WATERSHED ANALYSIS REPORT
FOR THE
THREEMILE, SEVENMILE, AND DRY CREEK WATERSHEDS

KLAMATH RANGER DISTRICT
WINEMA NATIONAL FOREST
KLAMATH COUNTY, OREGON
JUNE 1995

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I. INTRODUCTION

This report documents an analysis of the Threemile, Sevenmile, and Dry Watershed Area. The purpose of the analysis is to develop a scientifically-based understanding of the processes and interactions occurring within the watershed area and the effects of management practices. The analysis focuses on issues concerning values and uses specific to the area. These issues form the basis for discussions of the interactions between land-use activities, the physical environment, and its biological components. A detailed outline of the process used can be found in "A Federal Agency Guide for Pilot Watershed Analysis", version 1.2. The analysis was conducted by a five-member core team, which consisted of a hydrologist, soils specialist, fish biologist/aquatic ecologist, wildlife biologist, and botanist/terrestrial ecologist. Many others were consulted during the process (Appendix A). The analysis was limited by use of existing information on historical and current conditions.

Specific objectives of the analysis are to:

1. Define geomorphological/ecological riparian reserves.
2. Guide restoration and monitoring work in the watershed area.
3. Provide information and recommendations for project planning and management.

II. CHARACTERIZATION OF THE WATERSHED AREA

A. Social and Economic Resources

1. Location and Land Management

The 31,713-acre watershed area is located in Klamath County, just south of Crater Lake National Park and approximately 35 miles northwest of Klamath Falls (Figure 1). It includes the drainages of Threemile, Sevenmile, and Dry (tributary to Sevenmile Creek) Creeks. These creeks originate at the crest of the southern Oregon Cascades and flow eastward to the Klamath Lake Basin (Figure 2). Elevations range from 7,500 feet at the top of Lee Peak in the upper Threemile drainage to 4,100 feet in the basin. The upper portions of the watershed area are entirely within the boundaries of the Klamath Ranger District of the Winema National Forest. The lower portions contain tracts in private ownership (2,267 acres) and a small amount of Oregon State Forestry lands (20 acres).

Approximately 14,055 acres (44%) of the upper watershed area are part of the Sky Lakes Wilderness and are included in Management Area 6 in the Winema National Forest Land and Resource Management Plan (Figure 3). The remaining National Forest System (NFS) land lies in scenic, timber production, bald eagle habitat, and riparian management areas. A significant amount of timber harvest and road construction has taken place in these management areas during the past 30-40 years.

figure 1 vicinity map

figure 2 wa map from fireman's map

figure 3 mgt area map

Existing management areas under the Forest Plan were amended by the Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl (USDA Forest Service and USDI Bureau of Land Management, 1994). This document designated Late Successional Reserve (LSR) and matrix lands. Approximately 7,305 acres of LSR are located in the Sevenmile drainage (Figure 4). Matrix lands include all areas outside the wilderness and LSR. The amended Forest Plan also lists the Threemile and Sevenmile (including Dry) Creek watersheds as key watersheds, therefore making this area a high priority for watershed analysis.

2. River Basin Context

The Threemile, Sevenmile, and Dry Creek watershed area drains only 1.5% of the Upper Klamath Lake Basin and less than 1% of the Upper Klamath River Basin above the Iron Gate Dam. The watershed area contributes a small percentage of the total flow into Upper Klamath Lake. Water from Threemile and Sevenmile Creeks is diverted for agricultural use and passes through a series of irrigation ditches/canals on private land prior to entering Agency/Upper Klamath Lake. Upper Klamath Lake is operated as a reservoir for both irrigation and power generation, controlled by the Link River Dam. As such, it is important to the local economy. Water quality and quantity in Upper Klamath Lake greatly influences conditions downstream in the Klamath River.

3. Cultural Resources

Human occupation of the watershed began in prehistory and carries through into the recent historic era.

Archeological evidence pertaining to ethnographic and prehistoric Klamath use of the watershed is limited to isolated artifacts and locations of vision quest sites. Spier (1930) notes a village site belonging the gu'mbotkni (Pelican Bay division of the Klamath) located near the mouth of Sevenmile Creek. Because of historic alterations to this watershed, it is now nearly impossible to determine where this might have been. Several sites in the watersheds were used for vision quests; thus, the area is likely to have played a role in Klamath world-view and spiritual beliefs. Because much of the area is densely forested, relatively few areas appear to have been available for gathering dietary staples, such as wokas or meadow plants. Much of the resource gathering likely occurred along the perennial reaches of the three creeks.

Historical era use of the watershed area began in the 1860s. A transportation route between Rocky Point and Fort Klamath passed through the area. Archeological data include evidence of several cabins and other structures which were used during the early part of the 20th century. Historic sites include remnants of a sawmill, Forest Service Ranger Stations, and features such as fences related to early livestock grazing. Early settlers were attracted to the perennial streams and springs in the watershed area, as well as the adjacent expanses of marsh, which could be drained and used for pasture. Timber became increasingly important over time as local communities (Fort Klamath, Klamath Falls, Chiloquin, Klamath Agency, etc.) began expanding and growing in terms of population and industrial needs. A sawmill located in the area was used to process timber. Logs were shipped via wagon to Crystal Creek, then rafted by steamers to the Pelican Bay area and then across the lake to various mills.

figure 4 lsr/matrix map

4. Timber

Significant timber harvest did not begin in the watershed area until the 1950s. Prior to that, small scale harvest of individual large pines probably occurred in the lower elevations. In the 1950s, logging was done along the Threemile and Sevenmile drainages up to near the current wilderness boundary. Approximately 200 acres of logging also occurred in the wilderness southwest of Sevenmile Marsh. The number of acres harvested peaked in the 1960s and tapered off in the 1980s (Figure 5). In the 1950s and 1960s, harvest prescriptions were primarily overstory removals of large pine and Douglas-fir. With changing markets, utilization of large white fir became feasible in the 1970s, leading to overstory removals of all species. Thinnings of immature white fir stands were conducted in the 1980s, as smaller diameter trees became merchantable. This sequence of logging led to a total of 8,882 acres being harvested and many stands being entered more than once. Few regeneration cuts were done; of the total acres harvested since the 1950s, only 8% were clearcuts, shelterwood cuts, and other regeneration cuts.

Volumes per acre range from 10 MBF/acre in shelterwoods, to 20-25 MBF/acre in commercially thinned stands, to over 60 MBF/acre in old growth stands that have never been harvested. Most logging has occurred on the flatter slopes which allowed the use of ground-based skidding. On average, stands have the capability of growing between 80 and 120 cubic feet/acre/year at culmination, indicating high fertility. Old growth stands are currently growing at a slower rate than thinned stands. High levels of defect, produced by Echinodontium tinctorum, are common in stands over 150 years old, particularly in the Shasta red fir and mountain hemlock zones.

5. Roads

Construction of roads into the three watersheds began with large-scale timber harvest in the 1950s. Prior to that, roads primarily ran along the eastern edge of the forest, including precursors to the Westside Road, and Forest Roads 3300 and 3200. Currently, in the Threemile drainage, there are 31.6 miles of road. Total road density outside of the wilderness is 4.0 miles/square mile, which is typical for the District. Approximately 1.5 miles of road lie within 100' and 5.4 miles within 300' of Threemile Creek and its major tributaries. Road density within these zones is higher than the watershed average. In the 100' zone, road density is 4.6 miles per square mile, and in the 300' zone 5.6 miles per square mile. Forest Road 3413 parallels the mainstem of Threemile Creek for most of its length.

In the Sevenmile drainage, roads total 57.5 miles. Total road density outside the wilderness is 3.9 miles/square mile. Approximately 3 miles of road lie within 100' and 9.4 within 300' of the creek and its main tributaries. Road density in these zones is less than the overall average, at 3.4 miles per square mile. Two roads parallel the mainstem, Forest Road 3334 on the south and 3208-105 on the north.

Approximately 17.4 miles of road are located in the Dry Creek drainage. Total road density outside the wilderness is 3.5 miles/square mile. Seven tenths of a mile of road lies within 100' of the creek and its main tributaries, while 4.5 miles lie within 300'. Road density in the 100' zone is similar to the overall average, at 3.3 miles per square mile; however, road density in the 300' zone is double the overall average, at 7.1 miles per square mile. Three roads parallel the mainstem, Forest Roads 3208 and 3208-110 on the south and

Forest Road 3228 on the north.

figure 5 graph of harvest by decade

6. Agriculture/Grazing Allotment

Lands in the lower portion of the Sevenmile and Threemile watersheds have been used for agricultural purposes since settlers first came to the area. Both Sevenmile and Threemile Creeks were diverted for irrigation soon after settlement. An extensive system of irrigation and drainage canals was begun in the 1920s to improve fields and pasture lands and mitigate the effects of installation of the Linkville Dam on Upper Klamath Lake, which raised high water levels 3.3 feet. Both Sevenmile and Fourmile Canals were dredged at that time. Historically, livestock grazing and haying were the main agricultural uses on private lands in this area. Cattle grazing is currently the main use.

Almost all NFS lands in the watershed area were grazed by cattle until the mid 1970s. For the most part, cattle grazed upland areas without pasture fences or herding, concentrating in the wetlands of the Sevenmile drainage, and open harvest units. In the low elevation areas, the Fourmile Springs Allotment remains, comprising approximately 100 acres or 1.5% of the Threemile Creek drainage (Figure 6). The Fourmile Springs Allotment consists primarily of seasonally moist meadow, but includes forested land and wet meadow, as well. A portion of the allotment was used as a feedlot in the past; haying of native species also occurred. Currently 50 head of cattle are grazed from July to October.

7. Recreation and Scenic Values

The watershed area provides opportunities for several recreational activities, including hunting, fishing, camping, backpacking, hiking, horseback riding, mushroom hunting, cross-country skiing, and snowmobiling. Elk, mule deer, bear, and cougar are the primary game species. Anglers fish in Threemile and Sevenmile Creeks and in Upper Puck Lake in the Sky Lakes Wilderness. A small campground is located near the Sevenmile Trailhead. The design and location of the campground and trailhead parking area contribute to runoff and sediment input into Sevenmile Creek in this area. Several dispersed campsites are located along Threemile, Sevenmile, and Dry Creeks.

Four miles of hiking trails are present in the wilderness portion of the watershed area. The Sevenmile Trail follows the upper Sevenmile drainage and connects with the Pacific Crest Trail near the summit. The Pacific Crest Trail weaves in and out of the area as it heads north along the summit into Crater Lake National Park. The Sevenmile Trail is a popular route to the Seven Lakes Basin west of the watershed area, especially among horse users. The absence of lakes, excluding upper Puck Lake, accounts for the low use in the remainder of the wilderness in this area.

During the winter, the watershed area is popular among snowmobilers. The Diamond Lake Snowmobile Trail runs for approximately 20 miles through the area. This trail connects Lake of the Woods to Diamond Lake and is part of a trail system which runs the length of the Cascade Range.

The watershed area has exceptional aesthetic quality. Among the outstanding features is the opportunity to experience solitude, particularly within Sky Lakes Wilderness. The scenic viewsheds in the area are of National significance, because portions are visible from Crater Lake National Park at background distances. The area can also be seen from State Highway 62 and from State Highway 97 to the east. The watershed area is also visible to travelers flying to and from the Klamath Falls area via Horizon Airlines.

Figure 6 allotment

In general, the visual quality of the watersheds is good to excellent. Only small openings created by harvest units are visible from the major ground-based viewpoints. Some larger units are visible from the air. The area currently meets Forest Plan visual quality objectives.

B. Physical Features

1. Geology

The southern Cascades has had three distinct geologic sequences within the last 100 million years: the Inland Sea, the Old Cascade series, and the New Cascade series. Each are different in orientation, dominant material, and displacement. Their individual characteristics integrate to influence the flow regime of creeks in the area.

During the Cretaceous Era (70-135 million years ago (MYA)) the development of the Inland Sea formation occurred. This formation dips east and underlies the Old Cascade sequence.

The Old Cascade sequence developed during the upper Eocene (40-60 MYA) and Miocene (10-15 MYA) Epochs, first erupting under the inland sea, then slowly gaining in elevation and developing islands. By the end of the Miocene, much of the Cascades to the west of the present central axis had developed. South of Crater Lake, the Old Cascade sequence accumulated to a thickness of 7,000-10,000'. The material is predominately basic andesites.

After maturation of the Old Cascades and prior to development of the New Cascade sequence, folding and faulting began, initiating the present system of north-south fractures strewn throughout the southern Oregon Cascades.

The New Cascade formation developed during the Pliocene Epoch (1-10 MYA). The dominant volcano culminates in Union Peak, approximately 15 miles southwest of Crater Lake. Several vents on the east flank of the volcano produced large volumes of basic olivine-bearing basalts. These repeated flows formed the bulk of the Cascades and the high plateau near the summit. Toward the end of the Pliocene, andesitic stratovolcanoes formed high peaks, including Mt. Mazama, Devils Peak, and Rustlers Peak. Development of composite and cinder cones followed during the Pleistocene Epoch (10,000 - 1 million years ago). Most noteworthy are Mt. McLoughlin, Pelican Butte, Aspen Butte, and Klamath Point.

Glacial events during the Pleistocene Epoch gouged and reshaped the topography laid by the basalts and pyroclastics. Glacial ice fields formed on the high plateaus near the summit and downcut into previously laid volcanic deposits forming valleys. At least six glacial events occurred in the area, the largest of which was the Varney Creek drift. Thick layers of till, composed of cobbles and boulders of weathered basalt and andesite, were deposited in glacial valleys extending into the marshlands on the east side of the Cascades. Subsequently, large streams eroded the till, carving deep valleys. Rock, Cherry, Threemile, and Sevenmile drainages formed on the east. As glaciers retreated, heavy blocks of ice broke away on the high plateau near the summit. The mass of these blocks created depressions in glacial deposits, forming lakes.

High angle normal faulting contorted and separated volcanic rocks and glacial deposits. These faults are oriented north-south and generally dip to the east. They are part of the system of normal faults which define the western margin of the Klamath Graben.

The eruption of Mt. Mazama 6,500-7,000 years ago blanketed the Cascades with pumice and ash. Deposits are greatest to the north and east of Crater Lake. In the watershed area, accumulations are greatest in the Dry Creek watershed.

2. Hydrologic Processes

In the east Cascades south of Crater Lake, peak flow appears to be a function of the relative abundance of glacial till, loose unconsolidated volcanics, and fracturing. The highest stream densities occur in areas dominated by glacial till. One could suppose this is due to the fact that these areas occur at upper elevations where precipitation is greater. However, high elevation peaks such as Klamath Point and Pelican Butte, which are composite volcanoes composed of cinders and blocky basalt flows, show little sign of a drainage network. The creeks draining these features have lower peak flows per drainage area than other creeks in the area. Nearly the entire southern half of the Sevenmile basin drains from Klamath Point. Additionally, the incidence of pumice soils with high infiltration rates is greater in the Sevenmile drainage (particularly in the Dry Creek sub basin) than in any other basin in the vicinity. These factors contribute to Sevenmile Creek having the lowest peak flow per drainage area of the four creeks north of Pelican Butte. Peak flows in Threemile Creek are likewise reduced by the presence of volcanic vents defining the the southern and northern ridgetops.

Springs arise at the base of composite cones at the edge of wetlands associated with Upper Klamath Lake. These include Blue Springs, and several unnamed springs in the watershed area; and Malone, Jack, Fourmile, and Mares Egg Springs outside the watershed area. It is speculated that the rapid infiltration rates of loose volcanics allows water to percolate down to the next stratum of the Cascades, the basalt flows. As water reaches this stratum, local fractures and the orientation of the layer dictate direction of ground water flow. Generally, the water drains to the east and is discharged at the contact zone between the declivities of the Cascades and the eastern margin of the Klamath Graben. This process reduces the water available for stream flow.

3. Climate

Cold, snowy winters and warm, dry summers characterize the climate of the watershed area. Precipitation is greatest during December to January and falls primarily as snow (Carlson, 1979). Deep snowpacks can accumulate, particularly at the higher elevations. The timing of peak runoff is determined by spring rains; the duration is a function of snow pack. Rain-on-snow events occur infrequently. A 100-year flood resulted from a rain-on-snow event in 1964 (Christmas flood). Significantly lower amounts of precipitation fall during the summer, concurrent with moderate to high temperatures. Thunderstorms occur frequently in the summer. Due to the rain shadow effect of the Cascades, annual precipitation decreases moving east from the crest. Average precipitation ranges between 60 inches per year near the crest and 25 inches per year at the lower elevations. Drought has occurred in the watershed area for 10 of the last 11 years.

