertical diversity in these stands through the creation of canopy gaps and large woody material.

Snags and Large Woody Material - Pacific Silver Fir

Forests in the Pacific silver fir zone are considered habitat for the three-toed woodpecker, black-backed woodpecker, and williamson's sapsucker. These forests are capable of producing trees large enough to sustain snag habitat > 18" dbh. The stands contain an average of 10 snags/acre ≥ 18" dbh (Table 3-14). Snags levels are high because of insect and disease mortality. Existing harvest units are contributing little snag habitat, and they will continue to be devoid of snags > 18" until late in their successional development (50-75 years). Species that depend on snags in this zone include 2 species of amphibians, 47 birds, and 25 mammals.

Table 3-14: Snags by species and size class in unmanaged late seral Pacific silver fir stands. (SAF=subalpine fir, GF=grand fir, DF=douglas-fir, LP=lodgepole pine, MH=mountain hemlock, WP=white pine, WH=western hemlock.

SIZE CLASS	SAF	GF	DF	LP	MH	WP	WH
11-12.9	12	2		10			
13-14.9	7	2		4			
15-16.9	6	3					
17-18.9				1			
19-20.9	1		1				
21-22.9						1	
23-24.9			2				41

Avg number of snags/acre for all size classes (0-25"+) = 39

The ROD requires that 100% habitat levels for black-backed woodpecker be retained in treated areas, as well as 40% of the other PCE's. This would require 1.8 snags/acre on the landscape. Stand exams indicate this level of snag habitat (on average) does occur in this area. However, managing the entire primary cavity excavator guild at 100% habitat levels is an intelligent, ecological move, since the majority of these species feed on insects that contribute to forest health "problems." This would require 4.2 snags/acre. Stand exams indicate that this level of snags is currently available.

Down woody material in this zone is very low in the managed stands. Natural stands have not been salvaged, and because of the high levels of insects and diseases, natural wood inputs have been high. The abundance of down woody material is not a concern in natural stands in this area.

Botanical Resources - Pacific Silver Fir

The Pacific silver fir/Cascades azalea/and beargrass plant association considered rare in occurrence is found in landform block 4. Four uncommon Pacific silver fir plant association are known to occur in landforms blocks 2A and 2B.

WESTERN HEMLOCK (TSHE) SERIES

Distribution and Description

The plant associations included in this group are: TSHE/VAAL/COCA, TSHE/BENE, TSHE/ACTR, TSHE/BENE/OXOR, TSHE/BENE/GASH, TSHE/BENE/ACTR, TSHE/RHMA-VAAL/COCA, TSHE/RHMA/XETE, TSHE/RHMA/BENE, TSHE/RHMA/GASH - WILL, TSHE/RHMA/LIBO2, TSHE/GASH, TSHE/ACTR, and TSHE/LIBO2.

Western hemlock forests are the most common forest type on the Willamette National Forest. They occur at the lower elevations throughout the watershed. Climatic conditions in western hemlock forests are considered relatively mild. Temperatures range from slightly below freezing in winter to 90 to 100 degrees F in summer. Precipitation amounts vary from about 60 to over 100 inches per year, mostly falling as rain or snow in the winter. Winter snowpack are not usually deep nor long lasting. Plant moisture stress seldom exceeds 15 bars during the growing season (Means 1980, Zobel et al. 1976). Western hemlock forests occur within the watershed below 3400 feet in elevation.

Fire Disturbance - Western Hemlock

Western hemlock is not well adapted to survive fire; it is a fire avoider. The dominance of Douglas-fir within western hemlock forests in the watershed is directly tied to fire.

The effects of fire on western hemlock forests are variable, depending on the age of stand, fire frequency, intensity and extent. Fire creates a wide variety of post fire effects and patterns in mesic to dry western hemlock forests.

Recent work suggests a higher fire frequency in the drier western hemlock forests of the Oregon Cascades. A high elevation site transitional to the Pacific silver fir zone near the H.J. Andrews Experimental Forest has experienced four fires since 1530. Some of these were in the settlement period and probably reflect setter caused fire over that period, which were used to create and maintain clearings (Stewart 1986).

At another site near the H.J. Andrews, Morrison and Swanson (1990) suggest a natural fire rotation of 95-145 years over the last 5 centuries, well below that generally quoted for western hemlock forests. Another fire frequency analysis was completed by Teensma (1987) near this same area studied by Morrison and Swanson. Using conservative methods that recognized only fires that resulted in substantial regeneration or fire scaring, Teensma estimated a natural fire rotation of 100 years over the last 5 centuries.

Working in the same area, Teensma (1987) calculated a mean fire return interval for stand replacement fires of 130-150 years, about 50 percent longer that the fire return interval that included moderate severity fires (both estimates excluded low intensity fires).

These studies in and near the watershed strongly indicate that the mesic to dry western hemlock forests of the Oregon Cascades have a variable fire regime with much higher fire frequency than that typical associated with moist western hemlock forests.

This moderate severity fire regime is characteristic of the southern portion of the western hemlock zone (Agee 1991). The landscape pattern associated with this fire regime is a complex mosaic of stands with variable date and severity of last burn. In the fire history study at Deer Creek, Morrison and Swanson found that fire created patches originating in 1800-1900 were mostly less than 10 hectares.

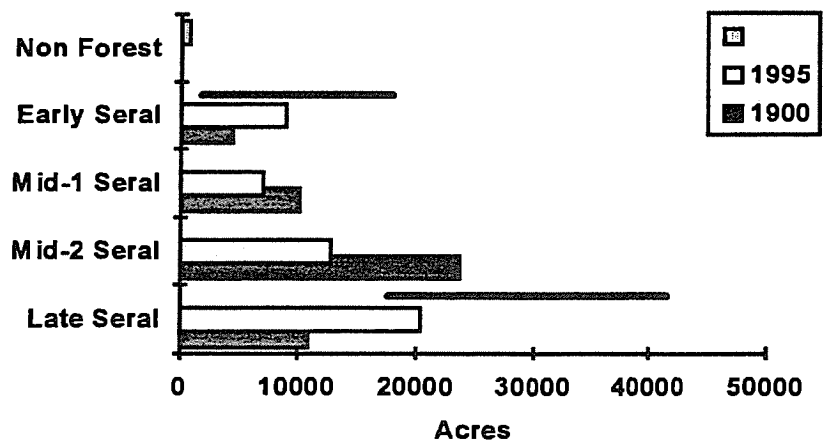
It is not unusual to have a long early seral tree recruitment period (40-100 years) within TSHE forests following a high intensity stand replacement fire (Franklin and Hemstrom 1981, Huff 1984, Yamaguchi 1986). Lack of seed source, brush competition, and/or reburns have been identified as factors delaying regeneration after stand replacement fires (Franklin and Hemstrom 1981). Redstem ceanothus (*Ceanothus sanguineus*) and snowbrush (*Ceanothus velutinus*) are two tall shrubs that tend to dominate early seral stands within the watershed. Douglas-fir regeneration is favored over western hemlock with high intensity fires.

A moderate or partial stand replacement event reduces the tree recruitment period. Beargrass, fireweed, Ceanothus, big leaf huckleberry, and bracken fern are typically reestablished in the early seral stage. Douglas-fir and western hemlock reestablish in the stand initiation stage following the herbs and shrubs. Conifers, shrubs, and herbaceous species continue to grow until the forest canopy closes and prevents further regeneration. This closed sapling stage is composed of a mixture of western hemlock and Douglas-fir. Competition for site resources reduces the number of saplings and poles. Douglas-fir tends to outcompete western hemlock and dominates the site. Shrubs, herbaceous species, and cryptograms are established during understory-reinitiation, because the dense canopy of the conifers begins to open and create gaps. As the conifers mature and die, the understory develops as an uneven-aged structure with an irregular canopy. Western hemlock is the major climax species, with twinflower, vanilla leaf, dwarf Oregon grape, and big leaf huckleberry in the herb and shrub layer. If the fire is less than a stand replacement event, sufficient overstory may remain to encourage regeneration of western hemlock and western red cedar, but not Douglas-fir.

Because of their thick bark, large Douglas-fir tend to be resistant to fire and may survive ground fires that eliminate thin barked species like hemlock and red cedar, and understory shrubs and young trees. Many of the stands within the lower elevations of the watershed contain scattered residual Douglas-firs that have survived numerous ground and partial stand replacement fires. All the old-growth stands within the watershed have evolved through understory and partial stand replacement fire disturbances.

Comparison of Historic Versus Existing Landscape Vegetation - Western Hemlock
The following information is patterned after the Regional Ecological Assessment Project. The REAP process stratified the landscape into 3 age groups: early (1-10 years old), mid (11-50 years), and late (200+ years). The age class between 50 and 199 was not analyzed during the REAP process. We are displaying that information for the years 1900 and 1995 as Mid-2 to compare the change in the landscape within this century (Figure 3-16).

Figure 3-16: Acres of Current and Historic Western Hemlock Seral Stages



The distribution of the vegetation shows an increase level of late successional forest. The current level of late successional forest is within the historical range of variability. The solid dark line represents the range of historical variability from 1600 to 1850.

Wildlife Use - Western Hemlock
Two hundred and nine species use the Western hemlock zone for breeding and feeding. Uncommon, non-TES species documented in these forests include long-eared owls, snipe, wood duck, cascade frogs, and red fox. Potential habitat for TES species such as spotted owl, peregrine falcon, bald eagle, white-footed vole, wolverine, harlequin duck, pond turtle, Townsend's big-eared, and red legged frog occurs here. Surveys have verified the presence of all of these species except the vole and bat. ROD species of concern include red tree vole and great gray owl. Both species have been documented in the area.

Habitat - Western Hemlock
Western hemlock forests occur commonly across the Willamette National Forest. It is the most common low elevation forested habitat in this watershed. The species that occur in this area vary by the developmental stage of the forest. Species such as California quail, northern alligator lizard, and brush rabbit are associated with early seral or open conditions, which can extend for several

decades under certain conditions. Pileated woodpeckers and spotted owls are associated with mid to the late seral conditions, which produce a complex, multi-canopied forest with abundant large woody material and horizontal diversity.

Early Seral - Western Hemlock

In the Western hemlock zone, early seral habitat has historically been created by catastrophic fire events and spotting. Post-fire conditions usually included abundant dead material in the form of snags and large woody material on the forest floor. However, very hot fires were not uncommon, which left little woody material. Western hemlocks are very susceptible to fire, while the co-dominant Douglas-fir is well adapted. Larger diameter trees survived fires to provide residual green trees in the developing stand, much like the Pacific silver fir zone. Fire disturbance in this area has heavily influenced the development of these stands, resulting in high levels of diversity. All of the old growth has evolved through understory and partial stand replacement fire disturbances. In areas to the north, the adjacency of this habitat type to the grand fir zone has resulted in even greater complexity. "Spotting" from adjacent grand fir forests created small gaps within these stands, providing small patches of early seral habitat within an otherwise contiguous stand of mid or late seral habitat.

Over the past 30 years, early seral habitat has been created only through clearcutting. These habitat patches do not resemble the complexity that would have occurred through natural fire or insect disturbances. Critical biological components, such as snags, large woody debris, and large residual Douglas-fir, are limited in these areas. Table 3-15 displays a comparison of the distribution and availability of this habitat during 1900 and 1994. The abundance of this habitat has doubled since 1900. The patches are now smaller with less variability in size.

Table 3-15: Characteristics of early seral western hemlock habitat in 1900 and 1995.

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
4476	13	343	1.5	8941	219	39	6.3
SD		459				67	

The abundance of this habitat type is well within the historic range. However, the available habitat is low in quality because of the lack of structural components. There are no wildlife species that are solely dependent on the early seral stage of Western hemlock habitat. Through future harvest activity (and the inevitable future fire), this habitat condition will continue to be provided on the

landscape. It is important that future management post-disturbance retain snags, down woody material, and live, large diameter Douglas-fir trees.

Mid and Late Seral - Western Hemlock

The distribution of these habitat conditions has not fluctuated since the late 1800's. Table 3-16 displays data comparing the landscapes from 1900 and 1994. These seral stages have dominated the Western hemlock habitat for over 100 years. Mid seral habitat has decreased, primarily through clearcutting. Four times as many patches occur now, and they are substantially smaller than seen historically. Late seral habitat has not significantly changed in abundance, but the patch sizes have become much smaller. Patches historically were generally large, but highly variable in size with convoluted edges. Now they are smaller, and edge density is much higher reflecting fragmentation within blocks.

Table 3-16: Characteristics of mid and late seral W. Hemlock habitat in 1900 and 1995.

Mid Seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
20760	37	560	4.2	6276	112	146	6.53
SD		2909				506	

Late Seral

YEAR 1900				YEAR 1995			
ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY	ACRES	# OF PATCHES	MEAN PATCH SIZE	EDGE DENSITY
24045	15	1603	5.0	23966	58	412	10.2
SD		304				2306	

This habitat type appears to be trending outside of its historic range of variability. There are species highly associated with this habitat type, such as the spotted owl and red tree vole. Future harvest activity will be the greatest landscape altering disturbance. Maintaining the largest blocks of mid and late seral habitat will be important to sustaining this landscape and its wildlife within the historic range of variability.

Insects and diseases are not expected to create large-scale disturbances to this habitat. They are currently increasing within-stand diversity.

Snags and Down Woody Material - Western Hemlock

We do not have information to summarize the snag and down woody material levels within these forests.

Botanical Resources - Western Hemlock

There are five uncommon western hemlock plant associations known to occur in the watershed. These plant associations are found in landform blocks 1, 2A, 4 and 5. The vascular plant, *Allotropa virgata,* a Table C-3 species, is known to occur in four western hemlock plant associations within the watershed. *Allotropa* is documented in three separate locations in the uncommon western hemlock/rhododendron-salal association and in three common western hemlock plant associations.

OVERVIEW OF RIPARIAN HABITAT

STREAMS

Figure 3-16a displays all streams by class within the Upper McKenzie. The McKenzie River Subbasin Surface Water Classification identifies the McKenzie River and tributaries upstream from Paradise Campground for domestic, livestock, commercial use for customarily domestic purposes not to exceed 0.01 cfs, and public instream uses (Oregon Administrative Rules, 1994). The McKenzie River downstream from Paradise campground is identified for the same uses, plus municipal, industrial/manufacturing, agricultural, commercial, power, mining, fish life, wildlife, recreation, pollution abatement, wetland enhancement, and off-channel power development in conjunction with storage.

A USGS gaging station approximately 2 miles upstream from McKenzie Bridge has been in operation since 1910. It has provided continuous flow records since that time. Based on 84 years of data, major flood events were recorded and recurrence intervals calculated (Table 3-17).

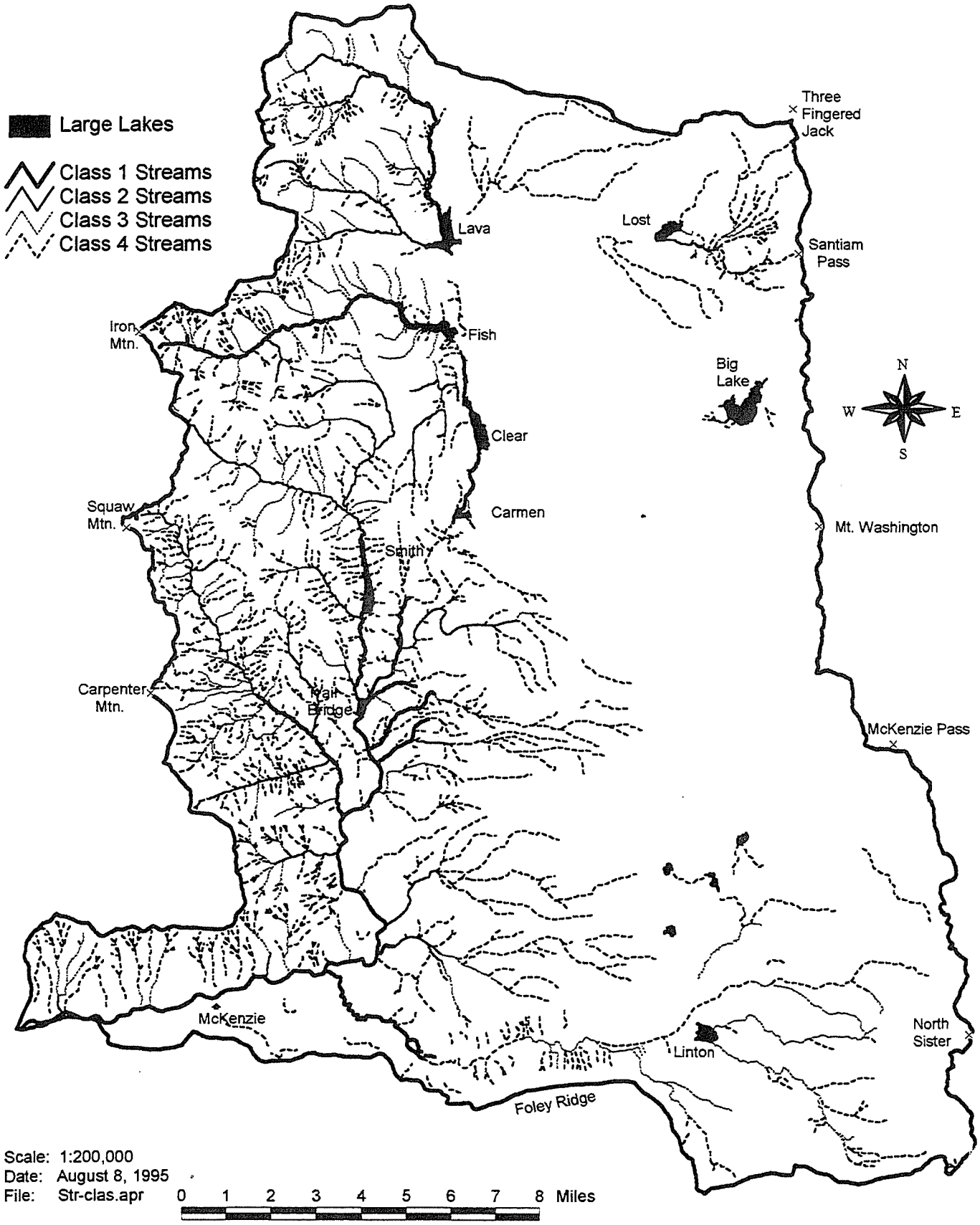
Table 3-17: Major flood events within the Upper McKenzie Watershed.

DATE OF EVENT	RECURRENCE INTERVAL
December, 1945	13 year event
December, 1946	12 year event
January, 1953	24 year event
December, 1955	35 year event
December, 1964	125 year event
December, 1977	11 year event
February, 1986	25 year event

Above normal precipitation and early melt of the high elevation snowpack on January 1, 1995 yielded the highest streamflow for nearly a decade, resulting in only a 3-year event. This followed several years of drought prior to 1995.

