# Forks/Bridge Watershed Analysis

April 1995

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Cooperative Agreement Between the City of Bend and the Forest Service; 1926
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Various District Inventories and Reports
Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl, 1994
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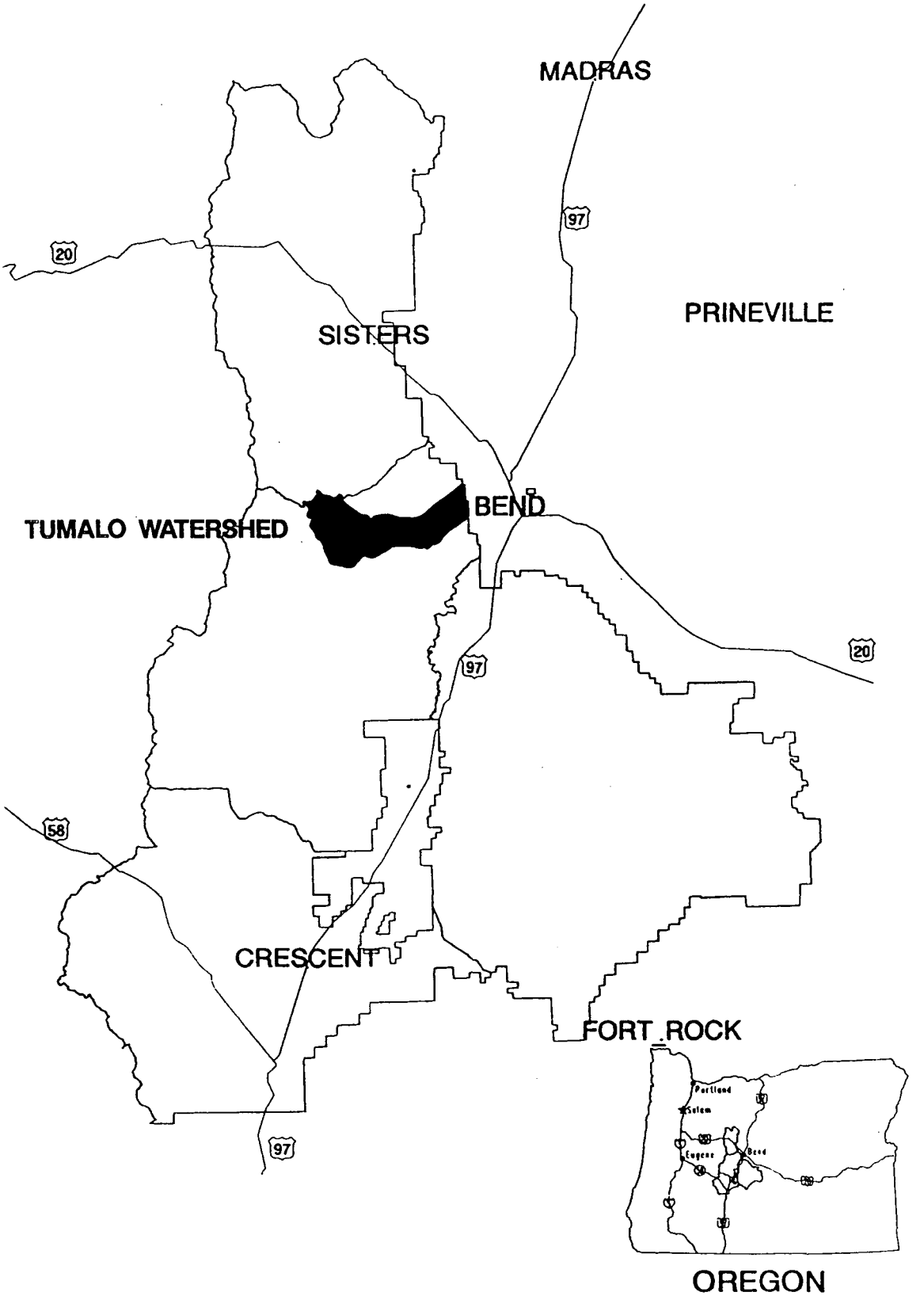
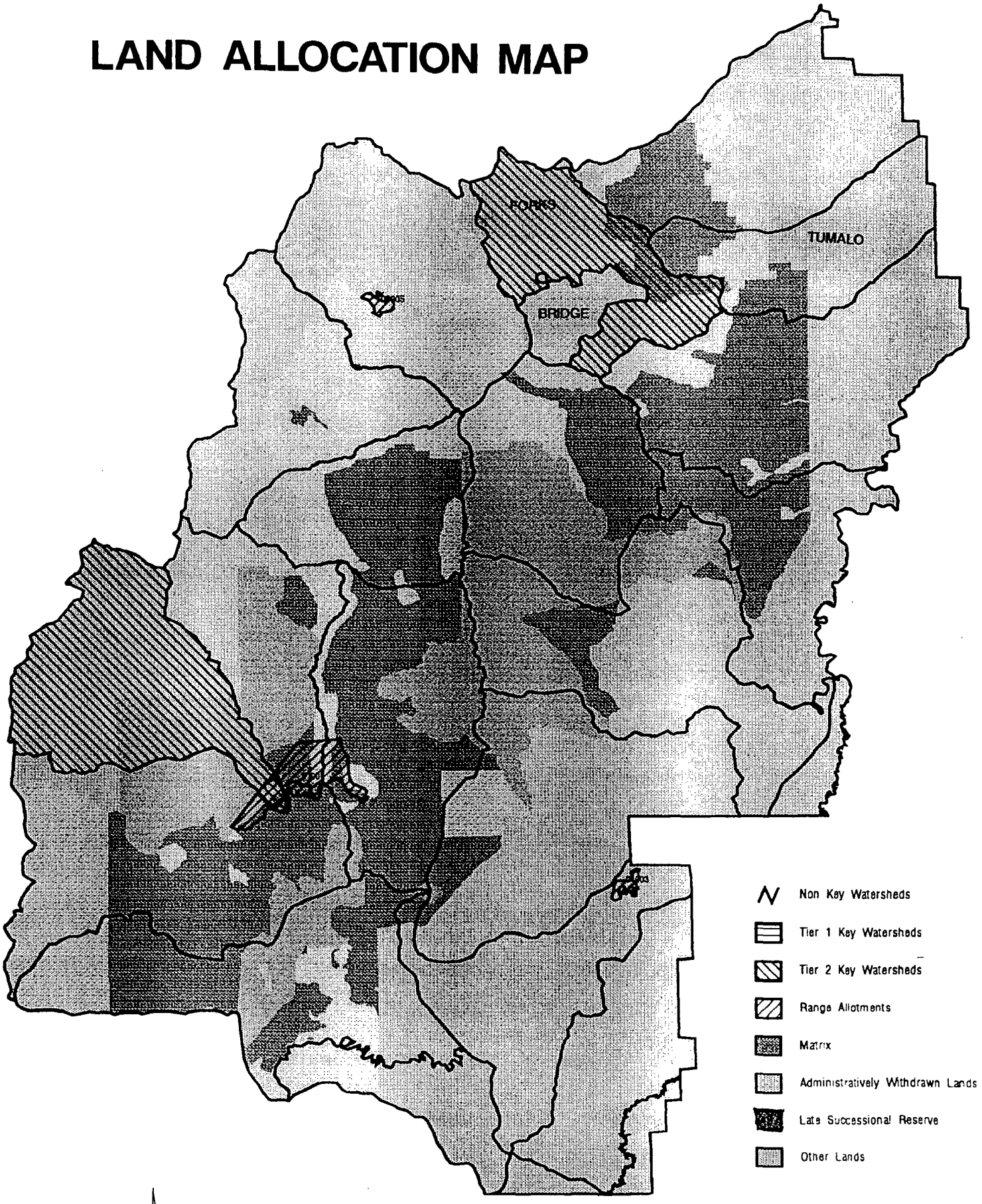