4. Soils

Unnamed soils of the "X" group (Carlson, 1979) formed from glacial till in the uplands of the Sky Lakes Wilderness and bottoms of the Threemile, Sevenmile and Dry Creek drainages, where slope gradients are less than 35% (see Figure 7). This group consists of well-drained gravelly to very gravelly and cobbly sandy loams and loamy sands. Gravel, cobble, and stones make up 15-75% of the soil material. Depth to bedrock is generally greater than 40". However, in many areas, impervious dense glacial till or mudflow material underlies the soil at fairly shallow depths. This limits rooting depth and water storage space and increases the chance for runoff.

Unnamed soils of the "D" group formed in the ash deposits of the basins of the upper Dry Creek drainage. A1 horizon soil textures are loamy coarse sands with loamy sand to gravelly loamy coarse sand in the Ac and C horizons. Pumice gravel content ranges from 5-35%. Depth to bedrock is greater than 60 inches, but natural fertility is low. These soils are excessively drained, with rapid infiltration except when surface soil is dry and has water repellent tendencies. Road surfaces are difficult to maintain due to lack of fines and gravel-sized material. The potential for compaction is low.

Unnamed soils of the "R" group, derived from a mixture of volcanic ash, weathered andesites, basalts, mudflows, and pyroclastics, are found on the upper to lower slopes of all three creeks. The R group consists of well-drained gravelly and cobbly fine sandy loams and loam soils. Gravel, cobble, and stones make up 10-75% of the soil material. Slope gradients range from 0-70%. Soils on concave slope positions tend to be less rocky, while those on steeper slopes are higher in coarse fragments. Depth to bedrock is generally greater than 60 inches and rooting depth, 20-40". R group soils have the highest productivity potentials of any on the District and the greatest potential for reduction in productivity due to management activities (Carlson, 1979). Soils with more than 60% coarse fragment content are unplantable and difficult to regenerate. Soils with less than 50% coarse fragment content are susceptible to compaction when moist. Soils on steep slopes have a potential for severe sheet erosion.

A cobbly glacial outwash fan formed where Threemile Creek reaches the Klamath Basin. This area includes landtypes 7 and 9. These landtypes have slopes of 0-15%. Soils are gravelly to very gravelly and cobbly sandy loams and loams. The coarse fragment content is 20-50%. Depth to bedrock is greater than 96". Landtype 7 is somewhat poorly drained, while landtype 9 is well to moderately well drained. Landtype 2 occurs around the edges of the outwash fan and adjacent to the marsh. This landtype includes flat to gently sloping valley bottoms which are somewhat poorly drained. Soils are deep sandy loams to loam and gravelly sandy loams.

Landtype 11 dominates the lower reaches of Sevenmile Creek. This is a somewhat poorly-drained broad, flat basin. Soils are deep sandy loams and loams to gravelly sandy loams.

Figure 7 soil map

C. Biological Features

1. Plants

Three different forested vegetation zones occur in the watershed area (Figure 8). Each contains more than one locally recognized plant association as described by Hopkins (1979). Non-forested communities occur on rock outcrops and talus slopes, in seasonally moist to wet meadows (generally dominated by tufted hairgrass or various sedges), and in small lakes and shallow ponds.

a) Forest Zones

Mountain Hemlock

The mountain hemlock zone comprises approximately 11,063 acres located on cold, high elevation sites, including most of the Sky Lakes Wilderness near the Cascade crest. Forests in this zone generally have partially open canopies and low species diversity. Mountain hemlock is the dominant overstory species, with Shasta red fir, and western white pine as minor components. Lodgepole pine is seral, except in basins where it persists. Grouse huckleberry, big huckleberry, and pinemat manzanita form the understory.

Shasta Red Fir Zone

The Shasta red fir zone occurs on the upper slopes above 5,500', including the steep slopes of the Klamath Point ridge, which approach 7,200' elevation. Approximately 9,804 acres lie in this zone. Forests in this zone are variable. On cold, high elevation sites, diversity is low. Mountain hemlock and western white pine are common associates of Shasta red fir, and lodgepole pine is seral. Pinemat manzanita and long stolon sedge form most of the sparse ground cover. In mid elevation forests, white fir, Douglas-fir, and ponderosa pine are common associates. Shrubs such as chinquapin and snowbrush inhabit disturbed sites. Herbaceous cover is more extensive and diverse. Forested riparian areas in this zone often have significant amounts of white fir, Engelmann spruce, Douglas-fir, and mountain hemlock.

White Fir Zone

The white fir zone begins at approximately 5,500' elevation and extends downward to the Klamath Lake Basin. It occupies 8,681 acres in the watershed area. Upslope and north-facing forests are primarily white fir dominated, while those on the lower, east, and south-facing slopes contain mixes of white fir, ponderosa pine, Douglas-fir, and sugar pine. Diverse shrub and herbaceous species occur under partial canopies, particularly on mesic sites. Snowbrush, green manzanita, and chinquapin occupy disturbed sites. A poorly-defined, highly variable, and diverse white fir-alder association occurs along the creeks.

b) Sensitive Species

Appendix B shows potential habitat and the likelihood of occurrence in the watershed area for vascular plant species on the Regional Forester's Sensitive species list, documented or suspected to occur on the Winema National Forest. Past surveys in 1991 and 1994 covered approximately 50% of the watershed area, including portions of the Sky Lakes Wilderness. None of the species on the Regional Forester's list were located during those surveys.

figure 8 vegetation zones

Many of the species rated as possibly occurring in the area would most likely be found either on high elevation slopes within the Sky Lakes Wilderness, or within riparian reserves. An exception is Mt. Mazama collomia (Collomia mazama) which grows in mesic lodgepole and fir forests on the District. If present, red-root yampa (Perideridia erythrorhiza), sticky catchfly (Silene nuda ssp. insectivora), and Thelypody (Thelypodium brachycarpum) may also occur outside protected areas, including private land. On the Klamath District, red-root yampa and sticky catchfly have been found in low elevation seasonally moist meadows at the edge of mixed conifer woods near Upper Klamath Lake/Marsh. An historical sighting of Thelypody was located in similar habitat. These habitats may or may not fall within riparian reserves. It is likely all three of these species originally were more widespread in meadows around the Lake/Marsh, prior to intensive grazing and manipulation of the water table.

c) Survey and Manage/Late Successional Associated Species

Surveys for lichens, fungi, and bryophytes have not yet been conducted. Potential habitat may be present for some of the survey and manage species listed in Table C-3 of the amended Forest Plan. Five of the fungi were located during a survey in another area of the District. These include Sarcodon imbricatum, Phaeocollybia scatesiae, Cantharellus cibarius, C. subalbidus, and C. tubaeformis. All five are associated with late successional habitats. Maintenance of late successional forests inside the LSR should provide habitat for these species.

In addition to the survey and manage fungi species listed above, another 10-13 late successional associated fungi may occur. Approximately 30 species of late successional associated vascular plants are present in the watershed area. Personal observation (Malaby, 1990-1994) suggests many of these vascular plant species are common. They occur in a variety of mid-to-late seral stands and respond more to light and moisture gradients than stand structure. A majority of the species are typically found in mesic or riparian stands with 55-70% canopy closure. Some also occur along the edges of wet meadows and lakes and in mesic openings (e.g. big huckleberry (Vaccinium membranaceum) and solomon's seal (Smilacina stellata)). None are common in open early seral stands, cutover stands, or dense pole/small-sized stands with 100% canopy closure.

d) Other Species of Interest

Bellard's kobresia (Kobresia bellardii) was located in the upper Threemile drainage inside the Sky Lakes Wilderness. This unusual species in the sedge family has not been previously documented in Klamath County (ONHP, 1993) and is on the Oregon Natural Heritage Program List 2. List 2 species are generally very rare in Oregon, and may be threatened by extirpation. The Threemile population is not affected by any management activities.

e) Communities of Interest

Sevenmile Marsh is a large and diverse wetland occurring at the headwaters of Sevenmile Creek inside the Sky Lakes Wilderness. Beaver dams, the presence of ponded and flowing water, and hummock formation have created numerous microhabitats for different species. Examples include: bog species such as sundews, bog buckbean, ladies-tress orchids, and sphagnum moss; aquatics such as pondweed, wocus, and burreed; wet meadow species such as Sitka sedge, spikerush, and other sedges; moist meadow species such as tufted hairgrass, other graminoides, and a variety of sedges and forbs; and clumps of shrubs including huckleberries, laurel, spirea, and willows. A large number of bryophytes occur at Sevenmile Marsh, and potential habitat for some of the survey and manage bryophyte species is present. The upper Sevenmile drainage was grazed by cattle in the past. Currently, there appears to be little use by recreationists. The marsh is not readily visible from the Sevenmile Trail.

Along the lower reaches of Sevenmile Creek and Threemile Creek, mosaics of seasonally wet meadows, marsh, aspen groves, and riparian hardwood/mixed conifer stands occur. Riparian communities along lower Sevenmile Creek on NFS lands appear relatively intact. However, riparian communities in the lower Threemile area and on private lands within the lower Sevenmile area have been modified, primarily for/by livestock use. On private lands, logging converted riparian stands into pasture, removing shading vegetation and the potential for large wood recruitment along lower Sevenmile Creek. Willow shrub cover also decreased. Most of the seasonally wet meadow and marsh was diked/drained for conversion to pasture. Kentucky bluegrass and other exotic grasses were introduced and are now major components of the pastures.

Riparian communities also occur in the lower Threemile drainage, part of which is managed as the Fourmile Springs Allotment. The allotment area has not been logged or diked and drained. However, introduction of exotic species and past soil disturbance has altered the composition of seasonally wet tufted hairgrass meadow in the allotment. Willow cover has also declined, probably due to past grazing.

f. Noxious Weeds

Noxious weeds are associated with major roads along the eastern edge of the watershed area. St. Johnswort has become common along the Westside Road and in places along Forest Roads 3200, 3300, and 3334. Small populations of spotted knapweed and dalmation toadflax also occur along the Westside Road. Because infestation is limited primarily to roadsides, displacement of native species is not currently a concern. Spread to other areas could occur in the future, if weeds are left untreated. Treatment of noxious weed species in the watershed area is addressed in the Winema National Forest Noxious Weed Environmental Assessment. Treatment in the past has been limited by funding.

2. Aquatic Species

Both Threemile and Sevenmile watersheds are designated as Tier 1 key watersheds, due to their ability to contribute directly to the conservation of bull trout and other resident fish species. In addition, the mouth of the Threemile Creek watershed (Section 2) is within proposed designated critical habitat for the Lost River and shortnose suckers.

The lower Threemile watershed is included in proposed designated critical habitat because of its ability to provide high quality water to downstream sucker habitat in Upper Klamath Lake. Suckers utilize this inflow of water when extremely poor water quality conditions exist in the main body of the lake during the summer. The ability of these watersheds to provide high quality water to sucker habitat has been minimized by irrigation practices on private property downstream of NFS lands.

Current native fish within the analysis area include inland rainbow (redband) trout and bull trout. Introduced game-fish include brook, brown, and rainbow trout. Both redband and bull trout are listed as sensitive species on the Regional Forester's list, and as category 2 species by the USFWS.

Although the original genotype may have been compromised over time as hatchery fish were stocked, the Upper Klamath Lake redband trout represents a unique unit of diversity among the several groups of redband and coastal rainbow trout identified in the Pacific Northwest (Behnke, 1992). Likewise, the Klamath Basin bull trout have ecological importance as the only significant population of bull trout at the southern edge of the species range (Howell, 1993). These populations have most likely adapted to a different set of environmental conditions than populations in more northern regions. The bull trout population in Threemile Creek is one of only two known populations persisting in streams on the east slope of the Cascades flowing into the Klamath Basin. This population is threatened by extinction, which would result in loss of unique adaptive characteristics, geographical distribution, and genetic and species diversity (Howell, 1993).

The watershed area also provides habitat for a variety of amphibians. Amphibian surveys were initiated in 1994. Amphibians located in the area include the rough skinned newt, Cascades frog, Pacific chorus frog, western toad, and long-toed salamander. Sevenmile Marsh has been identified as pristine amphibian habitat. Other areas of amphibian habitat include wetlands associated with Upper Klamath Lake; Sevenmile, Threemile, and Dry Creeks; Puck Lake; and other small ponds and springs.

3. Wildlife

The watershed area contains a variety of habitat types which support a variety of wildlife species. The three main conifer habitat types each support specialist species, as well as generalist species which occur throughout the watershed area. A variety of seral stages are represented in this area. Timber harvest has increased the amount of early and mid seral stands, and has decreased the amount of late seral habitat.

Species which may have been present in the past, but were extirpated from this area, include grizzly bear, wolf, lynx, wolverine, fisher, bighorn sheep, and possibly California condor. Other species, like elk and bald eagles, were greatly reduced and have since recovered.

Water is scarce in most of the upland areas of these watersheds, and limits the use of those areas by some wildlife species. About one-fourth of the area is more than one mile from a perennial water source. The scarcity of upland water sources makes each one important to many wildlife species. Several water sources have been developed in the last few decades, primarily for the benefit of big game species. These have also expanded the area available to many non-game wildlife species.

There have been several new species introduced to this area since European settlement, including starlings, house sparrows, Norway rats, and house mice.

Appendix C shows wildlife habitat designations in the watershed area.

III. ISSUES and KEY QUESTIONS

Issues were developed based on the Watershed Analysis Team's own knowledge and interviews with others interested or knowledgeable about the area (see Appendix A for a list of those contacted). Issues were used as main topics about watershed resources and processes, to be addressed during the analysis. Key questions were used to further focus the main topics.

The Klamath River Basin analysis was not completed prior to this analysis. The issues likely to come out of the basin analysis which pertain to the Threemile, Sevenmile, and Dry Creek watershed area are as follows:

Nutrient input into Upper Klamath Lake has increased due to nonpoint source pollution resulting from agriculture and forestry in the basin. Contributing factors are thought to include increased decomposition of peaty wetland soils caused by draining and aeration; loss of filtering wetland and riparian vegetation; livestock waste; increased sediment input from roads, logging, grazing, and irrigation; and alteration of the magnitude and timing of stream flow and nutrient input resulting from diversions and irrigation systems.

Increases in nutrient input have promoted wide-spread blooms of the blue-green alga Aphanizomenon flos-aquae. Algal blooms result in poor water quality in the lake, including high pH, low dissolved oxygen, and foul odors.

Water quality problems as well as fish passage barriers have degraded the habitat of fish in the lake. Two endemic species, the Lost River sucker and shortnose sucker have been Federally listed as endangered.

River basin concerns were incorporated into issues identified for the watershed area, listed below.

ISSUES

A. The pre-management forest structure, composition, and landscape pattern have been altered by management activities.

   Has this created forest health problems?

   What is the condition of riparian zones?

B. Habitat for listed and non-listed wildlife species has been altered by logging, fire suppression, and road construction. The existing open road density has contributed to the loss of wildlife habitat, altered wildlife movement patterns, and has improved hunting access and success.

How has habitat been changed by management practices?

What is the potential impact of the density and distribution of roads open to vehicular traffic on wildlife species and their available habitat?

How has this affected species of interest?

C. Soil quality has been altered by management activities.

Have the functioning characteristics of the soil resources been altered, and what are the impacts of the change?

D. The hydrograph has been altered in terms of base flow, peak flow, and timing of peak flow.

Has the natural draining process in the watershed area been altered by timber harvest, road building, and diversion activities?

E. Channel condition has been degraded by past management activities.

F. Fish habitat has been degraded.

What was the historical condition of fish habitat? What is the current condition of fish habitat? How have modifications of channel condition impacted fish habitat?

G. Native fish populations are nearly extirpated.

IV. ANALYSIS OF ISSUES

Issues are organized sequentially, such that information contained in the preceding issue is used in analysis of the following issue. Issues start with vegetation and upland concerns and progress to the aquatic zone as diagramed below.

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 Vegetation/Riparian
     |          |
Wildlife      Soils
                |
              Hydrology
                |
              Channel Condition
                |
              Aquatics
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A. ISSUE: The pre-management forest structure, composition, and landscape pattern have been altered by management activities.

KEY QUESTION: Has this created forest health problems?

SUMMARY: Fire, insects, and disease are important agents of disturbance in the watershed area. In the mountain hemlock zone, fires were probably infrequent, large stand-replacing events. Root rot infections are widespread in the northern third of the zone and may be related to poor conditions caused by pumice soils. Mountain pine beetles have caused mortality of lodgepole pine in the northern third and in small lodgepole basins. Canopy closure has declined in this zone during the past 50 years, primarily due to mortality caused by insects and disease. Most of this zone is in wilderness, and management has not had a large effect on forest structure. High fuel loads resulting from natural mortality should be considered in future prescribed natural fire plans.