Peak streamflows may occur as a result of rain events or rain-on-snow events. They potentially cause transport of large channel substrate, channel widening, and bank erosion. In a large basin study on peak flow responses to clearcutting on the Willamette N.F., Jones and Grant (1994a, in review) found that watersheds ranging in size from 15,000 to 150,000 acres had increased peak discharges as cumulative area harvest and road construction increased. Their data also suggests that peak discharges may have increased by 50% or more over the past 50 years as up to 25% of the area was cumulatively harvested with

Figure 3-16a. Stream Classes



roads. Their analysis also indicates that rain-on-snow events were only 10 to 15% larger than rain events.

A relative measure of the hydrologic recovery of a watershed used by the Willamette National Forest is the Aggregate Recovery Percentage (ARP). This is the percent of the watershed considered to have large enough trees to intercept and hold snow within their canopies. Within the WNF LMP the subwatersheds in the Upper McKenzie Watershed have threshold ARP values of 65-80%. They should not fall below this level to ensure peak flows are not augmented and channel damage does not occur. Table 3-17a displays the ARP values for the entire watershed, the subwatersheds, and selected smaller drainages.

Table 3-17a: ARP values for the Upper Mckenzie Watershed, subwatersheds, and selected smaller drainages.

SUBWATERSHED NUMBER	SUBWATERSHED NAME	DRAINAGE NAME	ARP VALUE
07-01	MCKENZIE BRIDGE		96
07-02	LOST CR/WHITE BRANCH		92
07-03	BOULDER/FRISSEL		72
		SPRINGS COMPLEX	74
		TWISTY	69
		BOULDER	62
		SCOTT	73
		FRISSEL	86
07-04	KINK/INLAND BASIN		81
		KINK	75
		SWEETWATER	68
		WASHINGTON	91
07-05	HACKLEMAN		96
		HACKLEMAN	N/A
07-6	SMITH		82
		BUNCHGRASS	61
		BROWDER	N/A
		SMITH	N/A
07-7	DEER CR.		73
		UPPER DEER	77
		CADENZA COMPLEX	68
		DEER COMPLEX	78
		FRITZ	70
		CARPENTER COMPLEX	69
		COUNTY	50

Table 3-17a continued

SUBWATERSHED NUMBER	SUBWATERSHED NAME	DRAINAGE NAME	ARP VALUE
		BUDWORM	88
		SLUICE	73
07-8	PARK CR.		N/A

N/A = Entire subwatershed or drainage is located outside of transient snow zone.

Figure 3-17 and 3-17a display the subwatershed and drainage locations. ARP values calculated for the Upper McKenzie Watershed are relatively high, ranging from 96% recovered in McKenzie Bridge and Hackleman subwatersheds, to lows of 72% in the Boulder/Frissell and 73% in the Deer subwatershed. Park subwatershed did not receive an ARP rating because it is entirely within the permanent snowpack zone. Park subwatershed is dominated by true fir species of mountain hemlock, grand fir, and white fir, so it does not fall within the transient snow zone.

To determine the relative contribution of the Upper McKenzie watershed to a potential rain-on-snow event, three factors were considered: snow accumulation; snow-melt rate, and; water yield from soils. The combination of all three factors resulted in Figure 17b. Since the effects of peak flows are believed to be observed within the channels of the smaller subwatersheds and drainages (vs. the entire watershed), peak flows resulting from rain and rain-on-snow events and ARP values will be discussed by landform block in Chapter 4.

RIPARIAN HABITAT - PAST MANAGEMENT

The character of the vegetation located within riparian reserves is determined by geology, climate, valley form, aspect, channel form and gradient, fire, and floods. In addition, changes to riparian vegetation may occur through manipulation by harvest, roading, recreation, or administrative sites. Figure 3-18 describes management within riparian reserves as a percent of the total riparian area of each landform block.

Blocks 1, 2A, 2B, and 5 have the most management within their riparian areas. Harvest has been the major activity followed by roads and recreation sites. The mainstem McKenzie River has roads, harvest units, and recreation sites located within 9% of the riparian area. Recreation sites dominate these managed acres (5%), followed by roads (3%). Additional information on management within riparian reserves is discussed in Chapter 4 by landform block.

Figure 3-17. Subwatersheds

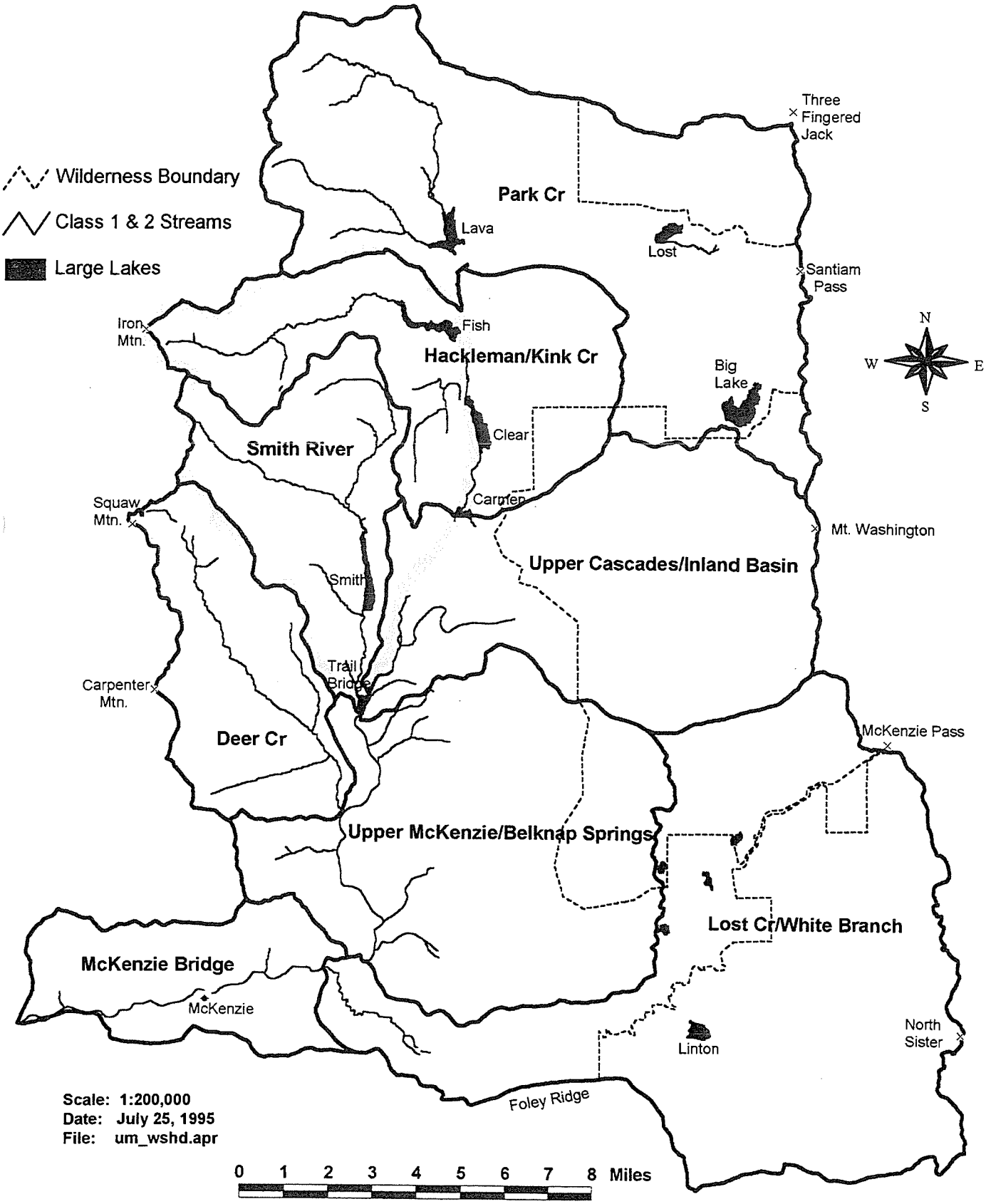
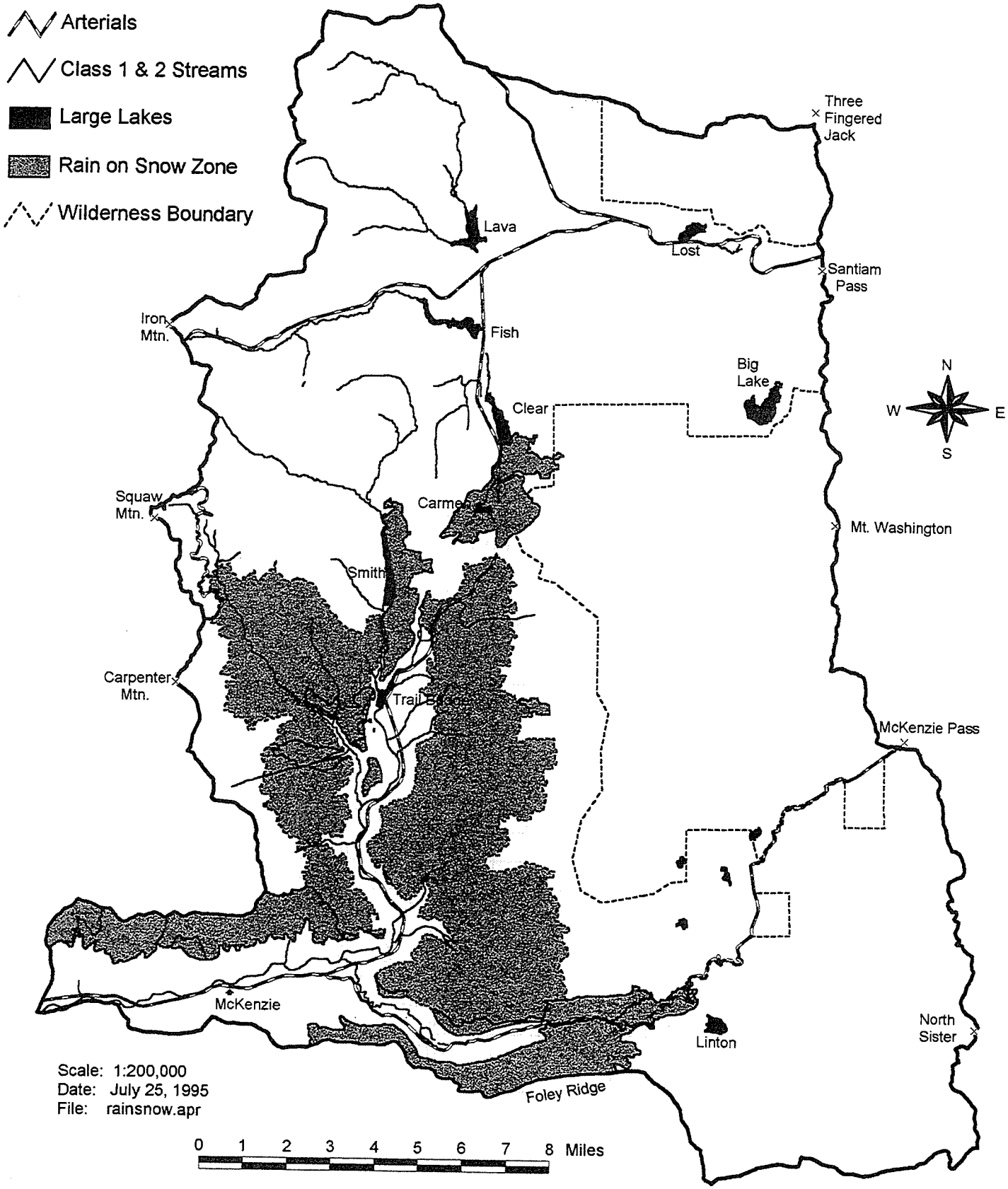
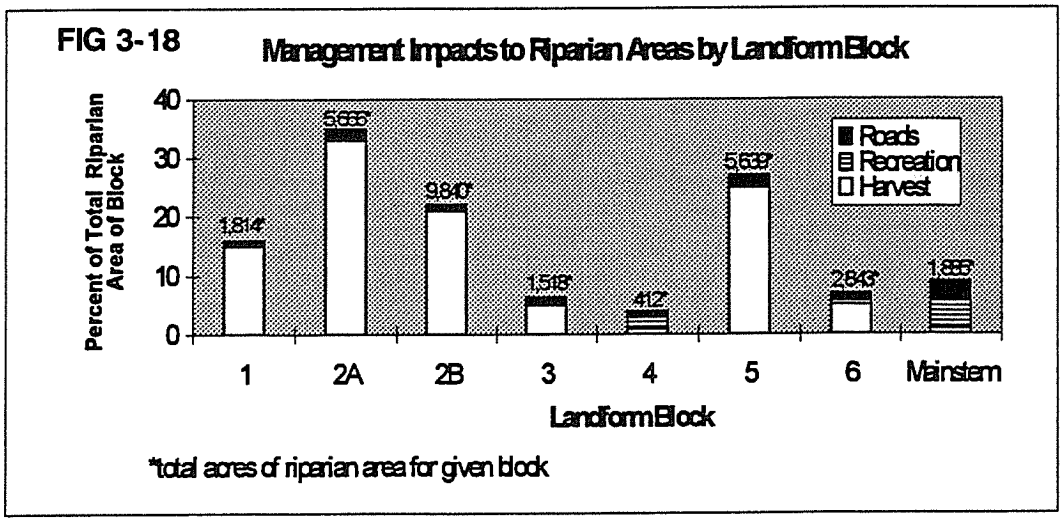


Figure 3-17a. Drainages Selected for Aggregated Recovery Percentage Values (ARP Values)

Figure 3-17b. **Rain on Snow Zones**





RIPARIAN HABITAT - FISH

The Upper McKenzie supports approximately twenty species of fish (Table 3-18). This analysis focused on at-risk salmonids, bull trout, and spring Chinook salmon because of their cultural, scientific, or economic value. The main stem McKenzie River and larger, historic anadromous tributaries have been designated a Tier 1 Key Watershed due to the importance of this habitat to bull trout and wild spring Chinook salmon. The habitat will be identified as we try to restore populations through application of the Aquatic Conservation Strategy. Lesser known species in the area will be included briefly in discussions, and future additions should update our current knowledge of all fish species in the Upper McKenzie.

Table 3-18: Fish species found within the Upper Mckenzie Watershed.

COMMON NAME	SCIENTIFIC NAME
Pacific lamprey	*Lampetra pacifica*
W. Brook lamprey	*Lampetra richardsoni*
Longnose dace	*Rhinichthys cataracta*
Blacksided speckled dace	*Rhinichthys osculus nubilus*
Redside shiner	*Richardsonius balteatus*
Mottled sculpin	**Cottus bairdi semiscaber*
Paiute sculpin	*Cottus belidingi*
Shorehead sculpin	**Cottus confusus*
Reticulate sculpin	*Cottus perplexus*

Table 3-18 continued

COMMON NAME	SCIENTIFIC NAME
Torrent sculpin	*Cottus rhotheus
Largescale sucker	*Catostomus macrocheitlus*
Mountain whitefish	**Prosopium williamsoni*
Chinook salmon	**Oncorhynchus tshawytscha*
Cutthroat trout	**Oncorhynchus clarki*
Rainbow Trout	**Oncorhynchus mykiss*
resident and steelhead	
Bull trout	***Salvelinus confluentus***
Brook trout	***Salvelinus fontinalis***
Brown trout	***Salmo trutta***
Atlantic salmon	***Salmo salar***
Kokanee (sockeye salmon)	***Oncorhynchus nerka***

introduced species ***confirmed sitings**

Willamette Spring Chinook
Status: of special concern

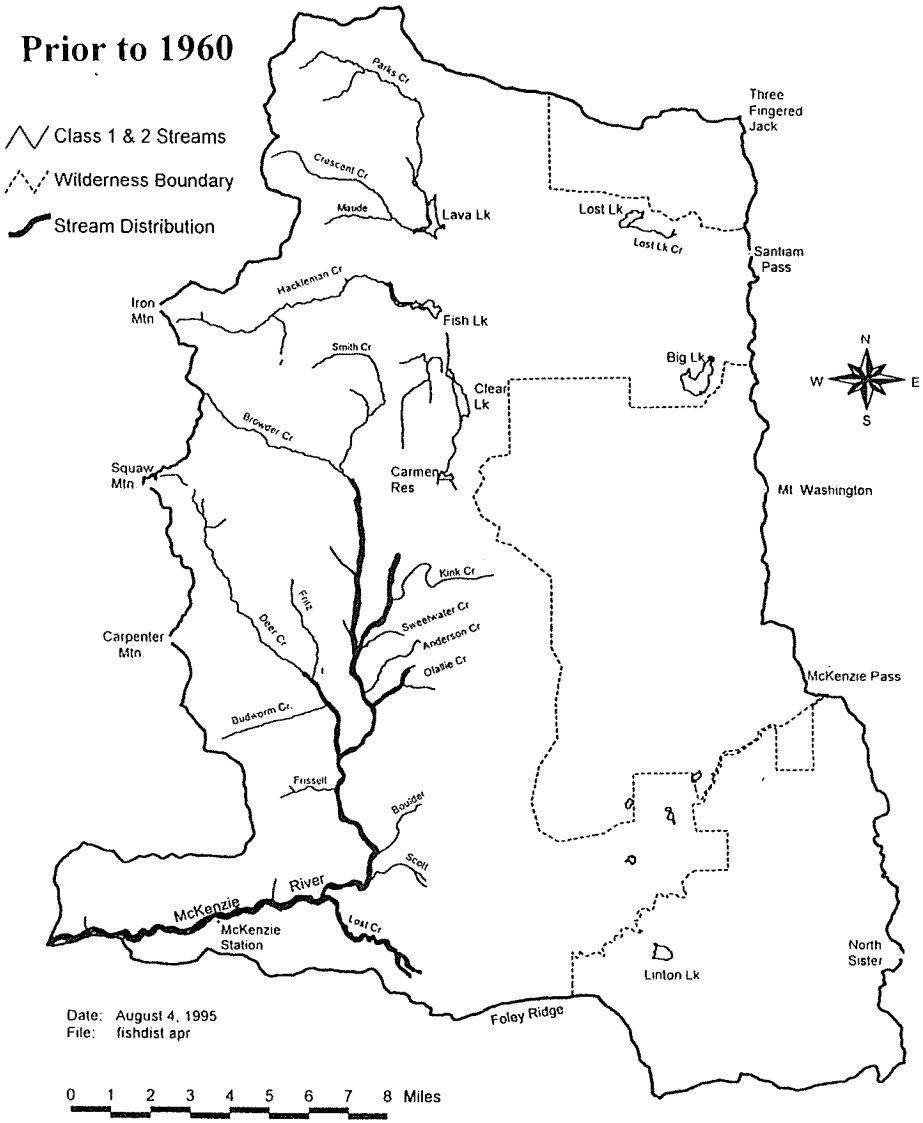
Production
The McKenzie River is considered the best source of natural production for spring Chinook within the Willamette basin (Smith and Zakel 1981).