# PRESIDENT'S FOREST PLAN

# LAND ALLOCATION MAP

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## GENERAL SETTING

The Tumalo watershed encompasses 3 subwatersheds: Forks, Bridge and Tumalo. For the purposes of this issue driven watershed analysis process only the Forks and Bridge subwatersheds will be analyzed.

The analysis area is located on the Bend Ranger District, Deschutes National Forest, Deschutes County, Oregon. The area is west of Bend, and northeast of Mt. Bachelor. The City of Bend Municipal Watershed occupies a significant portion of this area (3.7 thousand acres) and is under agreement with the U.S. Secretary of Agriculture.

The Forks/Bridge subwatersheds lie within the Deschutes River Drainage Basin and Upper Deschutes sub-basin (Figure 1). Tumalo Mountain is a dominant feature of the watershed. Bridge and Tumalo Creeks flow west to east, originating from springs and snowmelt in the western portion of the watershed. An irrigation diversion into Bridge Creek, built in 1955, diverts water year-round to augment the municipal water supply. The Forks/Bridge subwatersheds covers roughly 19,814 acres. Slightly less than 97% of the area is comprised of land administered by the Forest Service with the remaining 3% being privately owned (Figure 2).

The climate in the watershed provides for spotty light rains during spring and summer, with associated thunder showers. Most winter storms move in from the west and provide for 40-100" of snow annually. The range of minimum temperatures is about 25-40 degrees Fahrenheit at 3,000-4,000 feet during spring and fall, and 80-90 degrees Farenheit maximum in the summer (these temperatures will be lower at the higher elevations of the subwatersheds). During the summer the higher portions of the western drainages are usually cooler and more moist than the rest of the area.

The Forks/Bridge subwatersheds was derived from prehistoric volcanic and glacial events. The highest elevation occurs in the northwest corner at Ball Butte (8,091'), and Tumalo Mountain in the southwest corner (7,775'), with elevation generally decreasing easterly to Tumalo Creek at approximately 4,900'. This area occurs within the broad High Lava Plains. The largest single geologic event known to have occurred in the general vicinity was the eruption of Mt. Mazama 6,700 years ago, depositing approximately two feet of pumice and ash over the subwatersheds. Excluding the Bridge Creek Fire (1979), the subwatersheds have largely been undisturbed from human influence.

### Management Direction

In April 1994 the President's Forest Plan (President's Plan) was adopted by the Deschutes National Forest, which amends the existing Deschutes National Forest Land and Resource Management Plan (Forest Plan). The Forest Plan contains many standards and guidelines that are not amended by the President's Plan. Only standards and guidelines in conflict with the President's Plan are replaced. Forest Plan standards and guidelines that are more restrictive, or provide greater benefits to late-successional forest dependent species, will be maintained.

The Forks/Bridge subwatersheds are designated as Tier 2 Key Watersheds in the President's Plan. The Tier 2 designation is based on the source of high quality water these subwatersheds provide. The President's Plan requires watershed analysis to occur prior to management activities within Key Watersheds.

The President's Plan provides "management direction consisting of extensive standards and guidelines, including land allocations, that comprise a comprehensive ecosystem management strategy." Three of the seven land allocations are within this analysis area: Administratively Withdrawn Areas, Riparian Reserves, and Matrix.

Administratively Withdrawn Areas are defined as "areas identified in current forest and district plans...and include recreation and visual areas, back country, and other areas not scheduled for timber harvest."

Riparian Reserves are defined as "areas along streams, wetlands, ponds, lakes, and unstable or potentially unstable areas where the conservation of aquatic and riparian-dependent terrestrial resources receives primary emphasis. The main purpose of the reserves is to protect the health of the aquatic system and its dependent species..."

The Matrix is described as "federal land outside the six categories of designated areas...in which most timber harvest and other silvicultural activities will be conducted."

The President's Plan allows for a "transition" that provides for "implementation of certain interim procedures in order to realize the goals and objectives of the management strategy while making project decisions with reasonable promptness that do not preclude long-term options or impair resources sought to be protected."