In the Shasta red fir zone, 100-300 acre stand-replacing fires were evident over 12% of the area in 1940. More frequent low intensity fires may also have been important in thinning stands, prior to fire suppression. Large root rot infections are present in the northern part of the zone and on Klamath Point. Mountain pine beetles have killed lodgepole pine in the upper Dry Creek and Threemile Creek drainages. Timber harvest has occurred over approximately 30% of the zone. Changes since 1940 include loss of canopy closure due to timber harvest, insects, and disease; and loss of late seral habitat due to timber harvest. Forest health concerns are generally low outside of wilderness.

Historically in the white fir zone, frequent low intensity fires promoted development of ponderosa pine and mixed conifer stands in the low elevations and on dry slopes. Insect and disease mortality is not evident on 1940 photos and probably occurred at low levels. Large blocks of late seral habitat were present. Almost all of the zone lies outside wilderness and since 1940, over 68% of the zone has been logged. Late seral habitat has decreased dramatically as a result of overstory removals. Previous large blocks of late seral habitat have been fragmented. Overall canopy closure has also significantly declined. A shift in species composition to true fir dominance has resulted from selective logging and fire suppression. Forest health concerns are high in some stands, particularly risk of ponderosa pine mortality and fire hazard.

DISCUSSION

Knowledge about pre-management conditions is limited. The oldest aerial photographs taken in the watershed area date to 1940. At that time, little timber harvest had occurred and roads provided access only to the eastern-most parts of the watershed area. Leiberg (1900) described general forest type and condition in the Cascade Range Forest Reserve by section. Descendants of some of the original settlers of the area also provided historical accounts of forest condition during interviews.

1) Pre-management Condition and Processes

Mountain Hemlock Zone

Aerial photos indicate that fire, insects, and disease are important natural agents of disturbance in all three forest zones. According to Agee (1993), fire regimes in mountain hemlock forests are often characterized by a long average return interval (est. 200-500 years) and high intensity burns. Fire behavior and extent may be controlled more by weather conditions, stand continuity, and natural barriers (rocks, wet meadows, lakes, ridges, etc.) than fuel loads.

Trees in this zone have little resistance, and fires are often stand-replacing events. Shasta red fir develops moderate resistance to low intensity fires with age, as trees get larger and bark thickens (typically >120 years). Lodgepole pine generally colonizes burned areas, because mountain hemlock seeds in more slowly. Shasta red fir requires an existing partial canopy for frost protection and comes in under lodgepole or mountain hemlock stands. Agee (1993) notes that mountain hemlock (and Shasta red fir) begins to dominate sites after 100+ years.

Historically, lightning was probably the primary cause of fires, although Native Americans may also have set fires. Leiberg (1900) notes that white settlers burned to improve grazing and hunting and set off several accidental fires. Data since 1960 shows a rate of .04 lightning ignitions/1,000 acres/year. The historical rate may have been similar. Since 1960, the rate of human caused ignitions was .005 ignitions/1,000 acres/year.

Leiberg (1900) indicates the importance of fire in shaping forests in this zone. He states that "Fires have marked the entire forested area....In the burns which have occurred in the alpine-hemlock type, large tracts are entirely bare of vegetation...there is a slow reforestation process setting in, with lodgepole pine as the leading component." Burned areas are visible on 1940s aerial photos, primarily in the upper Sevenmile drainage. The burned areas are patchy and overlap with the Shasta red fir zone. Recently burned stand replacement patches are 35 to 115 acres in size and cover less than 5% of the area.

Insect and disease infestations are significant in all three drainages, and are most intensive where soils with high pumice content are present. Mountain pine beetles kill lodgepole pine trees which have slow growth due to poor site conditions or old age (>50-60 years old). Beetles thin mixed stands and cause stand-replacing mortality in pockets of pure lodgepole pine, which are typically on the order of 50 to 100 acres.

Root rot (Armillaria and possibly Phellinus) infections are widespread throughout the northern third of the mountain hemlock zone. Root rot creates a distinctive pattern. Mountain hemlock and/or Shasta red fir, which are susceptible to root rot infection, form a "network" on the better sites, in small drainages, north-facing slopes, and low-lying areas, while the more resistant lodgepole pine occupies the rocky ridges and upslope areas. Root rot and mountain pine beetles are both active in the same stands.

Shasta Red Fir Zone

The fire regime was probably characterized by an intermediate average return interval (40-60 years) and variable intensity and size of burns (Agee, 1993).

In low and mid elevation portions of the zone, severely burned sites convert to brush fields (chinquapin, snowbrush, manzanita) which may remain for several years (50+) before Shasta red fir re-establishes. Ponderosa pine is also an early seral species in the lower portion of the zone, but its range is limited by snow loading in the upper elevations. Lodgepole pine generally colonizes open sites at the higher elevations. Recent stand-replacing fires visible on 1940 photos were located along the entire ridge associated with Klamath Point and in the upper Sevenmile and Dry Creek drainages. Burned areas covered approximately 12% of the zone. Patch size ranged from 10 to 300 acres.

Low intensity fires may also have occurred in the Shasta red fir zone (Agee, 1993). Low intensity fires thin out mature stands, create gaps for regeneration, and promote development of multi-layered canopies. Shasta red fir regeneration typically forms dense stands in gaps and under remaining partial canopies.

Lightning is the main source of ignition in the Shasta red fir zone and may have been historically as well. Data from the past 35 years shows an average of .05 ignitions/1,000 acres/year caused by lightning and .003 ignitions/1,000 acre/year caused by humans.

Armillaria root rot infections are extensive in the high elevation Klamath Point area of the Sevenmile drainage and in the Dry Creek drainage. Root rot appears to be associated with poor sites, either steep and rocky, or with pumice soils. Although root rot infections approach the size of stand-replacing fires in this zone (50 to 200 acres), mortality spreads slowly, creating small pockets and thinning stands, and allowing regeneration of lodgepole pine in the openings.

Mountain pine beetles also attack lodgepole pine in this zone, similar to in the mountain hemlock zone.

White Fir Zone

Studies conducted in similar areas (Agee, 1993) suggest the fire regime was characterized by average return intervals of 10-40 years and low intensity burns. Shorter average intervals probably occurred at lower elevations and on dry slopes, and longer average intervals on more mesic sites and upper elevations, where white fir overlaps with the red fir zone (Agee, 1993).

Trees in the white fir zone have variable resistance to fire. Ponderosa pine is the most resistant, followed by incense cedar, sugar pine, and Douglas-fir. White fir, like Shasta red fir, becomes moderately resistant with age (typically 120 years).

Frequent low intensity fires promoted development of seral ponderosa pine-dominated stands. Fires thinned out stands, removed much of the white fir before it developed resistance, and created gaps suitable for regeneration of ponderosa pine and other shade-intolerant species (Douglas-fir, sugar pine, and incense cedar). Fires were patchy and typically resulted in small clumps of reproduction of individual species (Agee, 1993). Shrubs with the ability to resprout following fires were probably favored in the openings (chinquapin, manzanita, snowbrush, snowberry), since the frequency of fires would prevent maturation of seedlings in many cases. Fuel loads were probably low. On more mesic sites, longer fire-free intervals allowed white fir to dominate stands.

Both lightning and burning by Native Americans were probably important ignition sources (Agee, 1993). Leiberg (1900) suggests that accidental and intentional ignitions by Euro-american settlers also occurred. Since 1960, 11 ignitions occurred at the rates of .03 lightning ignitions/1,000 acres/year and .01 human-caused ignitions/1,000 acres/year.

Both interviews relating stories of the first settlers of the area and Leiberg (1900) described open ponderosa pine stands in the watershed area. Ponderosa pine dominated stands on the lower and drier slopes were also evident on 1940s aerial photos and covered approximately 29% of the white fir zone. Typically, these stands had large trees and relatively open canopies (<70% canopy closure). More mesic stands with mixed conifer overstories or white fir dominated overstories occurred throughout the rest of the zone, and totaled 34% and 36% of the area. In general, stand-replacing events appeared to be less frequent and smaller in size than in the red fir zone (10-30 acres). However, a large fire (150-300 acres) was evident at the northern edge of the Dry Creek drainage.

In this zone, mountain and western pine beetles probably thinned stands by attacking ponderosa and sugar pine trees under stress from overstocking, drought, or damage. Similarly, fir engraver beetles attacked true fir species under stress from root rot, drought, or overstocking. Because frequent fires thinned stands, it is likely that insect infestations generally remained at low levels.

Although present, Armillaria root rot may have been less important in this zone than in the Shasta red fir zone. Pockets of mortality are not clearly evident on 1940 photos. This may be because most stands were of mixed species composition, or dominated by ponderosa pine. Ponderosa pine, sugar pine, and Douglas-fir are more resistant to root rot than true fir species.

2) Management Effects

Mountain Hemlock Zone

Almost 90% of the mountain hemlock zone is within the Sky Lakes Wilderness boundary. Approximately 800 acres have been harvested, including 200 acres cut in 1950 inside the current wilderness boundary southwest of Sevenmile Marsh. Fire suppression began on the District in 1910. There is no evidence of any major fires in this zone since 1940. Records since 1960 show that although ignitions occurred, all were suppressed and none resulted in fires greater than 1 acre. Assuming a long return interval for major fires, it is unlikely that fire suppression since 1910 has had much effect on natural stand condition in this zone.

Comparisons of canopy closure and the distribution of stands in seral stage categories between 1940 and 1988 (see Appendix D) are shown in Figure 9. Overall, canopy closure declined in the mountain hemlock zone. Acres with less than 40% canopy closure increased by 25% during the 50-year time span. This was primarily a result of mortality caused by insects and disease. Timber harvest also contributed, to a lesser extent. These factors offset increases in canopy closure resulting from regeneration on previously burned sites. The amount of area in different seral stages remained about the same. A small decline in late successional habitat was caused by timber harvest and loss of canopy closure.

Shasta Red Fir Zone

Roughly 40% of the Shasta red fir zone lies within Sky Lakes Wilderness and has been little affected by past management. Most of the area outside the wilderness on flat to moderate slopes (3,000 acres, or 30% of the area) has been logged to some degree. There is no evidence of major fires in the Shasta red fir zone since 1940. Data since 1960 show that ignitions occurred, but were suppressed; none resulted in fires greater than 1 acre. The time since fire suppression began is probably within the range of variation for fire return intervals in this zone. It is unlikely that fire suppression has caused a change in stand conditions at this point.

In 1940, most stands in the Shasta red fir zone had 41-70% canopy closure (Figure 10). By 1988, the amount of area with less than 40% canopy closure increased by 22%. This resulted from both timber harvest and lodgepole pine mortality caused by mountain pine beetles. A slight increase in the amount of area with >71% canopy closure also occurred, and was probably caused by either absence of fire, or dense regeneration on burned sites. Late seral habitat was present in approximately 36% of the Shasta red fir zone in 1940. This figure dropped to 23% in 1989, largely the result of big trees being removed during timber harvest. Selective logging of large ponderosa pine and Douglas-fir also greatly reduced these species in lower elevation red fir stands. The amount of early seral habitat remained the same; creation of early seral openings by timber harvest and insects/disease offset regeneration of burned sites.

Recent stand exam information collected in the non-wilderness portion of the zone shows there is a high risk of ponderosa pine mortality caused by mountain pine beetles on approximately 850 acres. Less than 50 acres outside wilderness have high levels of Armillaria root rot. Most of the lodgepole pine mortality and largest root rot infection centers are located inside the wilderness boundary.

White Fir Zone

Less than 1% of the white fir zone is located inside the wilderness boundary. Timber harvest has occurred throughout the white fir zone, totaling 5,900 acres, or 68% of the zone. There is no evidence of major fires in the white fir zone since 1940. Like the other two zones, all recorded ignitions have been suppressed, and none resulted in fires greater than 1 acre. Because the fire regime in the white fir zone was historically characterized by frequent low intensity fires, it is likely that fire suppression has had a significant effect in this zone.

Figure 9 mtn hemlock graphs

Figure 10 red fir graphs

Currently, most stands throughout the white fir zone are in a climax condition dominated by small white fir. Recent stand exam information shows that stands where white fir comprises at least 75% of the total basal area now cover 65% of the white fir zone. Open stands dominated by large ponderosa pine no longer exist and pine regeneration is not occurring. This is a result of both fire suppression and selective overstory logging during the 1950s and 1960s. Historical accounts describe one-log loads and topping trees where they tapered to 22" diameter. Currently, few trees exceed 22" at breast height and much of the ponderosa pine and Douglas-fir component has been removed.

Figure 11 shows changes in canopy closure and seral stage in the white fir zone. While density has increased in some stands due to fire suppression, overall canopy closure has declined since 1940 as a result of logging. The amount of area with less than 40% canopy closure now totals 40% of the white fir zone. Similarly, there has been a dramatic decrease in late seral stands. Over 70% of the white fir zone was in a late seral condition in 1940. Most of these stands were dominated by large trees. In comparison, 1988 data show only 15% of the white fir zone is in a late seral condition. Many of these stands have remnant large overstory trees with dense white fir understories.

Insect and disease levels have increased in the white fir zone, as a result of past management and recent drought. Development of dense fir understories in some stands is stressing remaining large pines, increasing their susceptibility to pine beetles. Stand exam information indicates that pines are at risk in 36% of the zone. Overstocking is also increasing white fir susceptibility to fir engraver beetles in 15% of the zone. High levels of root rot are concentrated in the Threemile drainage and near the northern edge of the Dry Creek drainage. These areas total 7% of the white fir zone.

Past analysis indicates that high fuel loads generally occur in stands where risk of insect and disease-caused mortality is high. Fuel levels will continue to increase in the future as standing snags fall to the ground. Contiguous areas of high fuel loads increase the chance for large scale stand-replacing fires, and further loss of late seral habitat.

3. Conclusions

Understanding the role of insects and disease in the mountain hemlock and Shasta red fir zones will be necessary in developing a future wilderness prescribed natural fire plan. This northern area of the Sky Lakes Wilderness currently has higher levels of insect and disease-caused mortality than observed in other areas. Fuel accumulations in this area may be more important in affecting fire behavior than typically occurs in high elevation areas. Heavy accumulations may prevent the ability to limit fires to desirable size and intensity, if they are allowed to burn.

The loss and fragmentation of late seral Shasta red fir and especially white fir forests has important implications for wildlife species associated with these habitats, as discussed under Issue B. Large ponderosa pine trees and snags are important to many wildlife species. Past logging reduced this component, and current mortality and lack of recruitment will further this trend. The risk of additional loss of late seral habitat to insects, disease, and large scale fire is increasing in the white fir zone. This is the zone where the pre-management disturbance regime and forest condition has been most altered by management.

Figure 11 white fir graphs

KEY QUESTION: What is the condition of riparian zones?

SUMMARY: Three hundred foot riparian zones were analyzed along the mainstems and perennial tributaries using aerial photographs and field knowledge.

The riparian zones along the lower two reaches of Threemile Creek have been impacted by past logging, "stream cleaning" following the 1964 flood, and the presence of roads. Large wood recruitment potential and value to wildlife are low. Riparian zones along the upper two reaches are relatively intact. Spur roads leading to campsites are the primary impact.

Riparian zones along Sevenmile Creek on NFS lands have been extensively logged, but remain in good condition. Few roads are present, large wood recruitment potential is high, and cover is sufficient to allow use as a wildlife travel corridor. On private land, riparian forests have been converted to pasture.

The riparian zones along the Dry Creek have high road densities, reducing their value for wildlife and potential for large wood recruitment. Extensive logging and reduction of canopy closure has occurred along the lower intermittent reach. Riparian vegetation is absent. Along the upper perennial reaches, canopy closure generally remains high.

DISCUSSION

Riparian zones consisting of 300' on either side of the mainstems and perennial tributaries were analyzed. Aerial photo interpretation was used to characterize vegetation. This was compared to field knowledge of known locations. Photos from 1940 were used as a reference of pre-management conditions.