The McKenzie run of Willamette spring Chinook, the only native anadromous salmon in the watershed, utilizes many larger tributaries and the mainstream as spawning habitat (Figure 3-19). Other than the main stem, tributaries with greatest production are Horse and Lost Creeks, South Fork McKenzie River, and Gate Creek. Other tributaries such as the Mohawk, Blue, and Smith Rivers, and Upper Deer Creek also provided Chinook with spawning habitat. Although salmon return estimates have not been made until recently, declines in returns were evident during egg-collections in the McKenzie River in the 1940's. The average return to the McKenzie from 1945-60 was about 18,000 adults. This average was observed after significant loss of spawning and rearing habitat had occurred in the Willamette and Lower McKenzie from channelization, diversion, timber harvest, and agricultural development. Prior to construction of dams in the subbasin, the McKenzie run contributed approximately 40% of the Willamette spring chinook return (Howell, et al. 1988).

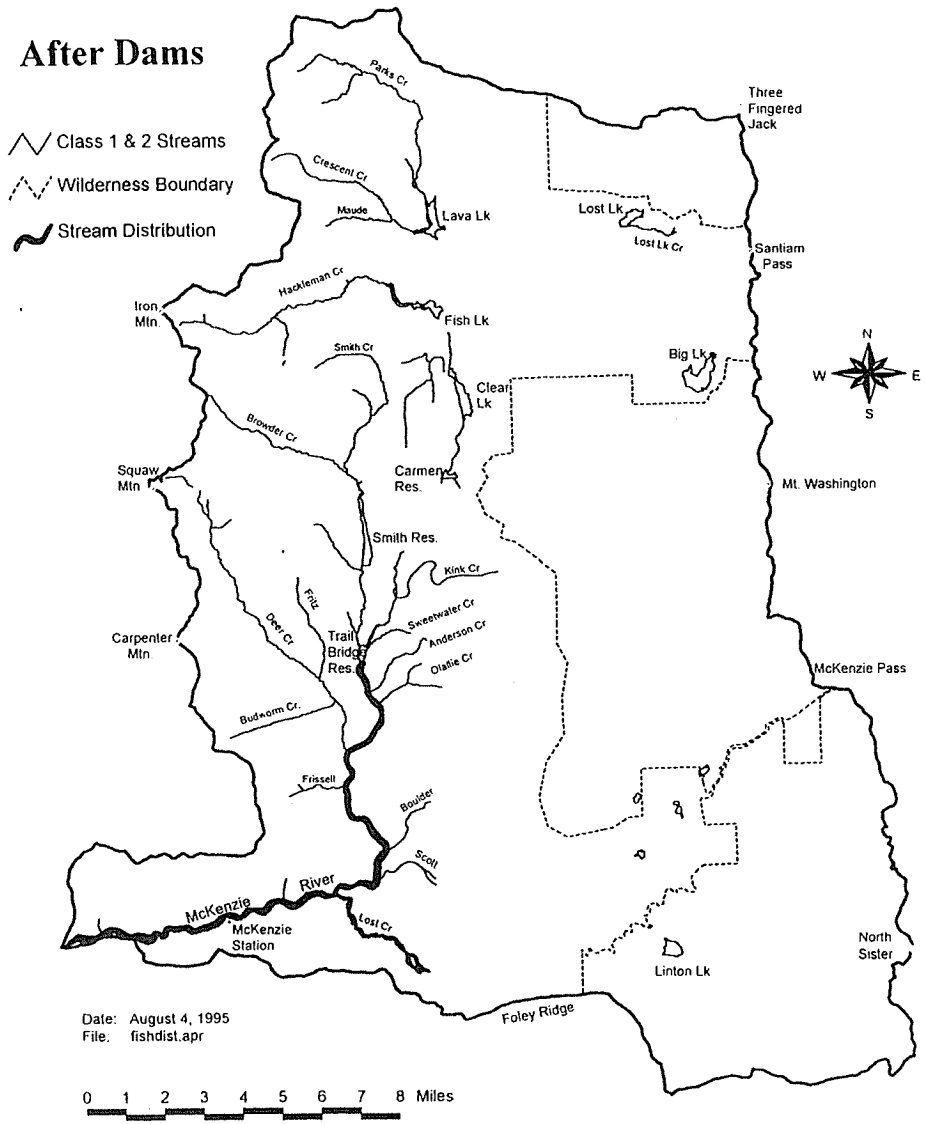
Significant loss of chinook spawning habitat occurred with construction of Cougar Dam on the South Fork McKenzie. Spawning habitat for about 4,000

Figure 3-19. Spring Chinook Distribution Prior to 1960 & After Dams

Spring chinook distribution prior to 1960.



Spring chinook distribution after dams



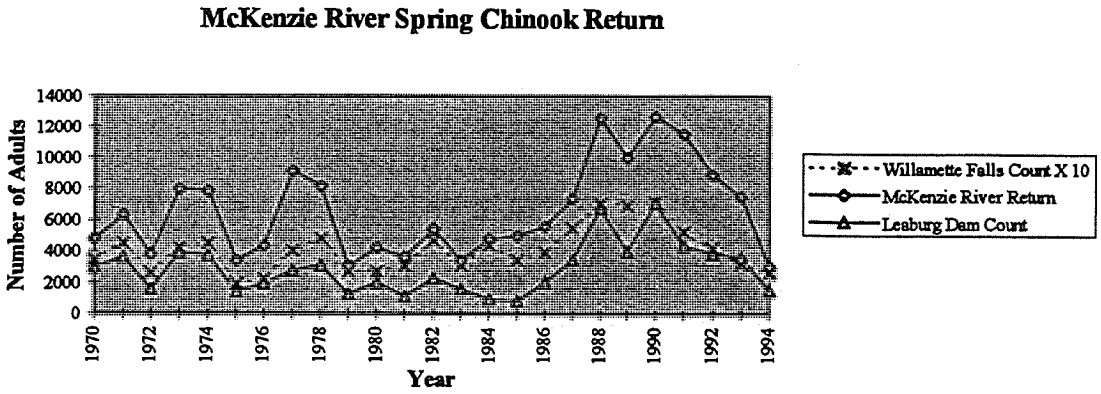
Historic and current spawning and rearing habitat of spring chinook salmon in the Upper McKenzie Watershed Analysis Area.

chinook was blocked. Loss in natural production was substituted using hatchery programs. Within the Upper Mckenzie, Trail Bridge Dam blocked access of 100-200 spring chinook to about 4 miles of main stem McKenzie River. Carmen Spawning Channel was built as mitigation for the loss of production after completion of the dam in the early 1960's.

A large hatchery program, located downstream of Leaburg Dam, supplements the wild run from McKenzie Salmon Hatchery. Currently the hatchery produces about one million smolts to achieve an 8,000 adult return. About half of the McKenzie Hatchery's production is to mitigate for losses above Cougar and Blue River dams. State management goals seek natural production of 10,000 or more adults to reach a subbasin production goal of 18,000 annual return.

Current spring chinook runs in the McKenzie River reflect a continuing depressed return (Table Figure 3-20). The late 1980's through early 1990's saw an increase in the number of salmon returning to the McKenzie, although not approaching 18,000 adults per year. The 1994 return was the lowest return of spring chinook to the McKenzie River in the 25 years that estimates have been made (ODFW 1995). Anticipated poor returns in 1995 initiated emergency fishing regulations requiring release of sport caught chinook without fin clips in the McKenzie River.

Figure 3-20: Counts of spring Chinook from Oregon Department of Fish and Wildlife (ODFW) 1994. (McKenzie spring chinook return = Leaburg count + hatchery return + sports catch + (redds below Leaburg X 4.5 fish/redd)).



Natural production in the river appears to be heavily influenced by hatchery chinook adults. Recent estimates of the proportion of hatchery origin chinook passing Leaburg dam indicate approximately half of the adult fish passing the dam originated from McKenzie Hatchery (ODFW 1995[a]). The proportion of naturally produced adults used in hatchery brood stocks is unknown. The

effects of hatchery stock hybridization with wild stock have been shown to weaken local adaptations to local conditions and alter wild stock's ability to persist in their native environment (Waples 1991).

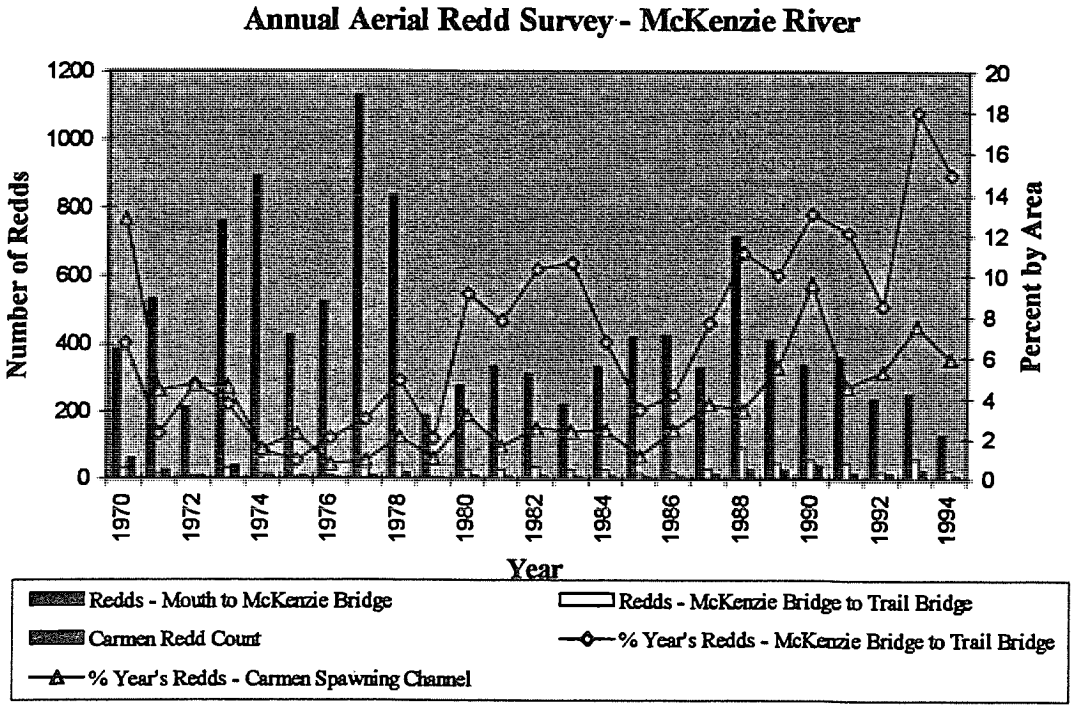
The lower portion of the basin provides important rearing habitat for juvenile salmon produced in the upper basin. Results from recent monitoring of downstream juvenile migration suggest a large portion of upper river offspring move to the lower McKenzie and Willamette to rear. Large numbers of fry have been observed moving past Leaburg Dam, leaving the upper river soon after emergence in January through April (Downey 1994), while no similar movements of smolt-sized salmon have been observed (Howell et al. 1988). Due to a long period of freshwater residency (one to two years), juvenile spring chinook are particularly vulnerable to habitat degradation. The simplification of the lower McKenzie and Willamette River channels since the late 1800's has reduced the basin's production capacity, and the loss of rearing capacity there likely limits production on the upper basin.

The upper portion of the basin remains in relatively good habitat condition compared to the rest of the basin and is now providing refugia for the Willamette spring chinook stocks. An indication of the refuge role the upper subbasin plays may be indicated in greater proportions of naturally spawning salmon using the upper river in recent years. Trends in habitat use are indicated by comparison of annual aerial redd surveys in the entire McKenzie River (Table F3). The proportion of redds in the river above McKenzie Bridge and in Carmen Spawning Channel, when compared to the number of redds in the entire river, have increased since the mid-1980's, possibly reflecting the upper basin's relative condition. This highest reach in the subbasin had remained mostly free of human impacts until 1945. For a discussion of past and present chinook habitat conditions, see the Landform block 6 Aquatic Habitat description of the main stem McKenzie River and Lost Creek in Chapter 4.

Location of Important Habitat for Willamette Spring Chinook

Habitats essential to spring chinook are the main stem McKenzie River, Lost Creek, and to a lesser degree, Lower Deer Creek (Figure 3-19). Adult holding areas consist of deep pools. Spawning habitats utilized by spring chinook are low gradient riffles and pool tail-outs rich in cobble and gravel. Rearing habitats and winter refuge consist of side channels, low velocity river margins and lower reaches of tributaries.

Figure 3-21: Annual aerial redd survey on the McKenzie River. EWEB 1970-94 unpublished data. The McKenzie River redd survey is an annual one-pass helicopter survey conducted by Eugene Water and Electric Board (EWEB) and ODFW. Carmen redd count is conducted on the ground throughout the spawning season by EWEB.



Role of the Subbasin in Recovery of Willamette Spring Chinook

To maintain or enhance the wild population of Willamette spring chinook, the upper McKenzie habitats have become increasingly important as lower basin habitats have degraded. Mitigation for dams by hatchery production has not maintained the McKenzie's historic level of production. Currently the McKenzie supports about 16% of the run, including hatchery production (1970-1994). The McKenzie River and larger tributaries within the analysis area now provide habitats (refugia) on a reach level for Willamette spring chinook, as lower reaches within the subbasin have been extensively altered by human development. Increases in upper river spring chinook production could be expected by maintaining and restoring channel complexity in the analysis area. However, greater increases in chinook production would likely come from restoration of lower river and Willamette channels, due to spring chinook life history requirements. Resource management agencies use of a top-down approach to habitat restoration, by beginning with healthier upper basin reaches, may find it necessary to simultaneously restore lower basin habitats to maximize spring chinook production. The genetic fitness of the wild spring chinook population may be placed at risk from the high proportion of hatchery

production in the subbasin. State monitoring efforts (ODFW 1995[b]) to determine the extent of hatchery influence will shape future wild fish policy and maintenance/restoration of McKenzie River wild chinook stock.

Bull Trout
Status: Category 1 candidate for Threatened/Endangered status

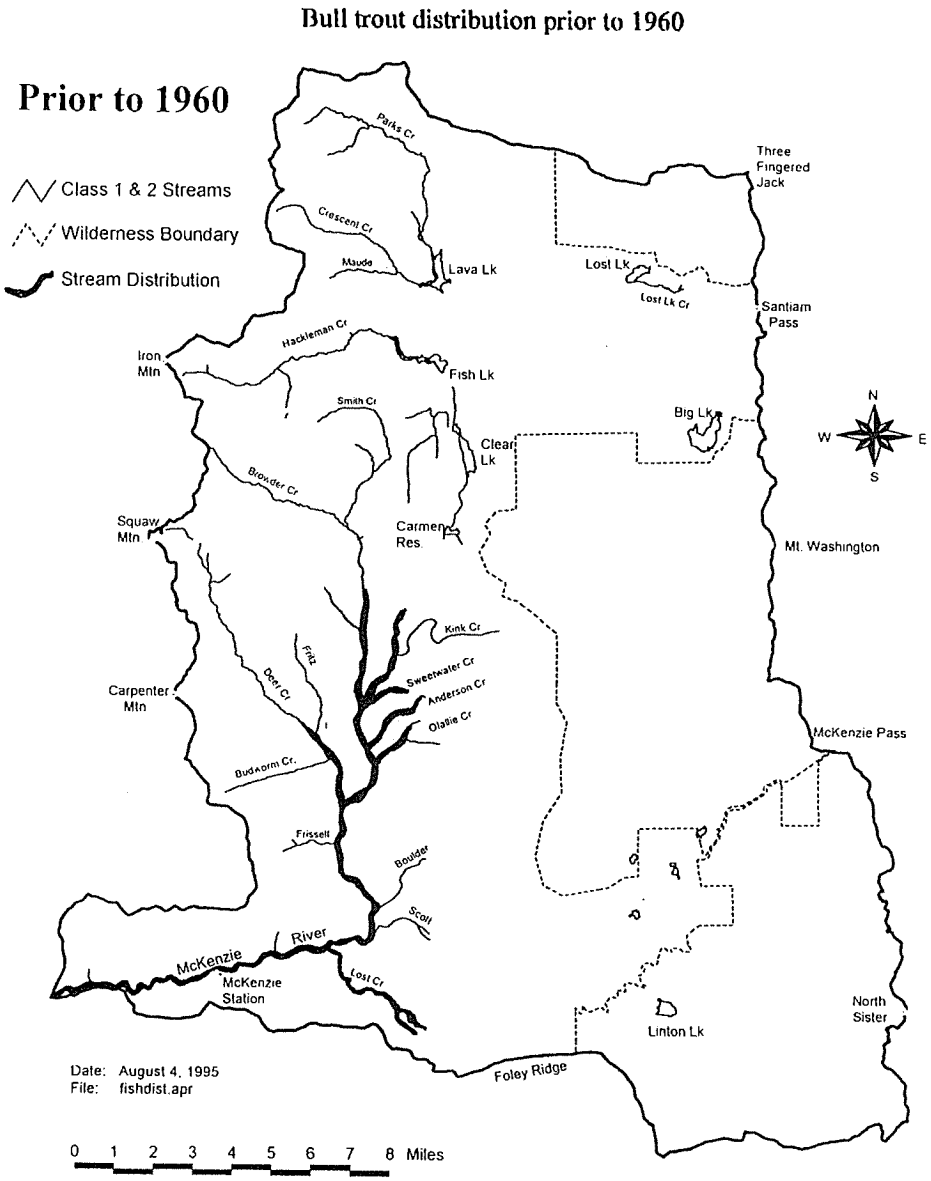
Production
The Upper McKenzie River and South Fork McKenzie River likely possess the only remaining population(s) of bull trout within the Willamette Basin. Populations that once existed in the Santiam and Clackamas River subbasins are probably extinct (Ratliff and Howell 1992). A very small population of bull trout is suspected to remain in the Middle Fork Willamette River, but no confirmed sighting has occurred in recent years. The Upper McKenzie population is considered the only viable population remaining in the Willamette Basin (Ray Bosch, pers. comm.) by US Fish and Wildlife Service.