The Forks/Bridge Watershed Analysis is a less detailed process of the Odell watershed analysis project completed on the Deschutes National Forest in 1994. It is less detailed for this "transition" period of the still new watershed analysis process, to allow for projects already proposed for this upcoming year to proceed if they are not in conflict with the President's Plan. It provides the following goals: 1) ensure that Forest Service ground disturbing activities which are now entering the planning phase will enhance or retain ecosystem health; 2) identify ecosystem restoration opportunities; and, 3) begin to understand ecological components and their interactions (including social values and their effects on the landscape). A non-abbreviated watershed analysis for this area is scheduled for 1996.

## Water Resources

### Streams

Perennial streams in the subwatersheds include: Bridge Creek, Spring Creek, Tumalo Creek, South, Middle, and North Fork of Tumalo Creek, and an unnamed stream draining Tumalo Lake. Bottle and Rock Creeks are intermittent streams. There are several small springs that feed Tumalo Creek within the Bridge Creek Fire area. The streams flow easterly off the Cascade crest, collecting in

Tumalo Creek, a tributary to the Deschutes River. The gradients of the streams are generally moderate to steep (3%-10%) with numerous scenic falls, the most notable being 97' high Tumalo Falls on Tumalo Creek. Streamflow is primarily a combination of spring runoff and snowmelt.

## Lakes

Tum Lake (2 acres), Tumalo Lake (16 acres), Swampy Lakes (4 acres), and a few small unnamed ponds comprise the lakes within the subwatersheds. These are all shallow lakes. Tumalo Lake is predominantly on private land, and is the only lake to contain fish. A small dam at the outlet has slightly increased the depth and surface area.

## Diversions

The natural hydrology of Forks/Bridge subwatersheds have been altered by human activity. Flow from Crater Creek, a tributary to Soda Creek in the Sparks subwatershed, is diverted through the Crater Creek ditch into the Middle Fork of Tumalo Creek high in the watershed. The water rights are owned by the Tumalo Irrigation District, which withdraws 3,000-4,000 acre-feet annually. The ditch has been in operation since about 1914, and runs from July to October most years. The maximum flow diverted at any one time is approximately 20 cubic feet per second (cfs). Tumalo Irrigation District withdraws water from Tumalo Creek through a canal downstream of the Forks/Bridge subwatersheds.

Spring water that would naturally flow into the Middle Fork is diverted through an earthen canal into Bridge Creek to augment the flow that is withdrawn by the City of Bend for it's municipal water supply. The diversion, about 0.5 mile long, was built in 1955, and occupies a natural draw. The springs discharge is approximately 17-20 cfs. The city withdraws approximately 11.4 million gallons daily from Bridge Creek, which equates to about 17.5 cfs. The water is withdrawn just upstream with the confluence with Tumalo Creek, and is piped to storage tanks where it is chlorinated before delivery to the city. Surplus water in the municipal system is released prior to chlorination into Tumalo Creek near Shevlin Park.

Withdrawal of water from the springs on the Middle Fork reduces the flow for fisheries and other aquatic organisms in the Middle Fork and Tumalo Creek, but during the summer months this effect is partially offset by the influx of flow from the Crater Creek ditch.

## Water Quantity

The drainage basin is 47.3 square miles above the gaging station. Discharge in Tumalo Creek fluctuates annually from about 50 cfs in the winter months to around 400-500 cfs in the spring months during the snowmelt period. The average flow for the years 1936-1986 was 102 cfs. The peak maximum flow was 1,140 cfs and the minimum was 25 cfs. The gaging station, no longer in operation, was located downstream of the irrigation diversion, which is 1.25 mile downstream of the road 4601 bridge crossing. The data therefore would under-represent the actual flow upstream of the diversion during the irrigation season. Tumalo Irrigation District withdraws up to 190 cfs during high flows in the spring.

The natural flow of Bridge Creek (without the diversion) is approximately 5-10 cfs during the summer months. The increased flow from the diversion has increased the channel size, and increased the habitat for fish and other aquatic organisms.

The Forks/Bridge subwatersheds respond to rain on snow, and quick snowmelt events, resulting in sudden large increases in flow. Even though this is normal for most of eastern Oregon watersheds, it is unusual in the Upper Deschutes Basin. The streams substrates are composed of gravels, cobbles, and small boulders, which provide for a stable stream system, although the system suffered from the Bridge Creek Fire and subsequent management activities. The substrate materials were deposited by past glacial activity, rather than by recent stream processes, giving the impression of an "undersized" stream.

Water Quality

The streams are cool and generally clear. Turbidity increases during the snowmelt period and heavy rains. The burn area (see Disturbance Factors section) within the Bridge Creek drainage has steep slopes that contribute sediment during heavy rainfall. There are substantial eroding stream banks on Tumalo Creek within the burn area that contribute sediment, particularly during snowmelt.

The water quality of Bridge Creek is among the best in the United States for a surface water system, primarily because of the purity of the spring water. Water filtration is unnecessary as long as there is compliance with water quality standards of the Safe Drinking Water Act of 1986, established by the Environmental Protection Agency. The fecal coliform test has met or exceeded the standard in 97.5% of the samples since testing began in 1988, exceeding the minimum requirement of 90%. The turbidity is monitored continuously and is normally only 0.2 to 0.3 Nephelometric Turbidity Units (NTU's). The city normally stops withdrawal when the NTU's exceed 1.0, although they are not required to under their permit until the NTU's exceed 5.0. There are normally 45-55 days annually when the turbidity levels are elevated, due to snowmelt, thunderstorms, or temporary bank erosion from the channel adjusting to a newly fallen tree in the channel.

Temperature data collected for Tumalo Creek found that the daily maximums rarely exceed 58 degrees Fahrenheit. The sampling stations were near the Skyliner Bridge and the bridge near Tumalo Falls. The annual temperature range of Bridge Creek is 34 to 50 degrees Fahrenheit.