1. Threemile Creek

In 1940, late seral forests comprised 95-100% of the riparian zone along reaches 1-2 (Figure 12) and over 75% of the area had canopy closure greater than 55%. The 300' riparian zones in the lower reaches 1 and 2 have been greatly modified by past logging, road building, and stream cleaning/modification following the 1964 flood. Beginning in the 1950s, almost the entire length of these reaches was logged. Large trees were removed, and canopy closure decreased. The 1964 flood also took out trees in the riparian zone. Currently late seral forests comprise less than 10% of the riparian zone. Although openings are rare, currently 40% of the area has canopy closures less than 55%. Forest Service Road 3413 is within the riparian zone along almost the entire length of reaches 1 and 2, and in some places, is less than 50' from the stream. Its presence limits upslope recruitment of large wood. Activities following the 1964 flood removed large wood from the stream and dug a single deep channel. This prevents flow into overflow channels. As a result of these changes, functioning of the riparian zone has been impacted: large wood recruitment potential has declined; suitability for wildlife travel corridors has been lessened; and riparian vegetation is limited to the banks of the main channel.

Figure 12 reach map

Impacts in the riparian zones of reaches 3 and 4 have been similar, but less intensive. Along reach 3, late seral habitat was reduced from 100% in 1940 to a current level of 40%. Canopy closures were consistently high in 1940; currently, closures of less than 55% occur over 50% of the area. Along reach 4, late seral habitat comprised only 45% of the area in 1940, reflecting the presence of lodgepole pine forests. Canopy closures were high. Little change in stand structure has occurred along this reach since 1940. Forest Road 3413 weaves in and out of the riparian zone along these two reaches. However, several spur roads leading to campsites near the creek are present. The junction of three major roads, 3413, 3414, and 3449, occurs within the riparian zone near the upper end of reach 4. Although flood damage occurred, stream cleaning was less intensive in these two upper reaches. Multiple channels and flood plain functioning remain. Several springs and boggy areas are present, particularly in reach 4. Overall, in these upper reaches, potential for future recruitment of large wood remains high; value for wildlife habitat has been reduced by logging and the presence of roads, but not to the extent of reaches 1 and 2; and riparian vegetation is more extensive due to springs, seeps, and a wider flood plain.

2. Sevenmile Creek

On 1940 photos, trees were growing in the riparian zones of reaches on private land in Sections 24 and 25. For the most part, these areas have been logged and converted to pasture, reducing stream shading and potential for large wood recruitment.

On NFS land, reach 1 (below the diversion) has been little effected by past logging. Stand structure appears to be similar to that of 1940, with approximately 25% in a late seral condition; meadows comprise 30% of the zone. No major roads and few spur roads are present. The effects on the riparian zone from diverting a large portion of the stream flow are difficult to determine. There are numerous small springs, wet meadows, and boggy areas along this reach which maintain riparian vegetation. Because of the diversity of habitats present, it is likely to be an important wildlife area.

Between 60-100% of the area in riparian zones along reaches 2-4 have been partially logged. Late seral forests with greater than 55% canopy closure occurred throughout these zones in 1940. Logging has reduced late seral habitat by 25-40% and reduced canopy closure below 55% in some stands. However, few openings exist, these are primarily small landing sites at the outside edge of the riparian zone. Road densities in the riparian zone are relatively low. Forest Road 3334 lies outside the riparian zone for the most part, running through it for short sections. Sections of Forest Roads 3208-100 and 3208-105 also lie in the riparian zone. A perennial tributary resulting from a large bank of springs flows into reach 3. Riparian zones along this tributary are mostly late seral. Although effected by logging and the presence of roads, riparian zones in reaches 2-4 appear to be mostly intact. Large wood recruitment potential remains high and the zones probably have sufficient cover to function as wildlife travel corridors.

Little logging has occurred along the upper reaches 5 and 6, and riparian zone forests appear much as they did in 1940. Roads are absent from the riparian zones in these reaches except for 3334-550 which leads to the Sevenmile Trailhead. Small meadow openings occur along the creek. Because of their connectivity to the wilderness and Sevenmile Marsh, riparian zones in these reaches provide important wildlife habitat.

3. Dry Creek

The lower intermittent portion of Dry Creek has been extensively logged. Late seral habitat has been reduced from 100% in 1940 to a current figure of 55%. Canopy closure has also declined; currently 55% of the area has less than 55% canopy closure. Forest Road 3208 lies in the riparian zone of the creek for the entire length of this reach, limiting upslope recruitment of large wood. A series of landing sites has created small openings along the road which total approximately 8% of the area. Sections of Forest Road 3228 also intersect the riparian zone. Riparian vegetation is largely absent due to unstable banks and intermittent flows.

Extensive logging has also occurred in the upper perennial reach of Dry Creek. Late seral habitat has been reduced from 84% in 1940 to 55%. Canopy closure remains high in most stands along this reach. Small openings resulting from landing sites total 4% of the area. Road density is high. Sections of Forest Roads 3208 and 3228 and small spur roads lie within the riparian zones. Small meadows and springs occur along the upper reach, providing diversity of riparian vegetation. Potential for future recruitment of large wood and value as wildlife habitat is probably lessened by the high road density.

B. ISSUE: Habitat for listed and non-listed wildlife species has been altered by logging, fire suppression, and road construction. The existing open road density has contributed to the loss of wildlife habitat, altered wildlife movement patterns, and has improved hunting access and success.

KEY QUESTIONS: How has habitat been changed by management practices?

What is the potential impact of the density and distribution of roads open to vehicular traffic on wildlife species and their available habitat?

How has this affected species of interest?

SUMMARY: Logging, road building, and fire suppression have altered wildlife habitat in the watershed area.

There are fewer large trees now than in the past, and the species mix within the white fir zone has been altered in favor of shade tolerant/fire intolerant true fir species.

Habitat patches are smaller and more fragmented now than in the past.

Roads have changed the habitat and provided access for hunting, poaching, and other activities that disturb wildlife.

Spotted owl surveys have been fairly intensive in this area since 1991. These surveys have identified nine owl territories. Four of those territories are below minimum habitat levels at this time. Dispersal habitat is generally well distributed in the watershed area, but is limited to the north and east.

Two bald eagle territories are present. Eagle nest tree availability is declining and should be closely managed in the future. The foraging area for these eagle territories has declined and may continue to do so.

American martens use most of the watershed area. Not much is known about their population levels or trends. Providing slash piles of the right size may improve the effectiveness of the habitat in this area for martens.

Only 7% of the watershed area contains meadow habitat that great gray owls are likely to use. They are known to have occurred here in the past, but little is known about their present use of the area.

Elk numbers in this area are increasing. They use the lower elevations in the spring for calving. In the summer they move to the high country and avoid roaded areas.

White-headed woodpeckers, flammulated owls, and pygmy nuthatches all use large ponderosa pines. The number of large ponderosa pines has declined and very few replacement trees are available.

Black-backed woodpeckers use ponderosa and lodgepole pine habitat. This species needs bark beetles and other insects within an area to sustain a population.

DISCUSSION:

1. Habitat Changes

Interpretation of 1940 aerial photos indicates approximately 48% of the watershed area had canopy closures between 56%-100%, and 82% of the area had canopy closures over 40%. Most of the understory in the white fir zone at this time consisted of trees younger than 40 years old. If one extrapolates back to 1900, at lower elevations, stand canopy was relatively open and most of the trees were large pines. There were several large fires evident in the upper elevations of the watersheds prior to 1940. The unburned areas of the upper watersheds were quite dense. The north slopes of the lower elevations also had high canopy closure in 1940. These areas provided good habitat for interior species like spotted owls, with a high level of security for movement across the area. Very few roads were present except along the edge of the forest and private lands at that time. The earliest road through this area was from Fort Klamath to Jacksonville, which was constructed in 1863. Road construction for timber access began in earnest in the 1950s and continued through the 1980s.

PMR satellite data from 1988 indicates canopy closure has declined since 1940. Approximately 32% of the watershed area has canopy closures between 56%-100%; and 58% of the area, canopy closures over 40%. The changes in vegetation since pre-management times have influenced wildlife populations.

In the lower elevations and on south-facing slopes of the white fir zone, ponderosa pine, sugar pine, and Douglas-fir have been selectively logged, and white fir has increased in the absence of fires. Because of the harvest prescriptions, large trees are less common now than in the past. Species which prefer large ponderosa pine, like bald eagles and white-headed woodpeckers, have less habitat in this area now. Timber harvest and road construction have fragmented the habitat and reduced the patch size in the white fir zone. This favors edge species like red-tailed hawks over interior species like northern goshawks.

The Shasta red fir zone still contains approximately the same tree species mix as in the past. The primary effect of management has been to make the stands younger and less dense. The openings are probably within the natural size and percentage range for disturbance in the area, except that they have been created by timber harvest instead of fire. Differences between burned and logged stands may have some effect on wildlife using them, but it would be difficult to quantify.

Most of the mountain hemlock zone lies within Sky Lakes Wilderness. Changes from the past are less visible in this zone. The buildup of fuels from natural mortality increases the likelihood of a big fire occurring. Human activities in this area are primarily focused around hiking and big game hunting.

Roads affect wildlife and wildlife habitat in several ways. First, the road itself takes away habitat that could provide forage and cover for wildlife. Second, roads create edges and linear openings which allow species normally associated with openings to access interior forest stands. These species would not be competitive in unroaded forests, but compete effectively with interior species where roads exist. Third, roads provide access to people that would not otherwise be there. This increased activity is highly disturbing to some species, even if they are not hunted or directly affected. Mushroom pickers and firewood cutters can be just as disturbing to elk and some furbearers as hunters. These species avoid areas near roads, which reduces the effectiveness of the habitat (Thomas, 1979). Fourth, the direct loss of wildlife to hunters and poachers is higher in roaded than in unroaded areas.

The current road density in the watershed area is 3.9 miles of roads per square mile outside of wilderness. Road density is even higher in the Threemile and Dry Creek riparian zones. This level of road density greatly reduces the habitat effectiveness for elk and other road sensitive wildlife species (Thomas, 1979). Many of the roads are level I, or temporary roads, which should have been closed after the activity they were built for was complete. In most cases, this has not happened.

2. Species Analyses

The following species which occur in the watershed area were selected for analysis: spotted owls, bald eagles, American martens, great gray owls, elk, white-headed woodpeckers, black-backed woodpeckers, flammulated owls, pygmy nuthatches, and bats. These species were selected because they are protected by the Endangered Species Act, require protection buffers in the Forest Plan, or have a high social value.

Spotted Owls: Federal status: Threatened

Klamath Ranger District has been extensively surveyed for spotted owls. Fifty-five activity centers were documented as of 1994. Habitat on the District occurs in mid to late seral white fir and Shasta red fir stands with 56%-100% canopy closure, multiple canopy layers, at least 1-5 large trees per acre, and high levels of large snags. Figure 13 shows suitable nesting/roosting/foraging habitat in the watershed area.

Thirty two percent of the District has been designated as Late Successional Reserve to benefit species like spotted owls. LSR RO-229 in the Sevenmile drainage provides a link between Crater Lake National Park to the north and LSR RO-227 to the south. The matrix between LSR's should provide enough cover for owl dispersal. Matrix lands are not intended to provide habitat to support a pair of spotted owls for extended time periods. Most of the matrix lands within the watershed area have been selectively logged, but still provide adequate dispersal habitat (Figure 14).

The watershed area lies near the eastern edge of the range for northern spotted owls. Little suitable habitat lies to the east. Portions of the crest of the Cascades are sparsely vegetated which may limit dispersal to LSR's on the west slope. In places, it is only a few miles across to good habitat, so dispersal could occur to the west. To the north, Crater Lake National Park contains suitable spotted owl habitat in the lower elevations. However, suitable habitat on the east slope of the Cascades is scarce between Crater Lake and Crescent Lake. Owls that disperse to the north of Crater Lake may not be able to find enough suitable habitat to live in.

The watershed area was surveyed to protocol in 1991, 1992, and 1994, and is scheduled to be surveyed again in 1995. To date, the surveys have located eight spotted owl activity centers within the watersheds plus one additional activity center whose home range is partly within the Threemile watershed. Productivity for these pairs has been 0.4 young per pair each year over the last four years. The US Fish and Wildlfe Service recommends a minimum of 500 acres of nesting, roosting, and foraging (NRF) habitat within 0.7 mile of an activity center and 1,182 acres of NRF within 1.2 miles to assure viability of the site. Of the nine territories, four are presently below USFWS recommended acres of NRF habitat. Productivity for the territories which exceeded the USFWS minimum habitat levels was 0.6 young per year, while productivity for the pairs which were below the USFWS minimum habitat levels was 0.3 young per year. While the sample size was quite small and the survey intensity varied, the results tend to support the USFWS minimum habitat recommendations.

Dispersal habitat (11" trees with 40% canopy closure) makes up 62% of NFS lands in the eight 1/4 townships outside of wilderness in these watersheds. Two of the 1/4 townships on the northeast side of Sevenmile Creek have less than 50% dispersal habitat at this time, while the other six exceed 50% dispersal habitat.

Overall, the amount of spotted owl habitat has not changed much since 1940. Fire suppression has created about as much habitat as logging has removed. Some of the habitat on lower elevations is located on less productive sites which are unlikely to sustain suitable habitat for long periods. Also, the habitat is more fragmented now than 50 years ago, occurring in smaller patches with more edge.

Figure 13

Figure 14

Spotted owls seem to tolerate the presence of roads. However, roads probably allow spotted owl competitors like great horned owls, barred owls, and red-tailed hawks to access areas that they otherwise avoid. Once there, these species prey on spotted owls as well as compete for food.

Bald Eagles: Federal status: Threatened

Bald eagles use the Klamath Basin for nesting and winter habitat. A high percentage of the bald eagles in Oregon visit this basin during some part of the year. Most of the use is centered around the large lakes, including Agency Lake and Upper Klamath Lake. Eagles are attracted to this area by the availability of fish and waterfowl. Fish and waterfowl habitat has been reduced from historic conditions by draining over 80% of the original wetlands around the lake for conversion to farmlands. Eagles use large ponderosa pine, sugar pine, and Douglas-fir near these lakes for nesting. Many of the preferred nest trees were cut for lumber during the last 80 years. Remaining large pines are at risk of mortality from pine beetles in many stands.

There are two bald eagle nest territories in the watershed area. The Threemile nest has been very successful over the last 10 years, producing 15 young. The Sevenmile territory has been occupied every year since it was discovered in 1990, but has produced only 2 young. The foraging habitat near the Sevenmile nest is not as good as the Threemile foraging area, which may account for the difference in productivity. Site plans have been completed for both of these nests.

Bald eagles are at or near the recovery objectives for this area. The number of suitable nest trees is declining in these territories. This makes it important to maintain existing nest replacement trees and enhance potential future suitable nest trees in this area. If attention is given to this from now on, lack of nest trees should not become a limiting factor in these territories.

The amount of foraging area for eagles has declined in the Threemile and Sevenmile territories, as well as in most of the Klamath Basin. This reduction is a result of the eutrophication of the lake which reduces the amount of open water available, as well as agricultural modification. Prey levels may still be declining in the Klamath Basin, but it is not known how much that will affect eagle populations in the future.

Eagles vary in their tolerance of roads during nesting season. The two eagle pairs in the watershed area have constructed their nests near roads. The Threemile eagles appear to accept high traffic levels on the Westside Road a short distance from the nest. However, they become upset when vehicles use a gravel road infrequently on the opposite side of the nest. Since the gravel pit has been closed during the nesting season, productivity of this nest has been high.

American Martens: Winema National Forest Management Requirement Species

American martens use all three conifer zones found in the watershed. Complex structure near the ground is important for marten habitat, especially in winter. Man-made slash piles are used by martens to gain access under the snow in winter. This is important for winter foraging and thermal protection, since martens have little body fat. Marten territories have multiple den sites, both above and below ground. Douglas squirrels and flying squirrels are the preferred prey species. Martens prefer stands with 40% or higher canopy closure, and they avoid areas with less than 30% canopy closure (Spencer, et. al. 1983). Home ranges for 127 male martens in 12 studies averaged 1312 acres. Female home ranges averaged 808 acres for 72 females in 13 studies (Clark, et. al. 1987). Females have smaller home ranges than males because of their smaller body size (Marshall, 1992).

Canopy closure reduction since 1940 has reduced the suitability of habitat for martens. Oversnow track surveys on 2/9/82 identified 14 sets of marten tracks in 14 miles of transect in the Sevenmile drainage. Ongoing research on the Winema NF suggests that habitat for martens may be improved by leaving some large slash piles in timber harvest units (Simpson, personal communication, 1994).

Martens are suspected to avoid roads most of the time. Some road mortality has been known to occur where roads cross marten habitat.

Great Gray Owls: Forest Plan Protection Buffer Species

Great gray owls are usually associated with meadows. They do not build their own nests, depending instead on nests built by hawks or cavities. Great gray owls generally select stands with at least two canopy layers. Home ranges are very large, measured in miles, and juveniles travel many miles when they leave the nest. Prey species include voles, pocket gophers, northern flying squirrels, and red squirrels (Marshall, 1992).