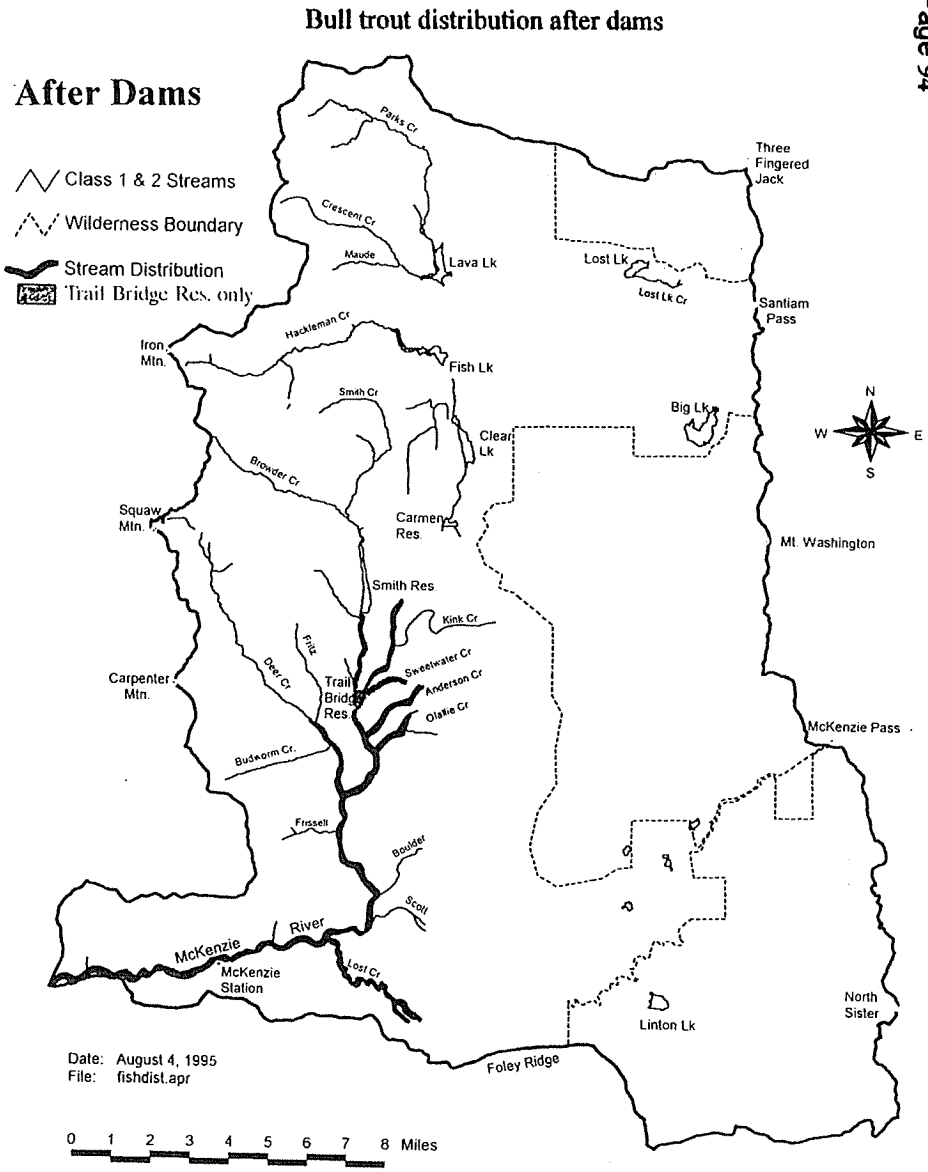
A river dwelling, migratory (fluvial) population of bull trout use the main stem McKenzie and tributaries, primarily above Leaburg Dam, as foraging and rearing habitat. Spawning and rearing habitat is found in spring-fed tributaries to the upper McKenzie. Streams fed by springs on the New High Cascades provide clear, cold, constant water temperatures necessary for bull trout spawning, egg incubation, and rearing. Volcanism of the past 3,000 to 6,000 years has created the spring-fed tributaries (Landform Block 5) that are currently essential to bull trout in the upper McKenzie watershed (Goetz 1994).

Bull trout historic range is similar to current distribution with the exception of fragmentation of habitat and populations by dams and other passage barriers (Figure 3-22). With the completion of Cougar, Trail Bridge, and Smith Dams (and possibly Carmen Dam) in the early 1960's, portions of the McKenzie's fluvial bull trout population were isolated above each dam. The Trail Bridge and Cougar groups survive, and both isolated populations have adapted to a lake dwelling (adfluvial) life history pattern. Spawning habitat was similarly fragmented with the construction of Highway 126 in the early 1960's and placement of impassable culverts in spawning streams. Over 2.5 miles of historic spawning and rearing habitat was made inaccessible to bull trout in Sweetwater and Olallie Creeks.

To what extent habitat disturbance in the lower basin (lower McKenzie and Willamette Rivers) has restricted bull trout migration is unknown. The migratory corridor below Leaburg Dam is unobstructed in terms of physical barriers, however degradation of habitat beyond the specialized needs of bull trout may restrict use of their historic Willamette Basin range to the McKenzie

Figure 3-22. Bull Trout Distribution Prior to 1960 & After Dams





Historic and current spawning and rearing habitat of bull trout in the Upper McKenzie Watershed Analysis Area.

River. Bull trout tolerance for changes in channel condition and water quality in their migratory corridors is information essential to basin recolonization.

Little is known about bull trout numbers prior to development in the subbasin. It is assumed that this aquatic predator was more abundant, based upon the former abundance of native prey fish. No estimate is available for healthy population density of fluvial bull trout, which is difficult to attain for any migratory species. Adult bull trout are opportunistic predators, feeding on the most plentiful and available food source - largely fish. Rearing and adult bull trout can be found where prey are concentrated, such as in late winter and spring concentrations of chinook fry and smolts in the upper McKenzie.. For this reason, the health of fish populations bull trout evolved and coexist with plays a significant role in bull trout recovery.

Bull trout populations have been shown to decline when chinook populations decline in shared river basins (Ratliff and Howell 1992). The coexistence of this population with spring chinook has possibly played a role in the increased number of spawning adult bull trout observed recently (Table 3-19). From 1987 to 1993, greater numbers of adult chinook returning to the upper river (Table 3-21) than in previous years (1975 through 1986) likely provided more numerous offspring upon which bull trout prey.

Changes in State game regulations have also likely enhanced recent increases observed in sexually mature populations. Beginning in 1991, Oregon fishing regulations no longer included bull trout among legal game fish. They are protected with a catch-and-release status.

Due to bull trout's fish-eating nature, stocked rainbow trout fishery in Trail Bridge pool from spring to late summer may provide easy prey and help sustain a population at high risk of extinction. Similarly, hatchery rainbow released into the McKenzie River may contribute to the diet of adult bull trout inhabiting the main stem, spring through summer.

Based upon recent redd counts in bull trout spawning tributaries, an estimate may be made of adult population size (Pratt 1985). An estimate of the main stem population range is achieved based upon two differing assumptions: 1) a sexually mature bull trout spawns every year, and 2) a sexually mature bull trout spawns every other year. There is some uncertainty about spawning frequency of fluvial bull trout (Goetz 1989), although it is likely dependent upon food supply. Recent monitoring of a McKenzie nursery stream suggests that there may be a portion of McKenzie bull trout spawning on an alternate year cycle (USFS McKenzie Ranger District 1994). Other fluvial populations (Fraley and Sheppard 1988) and the McKenzie bull trout (Jeff Ziller, pers. comm.)

Table 3-19: Total bull trout redds surveyed in the Upper McKenzie watershed spawning tributaries, 1989-1994.

YEAR	REDDS OBSERVED
1989	7
1990	9
1991	8
1992	13
1993	17
1994	33*

* includes additional habitat not previously surveyed

have been estimated to average about 3 spawning adults per redd. With a redd count of 33 in 1994 and 17 in 1993, the current number of mature bull trout in the Upper McKenzie is estimated to range from 99 to 150. To date, no evidence of bull trout spawning has been found in the McKenzie channel below Trail Bridge Dam. Population estimates will be higher if continuing surveys find main stem spawning.

To determine the viability of the McKenzie bull trout population it is important to first view the entire basin. If the McKenzie population is considered part of the historic Willamette basin larger population (metapopulation), it once drew stability from wide geographical distribution and genetic interchange of a migratory species between populations. Reduction to a single, isolated population, without benefit of immigration to replenish the gene pool, likely puts the McKenzie group at an elevated risk of extinction. There is no criteria for determining the viability of an isolated population and little available research on the minimum number necessary to avert genetic inbreeding (Rieman and McIntyre 1993). The main stem population no longer has exchange with the isolated South Fork McKenzie group, a possible separate or sub-population (USDA Forest Service 1994).

The limited current range subjects this population to additional risks. Additional risks include vulnerability of limited spawning and rearing habitat to natural and human caused disturbance. The specific habitat requirements of spawning adults and rearing juveniles below Trail Bridge Dam are currently met by three miles of habitat within two streams, all located within a one mile radius. Wildfire, or a chemical spill along a Hwy 126 crossing could devastate a significant portion of three year classes incubating or rearing in their natal stream. Spawning adults are vulnerable to poaching and incubating egg survival decreases sharply as sediment levels increase. Although recent increases in redd counts have been observed and are encouraging, long term

examination of spawning populations should be used to evaluate this small population's persistence (Fisheries Appendix). The population should therefore remain as it was classified by Ratliff and Howell in 1992 as at moderate risk of extinction.

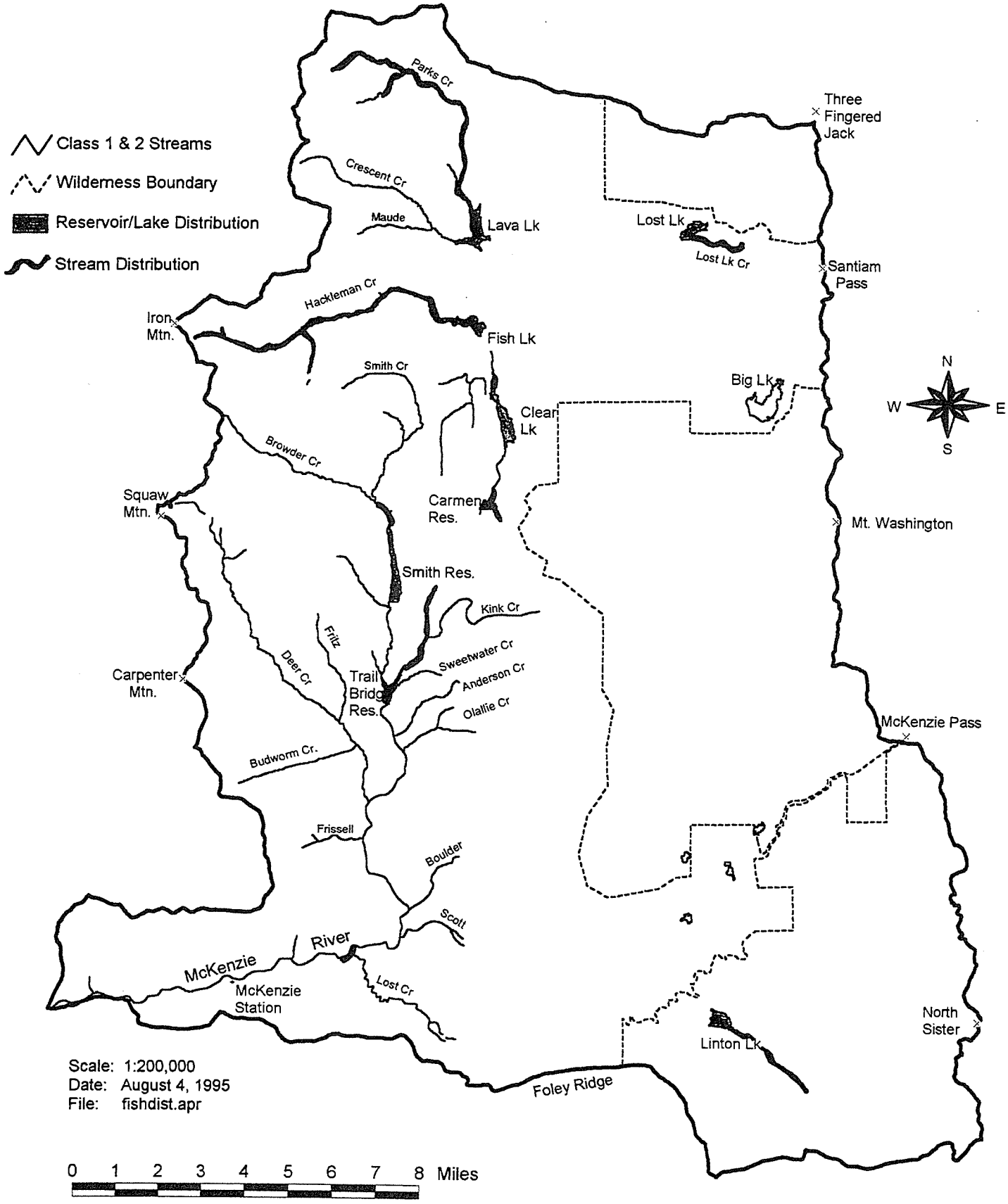
Bull trout isolated above Trail Bridge Dam are at high risk of extinction (Fisheries Appendix). Risks come from low population size (thought to range from 5 to 20 adults in 1993), passage barriers, over harvest of fish, habitat degradation, competition with brook trout, and limited available spawning habitat. Access to Sweetwater Creek spawning habitat was reestablished in 1992. Through human intervention, the main stem population is in the process of reestablishing the smaller Trail Bridge sub-population. Bull trout fry are being reseeded upstream of the dam in an effort to reestablish Sweetwater Creek spawning and rearing habitat and strengthen the number of Trail Bridge bull trout.

It is not likely that bull trout historically ranged above Tamolitch Falls. However, unverified reports of bull trout catch from Carmen Reservoir have occurred in recent years. Recent searches for bull trout in Carmen Reservoir have found none. Brook trout have been introduced to Carmen Reservoir and now reproduce naturally, ranging up the McKenzie to the base of Koosah Falls (Figure 3-23).

Location of Important Habitat for Bull Trout

Foraging and rearing habitats essential to bull trout within the analysis area below Trail Bridge Dam are the main stem McKenzie River, Lost Creek and Lower Deer Creek (Figure 3-22). Spawning and rearing habitat consists of Anderson and Olallie Creeks and historically, small, low gradient spring-fed seeps and streams, along the east bank of the upper McKenzie River. Above Trail Bridge Dam, foraging and rearing habitats consist of Trail Bridge pool, main stem McKenzie to Tamolitch Pool, and lower Smith River. Spawning and rearing habitat for the Trail Bridge sub-population consists of Sweetwater Creek and the main stem McKenzie above Trail Bridge pool. Adults and sub-adults utilize all habitats in the main stem and tributaries while foraging, their temporal distribution determined by concentrations and behavior of prey species. Adults are most often observed in deep pools utilizing available wood or undercut banks as cover. Recent monitoring of the main stem population prior to spawning saw increasing upriver concentration of adults in pools as they staged to enter spawning tributaries (ODFW 1994) or exploit drifting eggs of spawning chinook. Bull trout spawning habitats consist of low gradient pool tail-outs and riffles with abundant clean gravel and cobble. Unembedded substrates and cold water temperatures are essential for spawning and

Figure 3-23. Naturally Reproducing Brook Trout - Current Distribution



incubation success. The McKenzie spawning streams possess abundant in-stream large wood, high channel complexity and a mature conifer canopy. Main stem rearing habitats and winter refuge consist of side channels, river margins and tributaries.

Role of the Watershed in Recovery of Bull Trout

The upper McKenzie watershed retains one or two bull trout populations, including the S.F. McKenzie River. Maintenance and restoration of habitat essential to main stem bull trout is expected to provide for recovery of the local population. The response of the Trail Bridge sub-population to recent restoration will not be available until the late 1990's. Other populations in the Willamette Basin are extinct or no longer viable. Restoration of the Willamette Basin bull trout metapopulation will necessarily follow restoration of basin habitat and recovery of McKenzie populations. Following historic habitat recovery, reseeding basin tributaries with bull trout from the McKenzie River may be the only alternative available for re-colonization. Natural re-colonization, via the lower McKenzie and Willamette Rivers, will depend upon restoration of channels to conditions meeting bull trout habitat needs. Restoration of prey species and their habitat (spring chinook), with which bull trout have evolved and coexist in the basin, will be necessary for bull trout recovery.

Coastal Cutthroat Trout

Within the Upper McKenzie, native cutthroat are distributed in main stem and Class I and II tributaries. Seasonal use by cutthroat of some Class III and IV tributaries is likely. Three cutthroat life history patterns exist in the Upper McKenzie River and tributaries:

1. Fluvial populations utilize the main stem for most of their life, moving into tributaries to spawn, rear and seek refuge from high flow.
2. Resident populations spend most of their life in tributaries, utilizing this habitat as foraging, spawning and rearing habitat. Movement into larger tributaries and the main stem is possible with this life history form.
3. Isolated populations are located in higher reaches of tributaries, above barriers, spending their entire life in relatively short stream segments.

Considerable genetic variability between populations, particularly between isolated populations, is possible (Behnke 1979). Potential for genetically unique isolated populations exists in numerous upper tributaries and portions of the subbasin isolated by volcanic events. Cutthroat population trends have not been made as occasional trout inventories have been scattered throughout the subbasin. The extent and influence of hatchery stocking of non-native cutthroat is unknown, most of the activity having occurred in the early 1900's. Existing records describe planting of non-native hatchery stock in lakes (Clear Lake, Landform Block 2B). Where introduced brook trout overlap native cutthroat distribution, exists the potential for loss of cutthroat populations. Extirpation of

cutthroat trout is possible in the upper subbasin, especially in Hackleman and Parks Creeks. Loss of a possible Lost Lake and Lost Lake Cr. cutthroat population from brook trout competition may have occurred.

Rainbow Trout

A resident rainbow trout living a fluvial life history pattern is present in main stem and larger tributaries as an adult. Spawning and rearing occurs in the main stem and larger tributaries. Little is known of rainbow population trends or number. The best estimates are from creel proportions of wild fish to hatchery origin. Howell et al. (1988) found rainbow to be the most abundant fish in the Upper McKenzie River. Stocking hatchery rainbow fingerlings began in the early 1900's and ceased in the 1950's due to poor survival. Stocking of legal-sized rainbow began in 1947 in response to declines in number and size of catch (Howell op. cit.). Three stocks of rainbow have been released into the McKenzie, those originating from the spring spawning McKenzie population and fall spawning Roaring River and Cape Cod stock. Currently Cape Cod stock is utilized in the local hatchery program. The uppermost limit of hatchery stocking occur within the analysis area, beginning at Paradise Campground about 3.5 miles above McKenzie Bridge. 120-125,000 hatchery rainbow are stocked annually, evenly distributed between Paradise Campground and Hayden Bridge (River Mile 69 to 11).

In addition, various lakes and reservoirs in the upper subbasin are stocked with rainbow (Fisheries Appendix). Potential for natural reproduction exists, although no known establishment of introduced rainbow stocks have occurred. Some hatchery mixing of McKenzie and Roaring River stock is thought to have occurred inadvertently in hatcheries. The influence of hatchery origin rainbow and introduced summer steelhead upon native rainbow is not known. Monitoring of native populations will be necessary to avert potential detrimental effects of stocked rainbow, such as hybridization, disease transfer and displacement (Utter 1994). Potential impacts to native stocks may be represented in the proportion of wild rainbow observed in recent angler catches. The proportion of wild rainbow in surveyed angler catches throughout the McKenzie River dropped from 46% in 1950 to 11% in 1974 and 1983, possibly reflecting loss of wild McKenzie rainbow populations (ODFW 1983).