Aquatic macroinvertebrate (insects, worms, crustaceans, etc.) sampling has been accomplished on Tumalo Creek within the burn area. The analysis discovered the community diversity was high and the total abundance was moderate. The input of fine sediment was speculated to be limiting the total abundance.

In recent years, fine sediment monitoring has been implemented on Tumalo Creek within the burn area. Fine sediments are less than 1/4" diameter. The volume of fine sediments has varied from 5%-36%, and more than one half of the samples have exceeded 20%. Research has shown that there is decreased survival of incubating eggs and young fry of salmonids still in the gravel when fine sediment volume exceeds 20% (Meehan, 1991). Fine sediments fills in the

interspaces of the gravel, preventing the delivery of dissolved oxygen and the riddance of metabolic wastes.

## Fisheries

The fish species documented within the subwatersheds are eastern brook trout (Salvelinus fontinalis) and rainbow trout (Oncorhyncus mykiss). Sculpin may be present as the habitat exists, but electrofishing surveys have not documented any. The rainbow trout may actually be the native redband trout, a common name for the inland rainbow trout. Dr. Robert Behnke (fish geneticist) has divided the rainbow into three major evolutionary groups (Behnke 1992), and the Deschutes basin redbands belong to the Columbia River basin group. There is uncertainty to the genetic purity of the redbands because of possible interbreeding with hatchery rainbows. Fish were collected from Tumalo Creek (within the burn area) in 1994 for genetic analysis. Findings from this study are not yet available. The redband has been classified as a Category 2 sensitive species by the U.S. Fish and Wildlife Service, and is on the Region 6 National Forest sensitive species list.

The brook trout are native to eastern North America, and were introduced throughout the west. They now comprise about 75% of the fish population in Tumalo Creek within the burn.

Although there are no documented reports of bull trout in the Tumalo Creek drainage, they are suspected to have once inhabited Tumalo Creek from its confluence with the Deschutes River upstream to Tumalo Falls. Suitable habitat is present. The bull trout has been declared warranted for status as a threatened or endangered species by the U.S. Fish and Wildlife Service. This listing has been precluded at this time as the agency is concentrating on other fish species of declining numbers.

## Distribution

Historically, there were redband and possibly bull trout in Tumalo Creek up to Tumalo Falls, in the South Fork, and in Bridge Creek up to the first falls. The current distribution above the falls on Tumalo and Bridge Creek, which are migrational barriers, could be the result of official stockings made by the Oregon Department of Fish and Wildlife (ODFW) or by fishermen interested in increasing the distribution. The last official stocking of fish in the watershed was rainbow trout by the ODFW in the 1970's.

The rainbow trout has been documented in Tumalo Creek, including above Tumalo Falls, Bridge Creek up to near the headwaters, and the South Fork.

The brook trout is found in: Tumalo Creek, the Middle Fork up to and above the confluence with the springs that feed Bridge Creek, the North Fork up to Happy Valley, Tumalo Lake and the stream that drains it, the South Fork up to the junction of two channels, and in Bridge Creek up to the diversion dam.

The table below summarizes the distribution of fish populations:

TABLE I

| Stream Name | Class | Miles of Fish Habitat | Game Fish Species | Maximum Size | Flow Pattern |
|---|---|---|---|---|---|
| Bottle Creek | IV | 0.0 | -- | -- | intermittent |
| Bridge Creek | I | 3.3 | RB | 10" | perennial |
| Middle Fork | III | 4.0 | BK | 9" | perennial |
| North Fork | III | 2.2 | BK | 11" | perennial |
| Rock Creek | IV | 0.0 | -- | -- | intermittent |
| South Fork | III | 1.05 | BK | 8" | perennial |
| Spring Creek | I | 0.00 | -- | -- | perennial |
| Tumalo Creek | II | 5.00 | BK,RB | 8",10" | perennial |
| Unnamed Creek (Tumalo Lake) | III | 1.25 | BK | 4" | perennial |
| | | 16.8 | | | |

BK = Eastern Brook Trout
RB = Rainbow Trout

Riparian

There are approximately 2,000 acres of riparian zone within the Forks/Bridge subwatersheds, accounting for 10% of the area. This was determined from a summation of acres of stream, lake, landtypes 2, 5, 8, and a 100 foot zone on both sides of a stream where it did not flow through the aforementioned landtypes.

Landtype 2 includes narrow draws, glacial valley floors, wet depressions, and drainages. These are wet areas that generally support forest vegetation. Tree species consist of lodgepole pine, mountain hemlock, Engelmann spruce, and true firs. Slope may range from nearly level up to about 50%. This landtype also includes seepy spots that occur under a forest canopy, and some very brushy sites with willow and alder at high elevations.

Landtype 5 consist of wet, non-forested areas, including meadows, depressions, and swampy areas. Soils are generally wet all or most of the year, and may range from sandy gravels to peat. Vegetation consists of sedges, grasses, wetland forbs, mosses, willow and alder.

Landtype 8 occurs on bottomlands, terraces, and gentle sideslopes along drainages. Soils are often gravelly and subject to periodic flooding and washing. Slopes are typically less than 15%. Tree species include white fir, Engelmann spruce, lodgepole pine, aspen, Douglas fir, Pacific yew, cottonwood, and some ponderosa pine. A wide variety of shrubs, sedges, grasses, and forbs

are present. This landtype is similar to landtype 2 but occurs at lower elevations.

Because riparian zones have high water tables and are sensitive to compaction and erosion, they are considered inherently sensitive areas. Riparian zones are found within all the plant association groups identified for the subwatersheds (see Vegetation section).

Riparian Reserves

Riparian Reserves have been established by the President's Forest Plan as a component of the Aquatic Conservation Strategy. They are "lands along streams and unstable and potentially unstable areas where special standards and guidelines direct land use" (page B-12 of the President's Forest Plan). There are five categories of streams or water bodies that determine the interim widths of the Riparian Reserves until watershed or site-specific analysis is completed and the National Environmental Policy Act (NEPA) is complied with. The interim widths are adopted under this analysis, and are described on page C-30,31 of the President's Forest Plan.