Meadows make up 7% of the watershed area, but only 1% of NFS lands. Most of the meadows on NFS land are very small; only three are over 20 acres. The large marshlands east of the watershed area have limited value to great gray owls because trees are only found on the edge. Great gray owls have been found nesting along this edge in the past, but none have been located in recent years. Surveys for great gray owls in the watershed area have been sporadic and at low intensity.

Great gray owls are generally not affected by roads. One road mortality was documented on Highway 140 in January 1995, outside of the watershed area.

Elk: Winema National Forest Monitor Species

Elk were probably scarce in the watershed area before 1900 (Waterbury, personal communication, 1995). Rocky mountain elk were introduced in the early 1900's near Crater Lake National Park. The elk population in the watershed area has grown steadily since that time. Logging practices have created more forage for elk in the forested areas now than probably existed in the past. Elk primarily use the eastern half of the watershed area in the spring. The high quality forage available on private pastures is important to elk prior to and during calving. NFS land near the pastures provides cover and travel routes to and from the pastures. The elk cause some damage to private pastures and fences during this time.

High road density outside of the wilderness limits elk use. According to ODFW, elk summer range should have no more than 1.5 miles of open road per square mile. Hiding cover makes up 72% of the non-wilderness area. After calving, elk move higher to wilderness and other areas with better security. This area offers both rifle and archery elk hunting seasons each fall. Success has been fair most years, and the number of hunters has grown as the elk numbers grow. Some elk poaching has occurred in this area, mostly in the roaded portions. This area contains no winter range habitat for elk, so most move west into the Rogue River drainage before winter.

White-headed woodpecker: Forest Plan Protection Buffer Species

White-headed woodpeckers usually select ponderosa pine snags averaging 18" DBH for nesting, and forage in pines greater than 20" DBH. Most nesting and foraging occurs on the lower 15' of the trees. In central Oregon, white-headed woodpeckers show a preference for nesting near openings. Two radio-tagged birds had home ranges of 250 acres and 500 acres, respectively (Marshall, 1992).

Most of the potential habitat for white-headed woodpeckers occurs along the eastern edge of the watershed area. Observations of white-headed woodpeckers are also concentrated along the eastern edge. In the past, this area had more potential white-headed woodpecker habitat than is available now. There are few young and middle aged ponderosa pines available to replace the existing large ponderosa pines in this area. When the existing snags fall, it will take many decades to replace them.

The main effect of roads on woodpeckers is that they provide access for firewood cutters who remove snags that would have provided nesting and foraging habitat.

Black-backed woodpecker: Forest Plan Protection Buffer Species

Black-backed woodpeckers in the eastern Cascades show a preference for nesting in live or dead ponderosa pine and lodgepole pine. The nest trees average 11" DBH on the Deschutes NF. Forage trees average 13" DBH and 62' (Bull, 1986). Black-backed woodpeckers key in on bark beetle infestations and areas with high mortality, such as fires or windthrown stands. They are most common in mid elevation forests between 3,000 and 5,400 feet elevation. The average home range size on the Deschutes was 430 acres for three radio-tagged individuals. (Marshall, 1992).

The watershed area contains areas of beetle-killed lodgepole pine above 5,500'. Ponderosa pine has been reduced by selective logging and white fir competition.

Flammulated owl: Forest Plan Protection Buffer Species

Flammulated owls occur mostly in mid-elevation ponderosa pine and Douglas-fir forests. This habitat provides the moth and butterfly species which flammulated owls forage on. Flammulated owls are secondary cavity nesters, depending on cavities excavated by other species like pileated woodpeckers. In northeast Oregon, nest tree sizes were 12-23" DBH, and 80% of the nests were located near a forest opening. The study area contained one breeding pair per 210 acres. Dense conifer stands are used for roosting by this species (Marshall, 1992).

Ponderosa pine and Douglas-fir have been reduced from historic levels in the watershed area, by selective logging and white fir competition, reducing the amount of habitat available. Firewood cutting has reduced the amount of habitat available near roads.

Pygmy nuthatch: Forest Plan Protection Buffer Species

Pygmy nuthatches also prefer ponderosa pine stands for nesting and foraging. They excavate their own cavities at least 20' above the ground in ponderosa pines which usually exceed 20" DBH. Whole flocks of 100 or more birds may roost together in a single, large cavity. These roosts may be important for winter survival. Breeding pair territories are about 5 acres in size. Foraging can occur in young or old ponderosa pines (Marshall, 1992).

As described above, ponderosa pine has been reduced from historic levels in the watershed area. Firewood cutting has reduced the amount of habitat available near roads.

Bats: Forest Plan Protection Buffer Species

Several species of bats are suspected to use habitat within the watershed area, including fringed myotis, silver-haired bats, long-eared myotis, long-legged myotis, and possibly pallid bats. These bats roost in caves, mines, abandoned buildings, bridges, snags, and decadent trees.

Bat surveys were done in 1994 in the Threemile watershed and adjacent watersheds by Dr. Steve Cross. These surveys focused on small water sites that were used for drinking and foraging. The bridge over Threemile Creek in Section 3 was inspected for evidence of bat roosting. There was evidence that bats roost at this site, probably for short durations at night (Cross, 1995). No caves or mines are known to exist in the watershed area.

Although the number of large trees has been reduced, large snags still exist at a high level. Large snags provide habitat for many of the bat species in the area. It would be reasonable to expect the number of large snags to decrease in the future as the existing snags fall. There are not many large trees left to become replacement snags, and it will take a long time to grow the existing trees to that size. Firewood cutting has reduced the amount of habitat available near roads. Bats may have benefited from water developments in this area.

C. ISSUE: Soil quality has been altered by management activities.

KEY QUESTION: Have the functioning characteristics of the soil resources been altered and what are the impacts to forest health?

SUMMARY: Soil quality is based on the ability of a soil to accept, hold, and release nutrients and water; promote and sustain root growth; maintain suitable soil biotic habitat; respond to management; and resist degradation. Soil quality plays a direct role in the health of a watershed and its hydrologic functioning.

In order to analyze the influence of soil resources and the direct role that it plays, inherent soil quality and existing soil quality must be established. The determination of inherent and existing soil quality was based on basic soil properties, integration of soil-forming processes as expressed by above-ground productivity, ecosystem disturbances, and the inherent sensitivity of each soil type.

Inherent soil qualities have been altered in areas that have detrimental soil conditions, particularly from compaction. This occurs over approximately 10% of the watershed area. Detrimental soil conditions are likely to reduce forest growth rates. Subsoiling is used prior to reforestation as a mitigation. Effects on other resources occur primarily in riparian areas, where roads route water and accelerate sedimentation.

DISCUSSION

1. Inherent Soil Quality

Inherent soil quality, as represented in Figure 13, is divided into low, moderate, and high classes. The classes are based on site productivity of a plant association that a particular soil type supports. Above-ground biomass produced in each plant association was utilized as an integrator of soil-forming processing, which includes climate parent material, its positions on the landscape, vegetation, and other organisms that all work together over time. Information was derived from Carlson (1979) and Hopkins (1979).

As can be seen in Figure 15, the majority of the watershed area, 17,000 acres, has low inherent soil quality. Approximately 4,270 acres have moderate inherent soil quality, and 10,055 acres, high inherent soil quality. Soil types X6, X2 and R8, when found with CM-S1-11 and/or CL-S4-14 plant associations, have low inherent soil qualities. These areas have relatively shallow soils, or soils with an impervious layer of till less than 20" below the surface. Rock content greater than 45% and high amounts of clays are common. These soils occur primarily on the high plateau of the Sky Lakes Wilderness. Soils with moderate inherent soil quality support plant associations such as CL-S4-13, CR-S1-12, and CW-S3-12. These soils have low rock content, between 5-25%; soil depth of 20-40"; and sandy and silty loam surface textures. High quality soils commonly support the CR-S3-11, CW-C2-15, and CW-M1-11 plant associations. These are deeper soils, often greater than 40", with rock contents of 20-50%, and deep organic layers. Areas with moderate or high inherent soil quality produce faster vegetative growth than areas with low quality.

2. Soil Sensitivity and Past Management Effects

In order to assess the existing soil quality, soil sensitivity to impacts was first determined, then actual disturbances that may have changed soil properties were analyzed.

Figure 15. Inherent Soil Quality

An overall sensitivity rating was determined for each soil type, based on its susceptibility to impact and its resilience for long-term degradation. Figure 16 represents the overall sensitivity of each soil type to accumulative disturbances. Soil porosity, the organic capital in surface litter, and the surface soil horizons were analyzed to establish each soil type's susceptibility and resilience to compaction, erosion, and nutrient loss. Comparing the susceptibility and resilience of each soil type relates the magnitude of an impact that human and natural disturbances will have. The rating for each soil type is listed in Appendix E. Appendix E, along with Figure 14, should be used in making future management decisions that could affect soil resources.

Actual disturbances were obtained through past activity records, engineering reports, silvicultural records, recreational data, and aerial photo interpretation. Disturbances were determined based on a cumulative assessment of the level of compaction, erosion, and nutrient loss. The largest amount of disturbance in the watershed area can be attributed to past harvest activities and road construction. Approximately 3,050 acres are estimated to be detrimentally impacted from compaction and erosion. These units or activity areas currently exceed the Forest Plan standard and guideline which states that no more than 20% of an activity area be detrimentally impacted.

Compaction reduces microbial activity, thereby increasing leaching of nutrients; lowers the water holding capacity of soils; impedes root development; and accelerates erosional processes. In untreated areas of detrimental compaction, "J" roots are evidence of a hardened underlying layer that restricts root growth. Low growth rates have not been recorded in plantations less than ten years old on the District. This may be due to their location on productive R and X soils, and silvicultural site preparation to reduce compaction and competing vegetation. Site preparation typically is successful in reducing compaction in the top 6-8". This may allow seedlings to develop at sufficient levels to meet stocking requirements at the five year index. Long-term growth studies and comparisons with uncompacted sites have not been completed in this area, however. Data from other forests indicate a correlation between compaction and lower growth rates.

Past activities that have caused compaction have also led to the acceleration of erosional processes, including overland flow and gullying. In areas more than 300' from a stream, overland erosional processes usually only occur for short distances before being dissipated, thus limiting the amount of disturbance and minimizing the effects on other resources. In areas within 300' of a water source, erosional processes have a high probability of routing sediments into the streams. Forest Roads 3449, 3414, 3413-110, 3334, 3208-100, and 3208-105 all route overland flow towards streams. The Dry Creek basin, due to its high pumice content and weak structure, is particularly prone to gully formation when land forms become disturbed. For example, Forest Roads 3208, 3228, and the adjacent spur roads in this area, have eroded downward since their creation. The high number and poor placement of roads in this area have accelerated erosional processes.

Landslides and debris flows are not common in the watershed, primarily due to the geologic fault lines that allow for deep water infiltration and high storage, as discussed in Chapter II under the geology section.

Figure 16. soil sensitivity.

3. Current Soil Quality

Current soil quality reflects soil sensitivity to impact, the degree of impact from past management, and soil resilience to impact. Figure 17 shows current soil quality. Approximately 3,000 acres which had high or moderate inherent soil quality were degraded to moderate or low soil quality due to past management that resulted in detrimental soil conditions. This is approximately 10% of the watershed area. This figure was derived using Appendix E and aerial photos. Soil types with high-to-moderate inherent quality and low-to-moderate resilience, which were subjected to soil impacts totalling 40% or more of an activity area, were considered to be degraded. These areas should be rehabilitated through sub-soiling to achieve adequate growth and survival of trees.

4. Conclusions

The areas of higher impact from past activities correspond directly to the sensitivity of the soil type. Thus, future management activities should consider sensitivity ratings. Rehabilitation projects should be prioritized to address sites with higher inherent soil quality and resiliency first. These areas will show the most improvement.

Figure 17. Current Soil Quality

D. ISSUE: The hydrograph has been altered in terms of base flow, peak flow, and timing of peak flow.

KEY QUESTION: Has the natural draining process in the watershed area been altered by timber harvest, road building, and diversion activities?

SUMMARY: In the Threemile drainage, equivalent clearcuts have increased since 1940 as a result of both logging and natural mortality. However, it is unlikely the magnitude has been significant enough to affect flows. Little overland flow is associated with compacted upland areas. Adjacent roads route water into the creek, but do not appear to be increasing the timing of peak flows. Base flow and the limits of perennial flow may have been increased in the lower reaches of Threemile Creek as a result of mechanically lowering the channel bottom.

Increases in equivalent clearcuts in the Sevenmile drainage also have probably not affected flows. Dry Creek appears to naturally have rapid peak runoff. This has been accelerated by road construction in the upper watershed. However, there is no evidence that Dry Creek is altering peak flows in Sevenmile Creek. An irrigation diversion removes a large percent of the base flow from the lower reach on NFS lands. Peak flow is also removed during low water years. Downstream irrigation systems on private land further alter the delivery of water to Agency/Upper Klamath Lake.

DISCUSSION

The analysis procedure is described in Appendix F.

1. Threemile Creek Drainage

a. Hydrology

The Threemile Creek drainage is approximately 8,165 acres in size. Threemile Creek is a second order channel; the upstream limit of perennial flow is near Forest Road 3449 in Section 5. Other than a small spring-fed tributary in Section 4, water input from tributaries occurs only during spring runoff. Connectivity with Upper Klamath Lake is constant via Crane Creek to Fourmile Creek to Fourmile Canal, which flows into the lake. A non-tributary spring-fed creek arises in Section 4 and parallels Threemile Creek on the north. It is perennial for approximately 200 yards. (See Figure 18).

Peak flow in Threemile Creek is 40-50 cfs. The high infiltration rates of the volcanic vents defining the ridge tops to the south and north limit annual water yields. These peaks receive approximately 50" of precipitation. However, with very little drainage development, it is probable that they function as a recharge zone for springs, as described in the geology section of Chapter II.

Figure 18. Hydrology Map

Tributary density increases in the wilderness area near the Cascade summit. Soils in this area formed from glacial till and are less permeable. Upper Puck Lake provides a catchment and storage area for surface flows on the glacial plateau. Water contribution from the lake to the stream network is infrequent, as indicated by little channel development below the lake.

Currently, baseflow for Threemile Creek is under 1 cfs (Figure 19). Springs and seeps in the riparian zone of reach 4 provide the major source of water during low flow periods.

b. Management Effects

Although widespread logging occurred in non-wilderness areas, most prescriptions were partial cuts, which decreased canopy closure, but did not create openings. Regeneration harvests consisting of shelterwood cuts, seed tree cuts, and clearcuts occurred on only 4% of non-wilderness lands. Many of the regeneration units were harvested in the 1960s and 1970s and have since fully or partially recovered hydrologically. Currently, equivalent clearcuts total 580 acres, or 17% of the Threemile drainage (see Appendix F for the analysis method used). In 1940, clearcut equivalents totaled 7% of the watershed. Pine beetle kill in upper elevation lodgepole pine stands and logging in the white fir zone are primarily responsible for the increase in equivalent clearcuts. Studies in literature suggest that measurable change in magnitude of flows does not occur until approximately 30% of a watershed is clearcut. It is unlikely that timber harvest in the Threemile drainage has produced a measurable change in flows since 1940. Given the potential for natural disturbance in the drainage, it is probable that an equivalent clearcut level of 17% is within the natural range of variation.

Approximately 31.6 miles of road and an additional 950 acres of compacted surface from timber harvest activity are located in the drainage. Field reconnaissance indicates there is little overland flow occurring in the compacted areas, except on non-native surface roads or in natural drainages. This is due to build up of a duff layer and the high percentage of coarse fragments in the soils, which allows for high infiltration.

Roads and areas of compaction within 100' of the channel have the highest potential to alter water delivery into the stream channel and affect flows. There are 1.5 miles of road within 100' of the creek. Forest Road 3413 parallels the creek for nearly the entire length of the main channel; water discharged from culverts along this road has a high probability of being delivered directly into the channel. Likewise, four road crossings on the mainstem deliver water and sediment. However, there appears to be no effect on timing of peak flows. In comparing the peak flow timing of Threemile Creek with Cherry Creek, which has low road densities adjacent to its tributaries and main channel, there appears to be no appreciable difference. In fact, all streams in the vicinity (Rock, Cherry, Threemile, Sevenmile) "peak" within the same week.