Summer steelhead (anadromous rainbow trout)

Summer steelhead were introduced into the McKenzie subbasin in 1968. A Skamania River stock is currently utilized as previous Siletz stock was found susceptible to a naturally occurring disease organism (Howell et al. 1988). Spawning surveys found adults are reproducing naturally in suitable larger tributaries upstream of Leaburg Dam such as upper Deer Creek and Lost Creek in late winter and early spring. State managers release all hatchery reared smolts below Leaburg Dam to avoid potential competition between native trout/spring chinook and introduced steelhead. 100-160,000 steelhead smolts

are released annually below Leaburg Dam. Counts of steelhead adults passing Leaburg Dam range from 200-2,000 since 1986 when ratios of wild to hatchery origin fish were first kept. The percentage of naturally produced steelhead passing Leaburg has ranged from 3-51% since 1986 and has dropped to 8-15% since 1990. Hatchery origin steelhead compose the remainder. Similar habitat utilization by spawning steelhead adults as native rainbow and rearing habitat use by juvenile steelhead and native rainbow/chinook salmon likely poses production limitations on native species.

Brook Trout

This popular game fish and successful exotic was first introduced into the subbasin in the early 1900's. Utilization of brook trout as a game fish has ceased in all waters where potential impacts to natives species is possible. Naturally barren high mountain lakes lacking opportunity for downstream migration are the only locations currently used for brook trout stocking. Brook trout have established naturally reproducing populations in the upper subbasin. Competition between brook trout and native cutthroat threaten isolated populations of cutthroat in Hackleman and Parks Creek drainages. The potential for hybridization between native char bull trout and brook trout exists in the subbasin. Bull trout isolated above Trail Bridge Dam are at risk of extinction, in part due to the presence of brook trout.

Mountain Whitefish

A fluvial population of whitefish is found in the main stem and larger tributaries of the Upper McKenzie River. Little is known of their abundance or population trends in the subbasin. Mountain whitefish are described as plentiful in the main stem (Howell et al. 1988) and possibly the most prevalent sport fish in the subbasin. In 1983 whitefish, seldom sought by anglers, accounted for about 1% of total sport catch in the Upper McKenzie River (ODFW 1983).

RIPARIAN HABITAT - WILDLIFE

ROD STRATEGY

The riparian protection strategy outlined in the 1994 ROD assumes that the riparian buffers will provide protection for riparian-associated species and dispersal habitat on the landscape for forest-dwelling species. The following discusses the condition of the UPMAKWA riparian network and evaluates the potential for success of the ROD riparian reserve strategy on this landscape.

There are 60 species of wildlife within the watershed that use riparian areas as primary habitat for breeding and for feeding. Table 3-20 displays these riparian-associated species and what stream classes they use as primary habitat. The majority (30%) are migrating waterfowl that primarily utilize the water column

while they are in the area. Thirteen of these species require mid or late seral forests adjacent to class 1-3 streams, lakes, and ponds.

The intermittent nature of class 4's probably precludes primary use by most species. The only species that appeared to use class 4 streams as primary habitat are the Dunn's salamander, Cascade Salamander, and water vole. It is unknown what classes the Pacific water shrew may use. Species associated with riparian habitat generally require clean, cold, running water.

Table 3-20: Species that use riparian habitat primarily for breeding and/or foraging by stream class.

SPECIES	STREAM CLASS
Water column of riparian reserve only	
American coot	1
American widgeon	1
Blue-winged teal	1
Canvasback	1
Cinnamon teal	1
Common loon	1
Eared grebe	1
Gadwall	1
Greater scaup	1
Green-winged teal	1
Horned grebe	1
Lesser scaup	1
N. Pintail	1
Pacific Loon	1
Red-throated loon	1
Redhead	1
Ruddy duck	1
Surf scoter	1
Western grebe	1
Pied billed Grebe	1
Water column and open condition on banks	
Canada goose	1
Killdeer	1
Mallard	1

Water column and open condition on banks	
Water vole	1-3 4?
W. Pond turtle	1
Water Column and banks/generalists	
Dunn's salamander	1-3 4?
Bald Eagle	1
Common egret	1
Common egret	1
Great Blue heron	1,2
Green backed heron	1,2
Osprey	1
Pied-billed grebe	1
Ring-necked duck	1
Beaver	1,2
Mink	1,2
Muskrat	1,2
River Otter	1,2
Pacific Water shrew	unknown
Water column and mid/late seral banks	
Cascade torrent salam.	2,3 4? (seepy areas)
Pacific giant salamander	1,2 3?
Tailed frog	2,3
American dipper	1,2
Barrow's goldeneye	1
Belted kingfisher	1,2
Bufflehead	1
Common goldeneye	1
Common merganser	1
Harlequin duck	1,2
Hooded merganser	1
Wood duck	1,2
Water shrew	1,2,3
No water column use—needs open plant community on bank	
Common yellowthroat	1-3
Marsh Wren	1

No water column use–needs open plant community on bank

Yellow-breasted chat	1-3
Spotted Sandpiper	1-2

No water column use–generalist in adjacent forest

American redstart	1,2
Bank swallow	1
N. roughwinged swallow	1,2

No water column use–mid/late seral adjacent forests

Red-eyed vireo	1,2
White-footed vole	1,2

No water column use–deciduous riparian vegetation required

Downy Woodpecker	1,2
Warbling vireo	1,2,3?

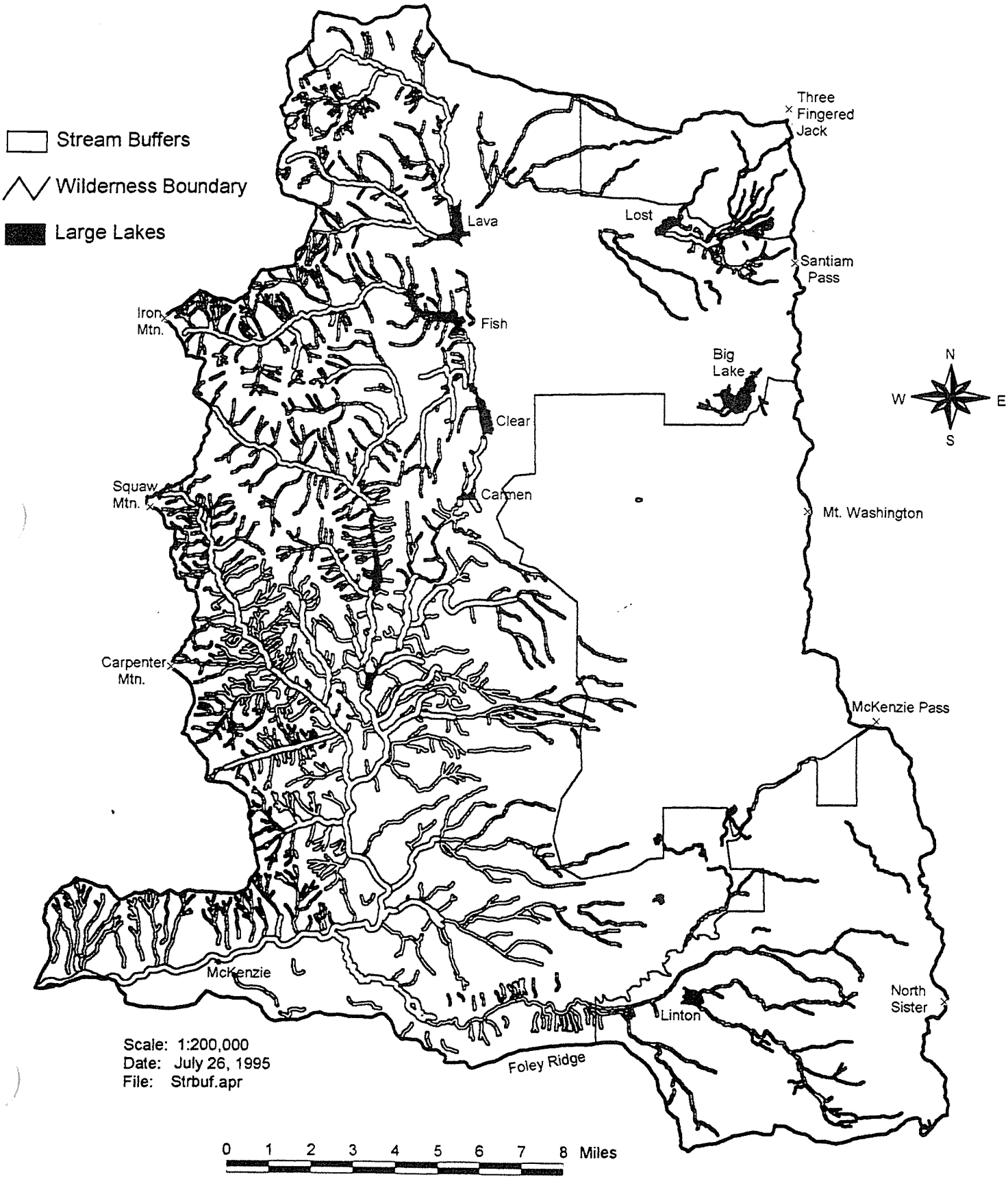
Figure 3-24 displays the riparian reserves. Table 3-21 displays the acres of habitat within default riparian reserves by stream class. The majority of all stream classes are located within a reserve with late successional habitat. Early seral habitat is primarily associated with the class II and III streams. The table above indicates that those stream classes are used by species associated with open stand plant communities. It will be important to maintain natural open communities within the riparian reserves, which are not well-represented in Fig. 3-24.

Table 3-21: Seral stage of stands within default riparian reserves in the UPMAKWA.

CONDITION OF RIPARIAN RESERVE FOREST *	ACRES CLASS I	ACRES CLASS II	ACRES CLASS III	ACRES CLASS IV
STAND INITIATION	132.3	729.4	888.9	1931.5
percent	4	18	21	14
STEM EXCLUSION	982.2	724.9	1165.6	4195.0
percent	28	28	27	30
UNDERSTORY REINITIATION	356.9	176.5	295.3	1488.9
percent	10	4	7	11
OLD GROWTH	2023.3	2390.7	1943.2	6320.8
percent	58	59	45	45
TOTAL	3494.6	4021.5	4293.0	13936.0

*See Silviculture Appendix for definitions of stand conditions

Figure 3-24. Streams with Default ROD Buffers



The REAP report (1993) modeled the range of early and late seral habitat that occurred in the McKenzie subbasin between 1600 and 1850. Table 3-22 displays this range of variability and compares it to current habitat abundance. The watershed is currently well within the historic range of variability for these habitats.

Table 3-22: Historical range of stand conditions in the McKenzie basin between 1600-1850 compared with current abundance.