Air Quality

The Tumalo watershed must meet Class I and Class II air quality standards. All of the watershed must meet Class II standards, except for the Three Sisters Wilderness, which must meet Class I standards. Air quality within the watershed is generally believed to be good to excellent. The Department of Environmental Quality monitors for two pollutants regulated under the Clean Air Act: inhalable particulates and carbon monoxide (CO). The nearest monitoring location is the city of Bend.

Within the watershed, particulates are produced mainly by wood smoke and dust from roads and construction activities. The major human-caused source of CO is exhaust from automobiles and other internal combustion engines, however, wood smoke also contributes. In the summer months, agricultural field burning west of the Cascade Mountains also has a negative impact on air quality (mainly particulates).

Soils and Geology

The soils within the Forks/Bridge subwatershed can be separated into three general zones that coordinate with the broad vegetative breaks on the plant association group (PAG; see Vegetation section) maps. These include the mid-elevation lodgepole and mixed conifer and the upper elevation mountain hemlock/meadow types. The Tumalo watershed vegetation is made up mostly of lower elevation ponderosa pine, but as stated previously, will not be addressed in this analysis.

The entire analysis area has been glaciated in the past, with nearly 1,000' of ice covering the Bridge Creek and Tumalo Creek drainages as recently as 14,000 years ago. Residual soils developed prior to this glaciation but have been either covered by glacial till or scoured away by the glacial movement. The entire area has been covered by moderate amounts of coarse pumice and ash from Cascade volcanic events such as Mt.Mazama, Devils Hill and Rock Mesa. Volcanic bedrock underlies most of the area.

The glacial outwash material consists of sand and gravel sized volcanic tuffs, breccias and pumice ground by glaciers and transported by water. Slopes throughout the area are generally between 10-30%.

The soils in the mid-elevation lodgepole and mixed conifer areas also fall into two categories by landform. Glaciated uplands have moderate layers of pumice and ash overlying glacial till or residual soils. Steep, glaciated side slopes of drainages in the area also contain glacial till in the substratum. Slopes throughout this zone range from 10-65%.

Both the lower and mid-elevational areas are dissected by perennial streams and associated bottomlands.

The soils in the upper elevation mountain hemlock/meadow areas are a mixture of coarse textured pumice overlying glacial or volcanic material. Soils are generally lower in productivity due to their coarse textures and cold temperatures.

Existing impacts on the soil resource vary in the three areas. Much of the private land was burned and salvaged after the Bridge Creek fire. The slopes in the burn area have been stabilized by the growth of brush and trees. The soil in stands to the south of Tumalo creek have been impacted to varying degrees by past harvest entries that removed much of the overstory ponderosa pine.

The mid-elevation lodgepole and mixed conifer areas can be separated into two impact areas. Below the Tumalo Falls site there are many roads from fire salvage, past harvest and private land access activities. The slopes of the Bridge Creek burn in this area have heavy amounts of brush that have stabilized soil movement, with the planted ponderosa beginning to establish itself above the height of the brush.

The upper half of the mid-elevation area is essentially roadless, except for the 370 road (Happy Valley) and a few short spurs to dispersed camping sites. Soil movement is evident on these surfaces with rill and gully erosion present. The road crosses the North Fork of Tumalo Creek at a very gravelly section of the streambed, however, the entrance and exit banks show some erosion impacts. The extensive trail system through this area also has had some impacts on the soil resource through increased recreational use and its associated traffic in riparian areas. The hillsides that were burned along Bridge and Tumalo creeks have not revegetated as heavily with brush and show evidence of sediment loading on the streams. The proximity of trails to the streams in these areas has contributed to this movement of soil.

The upper elevation mountain hemlock/meadow area is also dissected by the 370 road and shows evidence of soil movement. The slopes of this section are, however, more gradual than the mid-elevation zone and the presence of more coarse textured pumice on the surface makes this area slightly less susceptible to soil movement. The road does cross the Middle Fork of Tumalo creek and one of its tributaries in this area, with erosion evident at these points. Impacts from trails is fairly minimal in this area, although dispersed camping and the spur roads to trailheads have contributed to compaction and surface erosion.

## Vegetation

The majority of the Forks/Bridge sub-watersheds are within the Upper Flanks of Cascades Ecological Unit (Orr et.al. 1992). This ecological unit is characterized by glacial landforms, precipitation between 60-100 inches per year, and high elevation moist vegetation types. A small portion of the Forks sub-watershed lies within the Lower Flanks of the Cascades Ecological Unit and supports a drier vegetation type. This ecological unit will not be addressed further due to its small acreage within the sub-watershed.

Existing vegetation within the sub-watersheds was summarized by referencing and analyzing the Deschutes National Forest Soil Resource Inventory (SRI; 1976), U2 infra-red aerial photography (1991), and Integrated Satellite Imagery data (ISAT; 1988). The Forest SRI vegetative mapping displays potential vegetation given a specific soil type. ISAT data displays the existing vegetative condition. It was found during this analysis that there is a strong correlation in mapping vegetation landscape patterns from the SRI potential vegetation information and existing vegetation from ISAT data. Vegetation structural characteristics were also analyzed using ISAT data and categories modified based on local expertise.

The following vegetation plant association groups (PAGS) were defined for the Forks/Bridge sub-watersheds and summarized as follows:

| PAG | Acres |
|---|---|
| * Sparsely vegetated | 4,928 ac. |
| * Mountain Hemlock | 5,441 ac. |
| * Lodgepole Pine | 3,133 ac. |
| * Mixed Conifer | 4,377 ac. |
| * Bridge Creek Burn | 1,935 ac. |

Note: Acres of the PAG areas are visual estimates based on the vegetation mapping. Sparsely vegetated includes rocky areas. The PAG's also encompass approximately 500 acres of private land within the Forks subwatershed. Please refer to Table 1, Tumalo Vegetation Map (Figure 3), and Tumalo Forest Structural Stages Map (Figure 4).