Interviews with long-time residents in the area indicate that connection with Crane Creek was once seasonal. Flows likely subsided into the alluvial fan. Presently connection occurs year round. The probable cause for this change is mechanical downcutting of the channel bottom following the 1964 flood. The channel bottom was lowered as much as 10'. This moved the channel closer to the ground water table, increasing opportunity for ground water to contribute to surface flow.

Figure 19. Threemile Creek Hydrograph

c. Conclusions

Although adjacent roads route water into the creek, management activities in the Threemile watershed do not appear to have significantly changed peak flow magnitude or timing. This is expected to continue under current management direction.

Lowering of the channel bottom in reach 1 has probably increased base flow. It may also have extended the limit of downstream perennial flow.

2. Sevenmile/Dry Creek

a. Hydrology

The Sevenmile drainage totals 23,545 acres; the Dry Creek basin constitutes 8,535 acres of this. Sevenmile Creek is a third order channel and is entirely perennial from Sevenmile Marsh to irrigation systems on private land. Connectivity with Upper Klamath Lake occurs all year, via the Sevenmile Canal. A perennial tributary arising from springs occurs in Sections 9 and 10. Other tributaries, including Dry Creek, are intermittent.

Peak flow for Sevenmile Creek is 50-70 cfs. This is the lowest peak flow per drainage area of streams in the vicinity. Two features may contribute to the low peak flows. Sevenmile Marsh intercepts many of the headwater tributaries. This acts to reduce the instantaneous input of water, thereby attenuating peak flows. Klamath Point is the highest peak in the drainage and comprises the entire southern half. Drainage density is low, indicating rapid infiltration, as described in the geology section in Chapter II. It is speculated that Klamath Point is a recharge area for springs.

Base flow is 15 cfs (Figure 20). Sevenmile Creek has the highest baseflow per drainage area of streams in the vicinity. This is primarily due to the spring activity of the perennial tributary and the Sevenmile Marsh wetland. Sevenmile Marsh is a 40 acre wetland capable of capturing and storing large volumes of water. The stored water is then released during low flow months. Small springs and wetlands also occur in reach 1 and become much more extensive in reaches on private land.

Dry Creek is an intermittent channel. Peak runoff from the basin appears more rapid than in other channels draining the vicinity. A combination of roads and the glacial till soils account for this. Spring activity in the upper reach creates a perennial stretch for approximately 1.5 miles.

b. Management Effects

Timber harvest in the Sevenmile drainage has been similar to that of the Threemile drainage. Currently, clearcut equivalent acres total 4,616 acres, or 20% of the drainage. In 1940, clearcut acres totaled 7% of the drainage. Pine beetle kill in upper elevation lodgepole pine stands and extensive logging in the white fir zone have caused the increase in equivalent clearcuts. These factors offset regeneration of burned stands in the Shasta red fir zone. For reasons stated above under the Threemile discussion, it is unlikely that the magnitude of flows in Sevenmile Creek has been effected by timber harvest since 1940, or that the current condition is outside the natural range of variation for the drainage.

Figure 20. Sevenmile Creek Hydrograph

Approximately 17.4 miles of road and an additional 1,790 acres of compacted surface from timber harvest activity are present in the watershed. As in the Threemile drainage, little overland flow is associated with compacted areas, except on non-native surface roads and roads located in natural drainage features. Roads are primarily a concern in the Dry Creek tributary. Several roads in the upper Dry Creek drainage are concentrating water, resulting in gullies and rills. Water and sediment delivery into the system has increased. The influence of Dry Creek on flows in Sevenmile Creek occurs between the confluence and the Sevenmile Diversion Ditch, a distance of approximately one mile (the diversion becomes the dominant influence on flows downstream). There is no evidence indicating roads in Dry Creek are altering peak flows in this one-mile stretch.

Irrigation practices are affecting peak flows in reach 1. Although the diversion has a larger influence on the receeding limb of the hydrograph, during dry years water is removed near the peak of the hydrograph. Below NFS lands on private property, other ditches and headgates impound and route water.

Baseflow is unaltered above the Sevenmile diversion ditch. Below the diversion, discharge measurements from 1994 show a greater than 90% reduction in streamflow. Downstream on private land, base flow, like peak flow, is determined by irrigation practices.

c. Conclusions

On NFS lands, the hydrograph above the diversion in Sevenmile Creek appears to be little affected by past management activities. Below the diversion, flows have been significantly reduced. On private lands, irrigation systems control flows and determine the timing, quantity, and quality of water delivered to Agency/Upper Klamath Lake. Irrigation activities have a much greater effect on flows and nutrient loading into the lake than activities on NFS lands.

E. ISSUE: Channel condition has been degraded by past management.

SUMMARY Threemile Creek is characterized by high gradients, a confined channel, and bank erosion processes. Large wood is important in development of a step pool system. An alluvial fan developed in the lower reach as the creek approached the Klamath Lake basin. Cleanup following the 1964 flood and past logging in riparian areas removed large wood and potential for future recruitment in reaches 1 and 2. Riffles now dominate these reaches. Roads are introducing sediments into the creek, particularly in Reach 4. Mechanical lowering of the channel bottom in reaches 1 and 2 has confined flows to a single channel and prevents functioning of overflow channels. Potential for extensive damage from future floods is high.

Processes in the upper reaches of Sevenmile Creek are similar to those of Threemile Creek. In the lower two reaches on NFS land and on private land, gradients decrease and floodplains are wide. Sinuosity is high and pools are formed by lateral scouring. Beaver activity is high. Channel conditions above the irrigation diversion approach historical conditions. Below the diversion, flow reductions have led to excessive bank erosion and bar development. On private lands, irrigation systems have modified channel condition.

DISCUSSION

1. Threemile Creek

a. Channel Condition and Processes

Nearly the entire Threemile drainage network is characterized by high gradients, confined channels and large substrate. The mainstem and a short tributary are the only perennial reaches in the drainage; therefore, sediment routing into the mainstem is minimized. The sediment regime is dominated by bank erosion processes. The bank material is unconsolidated glacial till composed of 80% sands and gravel and 20% larger material. This material lies on steep slopes and confines the channel. Raveling of side slopes is common and provides material for bank development in the active channel.

A lack of fluvial features indicates sediment transport processes are dominant over sediment depositional processes, and stream velocities are competent in removing most of the fine material. Below the slopes of the Cascades, stream power decreases abruptly with the change in gradient. The stream deposits its payload of silts, sands, and gravels in this area, building an alluvial fan.

Channel forming processes can be generalized as an A and B system, according to the Rosgen classification system. With very low sinuosity and floodplain development, the majority of energy dissipation is turbulence generated by large roughness materials. Substrate and large wood debris create turbulence which directs flow velocities, or kinetic energy, into the channel bottom or adjacent substrate. When the velocities are directed toward the channel bottom, the energy forms pools. Similarly, small pocket pools are formed when turbulence around large substrate removes the smaller material at the base. This sequencing of turbulence and pool formation creates a step-pool system.

During infrequent large flow events, substrate occupies a small proportion of the water column and has little effect on slowing velocities. In confined reaches, the energy is directed toward the upper bank, resulting in high erosion. This occurred during the 1964 flood, causing banks and associated vegetation to be scoured away. Many of these bank failures are still producing sediment. In unconfined reaches, the stream spreads out in overflow channels.

Due to the high gradient, the natural frequency of step pool sequencing is estimated to be approximately 3-5 channel widths apart; increasing in frequency with increasing gradient. Large wood is a significant factor in quantity of pools. Water flowing over logs is directed to the channel bottom, scouring the substrate. Large wood also creates dam pools upstream and slows velocity, allowing for the deposition of gravels.

b. Management Effects

The step-pool system has been altered, primarily by stream clean-up after the 1964 flood. During the flood, debris plugged culverts and caused considerable damage to the road system, particularly Forest Road 3413. On the alluvial fan, the water jumped the existing channel and began flowing down overflow channels. These events initiated stream clean-up and channel reconstruction projects. From the Forest Road 3413 crossing in Section 3 down to the mouth of the creek (reaches 1 and 2), all wood debris was extracted from the channel and banks. Use of heavy equipment in the channel and on the banks also displaced much of the large substrate. Due to the removal of the large roughness component, the system in these lower reaches is now dominated by shallow riffles. The processes of pool scouring and deposition of gravels have been reduced. Equipment activity on the bank caused numerous areas to dry ravel. However, the increased sediment load is quickly transported downstream.

The function of overflow channels in reach 1 has been lost. Heavy equipment was used to dig the main channel down approximately 10'. Berms were also built in this reach to prevent future adjustment of the channel. With the dropping of the stream channel and build-up of berms, flood flows will be contained in a single channel.

As described under Issue A, logging in the riparian zone has reduced the potential for future large woody debris recruitment in the lower reaches. The close proximity of Forest Road 3413 further reduces the potential for future recruitment.

The largest impact from roads on channel condition occurs in reach 4, where Forest Roads 3449 and 3413 intersect. Spur roads also lead down to the creek in this area. Road sediments are routed into the creek and affect approximately 1/2 mile of the stream.

c. Conclusions

The consequences of alteration of channel conditions are as follows. Current conditions will persist into the future. The removal of wood from the stream in reaches 1 and 2 has simplified channel form. With the removal of late seral riparian vegetation during logging and flood clean up, reintroduction of large wood will be low for the next 100 years. During future flood events, there is a high risk of massive bank failure throughout most of the lower reach. Historically, flood water spread out in overflow channels. Since this is no longer possible, a high velocity wall of water will be directed toward downstream roads, including the Westside Road. Forest Road 3413 was reconstructed after the 1964 flood using the same design. It is likely heavy damage would re-occur to this road in the event of a large flood.

2. Sevenmile/Dry Creeks

a. Channel Condition and Processes

Channel processes in Sevenmile Creek are generally determined by gradient. The upper reaches (reaches 3-6) are characterized as a B channel, according to the Rosgen classification system. The channel is moderately confined with low sinuosity and has moderate to high gradient. Pool formation is generated from large roughness material such as substrate and large woody debris. The roughness components redirect flow velocities toward the channel bottom, which scours the bottom and creates pools. Channel, bank, and bottom material is a mixture of cobbles to sands.

Reaches P1, 1, and 2 are characterized by the Rosgen classification system as a C channel. These reaches have a lower gradient, and the channel is less confined. This allows for greater bank adjustment and larger floodplain development. Pools are not only formed from large roughness material, such as large wood debris, but also from lateral scouring. Sands and silt dominate the channel and bank sediments. These factors combine to create a sinuous system. Riffles are replaced by deep glides, and pools are predominately scour holes on the outside of bends. Undercutting of banks is prevalent. Beaver activity is common, raising water surface elevation and creating large wetland habitats adjacent to the stream channel.

During high flows, flood waters leave the bank, spread over the floodplain, and scour channels paralleling the stream. In doing so, the riparian areas increase stream width and slow velocities. Because of energy dissipation on the flood plain, flood damage during the 1964 event was minimal in Sevenmile Creek compared to Threemile Creek. However, Forest Road 3334, which parallels Sevenmile Creek on the south side, was heavily damaged during the flood.

Dry Creek drains the northern-most area of the Sevenmile drainage. Unlike the rest of the watershed area, the Dry Creek drainage has soils with a high pumice content. Consequently, the majority of material available for delivery to the stream system is low density and easily transportable. In the upper watershed, glacial till underlies the pumice material. Glacial till does not have the high infiltration rate of pumice. In natural drainage features, water moves along the glacial till-pumice interface, picking up pumice and delivering it into Dry Creek.

Upper Dry Creek is a confined system with moderate gradients. The lower reach decreases in gradient and is less confined. Consequently, the majority of pumice material is transported to the lower reach. The lower intermittent section of the channel is wide and shallow. Large accumulations of sands to small gravel pumice dominate channel form throughout the stream corridor. Peak flows readily erode banks which are naturally unvegetated.

b. Management Effects

Channel condition and processes in Sevenmile Creek remain unaltered except for the reach below the Sevenmile Diversion Ditch. Roads parallel Sevenmile Creek on both sides. The roads, however, are generally greater than 300' from the stream. Within this distance, there is sufficient hillslope roughness to disperse runoff from the road and prevent sediment from entering the creek. Two native surface roads cross the creek; these create local bank disturbances but do not change stream processes.

Below the diversion, the combination of water withdrawals and sediment input from Dry Creek has altered channel form. During the irrigation season, the diversion removes approximately 95% of the flow. The cross-sectional area below the diversion is half the area of the channel above the diversion. Consequently, this reach does not have the capacity to efficiently convey peak flows, resulting in accelerated bank erosion. Bank erosion is a full magnitude higher in the reach below the diversion. This sediment, in combination with the input of sediment from Dry Creek, produces bar development in excess of historic levels. Residual pool depth has also decreased.

As the creek leaves NFS lands and winds through the marsh, processes continue to be modified. Irrigation systems remove and discharge water into the creek. Flows ultimately enter Sevenmile Canal, which leads into Agency Lake. More detailed surveying would be needed to fully assess channel condition and flow manipulations in this area.

In Dry Creek, the present sediment regime does not appear to be natural. A combination of natural and road related features are responsible. Compacted road surfaces amplify the quick runoff process associated with dense glacial till. The incidence of rills and gullies associated with roads in Sections 4, 5, 8, and 9 are higher than in any other area on the District. Road maintenance records indicate culverts downstream have "blown out" more frequently than in other areas of the District. This indicates the instantaneous movement of water and sediment exceeded engineer's predictions.

c. Conclusions

Channel condition for the Sevenmile drainage above the diversion has been little altered by past management and will remain good, provided riparian reserves are implemented. Below the diversion, excessive bank erosion and bar development will continue. Forest Road 3334 was reconstructed after the 1964 flood using the same design. It is likely heavy damage would re-occur to this road in the event of a future large flood.

Roads will continue to increase sediment loading into Dry Creek until revegetated. Downstream culverts may blow out again during future high flows.

F. ISSUE: Fish habitat has been degraded.

KEY QUESTIONS: What was the historical condition of fish habitat? What is the current condition of fish habitat? How have modifications of channel condition impacted fish habitat?

SUMMARY: Habitat in Threemile Creek has been degraded, particularly in the lower reaches. Deep pool, hiding cover, and spawning habitat have been reduced as a result of stream cleaning activities. Roads are delivering sediments into the system, and a culvert is preventing upstream fish movement. On private lands, irrigation practices have altered the original channel to such an extent that fish habitat is minimal.

Fish habitat in most of Sevenmile Creek has not been significantly impacted by land management activities on NFS lands. On private property, Sevenmile Creek is used for irrigation, and portions of the creek are channelized. Fish migration to Forest Service reaches has been impaired by irrigation systems, and habitat has been reduced.

DISCUSSION

1. Historic Condition

Aquatic habitat surveys were not conducted prior to management activities in the analysis area. 1940 aerial photos, which document pre-harvest riparian conditions, and native fish life history requirements were used as indicators to make an assessment of historic aquatic habitat conditions.

The majority of the riparian area for Threemile (reaches 1-4) and the steeper gradient reaches (3-6) of Sevenmile Creek were historically vegetated with late seral (DBH >20") white fir forests. Canopy closure was fairly dense, being greater than 55% throughout the riparian area. Because of the gradient and confined nature of these streams, these forests were instrumental in creating fish habitat. Large wood was a primary factor in forming deep pool habitat used by fish for feeding, rearing, and overwintering. Substrates were predominately small boulders and cobbles; large wood served to trap spawning gravels that would otherwise have been transported downstream. The presence of bull trout also indicates the historic condition of these creeks. Bull trout are strongly influenced by temperature, and are seldomly seen in waters with summer temperatures over 18oC (Pratt, 1989). This indicates dense canopy closure in the riparian area was keeping these spring-fed systems cool.

Reaches 1 and 2 of Sevenmile Creek provides a unique type of habitat on the District. Within these reaches, gradient is low and the stream meanders through a wide valley floor. Historic riparian condition was similar to that of present day conditions. Wood and lateral scour were the primary sources of deep pool habitat. Undercut banks and vegetation played a much more significant role as forms of cover than in upper reaches. Hardwoods dominated the riparian area, with some late seral conifers on the outer edges. Canopy cover was dense. There is still a fairly active beaver population in this area, and historically, the population was larger. Beaver activity improved fish habitat by creating pond and side channel rearing habitat, but degraded spawning substrates by trapping sediments.

No natural barriers to fish passage existed in Threemile Creek. There is a waterfall at the end of reach 5 in Sevenmile Creek that most likely prevented the upstream movement of native fish. Instream flow was sufficient in both streams to allow for migration from Agency/Upper Klamath Lake. During summer low flows, the connection between Threemile Creek and the lake could have been disrupted.