- - - - - range in abundance from 1600-1850
* current abundance

```
                                  Percentage
                                0   20   30   40   50   60
EARLY SUCCESSIONAL              ----
                                  *
LATE SUCCESSIONAL                     ----------------
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RIPARIAN RESERVE - MANAGEMENT OF WILDLIFE HABITAT

If the riparian reserve standards and guidelines are altered, additional analysis is recommended for several species (Appendix 2, Terrestrial Module for Watershed Analysis) (USDI, USDA 1994; ODFW 1992). The Wildlife Appendix displays potential affects to wildlife species with the implementation of various projects in riparian reserves. Table 3-23 displays the risk factors associated with management of these species.

Table 3-23: Conditions that could pose risks to populations of wildlife intended to benefit from riparian reserves.

SPECIES	RISK FACTORS
P. Dubium	road maintenance in rockslide areas, loss of riparian habitat
N.Spotted Owl	fragmentation and conversion of LS habitat
Marten	fragmentation and conversion of LS habitat, loss of LWD
Red Tree Vole	fragmentation and conversion of LS habitat
Tailed Frog	loss of streamside habitat, increase temps, sedimentation
Cascade Torrent Salamander	loss of headwater, intermittent, and seep habitat

Table 5-2 in Chapter 5 discusses the recommended riparian buffer widths for each stream class by Landform block. Generally, it was recommended that class 1-3 streams maintain the ROD default buffer widths to protect the hydrological function, plant community, fish and wildlife habitat. It was recommended that class IV streams may receive variable widths after additional site-specific analysis is conducted. Recreating patterns similar to those created from past disturbance events would be the impetus for alterations to class IV streams.

The default riparian buffers for class IV streams appear to have been prescribed by the ROD to perform 3 functions for wildlife: 1. dispersal habitat for terrestrial upland species such as the spotted owl, marten, and red tree vole; 2. dispersal habitat for species associated with the wetted portion of the riparian buffer such as tailed frog and Cascade Torrent salamander; and breeding habitat for species such as the Cascade Torrent salamander. Proposals to alter the class IV buffers should take these functions into consideration.

The dispersal for the upland terrestrial species can be accomplished through other landscape patterns not necessarily related to Class IV distribution. Table 3-24 displays the percentage of each landform block in a riparian reserve. None of the landform blocks' riparian reserve networks are of sufficient abundance and density to maintain a 50-11-40 condition without additional landscape level management of the matrix. Well-distributed patches of late successional habitat linked by patches of mid seral forest in a pattern similar to the 50-11-40 rule would adequately provide for this function. The existing abundance of late successional habitat in class IV buffers should be retained on the landscape. Instead of linear strips along the class IV's, patches could be extended out into the matrix to serve as small refugia for dispersing animals. These patches should be closer together in highly fragmented landscapes or steeply incised drainages to facilitate movement.

The breeding and dispersal habitat functions for amphibians and other species listed in Table 3-20 could be provided for by maintaining high quality cover on portions of these streams. Buffers of a width that would adequately protect the water quality and temperature of seep areas should be a high priority. Surveys for Dunn's and Cascade salamanders should be a priority in areas proposed to be managed without a riparian reserve.

Table 3-24: Percentage of riparian reserves currently and potentially meeting an 11-40 condition within each landform block.

LANDFORM BLOCK	% OF LANDSCAPE IN RIPARIAN RESERVE THAT IS CURRENTLY IN A DISPERSAL CONDITION	% OF LANDSCAPE IN RIPARIAN RESERVE THAT COULD BE IN A DISPERSAL CONDTN IN FUTURE
1	14	20
2A	20	33
2B	15	22
3	4	5
4	2	2
5	9	14
6	7	9

Many of the survey and manage species of bryophytes, lichens, fungi and vascular plants are associated with riparian zones and the transition Ecotone between the upland terrestrial vegetation communities. Field data is lacking to determine the zone of influence of individual streams. The draft Terrestrial Ecology Addendum (1995) contains a list of plant species that must be considered prior to modifying riparian reserve boundaries. These species were considered by the team when Table 5-2 was created. **This is an area, however, where additional information is needed to fully support the recommendations in Table 5-2.**

OVERVIEW OF WILDLIFE

Viability for many of the late successional and riparian associated species that occur within the Upper McKenzie Watershed Analysis were analyzed within the FEMAT (1993). These species were all shown to exhibit moderate to high levels of viability under the management strategy of the President's Plan. Other species, including ROD C-3, TES, and those listed in the ROD with specific S&G's, may require additional analysis at finer scales to ensure viability. Species that were outside of the scope of the FSEIS and at risk, such as some early seral species and those associated with special habitats, may also require additional analysis. The following is an overview of species that require additional analysis (Table 3-25), highlighting viability concerns that may occur with the implementation of the ROD. Species of concern for other reasons, such as economic and hunting experience, are also discussed below. Viability is generally not a concern for these species, but maintenance of populations to meet

recreational needs (i.e. determined by ODFW and WNF Forest Plan targets) is important.

Table 3-25: Species within the UPMAKWA boundary that require finer scale analysis during watershed analysis..

Threatened or Endangered	Sensitive	Table C-3 and S&M Species
Northern Spotted Owl	California Wolverine	Great gray owl
Northern Bald Eagle	California Wolverine	Red tree vole
Peregrine Falcon	Harlequin Duck	Black-backed woodpecker
	Sandhill Crane	Flammulated owl
	T.Big-eared Bat	*Prophysaon coeruleum*
	White-footed vole	*P.dubium*

Recreation Concern
Roosevelt Elk

NORTHERN SPOTTED OWL (*Strix occidentalis*)
There are 43 owl sites within the UPMAKWA. An additional 24 have activity centers that fall outside of the UPMAKWA boundary, but portions of their home ranges extend into the watershed. Eight of the sites within the boundary are currently in a "take" situation for available acres within 1.2 miles. There are 8 quarter-townships in the watershed (out of 67) that do not meet the 50-11-40 rule currently, and an additional 16 that are approaching the 50% level. There are currently few concerns for dispersal throughout the watershed and between LSR's even with these deficit quartertownships. However, a critical linkages across the Santiam Pass need to be maintained to fulfill the objectives of the Critical Habitat Unit and Area of Concern in that area. Detailed information for future incidental take calculations, assessment of the Late Successional Reserve system and Critical Habitat Unit, and 50-11-40 analysis is included in the Wildlife Appendix.

ROD S&G's ensure the continued viability of this species on the landscape. The USFWS has recommended that take be avoided if possible in the matrix while the LSR's recover habitat and begin to fully function. Incidental take will be granted by the USFWS in the matrix.

NORTHERN BALD EAGLE (*Haliaeetus leucocephalus*)
Potential nesting, foraging, and roosting habitat is recognized within the vicinity of four lakes: Big Lake, Clear Lake, Linton, and Lost Lake; and three Reservoirs: Smith, Trailbridge, and Carmen. Additional habitat may be available in smaller lakes within the wilderness.

The majority of these lakes, with the exception of Big Lake, are providing moderate to high quality bald eagle habitat. All of these areas have been surveyed over the past 4 years. Bald eagles have been observed utilizing all of these areas. An historic nest at Clear Lake appears to have been abandoned. Survey efforts have not identified a new nest site. The Clear Lake site is monitored yearly by the Oregon Cooperative Wildlife Research Unit at Oregon State University through a contract with Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and Wildlife Management Institute. The historical status of this site is described in Table 3-26. This site is counted in the Target Recovery territories. When a new nest site is discovered, a Bald Eagle Management Plan will be completed, as required under the Recovery Plan.

Table 3-26: Historical status of bald eagle occupation at the Clear Lake site, site number 269-101 (info from Anthony and Isaacs 1992).

YEAR	STATUS
1989-1990	site occupied, at least 1 adult and nest, no evidence of eggs or young at known nest (occupied or breeding failure).
1991-	
1992-1993-	site occupied, at least 1 adult and nest, no evidence of eggs or young at known nest (occupied or breeding failure). Nest used or location uncertain; need to determine or verify locations or territories.
1994	same as 1992-93
1995	" " "

ROD buffers on riparian areas will help to maintain the viability of this species. WNF LMP and the Bald Eagle Recovery Plan mandate additional protective measures that are in place on this landscape to ensure the continued viability of this species.

AMERICAN PEREGRINE FALCON (*Falco peregrinus*)

In 1981, 1990, 1991, and 1992 the Oregon Department of Fish and Wildlife completed an aerial reconnaissance of cliffs on the McKenzie RD that identified nest site potential. Ground surveys have also identified potential habitat in the area. Ground inventories in 1992-1994 did not document any occupied eyries areas in this watershed. In 1995, a new eyrie was verified. Sitings have occurred in 6 areas with cliff habitat, and efforts continue to verify use and additional eyries. Additional information on potential cliff habitat is described in the Landblock section. ROD buffers on riparian and wet meadow habitats will help to maintain the viability of this species. WNF LMP and the Peregrine Recovery Plan mandate additional protective measures that are in place on this landscape to ensure the continued viability of this species.

GREATER SANDHILL CRANE (*Grus canadensis*)
Sandhill Cranes are known to nest at Lava Lake, which lies on the northwest boundary of the UPMAKWA. They are part of the Central Valley Population (CVP), which is one of four populations in North America. It is the westernmost and second most numerous (Schlorff et al. 1985). This population is fairly stable at this time (Littlefield, pers. comm., Marshall et al. 1992), and it has expanded its range into new areas, including the Cascade Range. Cranes have been documented at Lava Lake since 1981, but nesting success has only been monitored for the past 5 years. Two chicks were observed in 1988, but it is unknown if they successfully fledged. Most pairs do not begin nesting until age 4 or 5, and most fail at fledging young the first few seasons because of inexperience (Paullin 1989). Some birds are never successful (Ivey, pers. comm.). Factors such as predation, brood strife, disease, starvation, and livestock grazing probably all contribute to pour reproductive success at Lava Lake. Predation most likely has a greater impact than effects of grazing, which has occurred in the meadow since between 1911 and 1995. Reducing grazing may not alter the reproductive success rate. It has not been seen to significantly alter the success of cranes on the Malheur National Wildlife Refuge (Paullin 1989).

The Sweethome Ranger District has developed an Environmental Analysis for managing a grazing permit in that area. The grazing permit will be void within the next year, eliminating potential impacts to this site from grazing.

ROD buffers on wet meadows within this landscape will aid in the continued viability of this population.

CALIFORNIA WOLVERINE (**Gulo gulo luteus**)
Potential habitat for wolverines does occur in the UPMAKWA area. High elevation areas in the Mt. Jefferson, Mt. Washington, and Three Sister's Wildernesses probably serve as their primary habitat for the majority of the year. In 1977 the Sweet Home Ranger District had a suspected road kill on Hwy 20, which runs through the project area. A wolverine was observed near Hoodoo Butte in the winter of 1993 and in the Cupola area in the fall of 1992. The McKenzie RD began using baited camera stations to assess the population of wolverines in the Santiam Pass area in the winter of 1993. This survey technique has yet to document their presence. ODFW in Bend is also surveying for wolverines on the Sister's RD (adjacent to the watershed) using a winter track-intercept method. They have not documented any wolverines in the area. ROD S&G's do not specifically address this species. Risks to their continued viability lie primarily in the loss of solitude at high elevations. Increased recreational activity in the wildernesses and development in the Santiam Pass (i.e. Hoodoo Ski Bowl) will need to be assessed.

TOWNSEND'S BIG-EARED BAT (*Plecotus townsendii townsendii*)
Isolated populations of this bat have been found on the WNF. Potential habitat has been mapped throughout the UPMAKWA area. Lava tubes provide the highest quality habitat in the area in the Santiam Pass. Surveys have documented occupied hibernaculum. This species is extremely sensitive to human disturbance. The hibernaculum are currently being disturbed by recreationists. We believe the potential of these sites to continue to provide wintering habitat is on the decline. Surveys over the past 4 years have indicated a decline in use. ROD S&G's specifically protect this species from the direct impacts of logging through buffers on caves (C-43) and from indirect impacts through protection for riparian and wet meadow habitats. Additional threats to the continued viability of this species include human disturbance. A cave management plan for the occupied hibernaculum in the analysis area will alleviate this threat.

RED-LEGGED FROG (*Rana aurora*)
Red-legged frogs have been documented in the lower elevations of the UPMAKWA area in ponds, warm springs, and in sidechannels of the McKenzie River. They appear to be relatively common. ROD S&G's aid in maintaining the viability of this species through buffers on ponds and riparian areas. Interconnectedness of the population is probably not a concern in this area. The landscape will be well connected through the riparian reserve network, and this species can also migrate through mid and late seral habitats to reach breeding sites.

HARLEQUIN DUCK (*Histrionicus histrionicus*)
Surveys have been conducted for Harlequin ducks on the McKenzie River for the past 3 years. Research for a Master's thesis is in its second year investigating nest site characteristics. Ducks and broods have been sited on the McKenzie River and several of its tributaries. A total of 13 potential sites exist in the watershed. During nesting season (April-July) adult harlequins require fast-flowing water with one or more loafing sites nearby. High quality habitat is being provided in the McKenzie River. Potential impacts to the population include human disturbance, loss of water quality, and loss of loafing sites. The McKenzie River receives heavy boater use throughout the season. The adults do not appear to be significantly disturbed by boaters, and guides have been informed to avoid disturbing them. Females with broods appear to spend their time in the adjacent tributaries or in areas of the river that are inaccessible to boaters. Harlequins nest on the ground under the shelter of vegetation, rocks, or large woody debris. Of the nests found, several were near areas of human activity. This species may be less sensitive to human disturbance than previously thought. Midstream loafing sites are very important, and the McKenzie has abundant boulders and islands to provide this type of habitat. Removal of large woody debris from the banks or within the stream channel

could impact this species if adequate habitat is not available. ROD riparian buffers will aid in maintaining the viability of this species.

WHITE-FOOTED VOLE (*Arborimus albipes*)
No surveys for this species have been conducted in the watershed. There were 3 individuals trapped on the H.J. Andrews Experimental Forest adjacent to the watershed, so we expect them to be here. White-footed voles are extremely rare. Data from trapping indicates they are associated with mature riparian stands (D. Gomez, 1990) and red alder riparian habitats. They are often found in heavy cover consisting of downed logs and/or brush. Threats to their habitat include impacts to riparian vegetation, either through logging or human disturbance, and connectivity of the population within the watershed. ROD riparian buffers will aid in maintaining the viability of this species. Mature riparian habitat within the watershed will be well-connected with the prescribed riparian reserve network and other no-harvest allocations..

BLACK-BACKED WOODPECKER AND FLAMMULATED OWL
The Black-backed is a rare but known occupant of the UPMAKWA in the higher elevation lodgepole pine/true fir forests. The Flammulated owl is suspected to occur, though it is known to occur more commonly to the east. Loss of snag habitat is the primary concern for these species. Impacts to their prey base is also a concern. Black-backed feed on wood-boring insects; flammulated owls feed on insects including lepidoptera species.

ROD guidelines should aid in maintaining the viability of these species. Guidelines include maintenance of adequate numbers of large snags and green-tree replacements for future snags. Where feasible, green-tree replacements for future snags can be left in groups to reduce blowdown. No snags over 20" dbh should be marked for cutting. Full (100%) population potential for each species must be maintained. The 100% level for black-backed woodpeckers equates to 0.12 conifer snags per acre. These snags must be at least 17" dbh or largest available and in hard decay stages. This requirement must be added to provisions for other cavity nesting species already required by the WNF LMP (1990), which requires 40% levels for the guild. This equates to 4.94 snags per acre at high elevation sites. The Wildlife Appendix describes snag requirements for primary cavity excavators in the watershed. Black-backed woodpeckers also require beetle infested trees for foraging. Some trees should be provided in appropriate habitat, and sanitation harvest of all such trees would be detrimental to the species. Riparian buffers will also aid in the maintenance of the flammulated owl population. Lepidoptera communities achieve their highest diversity in riparian area.

GREAT GRAY OWL (*Strix nebulosa*)

The GGO is a known inhabitant of the UPMAKWA. There are 8 activity centers in the watershed, including 4 historic nests. An additional 3 areas have responses and work is currently underway to determine site status. The most recent documented nest site was found in 1995 near Pebble Seed orchard. This species is most commonly found near meadow complexes on the eastside of the Cascade Crest. It may be a rare occupant of the westside. Only 15 activity centers are known on the entire WNF, the majority being in the UPMAKWA watershed. The abundance in this area may be influenced by the ability of individuals from the eastside to cross the Santiam Pass. Or, more intensive survey efforts that have occurred in this watershed may be skewing density information for the Forest. We suspect that the Santiam Pass is a dispersal corridor for this species. GGO's on the westside appear to forage in clearcut areas. Meadow complexes are widely dispersed in the landscape and do not appear to be associated with GGO known sites. Table 3-27 displays the abundance of meadow areas within varying radiuses of the known sites. Table 3-28 displays the acres of early, mid and late seral habitat within .25 miles of the sites.