### Sparsely Vegetated

Sparsely vegetated areas within this analysis are located predominantly at the highest elevations within the sub-watersheds, along the slopes of the Cascade Crest. Included within this PAG are areas of rock and grass as defined by the ISAT imagery interpretation. Shrubs and trees found within this area will be of an old age and very stunted in form and growth due to the extreme weather conditions at this elevation. The sparsely vegetated area is predominantly within the Three Sisters Wilderness area.

### Mountain Hemlock

Descending down slope, mountain hemlock becomes the dominant vegetation type. This type is characterized by dense stands with closed canopies of pure mountain hemlock to stands with mixes of tree species where mountain hemlock will still be the dominant or co-dominant tree. These latter stands also have

dense canopies. Structurally, the majority of the mountain hemlock type exhibits a range of diameters at breast height (dbh) from 9-21", are multi-sized and multi-storied. Some stands show more second growth type characteristics and some stands show more late to old growth characteristics. Mountain hemlock is not considered commercial timber and is within the dispersed recreation and Bend Municipal Watershed (BMWS) management areas. This PAG is found on all aspects within an elevation band of 6,000-6,800 feet.

Lodgepole Pine

The lodgepole pine PAG's are located mainly within an elevation band of 5,800-6,800 feet with some stands located as low as 5,200 feet. This is considered high elevation lodgepole and given natural disturbance and succession process, the lodgepole will probably be replaced over time by mountain hemlock and fir species. The majority of the lodgepole type is mapped as pure lodgepole stands and includes mixes of lodgepole and fir species within other stands. Structurally, the lodgepole pine is a mix of pole size (5-9" dbh), multi-sized, low density stands and pole size dbh's in single storied stands. The ISAT data also indicates a pole size of larger than 9" dbh in a portion of the lodgepole pine type. This structure indicates second growth vegetation characteristics. The only Matrix area within these sub-watersheds is in the lodgepole pine type.

Mixed Conifer

The mixed conifer type is composed of a true mix of species based on canopy cover that includes white fir, Douglas-fir, mountain hemlock and lodgepole pine. This type occurs on north and south aspects and will show differences in stand densities, crown and canopy cover, and species mix between the aspects. Ponderosa pine begins to be picked up within the mixed conifer type at the lowest elevations on slightly drier sites. At higher elevations on drier site though, ponderosa pine is a very minor component if present at all. Structurally, the mixed conifer type is composed of mixes of small diameter to large diameter trees (5-21" dbh) and canopy covers of 25-75% with the majority canopy cover classes towards the low to mid percentage range. Stands are multi-sized and multi-storied with a small number of stands in the multi-sized low density class, meaning a more open stand condition. A portion of the mixed conifer stands show second growth type characteristics and some show more late to old growth characteristics. Included within this mixed conifer type are 86 acres of timber harvest that have been planted or naturally regenerated. The mixed conifer has an elevation range of 5,200-6,800 feet with some mixed conifer found as high as 7,800 feet.

Bridge Creek Fire

The Bridge Creek fire started on July 24, 1979 and burned a total of 4,300 acres. Of this approximately one half of the acres are within the Forks and Bridge sub-watersheds. SRI mapping describes potential vegetation for this area as mixed conifer. The intensity of the burn moved the vegetation within the burn area from a mixed conifer mid/late/old growth seral stage to an early seral stage. Due to the variety of tree species planted and the intensity of grass seeding, a definite plant association group is difficult to define for the current condition of the burn area. Therefore, the burn was split out as its own group with no associated vegetation PAG attached.

## Landscape Patterns and Patches

Meadow and rock areas are easily identified patches within the subwatersheds. Most meadow areas are located within the higher elevations along the fringe between the sparsely vegetated and mountain hemlock areas and within the mountain hemlock areas. The rock areas occur mainly at the highest elevations and are main geologic feature. In addition, rock outcrops occur within the Bridge Creek burn area.

Definitive vegetation landscape patterns and patches are somewhat difficult to define within the Forks/Bridge subwatersheds. Long term natural fire regimes have allowed for most of the vegetation types to begin development of old growth structural characteristics. Patch patterns are minimal except for changes in vegetation structure and changes in canopy densities due to past defoliator pests. No large areas of mortality have been found that would contribute to discernible vegetation pattern changes.

One catastrophic fire event has occurred in the recent past that devastated all vegetation within its boundaries. Other fire events that occur are small lightening strikes that smolder along the ground for days and cause little resource damage.

Overall within the subwatersheds, meadow areas, rocky areas, sparsely vegetated areas, and the Bridge Creek burn are the only contributors to noticeable landscape pattern changes and patch patterns. Defoliators and bark beetle outbreaks create less noticeable changes unless these pests occur in epidemic proportions and major mortality occurs to create open areas. Nine timber sale units are located in the southeast portion of the Forks subwatershed and have created openings within a mixed conifer forest type that is drier and supports more ponderosa pine. These openings have been planted and are naturally regenerating.

### Riparian

Riparian areas within this analysis include meadows, lakes, and perennial stream courses. The riparian flows through the sparsely vegetated types, the mountain hemlock types, the mixed conifer types, and the Bridge Creek burn . At higher elevations mountain hemlock will readily encroach upon meadow areas as part of natural ecological processes. At lower elevations lodgepole pine will readily encroach into meadow areas. Associated with the mixed conifer type and the Bridge Creek burn are Englemann spruce bottomlands. Within the burn area, the spruce bottomlands have had minimal restoration and are in need of further restoration activities.