2. Current Condition/Management Effects

Threemile Creek

Stream surveys conducted in 1994 (using the Hankin and Reeves methodology); 1992 aerial photos, showing the current condition of the riparian area; and channel condition analyses were used to assess impacts to fish habitat and develop a current condition.

In Threemile Creek, the primary changes to fish habitat have been a decrease of habitat diversity, a decrease of in-stream large wood and future recruitment potential, and an introduction of road fill into the stream.

Within reaches 1 and 2, in-stream wood is virtually absent. Removal of this wood has resulted in a loss of habitat diversity. Approximately 85% of the habitat now consists of wide, shallow riffles. The quantity and quality of pool habitat has decreased. There is little primary pool habitat available, and pools present are small and shallow (residual depth estimated to be approximately one foot deep). This impacts fish by reducing resting/rearing, feeding, and overwintering habitat. Retention of spawning substrates has also been reduced as a result of removing large wood, since it is one of the primary mechanisms for slowing down the transport of gravels through the system. Large wood removal has also resulted in elimination of hiding cover, as wood is a main source of hiding cover for fish in this system. Hiding cover is estimated to be no more than 5% in reach 1 and no more than 20% in reach 2. Stream banks in these reaches have been turned into steep berms that are prone to ravelling and are not well vegetated. Little hanging vegetation cover is available as a result.

Along reaches 1 and 2, late seral forests have been partially logged and replaced with younger stands. This means that the potential for recruitment of large wood into the system will remain low over the next several decades. Roads within the riparian zone also limit recruitment, as the riparian area upslope of the road is no longer able to contribute woody material. This means that fish habitat which has been degraded as a result of large wood removal will not recover until large wood is replaced.

Roads are transporting sediments into reaches 2 and 3. At this time, road fill is not accumulating - the system, in its currently degraded state, quickly transports sediments downstream. However, as habitat conditions improve over time, this could become a problem, affecting fish habitat by covering spawning gravels and decreasing residual pool depth. The culvert on the 110 road crossing is a barrier to fish migration. However, this is beneficial to the bull trout population in the system, as it prevents further brook trout movement upstream.

Irrigation practices on private property have altered the historic condition of Threemile Creek to such an extent that fish habitat is minimal.

Sevenmile Creek

Above the diversion, in reaches 2-6, fish habitat in Sevenmile Creek approaches that of historical conditions. The two primary sources of fish habitat degradation on the District - building of roads in riparian zones and removal of riparian wood - did not occur in this system to any extent. Although the riparian zones of reaches 2-4 have been partially logged, a sufficient amount of large trees remain to provide for future wood recruitment while the riparian zone recovers. In-stream large wood is good, averaging 90 pieces/mile. The system is riffle dominated, but there is diversity in types of habitat. Hiding cover is good and is of diverse types throughout the system. There are no man-made barriers to fish passage. Substrates suitable for spawning are dispersed throughout all reaches, and are the subdominant substrate in reaches 2 and 5.

Dry Creek is an intermittent tributary that enters Sevenmile Creek in reach 2. Historically, it may have provided seasonal forage habitat for fish. Fish surveys in 1992 did not locate any fish in the perennial section of the creek. Historical use, if any, of the perennial section is not known. Currently, Dry Creek provides minimal habitat for fish.

In reach 1 below the diversion, there have been modifications to Sevenmile Creek that influence fish habitat capability. Flow is significantly reduced by the diversion, but numerous springs enter the reach below the diversion, which increase flows and allow this reach to provide overall good fish habitat. Beaver dams have turned the reach into a series of glides. This creates excellent rearing habitat and hiding cover, as the glides are three to five feet in depth. However, sediments delivered from Dry Creek and resulting from local bank erosion are trapped by the numerous (22) beaver dams. As a result, streambed substrate is 100% silt/sand substrate and spawning gravels have been covered.

Reach P1 on private lands has not been surveyed for condition of in-stream aquatic habitat. An aerial survey of the reach and changes in land use indicate that the condition of the creek has been altered to the detriment of fish habitat. This area has been drained and converted to pasture. The creek is used for irrigation and is eventually diverted into Sevenmile Canal. Water quality is most likely degraded as the creek passes through this section. Fish passage is impaired because of head gates on irrigation canals, but is most likely not blocked year round.

3. Conclusions

Meeting the potential large wood capability of Threemile Creek is important to maintaining the bull trout population. Hicks et al. (1991) state that the abundance of salmonids is closely associated with abundance of woody debris. The Threemile Creek bull trout population is one of six isolated populations remaining in the Klamath Basin and the only population on the District. Its extinction would equate to loss of significant genetic diversity.

Sevenmile Creek and its associated springs could potentially provide a source of high quality water to Agency/Upper Klamath Lake. Water diversion for irrigation and habitat degradation on the private reach of Sevenmile Creek currently limit its contribution. Hypereutrophication of Upper Klamath Lake is regarded as a major limiting factor to the recovery of Lost River and shortnose suckers. When poor water quality conditions in the lake reach near lethal extremes, fresh water inflow from Sevenmile Creek could help sustain the species.

G. ISSUE: Native fish populations are nearly extirpated.

KEY QUESTIONS: What was the historical distribution of native fish? What is the current condition? How has the introduction of non-native species impacted native fish distribution?

SUMMARY: Sevenmile Creek originally provided habitat for several species of native fish, including bull trout, Lost River sucker, redband/rainbow (resident and migratory), Pacific lamprey, speckled dace, and slender sculpins. It is likely many of these species occurred in reaches on NFS lands. Threemile Creek is thought to have supported bull and redband trout populations.

Recent surveys found numerous introduced brook trout, but only one rainbow trout on NFS lands in Sevenmile Creek. In Threemile Creek, a small bull trout population remains above the 3413-110 culvert, which acts as a fish barrier. Because habitat conditions remain good in Sevenmile Creek and are sufficient to support bull trout in Threemile Creek, the decline of native fish populations on NFS lands is most likely attributable to stocking of non-native species.

DISCUSSION

1. Historical Condition

Little historical data exist on the distribution of native populations prior to a fish-stocking program that was initiated in 1925 and continued until 1991. This limited data for Sevenmile and Threemile Creeks has been summarized in Fishes of United States Forest Service Streams within the Klamath Basin, Oregon (Thomas, unpublished).

As late as 1970, documented native fish species in Sevenmile Creek included bull trout, Lost River sucker, redband (resident and migratory), Pacific lamprey, speckled dace, and slender sculpins. These fish were sampled on private property, approximately 2 miles downstream of NFS lands. It is probable that most of these species historically occurred on the District. Fish associated with lower gradients, such as the sucker, most likely occurred within reach one and two. The remaining fish may have occurred in both the high and low gradient portions of Sevenmile Creek.

No records are known to exist documenting native fish composition or distribution in Threemile Creek. Based on current populations, and knowledge of nearby similiar systems, bull trout and redband trout most likely inhabited the entire Threemile system (Figure 21).

ODFW stocking records indicate that brown, brook, cutthroat, and rainbow trout were introduced into Sevenmile Creek between 1925 and 1991. Brook trout were introduced into Threemile Creek between 1927 and 1932.

2. Current Condition

Although historical data on fish composition and distribution in these systems is limited, it is apparent that significant changes in native fish populations have occurred. Electrofishing surveys conducted in 1992 in four locations along Sevenmile Creek found numerous brook trout, but only one rainbow trout on NFS lands. Brook trout now exist above a waterfall identified as a natural barrier to fish passage. On downstream private lands, brown, brook, and rainbow trout are known to occur. In Threemile Creek, electrofishing surveys conducted in 1992 and 1993 found a self-sustaining population of brook trout, a resident population of bull trout, and a small zone where hybrids (bull X brook) occur (Figure 22). This resident population of bull trout is extremely small, and is at a high risk of extinction. It is located above the 3413-110 culvert, which serves as a fish barrier.

Because habitat conditions in Sevenmile Creek have not been significantly altered from historic conditions within NFS reaches, and because Threemile Creek, although degraded, currently supports bull trout, this indicates that other factors have played a role in the decline of native populations besides habitat degradation. Native fish species evolved together, and for the most part, partition available resources by utilizing different spatial and temporal portions of the microhabitat within a stream. Introduced species can disrupt this natural allocation of resources, displacing natives through competition for food, space, and cover. This may lead to an exclusion of native fish from their habitat, reducing their capability to spawn, feed, or grow.

Brook trout are also able to hybridize with bull trout, making them an especially serious threat to bull trout populations (Ratliff and Howell, 1992; Markle, 1992). These species belong to the same genus, spawn at the same time, are able to produce hybrid offspring. However, life history differences favor brook trout; they reach sexual maturity at a younger age and are more prolific than bull trout. This leads to the displacement of bull trout (Ratliff and Howell, 1992). Hybridization often results in sterile offspring, thus leading to the gradual depletion of the bull trout gene pool and a trend toward extinction (Howell, 1992).

3. Conclusions

It is evident that native fish populations have been impacted by the introduction of non-native game fish. Bull trout in Threemile creek are restricted to the upper headwaters, and are at a high risk of extinction. Redband trout are virtually gone from both systems. Because so little is known about the slender sculpin's life history requirements, the magnitude of the effect of changes in these systems to the sculpin cannot be fully analyzed. However, all three of these fish are currently listed as sensitive on the Regional Forester's List, and are listed as category 2 species by the USFWS under the Federal Endangered Species Act.

Figure 21. Historical Fish Distribution

Figure 22. Current Fish Distribution

VI. MANAGEMENT RECOMMENDATIONS AND RESTORATION OPPORTUNITIES

This chapter focuses on management, restoration, and information needed to correct problems identifed under Issues A-G. Only general recommendations are given when detailed management is or will be developed in other documents, or existing information is not sufficient to make more specific recommendations. For the most part, standards and guidelines listed in the Forest Plan are not repeated here.

A. Forest Health

Management of upland forests is detailed in the Forest Plan. The Late Successional Reserve Assessment for R0227, R0228, and R0229 on the Klamath Ranger District describes potential treatment methods to reduce risk of loss of late seral habitat from insects, disease, and fire. Application of treatments will be decided during analysis of the Threemile/Sevenmile planning area.

B. Riparian Zones

Potential future impacts to riparian zones will be lessened through the use of riparian reserves. Recommendations for riparian reserves are shown in Figure 23. Reserves total 2,694 acres. Reserve locations have been scanned into GIS and should be referenced during planning of any project in the watershed area. The team recommends following the standards and guidelines listed in the Forest Plan for lake (320'), wetland and spring (160'), seasonally flowing or intermittent stream (160'), perennial fish-bearing stream (320'), and perennial nonfish-bearing stream (160') riparian reserves. These widths were determined using a site potential tree height of 160'. Reserves extend from both edges of the stream channel, and around the edges of the lakeshore or wetland margin.

The team recommends applying the timber standards and guidelines given in the Winema Forest Plan for Riparian Areas Adjacent to Class IV Streams to ephemeral drainages not meeting the definition of seasonally-flowing or intermittent streams in the President's Forest Plan. Although riparian vegetation is usually lacking in these areas, maintaining unimpeded water flow during high runoff periods is important for hydrologic functioning. Standards and guidelines apply to 25' on either side of ephemeral drainages and include the following:

1. Activity-created debris shall be cleared from stream channels except for large woody material keyed into stream banks.

2. Skid trails shall cross only at approved locations perpendicular to the stream and shall be designed to avoid altering the drainage characteristics.

Information Needs:

1. The locations of ephemeral drainages are not mapped, and will need to be determined by field reconnaissance during project planning.

Figure 23. Riparian Reserves

C. Wildlife Habitat

Manage the road system so that no more than 2 miles of road are open to vehicular travel per square mile in the management areas outside of wilderness.

Close the level I roads with berms, rocks, or gates. Gates should be used as little as possible because gated roads get used too often and gates are targets for vandals.

Obliterate temporary roads and other unneeded system roads.

Make an effort to regain the historic species diversity. This could include favoring seral species when marking for timber harvest or precommercial thinning, planting seral species when possible, using prescribed fire to maintain stands with fire resistant species, and culturing around shade intolerant species.

Enhance stands within the LSR, where feasible, to encourage late successional characteristics.

Manage matrix lands so that dispersal habitat is maintained in corridors that provide north-south as well as east-west travelways. The riparian reserves will provide east-west corridors in this area, but attention will be required to provide north-south corridors.

Develop additional water sources in deficient areas to expand the habitat available to many wildlife species.

Examine the potential to re-introduce native species which have been extirpated from this area. While it may not be feasible to bring grizzly bears back, reintroduction of fishers could be socially and economically feasible.

Utilize the final results of the ongoing marten study on the Forest; provide slash piles of a designated size and spacing to increase marten habitat effectiveness.

Maintain snag levels at 10-15 snags/acre after management activities, as described in the LSR Assessment. In addition to providing sufficient coarse woody debris levels, this will also provide cavity nester habitat. Leave most/all ponderosa pines to provide future snags for species like white-headed woodpeckers. Ponderosa pine snags are expected to decrease in the future due to the lack of replacement trees.

Implement a prescribed natural fire program in the wilderness, one of the benefits being maintenance of habitat in multiple seral stages.

Information Needs:

1. Initiate surveys for Forest Plan survey and manage species as protocol becomes available.

2. Gather baseline data for Forest Plan monitoring species and set up protocols for future monitoring. These species include mule deer, elk, bald eagles, spotted owls, peregrine falcons, primary cavity excavators, pileated woodpeckers, northern three-toed woodpeckers, goshawks, pine martens, and other sensitive species.

3. Survey for other ROD species which require protection: great gray owls, white-headed woodpeckers, black-backed woodpeckers, pygmy nuthatches, flammulated owls, bats, and lynx.

D. Soils

The areas of higher impacts from past activities correspond directly to the sensitivity of the soil type. Thus, future management activities should be representative of the soil type and its sensitivity rating. Refer to Figure 16 and Appendix E.

Identify skid trails, roads, and landings which are no longer needed and subsoil them to alleviate compaction, particularly where the percent of area compacted exceeds Forest Plan recommendations that no more than 20% of an area have detrimental soil conditions.

The meadow adjacent to Frog Pond in the Threemile Drainage has been compacted by firewood cutters. Created roads should be closed and compacted areas subsoiled.

To prevent future soil compaction, the team recommends setting the allowable soil moisture restriction for heavy equipment use to 17%. This is the level recent monitoring data suggests is needed to prevent a 20% increase in soil bulk density and meet Forest Plan standard and guideline 12-5.

Information Needs:

1) Additional soil typing and mapping are needed to expand upon and better define the information in the Winema Soil Resource Inventory (Carlson, 1979).

E. Hydrology/Channel Morphology

Limit construction of new roads and obliterate or improve existing roads within riparian reserves and the hydrologically sensitive areas shown in Figure 24. Achieve a 50% reduction in road density within these areas. Hydrologically sensitive areas are most likely to contribute to changes in the hydrograph caused by high road density and proximity to a stream channel. Roads that increase the drainage network or impact the morphology of the streams or their tributaries should be the highest priority for obliteration or improvement.

Dry Creek:

The upper part of the drainage in Sections 4, 5, 8, and 9 has been identified as a hydrologically sensitive area. Close and rehabilitate all unnecessary roads in this area. Forest Road 3208 should be closed at the 380 junction. The 381 and 420 spurs should also be closed. Plant unvegetated areas.

Sevenmile Creek:

Permanently close and rehabilitate the 3208-100/105 spur and eliminate the stream crossing. Remove the culvert which is altering flow of the perennial tributary in Section 9.

Investigate methods to improve drainage at the Sevenmile Trailhead campground. The remaining bridge supports should be removed.

Figure 24. Hydrologically Sensitive Areas

Threemile Creek

Obliterate spur roads off of Forest Road 3413 which lead down to the creek in Section 5.

F. Fish/Aquatic Habitat

Threemile Creek

Reintroduce large wood into reaches 1 and 2 of Threemile Creek.

Implement the Bull Trout Working Group plan for reclaiming bull trout habitat. This includes isolating bull trout populations above the 3413-110 culvert barrier and eradicating brook trout above the barrier.

Maintain the culvert on Forest Road 3413-110 as a barrier to upstream fish migration. This will ensure that as upstream bull trout habitat is reclaimed, it will not be re-invaded by brook trout. The culvert should be improved to allow for fish passage only after brook trout are removed from the system.

Obliteration or improvement of roads adjacent to Threemile Creek should be designed and scheduled to prevent impact to the existing bull trout population.

Sevenmile Creek

The importance of Sevenmile Marsh as amphibian and bryophyte habitat should be recognized and the area protected from potential future recreation impacts.