Table 3-27: Meadow habitat within 0.25 miles of known great gray owl sites..

SITE NUMBER	ACRES OF NON-FOREST HABITATS
1	148.13
2	32.9
3	343.1
4	344.24
5	343.0
6	157.4
7	32.8
8	35.0

Table 3-28: Percentage of forested habitat by seral stage within 0.25 miles of known great gray owl sites.

SITE NUMBER	% EARLY SERAL	% MID SERAL	% LATE SERAL
1	0	21	77
2	15	0	83
3	28	6	66
4	16	18	65
5	63	6	31
6	77	0	23
7	42	0	57
8	37	0	49
MEAN	34	6	56

ROD S&G's were offered to specifically protect this species. Meadows within potential habitat must be buffered with 300' no harvest areas and 1/4 mile protection zones must be established around nest sites. This requirement appears to be based on ecosystems where GGO's are foraging in meadow complexes and nesting near the meadows. The GGO population in the UPMAKWA appears to forage in cutover areas. Of the 8 activity centers, meadow habitat abundance ranges from 32-344 acres within 0.25 miles of the site center. Most of these non-forested areas are small and highly scattered. No harvest zones around nest sites may protect the nest tree, but they may not adequately provide foraging habitat near the nest site if the owls are relying on early seral forested habitat created through clearcutting. Currently, an average of 34% of the habitat within a 0.25 mile radius of the GGO sites is in an early seral stage. ROD standards and guidelines may not adequately provide for continued viability of this species in this watershed because of their apparent use of clearcuts versus meadow complexes for foraging.

AMPHIBIANS

None of the amphibians listed in the ROD occur in the UPMAKWA. Riparian reserve buffers, large woody debris retention requirements, special habitat buffers, and limitations on the removal of duff layers during burning required by the ROD and WNF S&G's should adequately protect the 17 amphibian species that do occur in the watershed. An additional threat to some amphibians not covered by the WNF Forest Plan comes from introduced fish species in some high mountain lakes. Data has shown that long-toed salamanders are heavily impacted by introduced fish in high mountain lakes (Liss 1994). Undocumented impacts to other species may also be occurring. Management strategies for maintaining the native biota of the wilderness lakes should be explored.

OREGON RED TREE VOLE (*Arborimus longicaudas longicaudas*)
This species occurs in the UPMAKWA. Their remains have been found in spotted owl pellets collected by researchers with the Oregon Cooperative Wildlife Research Unit (Swindle 1995) on Blue River RD, adjacent to the watershed, and within the watershed by Al Dohmen (1990 pellet study) at the Great Springs owl site. Records from various other research projects will be checked. This species is highly associated with late successional forest patches, though recent survey efforts have also been finding nest sites in younger stands in the coast range (Biswell, personal comm.). Huff et al (1992) rated this species as the most vulnerable of the arboreal rodents to local extirpations resulting from the loss or fragmentation of old-growth forests.

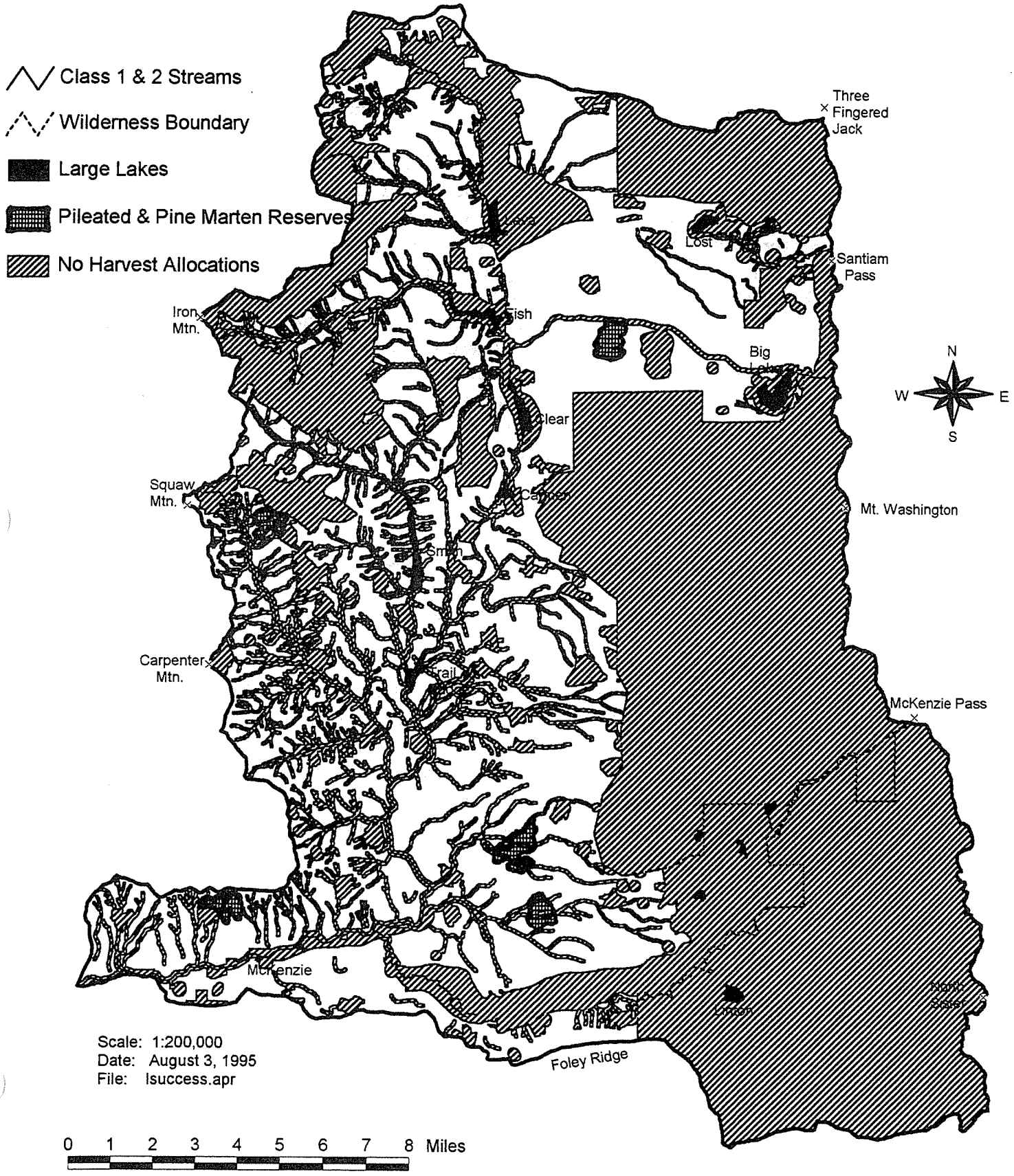
There is a likelihood they do not occupy the higher elevation vegetation series. The presence of Douglas-fir trees is a very important component of the overstory. Huff et al. (1992) described their range up to 3000' in the Central and Northern Cascade Range. However, owl pellets with voles have been found up to 4400' in the watershed. The Great Springs site is in a grand fir series, and a site on Blue River RD is in a transition area between Douglas-fir/Western hemlock and Pacific silver fir forests.

The populations are likely to be sparce in forest matrix between Late Successional Reserves in the future (Appendix J-2). The species has limited dispersal capabilities, so a fragmented matrix could limit movement between populations within Late Successional Reserves. ROD buffers for riparian areas and retention of the oldest and largest green trees in harvested areas will aid in maintaining the viability of this species by increasing the probability of successful flow through the landscape. The flow may also be facilitated by providing well distributed blocks of late successional habitat. Also, mid seral habitat should be dispersed between high quality late seral habitat over time. The LSR's are providing well-distributed, high quality patches of late successional blocks. There are several gaps, however, and recommendations for retained pileated and pine marten cores and other blocks of habitat are displayed in Figure 3-24.

The ROD also protects this species by requiring survey prior to activities and management of sites identified. It is unknown at this time what the protective measures may be for known sites. Surveys must precede the design of all ground-disturbing activities that will be implemented (contracts sold) in 1997 or later. Verification of their presence at higher elevation sites that contain Douglas-fir trees need to occur.

A habitat mapping and ranking process was described by Huff et al (1992). Time constraints and lack of data inhibited this WA team from implementing

Figure 3-24a. Potential Connectivity of Late Successional Habitat



that process. To identify high quality habitat areas, this model should be considered in the future. High quality was mapped through the guilding/Habscapes process described below.

MOLLUSKS

Of the 43 mollusks listed in Table C-3 and 97 analyzed for Appendix J2, only two have a "reasonable chance" of occurring on the WNF, according to Dr. Furnish, a researcher who reviewed the list for the S. Fork Pilot Watershed Analysis process. *Prophysaon coeruleum* is a slug that occurs in relatively moist coniferous forests from low to middle elevations from south Puget Sound down into the Willamette Valley. Historic sites are now within urban areas. There are no currently known locations on the WNF. *Prophysaon dubium* is another slug that is moderately associated with riparian areas. It is also found in rockslide areas. Road building and road maintenance are potential disturbances to this species in rockslide areas. The ROD protects these species through managing known sites and conducting surveys. These surveys must be completed prior to ground disturbing activities implemented (i.e. contract sold) 1999 or later. ROD riparian reserves will provide some level of protection for these species, but rockslide areas outside of riparian zones will need to be identified and protected for *P. dubium*. Appendix J2 admits that local extirpation of these species will probably occur even with the above protective measures.

ARTHROPODS

There are four general groups of arthropods listed in the ROD Table C-3. These species occur in the southern portion of the Spotted Owl's range in southern Oregon and Northern California. They do not occur in the UPMAKWA area.

ROOSEVELT ELK

There are 25 elk management areas in this watershed, including 11 High, 10 Moderate, and 4 Low emphasis (Figure 3-25). Elk habitat is displayed in Figure 3-26. Each emphasis area has different management objectives within the WNF LMP. Wisdom model outputs for each analysis area are listed in the Wildlife Appendix. Tables 3-29a and b display emphasis areas that are currently not meeting the LMP objectives. The location of these problem areas are shown in Figure 3-25.

Table 3-29a: High Emphasis Elk areas that are not currently meeting LMP objectives. (x indicates model value below LMP objectives)

EMPHASIS AREA	HEs	HEc	HEc-w	HEf	HEr	HEi
Kink		x	x	x		x
Anderson/Olallie		x	x	x		
Norwegian/Twisty		x	x	x		
Boulder		x	x	x		
Scott		x	x	x		
Hackleman			x	x	x	x
Ikenick/Gate				x		
UW McK/Fritz/Bunchgrass		x	x	x	x	
Florence/Mill				x	x	x
N.FK Parks				x	x	
Browder				x		
Maude				x	x	

Table 3-29b: Moderate Emphasis Elk areas that are not currently meeting LMP objectives. (x indicates model values below LMP objectives)

EMPHASIS AREA	HEs	HEc	HEf	HEr	HEi
Old Squaw/W&E Brush				x	
Budworm/Frissel			x		
Frost			x		
Hoodoo		x			x
UN Santiam			x		
W.Branch	x	x			

Biologists using the Westside elk model are concerned about how well it actually reflects elk habitat. Elk numbers continue to rise in this area. This Unit has the highest bull to cow ratio on the westside even with low HE values. The ability of managers to effectively make change to model results varies depending on the index. Low HEr values can be increased to meet LMP objectives through closing of roads. The majority of areas where HEr is low are currently being reviewed as part of road management plans. Low HEf values will be more difficult to change in the future, and model outputs may not be accurately reflecting the availability of forage on the landscape. Fewer areas will be clearcut and more areas will be thinned. Burning and fertilizing are also being used less frequently. Model inputs need to be changed to reflect the management that will occur in the future. Strategies to maintain forage on the landscape could include permanent forage areas and wider thinning of plantations. Low HEc values will also be difficult to change. A flood of low quality hiding cover will effectively

Figure 3-25. Big Game Emphasis Areas with Winter Range & Problems Identified

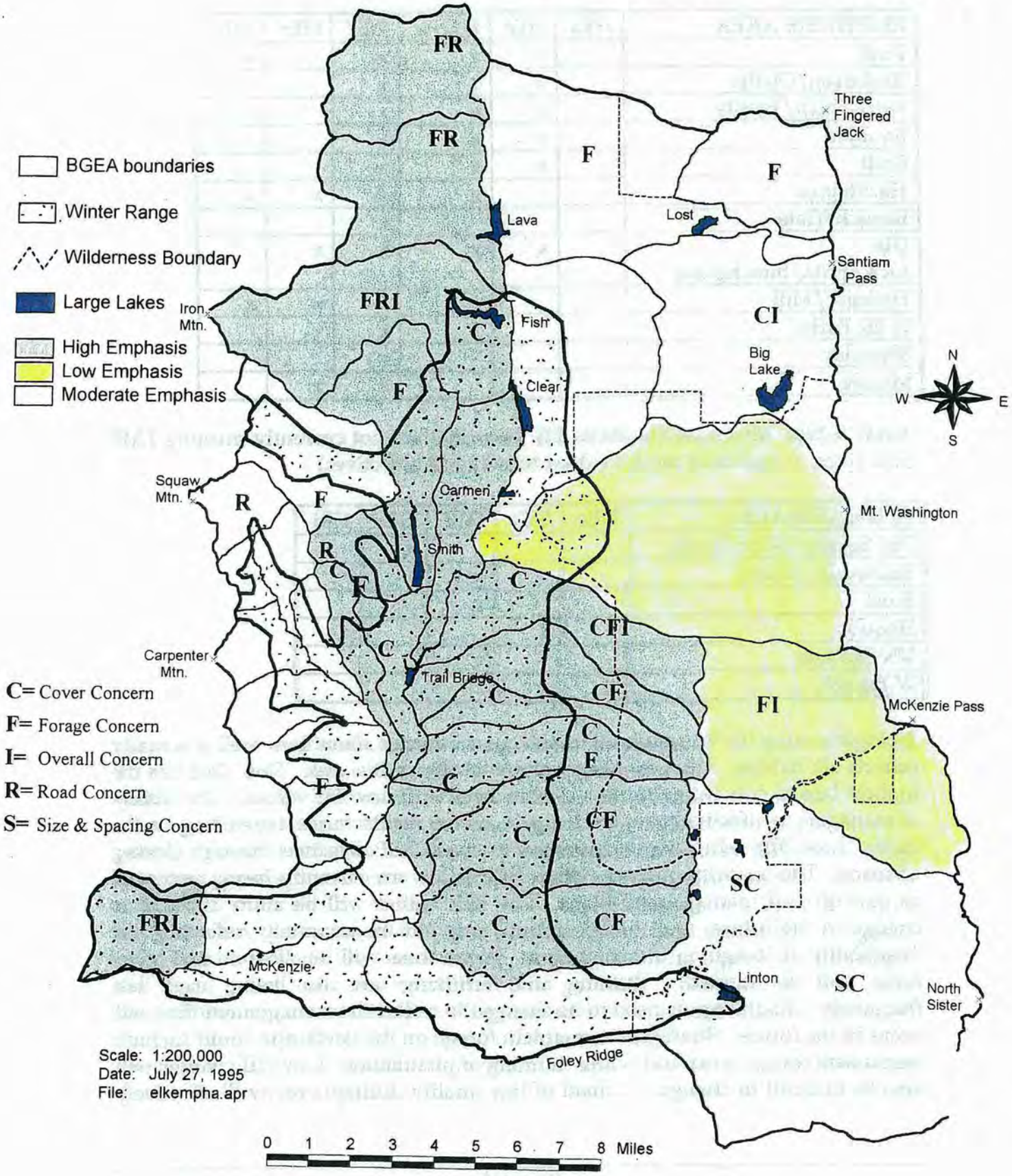
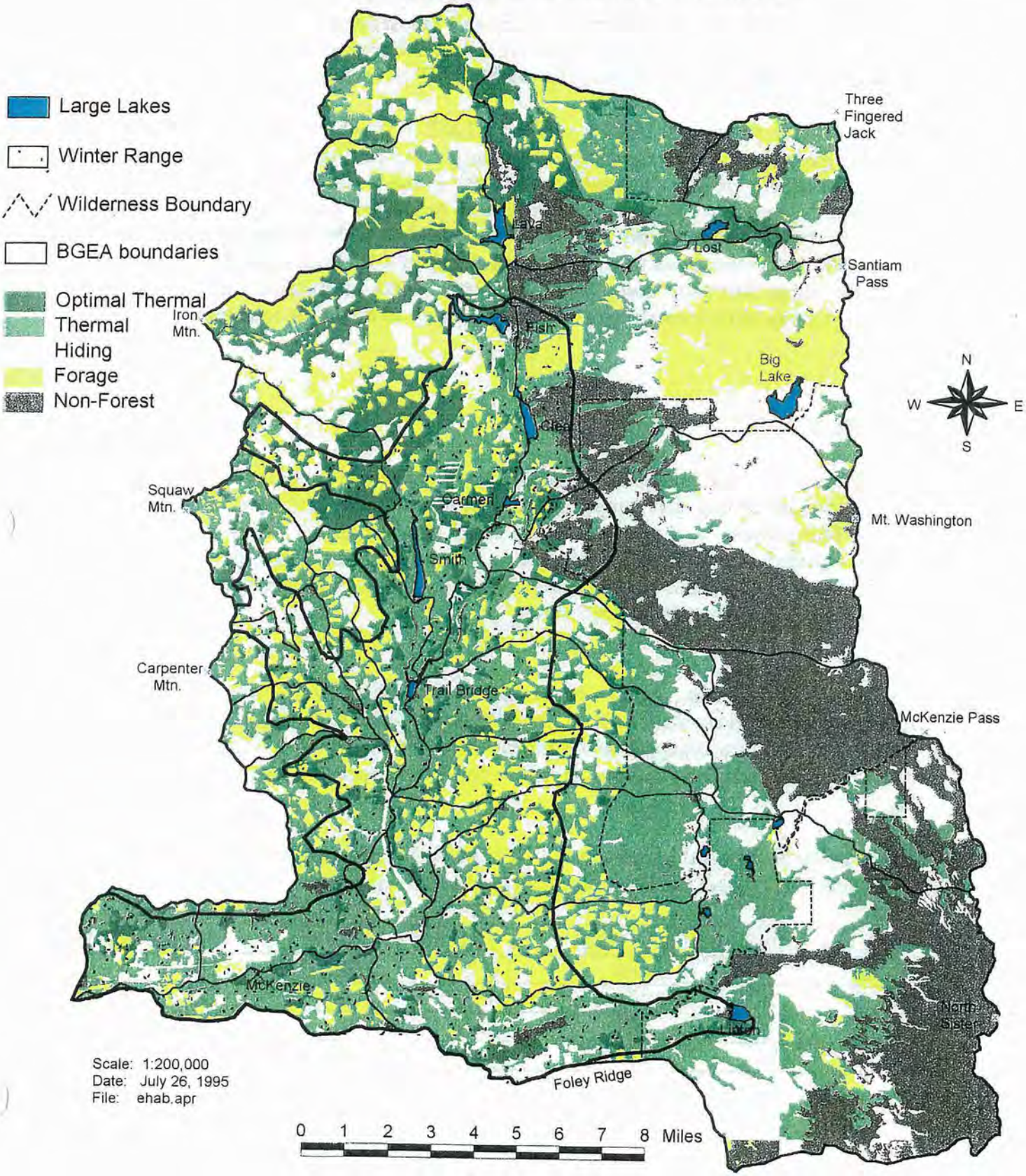


Figure 3-26. Elk Habitat with Big Game Emphasis Areas Outlined



wash out the value of the optimal cover within the next 5 years according to the model. Maintenance of blocks of late successional forest within the emphasis areas while the low quality cover succeeds into thermal cover will be important. Areas such as Hoodoo (Landform block 5) and the flat country (LFB 3) probably will never be able to attain the target HEc values because of the forest types in these areas. HEs values are generally within LMP guidelines.

As additional roads are closed to attain LMP HEr objectives, concern from hunting groups on the accessibility to hunting areas continues to grow. Elk and deer hunting is a primary recreational activity in the watershed in the fall. High open road densities are known to result in increased poaching. Figure 3-27 shows that the majority of the watershed is accessible within 0.5 miles of an open road. Scattered core areas that require greater than a 1.0 mile hike from an open road do occur, but they comprise a minority of the landscape. Education to highlight areas with accessibility will be necessary to alleviate concerns from the public.

WILDLIFE GUILDS

The Willamette National Forest utilized a process developed by Mellen et al. (1994) for identifying and mapping habitat for wildlife guilds at a landscape scale. The process was applied to the WNF landscape. A description of the guilds is listed in the Wildlife Appendix . The following is an analysis of the results for terrestrial and special habitat guilds. Riparian guilds were discussed in the Riparian Habitat-Wildlife Section.

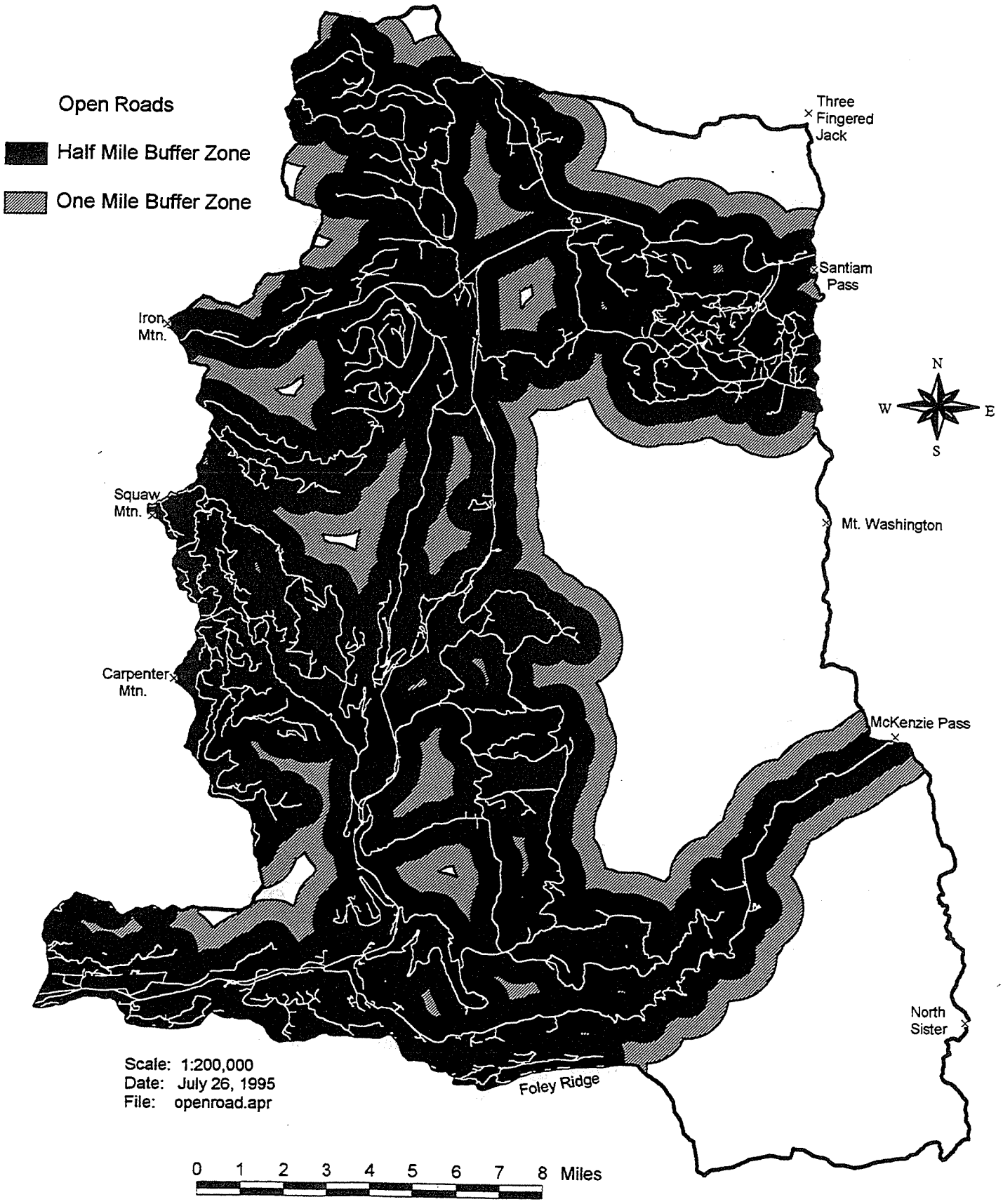
Early Seral Species

There are 43 species in the watershed (15%) that based on life history information use early seral habitat as primary breeding and/or foraging habitat. These species were lumped into 4 guilds listed in Table 3-30. The amount of quality habitat currently on the landscape for these species is also listed Table 3-30.

Table 3-30: Early seral species in the UPMAKWA landscape and the percentage of the total early seral habitat available classified by quality.

GUILD	# SPECIES	HIGH	MEDIUM	LOW	NONSUIT
TLME	3	24	2	22	53
TMME	2	31	1	26	42
TSME	14	91	0.06	1	8
TSPE	24	87	———	———	13

Figure 3-27. Areas Accessible for Hunting Within 0.5 & 1.0 Mile of Open Roads



Currently early seral habitat comprises 34,582 or 15% of the watershed. The majority of the early seral habitat is suitable small and medium home range species and patch species based on patch size and distribution on the landscape. Most early seral species are in these guilds. Less than half of the early seral habitat is suitable for large home range species. This is a reflection of the low density of early seral patches in the wilderness area of the watershed. In matrix lands, the majority is suitable. None of the species in these guilds require large patches of early seral habitat.

It is unknown whether the amount of available habitat is adequate to maintain viability of these species. Also, the majority (roughly 80%) of this habitat type is currently lacking structural components (snags and down woody material) critical for successful reproduction of all of the species in these guilds. This fact reduces the potential species' richness and population levels within early seral forests currently on the landscape.

Early seral forest has been created almost exclusively through timber harvest in the past 40 years, with the exception of the Big Lake Burn. A mean of 720 acres per year has been produced in the UPMAKWA. This is expected to decline in the future under Option 9 to 300 acres per year. Viability analysis is needed to determine impacts to early seral species. The availability of structural components in future early seral stands is critical to maintain viability of these guilds on the landscape.

Mid Seral Species

There are no species in the watershed that use mid-seral habitat as their primary habitat for breeding and/or foraging. There are species, however, that can use early and mid (5) or mid and late (11). Because these species can use more than one habitat type, they have been classified as generalists. The availability of habitat for these species is summarized in Table 3-31.

Table 3-31: Habitat for species that can use a combination of early and mid patches or mid and late seral patches in the UPMAKWA landscape and the percentage of the habitat available classified by quality.

GUILD	# SPECIES	HIGH	MEDIUM	LOW	NONSUIT
TSGML	11	44	.01	.08	44
TSGEM	5	98	.02	.003	2.3

Currently mid and late seral habitat comprises 148,372 acres or 64.3% of the watershed, and the majority is of high quality in terms of patch size and distribution. The patches appear to be well-distributed throughout the landscape. Early and mid seral habitat comprises 97,634 acres or 42.3% of the watershed. The majority is suitable, though the discussion on missing structural

components described above for the early seral species applies here as well. Species with the plasticity to use mid and late seral habitat generally require structural elements of snags, large green trees, and large down material to maximize potential use by mid seral habitat. Approximately 80% of the existing mid seral stands have been created from historic fires, with the remainder a product of clearcutting. We estimated that structural elements are present in approximately 40-60% of the mid seral stands in the UPMAKWA. To provide for the highest potential species richness in the mid seral stands, structural elements will need to be present.

Late Seral Species

There are 12 species in the watershed (4%) that based on life history information use late seral habitat as primary habitat for breeding and/or foraging. These species were lumped into 3 guilds listed in Table 3-32. The amount of quality habitat currently on the landscape for these species is also listed Table 3-32.

Table 3-32: Late seral species in the UPMAKWA landscape and the percentage of the habitat available classified by quality.

GUILD	# SPECIES	HIGH	MEDIUM	LOW	NONSUIT
TLML	6	48	7	36	10
TMML	2	73	4	17	6
TSPL	64	97	——	——	3

Currently late seral habitat comprises 85,321.21 acres or 36.9% of the watershed. The majority is high quality in terms of patch size and distribution. This habitat type appears to be well-distributed throughout the landscape. Approximately 16% of the high quality LS habitat for these guilds in is Wilderness. An additional 17% is in other no-harvest allocations (not including LSR's or riparian reserves, and 5% is in LSR's, for a total of 38% is in no harvest allocations prior to including riparian reserves.

These species do not require large contiguous tracks of late successional habitat. They are either mosaic species (goshawk, spotted owl) or patch species (red tree vole, brown creeper). The viability of the large home range, mobile, mosaic species is moderate to high under Option 9 (FEMAT 1994). Concerns exist for the low mobility patch species, such as the red tree vole, and managing the landscape to provide high probability of flow is important to maintain their viability (see red tree vole discussion).

Contrast Species

There are 14 species in the watershed (5%) that based on life history information use edge habitat between early seral and other older forests as primary habitat

for breeding and/or foraging. These species were lumped into 3 guilds listed in Table 3-33.

Table 3-33: Contrast species in the UPMAKWA landscape and the percentage of the habitat available classified by quality.

GUILD	# SPECIES	SUITABLE	NONSUIT
TLC	7	16	84
TMC	4	16	85
TSC	3	10	90

The majority of the watershed is not providing edge habitat, but what is available is well-distributed, with the exception of the wilderness areas to the east. This distribution of this habitat is not expected to significantly change in the future, however the abundance will decline as less early seral habitat is produced under Option 9. Viability analysis for these species should occur to determine the amount of habitat required to maintain these populations.

Generalist Species

There are 115 species in the watershed (39%) that are considered generalists. They can use several different seral stages as primary habitat for breeding and/or forging. These species were grouped in 3 guilds: TLGG (9 species), TMGG (20 species), and TSGG (86 species). These species can be found throughout the watershed. In general, there are few concerns for the viability of these species within the watershed now or in the future. Management strategies that retain structural elements within all seral stages and provide a diversity of forested habitats throughout the landscape will benefit these species. Ninety-six percent of these species use snags for breeding, and 84% use large woody debris.

Special Habitat Species

There are 27 species in the watershed (9%) that are highly associated with special habitats. Wetlands, caves, meadows, and p provide habitat for the majority of these species. The presence of these habitats is described by Landform block in Chapter 4. Special habitats are protected through S&G's in the WNF LMP and ROD. Threats to these ecosystems currently include spelunking, grazing, and off-road vehicles. Specific threats are described in the Landform block section. The majority of the special habitats within the watershed are not at risk to loss of integrity. Flow between these habitats is required over time to ensure genetic diversity. Landscapes between special habitats should be managed over time to provide for flow. This can be accomplished through canopy closure maintenance, contiguous areas with large woody debris, and protected riparian areas.

OVERVIEW OF BOTANICAL RESOURCES

Non-Forest Habitats