### Old Growth Mapping

Old Growth in the watershed area has been mapped at several levels. The Forest Plan designated old growth is a small amount of area within the Forks subwatershed. The district old growth mapping done in 1988-89 shows a good portion of the Forks/Bridge subwatersheds as old growth. The "Gang of 4" old growth mapping encompasses all of Bridge and most of the Forks subwatersheds. Old growth mapping in the late 1980's by Bill Marlett, a representative of the Oregon Natural Resources Council (ONRC), only recognized an area around Tumalo

Lake and along the private land boundary (refer to map in Tumalo file for district mapping, "Gang of 4", and Bill Marlett old growth mapping.) Note: Wilderness areas are not included in this designation due to the sparse vegetation above the 370 road.

Old Growth Characteristics

Old growth structural characteristic development will vary according to forest type, climate, site conditions, and disturbance regimes. Rates of change in composition and structure are slower in old growth forests relative to younger forests. Sporadic low to moderate severity of disturbances are an integral part of ecological processes and dynamics within old growth systems. Canopy openings resulting from death of overstory trees will often give rise to patches of small trees, shrubs, and herbs in the understory. The structure and size of an old growth ecosystem will be influenced by stand size, landscape position and context. Refer to the Region 6, Interim Old Growth Definition (1993) for more information.

**Disturbance Factors**

Disturbance factors within the Forks/Bridge subwatersheds include fire, and insect and disease outbreaks (see Table 2 in Appendix X).

Fire and Fuels

The drainages run from west to east, with the elevation varying from approximately 8,000-5,000' at Tumalo Creek. Average slopes range from 0-56% with 75% of that range being from 0-25%. Aspects are largely north and south with minor east and west influences.

The forest stands are interspersed with small meadows. Most of the area is mature forest. Tree density is high and the canopy in some areas is almost impenetrable.

Historically, fire played an important role in east side forest ecosystems. Beginning about the turn of the century, wide spread fire suppression has altered disturbance regimes and some plant successional pathways. Fire suppression has allowed lodgepole pine forests to develop a structural complexity and large tree component that existed to a lesser degree in historic forests. Change in fire regime has been caused by human intervention of suppressing fires as well as the increase of human use of the area.

The risk of human-caused fire is high within the Forks/Bridge subwatersheds because of the concentration of recreation facilities and activities found there (see Social Domain). In the past, wildfires have been suppressed early and the resulting fires were kept small.

Vegetation succession, fire effects, management, fire frequency, and fire size modeling was developed for the Tumalo watershed area. The output for acres burned, under extreme weather conditions for fires not to be suppressed, showed an average of 15,000 acres burned on average every 32 years.

The watershed area is comprised mainly of the vegetative plant associated group of Mountain Hemlock , Lodgepole Pine, Mixed Conifer, Riparian, and the Bridge

Creek Burn area. Fire affects each of these associations differently. It is apparent in some of these associations that fire suppression has changed the fire regime for those areas.

Mountain Hemlock is easily killed by fire. The most common method of killing is root charring and crown scorching. Mountain hemlock is generally slow to regenerate after fire. Fire injury makes mountain hemlock very susceptible to insects and disease. Old growth mountain hemlock stands are very susceptible to stand-replacing fires. In the Pacific Northwest, the estimated pre-logging fire regime in mountain hemlock forest types is 611 years. Modeling of existing conditions showed Mountain Hemlock as having the potential in a 200 year span for 28 fires at moderate size of approximately 8,050 acres, 7 fires of severe size of approximately 15,150 acres, and 5 fires of extreme size of approximately 26,500 acres.

Lodgepole pine trees are killed by all but light ground fires due to cambial heating. Post fire recovery tends to be rapid as new stands quickly establish from seed released from serotinous cones. Although stand replacement fires were believed common in lodgepole pine forests, heavy fuel loads pose an increasing hazard for fires that may burn with extreme intensity. These fires could consume the seed source for native vegetation on the site. High intensity fires contribute to reduced scenic quality, loss of wildlife habitat, reduced recreation opportunities, loss of structural and vegetative diversity, air quality degradation, and detrimental impacts to the soil from burning. Modeling of existing conditions showed there is potential for 28 fires of moderate size of approximately 6,001 acres, 10 fires of severe size of approximately 9,401 acres, and 2 fires of extreme size of approximately 12,001 acres.

Mixed Conifer have a higher frequency rate which results in lower intensity fires due to low accumulations of dead and down fuels. With the rotation of fire in these areas trees are young and more susceptible to fire. Where fires are suppressed density has greatly increased in mixed-conifer forests, increasing the probabilities of stand replacing fires. Mixed conifer species are fire sensitive when young due to smooth, thin, resinous bark and low-growing branches which easily ignite from burning undergrowth. As the bark thickens and lower branches drop due to self pruning, trees progressively become more fire resistant. Modeling of existing conditions showed the Mixed Conifer vegetative type as having the potential in a 200 year span having 22 fires of a moderate size of approximately 8,973 acres, 5 fires of severe size of approximately 16,224 acres, and 5 fires of extreme size of approximately 27,645 acres.

The Bridge Creek plantation competes with a continuous heavy invasion of healthy snow brush. This fuel type would need a wind event to carry a fire that would threaten the live fuel moisture of this type of brush. Tree mortality would occur when the brush is dead and/or dying due to frost kill, or when the trees have gotten to the stage they out-compete the brush.

Fire exclusion has also had an impact on the availability of habitat for threatened, endangered, and sensitive (TE&S) plants. Several of the known or suspect species, including Newberry gentian, depend on openings in the forest canopy. Naturally-occurring fires create new openings and may serve to prevent the encroachment of tree seedlings into open habitats, including moist

meadows. With exclusion of naturally-occurring fires, which had tended to be frequent and of short duration, the buildup of fuels increases the risk of high intensity fires which may damage soil and destroy seed banks.

The fire effects described above shows that for the vegetative types of lodgepole and meadow areas there may be an opportunity for the reintroduction of fire through a prescribed fire plan to aid in the natural regenerative process. For the other vegetative types there may be an opportunity for a prescribed or prescribed natural fire plan to use fire as a measure to reduce fuels and the probability of a stand replacing fire.