Information Needs

1 Conduct a genetic study of the bull trout population in Threemile Creek to determine whether it is distinct from other stocks in the Klamath Basin.

2. Establish a monitoring program for fish.

3. Establish a monitoring program to identify amphibian and macroinvertebrate habitat and presence.

4. Investigate the possibility of improving the connection between Agency/Upper Klamath Lake and Sevenmile Creek to allow better fish passage.

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APPENDIX A. LIST OF PEOPLE CONSULTED

Core Team

Rick Hardy	Wildlife Biologist
Sarah Malaby	Terrestrial Ecologist/Botanist
Mike Mathews	Hydrologist
Lindsey Pruyn-sitter	Soil Specialist/GIS Specialist
Sherry West	Fish Biologist/Aquatic Ecologist

Agency Specialists

Joy Augustine	Fire Management Officer
Lila Clanton	Plantation Manager/GIS Specialist
Paul Im	Recreation Planner
Phil Jahns	Silviculturist
Pam Martin	Computer Clerk
Ray McClenathan	GIS Coordinator
Roberto Morganti	Landscape Architect
Jeanie Sheehan	Reviewing Editor
Chris Thompson	Archeologist

Other Agency Contributors

Denny Edwards	Reforestation Specialist
Tom Neal	Engineer
Charlie Thompson	Forestry Technician

Public/Other Agencies

Bob Brown	Rancher
F.J. Danforth	Cherry Creek Resident
Gail Danforth	Cherry Creek Resident
Jeffery Dambaucher	Biologist, Oregon Dept. of Fish and Wildlife
Garwin Carlson	Retired Soil Scientist
Roger Smith	Biologist, Oregon Dept. of Fish and Wildlife
Jack Inman	Retired Wildlife Biologist
Larry Dunsmoor	Biologist, Klamath Tribes
Ralph Opp	Wildlife Biologist, Oregon Dept. of Fish and Wildlife
Ellen Brown Riach	Former Cherry Creek Resident
Joe Riker	City of Klamath Falls

APPENDIX D. SOURCES OF VEGETATION DATA

Historical vegetation was mapped from 1940s aerial photographs of the watershed area. At that time, little harvesting had occurred. Photos taken in the 1950s were also used to determine stand composition and structure. Stands had been delineated on the photos in the 1950s, and stand exam codes indicating species, tree diameter, and canopy cover had been recorded. Using the information on the photos, stands were mapped at a scale of 1:24,000 and entered into GIS. Historical stand exam information was translated into codes used in the PMR (Pacific Meridian Resources) satellite data collecting system. Three characteristics of vegetation were coded: canopy closure, species, and size/structure of stands. The codes were entered into an Oracle database so that maps of stand characteristics could be produced.

The historical data was compared to 1988 PMR data. Because the two data sets were mapped differently, statistical comparisons of landscape spatial patterns were not attempted. Only visual and rough acre comparisons were made.

Size/structure and canopy closure were used to determine seral stage. The following definitions were used. Non-forested included rock, water, meadows, and wet shrublands. Early seral included brush, and stands dominated by pole (5-9" DBH) or smaller trees, where canopy closure was less than 41%. Mid seral included stands dominated by small trees (10-20" DBH) or pole trees with greater than 40% canopy closure. Open stands with larger trees but less than 41% canopy closure were also included in this category. Late seral included all stands dominated by medium (21-32" DBH) or larger trees. Stands with multicanopy structure with large overstory trees comprising approximately 30% of the canopy closure and total canopy closure greater than 55% were also considered to be late seral.

APPENDIX B. REGIONAL FORESTER'S SENSITIVE PLANT SPECIES LIST FOR THE WINEMA NATIONAL FOREST

SPECIES	STATUS	DOC. IN AREA?	POTENTIAL HABITAT	OCCURRENCE1
Botrychium pumicola	C1,OC	No	LP basins, high elev. slopes, pumice soils	Possible, in CLNP
Arabis suffrutescens var. horizontalis	C2,OC	No	Gravelly, rocky, pumice slopes, high elevations	Possible, in CLNP
Astragalus peckii	C2,OC	No	LP/bitterbrush openings, sagebrush, pumice soils	Unlikely, no habitat
Castilleja chlorotica	C2,OC	No	Gravelly slopes/summits, PP/LP openings, 5000' +	Unlikely, not found on KRD
Collomia mazama	C2,OC	No	Mesic LP & fir forests partial canopies, mid elev.	Possible, in CLNP & Cherry WS
Eriogonum procidiuum	C2,OC	No	Volcanic slopes, basalt flows pine woodlands 4200-8200	Unlikely, not found on KRD
Mimulus pygmaeus	C2,OC	No	Spring-wet depressions and flats, intermittent stream beds	Possible, tiny annual
Perideridia erythrorhiza	C2,OC	No	Spring-moist meadows edge of mixed conifer forest	Possible, difficult to I.D.
Penstemon glaucinus	C2,OC	No	LP/WF forests, high elevations	Unlikely, not found on KRD
Rorippa columbiae	C2,OC	No	gravelly streambeds, lakeshores	Possible, hist. site
Arnica viscosa	3C	No	High elev. rocky sites	Possible, in CLNP
Calochortus longebarbatus var. longebarbatus	3C,OC	No	dry-moist meadows, edge of LP/PP woodlands	Unlikely, not found on KRD
Eriogonum diclinum	3C	No	Dry, rocky ridgetops, sandy-gravelly slopes & flats, serpentine soils	Unlikely, not found on WIN
Thelypodium brachycarpum	3C	No	Sagebrush openings, meadows in PP forests, streamsides	Possible, hist. site
Asarum wagneri	OC	No	LP & fir forests, open canopies, rocky sites	Unlikely, outside range
Allium bolanderi		No	Dry rocky or clay soils, openings in brush or woodlands	Unlikely, not found on WIN

SPECIES	STATUS	DOC. IN AREA?	POTENTIAL HABITAT	OCCURRENCE1
Calliergon trifarium		No	Fens with standing water often submerged	Possible at 7-mile marsh
Cicuta bulbifera		No	Swamps, marshes	Possible, hist. site
Gentiana newberryi		No	Moist-wet meadows mid-high elevations	Possible in Sky Lakes
Haplopapus whitneyi var. discoideus		No	Open, high elevation rocky slopes	Possible in Sky Lakes
Hieracium bolanderi		No	High elevation slopes in the Cascades	Possible in Sky Lakes
Mimulus jepsonii		No	Openings in LP/PP forests, residual soils, E. Cascades	Unlikely, not found on WIN
Mimulus tricolor		No	Moist flats, vernal pools, pools, wet clay soils	Unlikely, not found on KRD
Perideridia howellii		No	Moist slopes & meadows, streamsides	Unlikely, not found on WIN
Silene nuda ssp. insectivora		No	Spring-moist meadows low elevations	Possible, in Cherry WS

C1 - Category 1 candidate for Federal listing
C2 - Category 2 candidate for Federal listing
3C - Taxa found to be more abundant or widespread than previously believed and/or which have no identifiable threats.
OC - State of Oregon Candidate for listing
LP - Lodgepole pine
PP - Ponderosa pine
WF - White fir
CLNP - Occurs in Crater Lake National Park north of the watershed area.
KRD - Not found on the Klamath Ranger District to date.
WIN - Not found on the Winema National Forest to date.
WS - Occurs in the Cherry Creek watershed to the south.
Hist. Site - Historical Sighting on District or in nearby areas.
Sky Lakes - If present, most likely to occur in the Sky Lakes Wilderness.

1Probability of occurrence in the watershed area, based on the known distribution and habitat requirements of species, past survey data, and the likelihood of detection of species during past surveys in the area.

APPENDIX C. WILDLIFE HABITAT DESIGNATIONS

3m7m watershed area	31,713 ac	
FS in 3m7m watershed	29,426 ac	
Sky Lakes Wilderness	14,055 ac	(48% of FS)
Late Successional Reserve	7,306 ac	(25% of FS)
STOC NRF in 3m7m watershed	9,598 ac	(31% of FS)
STOC NRF in 3m7m LSR	3,301 ac	(45% of LSR)
STOC disp. in 3m7m matrix	12,226 ac	(72% of FS outside wilderness)
Area with no program harvest	8,219 ac	(49% of FS outside wilderness)
Area with programed harvest	8,687 ac	(51% of FS outside wilderness)
Non-forested area	420 ac	(01% of FS)
Forested, non-sustainable	3,298 ac	(11% of FS)
Forested, sustainable area	25,708 ac	(88% of FS)

The combined Threemile, Sevenmile, and Dry Creek watersheds contain 31,713 acres, of which 29,426 acres are managed by the Winema National Forest. The Sky Lakes Wilderness Area comprises 14,055 acres, or 48% of NFS lands in the watershed area. A Late Successional Reserve, RO-229, covers an additional 7,306 acres (25%) of NFS lands. Four owl activity centers are located outside of wilderness and LSR; 227 acres (1%) are protected in core areas around them. Riparian Reserves cover 788 acres outside of wilderness and LSR. Approximately 6,607 acres (22%) of the watershed area is matrix. The LSR contains 3,301 acres (45%) of the spotted owl nesting, roosting, and foraging (NRF) habitat in the watershed area. Dispersal habitat covers 12,226 acres (72%) of the area outside of wilderness. About half (51%) of NFS lands outside of wilderness have programed timber harvest under the amended Forest Plan. The other 49% is not scheduled for harvest, and will be managed to protect LSR, eagle nest areas, riparian reserves, and other resources. Only 1% of NFS lands in these watersheds are non-forested and incapable of growing trees at this time (lakes, wet meadows, talus slopes, etc.). Of the lands capable of growing trees, 3,298 acres (11%) are not capable of sustaining NRF owl habitat over extended time periods. These occur at low elevations where the site potential is not sufficient to maintain dense, multi-layered canopies.

APPENDIX F. STREAM FLOW ANALYSIS PROCEDURE

The watershed area was divided into Sevenmile and Threemile Creek sub-basins. The first step was the quantification of the present flow regime. Comparing current flows to pre-management flows was not feasible due to lack of historical flow data. Instead, a cumulative effects analysis of the distribution and intensity of management activities was used to estimate the probability of changes caused by management.

Base flow analysis procedure

Base flow was ascertained from sketching hydrographs from the 1992 and 1993 water years. The hydrographs consist of several miscellaneous measured flows. Inflection points in the hydrograph were identified and used to determine annual low flow.

Peak flow analysis procedure

Peak flows at a 2-year return interval were used for this analysis. The 2-year return interval was chosen because of the inherent channel-forming properties associated with this stage. Because the product of the frequency and magnitude of the forces of discharge determines the effectiveness of sediment transport and the resultant channel characteristics, it can be inferred that the active channel is formed by frequently occurring medium-sized events (Wolman and Miller, 1960). While larger events modify floodplains and valley floors, they are too infrequent to maintain the active channel.

Peak discharge was quantified using United States Geological Survey (USGS) gauging statistics and miscellaneous flow measurements. Gauging station data indicate that in the Klamath Basin, there was, on average, a 7-10 year flood event during the wet year of 1993. Although there are differences in runoff patterns between the rivers with gauging stations and the the streams draining the Eastern Cascades, it is fairly certain that the watershed area experienced similar peak flows. During the peak runoff, discharge measurements were taken. A number of discharge measurements were made during the "over-the-bank" stage (while the floodplain was inundated). While an exact number for the two-year return interval peak flow cannot be made, a range of flows around this interval was measured; peak flow is expected to fall within this range.

Cumulative effects analysis procedure

In developing a conceptual model and forming assumptions for factors leading to changes in flow regime, findings from the Pacific Northwest, Intermountain Forest and Range Experimental Stations, and The Rocky Mountain Forest and Range Experimental station (e.g., Bethlahmy and Nedavia, 1972; Cline et al., 1977; Harr et al., 1979; J.D Cheng, 1980; Troendle and Leaf, 1981; Leaf, 1975; Troendle and King, 1985) were used, as well as Dennis Harr's summaries at Oregon State University (Harr, 1975; Harr et. al, 1975) and several papers included in the International Symposium on Forest Hydrology (Dortignac, 1965; Pereira, 1965). A summary of the key findings follow below:

- There ia a net increase in peak water equivalent in harvested/burned watersheds.
- Snow melt rates were highest in open plots.
- Accelerated snow melt occurs after harvest.
- Low to medium flows on the rising limb of the hydrograph were most altered in timing and magnitude.
- Mean daily peak flows increased.
- Duration of annual floods increased.
- Loss of transpiration accounted for 2/3 of the change in flow with 1/3 from loss of interception.

Using this background information, a cumulative effects procedure was developed.

Modification of vegetation distribution and irrigation water withdrawals were assumed to be the dominant factor influencing changes in base flow. Changes in vegetation structure and resulting changes in transpiration rates are directly proportional to changes in soil moisture content, which are directly related to base flow conditions.

The net effect of decrease in transpiration, increase in peak water equivalent, and design of the road system was assumed to be most influential in altering quick flow and peak discharge. The fundamental concepts underlying these assumptions are as follows: loss of transpiration allows quicker recharge of soil; reduction in canopy closure will reduce interception; and the presence of roads add to the drainage network. "Net effect" was chosen because all three factors are simultaneously involved. Consequently, determining the relative contribution of any one variable is not significant.

These assumptions focused the cumulative effects analysis on road densities, diversion activities, and the recovery rates of harvested units. "Recovered" in this analysis is considered to be "hydrologically recovered". Harvest units are hydrologically recovered when re-establishment of leaf area is sufficient to return transpiration rates to pre-harvest levels, and canopy closure is sufficient to prevent excessive snow loading. Leaf area index is the ideal variable to quantify recovery. However, this data was not available. Canopy closure was used as a surrogate. To standardize the data and facilitate comparisons among watersheds, recovery was expressed in terms of equivalent clearcut acres (ECA). Roads and areas of compaction are not incorporated in the recovery model as these conditions persist for long periods of time.

Changes in vegetation resulting from alteration of the fire regime were considered, but not quantified during the analysis. In the mid-elevation white fir mixed conifer stands, succession in the absence of fire has caused higher stocking levels and increased canopy closure in some stands. The change has likely increased transpiration rates. Reduction of snow accumulation has probably been minimal, since typical mixed conifer stands originally had 40-70% canopy closure. Therefore, the largest effect may be on the availability of water during late summer. This process may influence base flows if stocking levels increase on a significant portion of the watershed area. Because of past timber harvest, this does not appear significant in the watershed area.

ECA Method

Equivalent clearcuts were determined from canopy closure data. The current condition was estimated from 1988 PMR satellite data. A GIS layer created from typing 1940 aerial photos was used as a pre-management reference point. The watershed area was divided into forest zones to facilitate comparison. Typical stands in 1940 were used to determine average canopy closure for different species compositions within the forest zones. Stands with average canopy closures were considered to be "recovered".

In the mountain hemlock zone, forests are often sparse. Canopy closures of >40% were defined as recovered. In the Shasta red fir zone, 1940 data indicated similar canopy closures to the mountain hemlock zone. Shasta red fir occupies steep high elevation sites associated with Klamath Point in this watershed area. In other watersheds, canopy closure in Shasta red fir forests may more closely resemble white fir forests. In the white fir zone, mixed conifer and white fir forests with canopy closure >55% were defined as recovered. Ponderosa pine forests in the white fir zone tended to be more open. Ponderosa pine stands with canopy closures of >40% were defined as fully recovered.

Partial recovery was assigned as follows:

Red Fir/Mountain Hemlock Zone

Canopy Closure	Shrub Cover	% Recovery
0-10%	<40%	0
11-25%	>40%	20%
26-40%	?	40%
40-100%	?	100%

White Fir Zone

White Fir/Mixed Conifer

Canopy Closure	Shrub Cover	% Recovery
0-10%	<40%	0
11-25%	>40%	20%
26-40%	?	40%
41-55%	?	80%
56-100%	?	100%

Ponderosa Pine

Canopy Closure	Shrub Cover	% Recovery
0-10%	<40%	0
11-25%	>40%	20%
26-40%	?	40%
40-100%	?	100%

Recovery curves do not fit a smooth linear or exponential curve; limitations resulting from the way data was recorded in ranges of canopy closure (e.g., 41-55%) account for this. The team believes that recovery occurs exponentially.

The analysis is designed to compare the change in canopy closure over time and not give an absolute number. With this in mind, the results from the analysis are not sensitive to recovery curves.

Full recovery is expected to occur approximately 30 years following a stand replacing disturbance. Site specific data on stand density index versus time was used to support this conclusion. Temporally, the maximum difference in streamflow response generally occurs the first five years proceeding disturbance and decreases logrithmically with time.