Non-forested habitats (special habitats) contribute to the exceptional floristic richness and biodiversity found within the Upper McKenzie watershed. Special habitats range from very wet to seasonally dry meadows, bogs, rock outcrops, lava fields to extensive alpine and subalpine plant communities. Certain plant communities associated with these special habitats are losing species diversity and or habitat characteristics. This is due to past harvest activities, encroachment of surrounding forests, livestock grazing and the introduction of non-native plant species. Forestwide standard and guideline FW-211 assures protection for these habitats and for their continual contribution to landscape biodiversity. Most rare and uncommon plant species (as defined by the Regional Foresters' Sensitive Species list) occur in non-forested habitats. Six rare plant species on the Region 6 Sensitive Plant List are located in the watershed. Ten plant species on the WNF Review or Watch Lists and eight species on the Concern list occur in the watershed. The variety of habitats that occur over the range in elevation in the watershed provide habitat for twenty-four sensitive species to occur. Special habitats and rare plants are discussed in the Landform Block Section.

Rare Plant Associations

Several rare plant associations have been identified in the Upper McKenzie watershed (Botany Appendix). The distribution and occurrence of these and other uncommon forested plant associations contribute to the biological and ecological diversity of the watershed. These communities may reflect unusual environmental conditions or be at the northern or southern extent of their range (Dimling and McCain 1993). Plant associations are considered "rare" if they are known from only five or fewer sites on a district. Plant associations are considered "uncommon" if they are known from only 6-11 sites on a district. Field surveys are needed to verify plant association rarity. Rare forested plant associations are treated as special habitats and should be maintained as recommended in the Special Habitats Management Guide (WNF 1993).

ROD C-3 Plants

The watershed contains eighteen species of fungi, lichens, and vascular plants listed in the ROD Table C-3 (USDA and USDI 1994). These "survey and manage" species of fungi, lichens, bryophytes and vascular plants are most commonly associated with late-successional forests and are valued as indicators of biodiversity, stability, and forest health. Late seral forests make up 36.9% of the forested acres within the watershed. Of that, 33% is in no harvest allocations. In general, late seral habitat including Late Successional Reserves, is fairly well distributed across the landscape. There are several gaps where connectivity

would improve by adopting the recommendation for additional pileated woodpecker/pine martin areas or other blocks of habitat (see wildlife section).

Many of these species have poor dispersal capabilities and are unable to move across large landscapes of younger stands. Unsuitable habitat in fragmented areas may prevent gene flow and expansion of species. More old forest species are found in younger forests adjacent to older forest than in isolated young stands, (Petekin and Game 1984). In addition, some species are slow to establish in rapidly growing young stands.

The vascular plant, *Allotropa virgata*, a Table C-3 species, is found in sixteen sites in three conifer series: western hemlock, Douglas-fir, and grand fir plant associations (Botany Appendix). *Allotropa virgata* is the only species in its genus. It is an achlorophyllous, mycotrophic plant that tends to be found in dry soils, with a duff layer and coarse woody debris. Although it occurs more frequently in late-successional forests it has been found in conifer stands of various seral stages. *Allotropa* obtains its nutrients from its association with mycorrhizal fungi and a broad range of photosynthetic host species. The life cycle of this complex plant allows it to remain dormant underground for unknown periods of time. It may remain dormant until specific environmental conditions exist. It is unclear the effect fire has on the life cycle of this species. It occurs in stands that have had a history of frequent fire return intervals. Thinning may be detrimental to this species because it can result in increased competition from understory vegetation, reduces coarse woody debris, and may result in mechanical disturbance to the ground (Holthausen et al. 1994). The common name for *Allotropa* is "candystick," which accurately describes its brilliant red-on-white stripes stems. Activities that are implemented in 1995 must include provisions for these known sites.

Habitat for many of the Table C-3 species require large amounts of course woody debris and standing dead trees. Species diversity for the majority of these species appears highest in late-successional forests due to the diversity of habitat structures, host species, and large amounts of duff and down material. Species viability will benefit from harvest practices that allow for the retention of clumped green trees of various sizes and structural diversity, large amounts of course woody debris and minimizing soil compaction during harvest activities. Potential habitat exist in the watershed for 242 Table C-3 species to occur (Botany Appendix). Additional issues and species are discussed in the Landform Block Section.

Noxious Weeds

Introduced noxious weeds and other invasive non-native plant species are present in the watershed. Plant species abundance and distribution varies from

isolated plants to large well established populations. Species found in the Upper McKenzie watershed are located along state highways, forest roadsides, landings and in clearcuts, along trails, campgrounds, and non-forested habitats. Forest roads and Highways 20, 22 and 126 are conduits for continual weed dispersal and expansion. Noxious weeds and non-native species are introduced by timber harvest activities, recreational vehicles, and equestrians. Routine road maintenance and construction activities contribute to the spread of weeds through continued ground disturbance, seed spread by the use of mowers, road equipment and contaminated rock and fill material. Most weed species become establish as a result of a soil disturbance activity, either natural or artificial. Once established species are able to persist and reproduce with little competition from native vegetation.

ODOT uses 40 to 50 thousand cubic yards of volcanic cinders in the Santiam Pass area each year. About 40% of that amount is distributed within the Upper McKenzie watershed of which 10 to 15% is recovered and reused. The cinders generally fall within 100 feet of the highway edge. The application of the cinders inhibits most seed germination and growth of vegetation on the highway shoulders. However, some amount of noxious weed and other non-native plant seeds lodge in the cinders, germinate and reproduce thereby expanding the species along the highway. Most native plant species are unable to compete with the aggressive growth of noxious weeds and other non-natives. The application of cinders may provide easy establishment of these species at the exclusion of native vegetation.

Six noxious weeds and twenty-six non-native species occur in the watershed (Botany Appendix). The noxious weed spotted knapweed (*Centaurea maculosa*) is the most serious threat to native plant populations within the watershed. Spotted knapweed has a broad ecological tolerance, prolific growth and seed production. It is spread primarily by vehicular traffic and has quickly become established along Highway 20 and 126. The Integrated Weed Management Plan Environmental Assessment (WNF 1993) outlines the control strategies for noxious weed species found on the Forest. Control methods used in the watershed include manual removal and mowing, release of beneficial insects that feed on the seedheads of specific noxious weed species, and the selected use of the herbicide rodeo. Currently, biological control agents are used on six noxious weed species. In 1995, populations of spotted knapweed and dalmation toadflax were treated with the herbicide rodeo in accordance with the guidelines in the Integrated Weed Management Plan Environmental Assessment (WNF 1993).

OVERVIEW OF VISUALS

The Willamette National Forest Land Management Plan (LMP) has assigned Visual Quality Objectives (VQO's) for each Management Area (MA) on the Forest. Management of scenic resources are emphasized within the viewsheds, though some allocations with visual quality objectives are located outside the viewsheds. The Upper McKenzie is the location of a confluence of three viewsheds, the McKenzie viewshed, South Santiam Highway viewshed, and the North Santiam Highway viewshed.

Table 3-34 and 34a display information on the existing condition of visual allocations within these viewsheds. Management area 11f within the North Santiam viewshed is currently exceeding the rate of harvest for this management area. Assumptions in this analysis were conservative and a closer look at this area may indicate that harvest activities are consistent with the Forest Plan. This analysis assumed that it would take all stands 20 years to recover from any harvest activities. Some stands will recover faster. All other harvest activities are currently consistent with Forest Plan standards regarding the rate of harvest and percentage of the area allowed to be in a disturbed condition within one decade.

All land allocations designated in the Forest Plan have visual quality objectives with the exception of those allocations recently adapted as a part of the amended Forest Plan. Many allocations allow no harvest and therefore require little monitoring to assure VQO's are being maintained, and so are not displayed here.

Table 3-34: The five Visual Quality Objectives represented within the Upper Mckenzie Watershed.

VQO	ACRES	PERCENTAGE
P - PRESERVATION	62,157	34
R - RETENTION	27,053	15
PR - PARTIAL RETENT.	25,069	14
M - MODIFICATION	6,169	3
MM - MAX MODIFICAT	64,985	35

The acres represent only forested land, and do not include lakes and non-vegetated areas. Currently there is no inclusion of Late-Successional Reserve in this analysis, nor is there a VQO assigned yet to that allocation.

Stand ages were used to assume "Existing Disturbed Condition". There are some assumptions within that analysis that can influence results. For example the

height of a lodgepole stand at 20 years would be different than a Douglas-fir stand, but this analysis treats both the same.

Table 3-34a: Existing Visual Condition in viewsheds within the Upper McKenzie Watershed.

McKenzie Viewshed

Mgt Area	Vqo	Harvest Rate Objective	Maximum Disturbed Condition	Existing Disturbed Condition	Seedlings Saplings Ages 0-20	Poles Ages 20+ 5.0-8.9" dbh
10B	Partial Ret.	7%	14%	13.1%	1,270.01	1,210.25
11A	Mod	12%	24%	21.0%	1,058.88	1,015.44
11C	Partial Ret.	10%	20%	13.1%	1,585.91	2,481.05
11E	Reten-tion	7%	14%	3.6%	316.27	607.92
11F	Reten-tion	5%	10%	5.6%	326.08	504.39
14A	Max. Mod	13+%	26+%	18.8%	4,367.02	3,233.53
6D	Reten-tion	2%	4%	0.6%	24.76	173.88

Mgt Area	Larger Trees 9"+ dbh	Non-Forest
10B	7,189.23	3,379.96
11A	2,979.08	117.76
11C	8,083.02	577.43
11E	7,784.85	572.29
11F	5,044.76	840.01
14A	15,591.800	469.15
6D	3,814.000	277.79

North Santiam Highway

Mgt Area	Vqo	Harvest Rate Objective	Maximum Disturbed Condition	Existing Disturbed Condition	Seedlings Saplings Ages 0-20	Poles Ages 20+ 5.0-8.9" dbh
10B	Partial Reten-tion	7%	14%	16.7%	3.63%	0.00
10D	Reten-tion	5%	10%	3.9%	5.85	0.00
11A	Mod.	12%	24%	24.1%	4,257.92	3,527.22
11C	Partial Reten-tion	10%	20%	14.3%	1,789.57	3,173.47

Mgt Area	Vqo	Harvest Rate Objective	Maximum Disturbed Condition	Existing Disturbed Condition	Seedlings Saplings Ages 0-20	Poles Ages 20+ 5.0-8.9" dbh
11D	Partial Retenti on	7%	14%	9.3%	188.05	32.96
11F	Retenti on	5%	10%	14.8%	1,051.92	823.71
14A	Max.M odifica tion	13+%	26+%	31.2%	2,562.79	1,668.17

Mgt Area	Larger Trees 9"+ dbh	Non Forest
10B	18.14	0.00
10D	143.30	37.77
11A	9,865.05	374.24
11C	7,525.53	558.45
	1,791.97	27.76
	5,209.76	440.12
	3,979.94	112.19

South Santiam Highway

Mgt Area	Vqo	Harvest Rate Objective	Maximum Disturbed Condition	Existing Disturbed Condition	Seedlings Saplings Ages 0-20	Poles Ages 20+ 5.0-8.9" dbh
11A	Mod	12%	24%	12.6%	2,134.67	2,511.77
11C	Partial Reten-tion	10%	20%	14.5%	560.76	610.63
11D	Partial Reten-tion	7%	14%	5.2%	21.54	0.00
11F	Reten-tion	5%	10%	8.1%	588.91	905.64
14A	Max. Mod	13+%	26+%	23.9%	941.59	1,128.91

Mgt Area	Larger Trees 9"+ dbh	Non-Forest
11A	12,336.14	251.61
11C	2,706.83	18.32
11D	391.53	1.23
11F	5,783.24	191.41
14A	1,862.15	38.72

OVERVIEW OF AIR QUALITY

Fire history for this area was documented by Constance Burke in her thesis "Historic Fires in the Central Western Cascades." The study included nearly all of area covered by the Upper McKenzie watershed analysis (Burke pg. 16). Her work indicates that larger fires were more common during the latter half of the 19th century than they have been in recent decades. These large fires were primarily human caused and occurred along travel routes across the Cascades. The lightning fire pattern was difficult to identify, because thunderstorms are accompanied by varying amounts of rain.

Her text cites newspaper articles, records of investigations by the General Land Office, detailed field notes of the original cadastral surveys and other reports and mapping efforts. Statements were made indicating that "Every fall... fires occurred in many different localities so that the air was heavy with smoke." Along the Columbia River "The smoke is so thick along the river, that objects can be seen but a short distance." There are other quotes similar to these in her thesis that provide additional substantiation to the occurrence of a large fire.

A 1993 white paper prepared by the Regional Ecosystem Assessment Project team quantifies the average annual amount of PM-10 particulate released and acres burned for the historical period and the current situation. Table 3-35 approximates the findings for Western Oregon.

Table 3-35: Average annual acres burned and PM-10 emissions for historic and current time periods.

	Historic	Current
PM-10	13 million lbs	5 million lbs
Acres Burned	40000	15000

The Clean Air Act standards for allowable levels of particulates were set by the Environmental Protection Agency. They are called the National Ambient Air Quality Standards (NAAQS). The smoke from burning forest slash contains several kinds of particles that are regulated by NAAQS standards. The standard is best described by PM-10 (particles 0 - 10 microns in size).

The state standard of allowable level of TSP (total suspended particulate) is not to exceed an annual geometric mean of 60 micrograms per cubic meter of air, and not to exceed 150 micrograms in a 24-hour period. The allowable level of PM-10 is not to exceed 150 micrograms of pollutant per cubic meter of air per 24-hour period or an annual arithmetic mean of 50 micrograms per cubic meter.

These standards are for designated urban areas such as Eugene-Springfield and for wilderness areas.

The Clean Air Act directs Federal agencies to comply with state and local regulations designed to prevent and control air pollution. The State of Oregon has been delegated authority for attainment of standards set by the Clean Air Act. To do this, the state developed the Oregon Smoke Management Plan. The Forest Service has adopted this plan for national forest lands in Oregon.

The Oregon Smoke Management Plan and Oregon Visibility SIP (State Implementation Plan) have a number of requirements to meet Clean Air Act standards. The requirements include reducing the amount of smoke produced and reducing the smoke's impact on designated areas and wilderness areas. They have encouraged a variety of measures to reduce smoke emissions.

Designated smoke sensitive areas are established by the Oregon Smoke Management Plan. These are principal population centers and Class I airsheds, which include wilderness areas and other smoke sensitive airsheds. One purpose of the Smoke Management Plan is to protect air quality in these high priority areas. For the Upper McKenzie watershed, the closest designated areas are Eugene, 60 miles to the southwest and Bend, 45 miles to the southeast. The Class I airsheds are Mt. Jefferson Wilderness (north of Santiam Pass), Mt. Washington Wilderness (south of Santiam Pass), and the Three Sisters Wilderness (on the east side of the Upper McKenzie watershed analysis area).

The Oregon Department of Environmental Quality (DEQ), in cooperation with the State Forester, sets the daily limit on tonnage of woody debris that can be burned. The limit is adjusted each day, depending on weather conditions such as wind direction and inversions, and burning conditions such as fuel moisture, in order to meet standards for particulates and visibility. A forecaster issues the daily burning instructions. As an example, a typical day's instructions might restrict burning in the Cascades to units 500 tons or less, at least 10 miles apart.

Oregon's smoke management plan encourages slash burning to be done in spring when possible, with higher fuel moistures reducing the amount of smoke produced. Forest managers are encouraged to use alternatives to broadcast burning whenever possible. The Oregon Visibility SIP allows only limited smoke production from July 1 to September 15 in the Cascades, to ensure that visibility will be protected during the summer recreational season. The burning that is allowed is limited to research burns, hardwood conversion and some burning above 5000' elevation with Class I areas treated as "smoke sensitive" areas.

In addition to following the daily burning instructions, McKenzie Ranger District verifies the upper wind speed and direction locally on the day of

burning. Verification is done by releasing and tracking a balloon filled with a measured amount of helium. It is tracked with a theodolite, and observations are taken at one minute intervals. Smoke generated is monitored by fire lookouts, on-site observations, and through aerial observations when possible.

Air pollution has exceeded NAAQS standards in some communities during the winter. These communities are called non-attainment areas. The non-attainment area closest to the Upper McKenzie watershed is Eugene-Springfield. According to state meteorologists, 78% of the winter air pollution is from woodstove smoke, with prescribed burning smoke contributing less than 5% of the problem. However, DEQ has established some restrictions on pile burning during winter. These restrictions include no burn days if weather conditions could cause a smoke intrusion into affected communities. Other restrictions include monitoring burns for at least 3 days with requirements to extinguish if smoke affects the non-attainment areas; and prohibitions on new ignitions when woodstove use is prohibited because of excessive particulates. Table 3-36 displays the available data from the USFS IMPROVE Protocol Site, Three Sisters Wilderness (THSI). This is an air quality monitoring station operating on McKenzie Ranger District.

Table 3-36: Means of 4-hour* visual air quality (filtered data) expressed in b_{scat}(km-1) and distribution of PM-10 concentrations (expressed in micrograms/cubic meter).

Means of 4-Hour Visual Quality

Period	Mean of cleanest 20%	Mean of all data	Mean of dirtiest 20%	Cumulative Frequency 50%
12/1/93- 2/28/94	0.013	0.021	0.035	0.018
3/1/94- 5/31/94	0.015	0.029	0.051	0.025
6/1/94- 8/31/94	0.017	0.038	0.074	0.031
9/1/94-11/30/94	0.017	0.029	0.050	0.025

*The results of the 24-hour data were identical to the 4-hour data

Distribution of PM10 Concentrations

Period	Arithmetic Mean	Minimum	Median	Maximum
6/15/94- 8/31/94	14.60	4.22	14.10	23.00
standard	*50 per 24 hour period*			