Natural events such as, wind storms, needle cast, and insect and disease epidemics, typically create heavy build up of duff and litter, with much of the woody debris being more than three inches in diameter. Undergrowth is sparse and usually restricted to openings. Loadings are attributed to heavy windfall of large old growth trees along the flood plains of the drainages due to the nature of the soils there. Some "jackpots" of windfall accumulations along these drainages contain as high as 50-62 tons per acre of fuel loadings.

The heaviest fuel loadings identified in the subwatersheds, comprise approximately 30% or less of the area. This corresponds with Fuel Model 10 as defined in "Aids to Determining Fuel Models for Estimating Fire Behavior" (Anderson, 1982), and NFDRS (National Fire Danger Rating System) Fuel Model G. In Fuel Model 10 type stands, fire spreads through high loadings of dead, down woody fuels beneath over-mature timber stands. In Fuel Model G conditions consist of dense conifer stands where there is a heavy accumulation of litter and downed woody material.

The remainder of the natural fuel loadings within Forks/Bridge subwatersheds, comprising approximately 70% of the area, is represented largely by Fuel Model 8 (Anderson, 1982) and NFDRS Fuel Model H. Fuel Model 8 consists of closed canopies of healthy, short needled conifers or hardwoods that support fire in a compact litter layer. Little undergrowth is present. Fuel Model H are healthy stands of short needled conifers with sparse undergrowth and a thin layer of ground fuels.

An aerial reconnaissance by helicopter in July, 1993 showed no unusual signs of large groupings of recently dead snag patches that would indicate bug infestation. On the whole, the area looked healthy with typical snag accumulations of natural varying dispersal.

In a study documented and entitled, "Analysis of Alternatives to Prevent Damage from Stand Replacing Fries by Reducing the Probability of Crown Fire Occurrence in the City of Bend Municipal Watershed" (Esterbrook, 1994), historical fire weather and fuels data were analyzed to come up with an occurrence rate for crown fire conditions in the area of the Tumalo watershed. There is the potential risk of another catastrophic fire within these subwatersheds given the right kind of weather patterns and fuel conditions. However, the probability of another catastrophic fire is low because the right conditions occur only on about 6 days throughout the summer months, or 2% of the time during fire season. These conditions have been identified (Esterbrook, 1994) and should be monitored during the summer months.

Within the last 10 years, there have been four lightning caused fires and four human caused fires in the project area. The largest fires in the area were human caused. The largest fire in the area was the Bridge Creek Fire that destroyed 4,300 acres.

This fire is an example of a catastrophic event which literally burned all vegetation within its boundaries. The fire area has only a few mosaic patches scattered along a small portion of the fire boundaries. Due to the intensity of the fire the pumice soils became hydrophobic. Mitigation measures were immediately implemented after the fire to preserve the soil resource (refer to the Soils section). In recent history, this is the only catastrophic fire event to occur within the two subwatersheds.

Rehabilitation efforts began immediately after fire. Aerial grass seeding of annual rye grass was accomplished by mid-August, 1979. Ten pounds of grass per acre were seeded over the burn area, while the BMWS received 20 pounds per acre. Fertilization was completed after grass seeding to increase the vigor of annual rye germination and growth. Non-fertilization corridors were left along perennial streams. A perennial grass mix was also applied to the Bend Municipal watershed prior to the first snowfall. Debris was removed from Bridge Creek using helicopters due to lack of road access to the area. Log terraces were installed on 22 acres along Bridge Creek and resulted in 63% effectiveness of retarding sediment movement. The remaining terraces were either partially effective or did not experience sediment flow. Planting began in the spring of 1980 and continued over the next few years. Species planted included ponderosa pine, lodgepole pine, white pine, and Douglas-fir. Species regenerating naturally include white fir, Englemann spruce, mountain hemlock, and lodgepole pine. Native hardwood species were planted into the riparian areas such as thinleaf alder, willow, aspen, black cottonwood, currant, red elderberry, and serviceberry.

Reforestation certification surveys were completed in 1992 within the burn and the area certified. Trees are 10-15 feet tall, adequately stocked, and growing well enough with no additional reforestation work needed to be determined "established", which was done in 1994.

Historical records (1960-1985 inclusive, available at the Bend Ranger District Office) indicate that there is a .17 probability of ignition/thousand acres/year in the eastern portion of the study area, and a .05 probability of ignition/thousand acres/year in the western portion of the area. An analysis of lightning fires, fuel types, and risk from human caused fires show the eastern portion to be a high risk area for large fires and the western portion to be a low risk area.

As visitor use increases, the potential for human caused fires increases concurrently due to the potential additional fire ignition sources in the area. Due to the proximity of the BMWS, any occurrence of wildfires in that area is of great concern.

A Deschutes National Forest Fire Restriction exists in the watershed area. This restriction indefinitely prohibits "building, maintaining, attending or using a campfire outside of a designated camp (Order Number 87-4, 5/87, copy located at the Bend Ranger District Office).

Insects

Mapping of insect outbreaks has been recorded since 1983 on the forest. Outbreaks of Mountain pine beetle infestations have occurred within the subwatersheds over the years since 1983. Outbreaks have been confined to various scattered patches of lodgepole pine, less than 300 acres in size. Mountain pine beetle outbreaks have been recorded on the pest aerial flights in 1989, 1988, 1986, 1984 and 1983.

In 1985 almost the entire subwatersheds area was affected by an outbreak of the Western spruce budworm. Habitat types impacted by the budworm would be the mixed conifer areas and probably the lower areas within the mountain hemlock types where a mix of tree species occur.

An outbreak of the black headed budworm and continued outbreak of the western spruce budworm occurred in 1986. Again, a good portion of the subwatersheds was affected. The Black headed budworm kept to the west and higher elevations while the mountain pine beetle occurred to the east at lower elevations.

Since 1989 there has been no major occurrences of insect activity. Disturbances of insects over time are probably of moderate occurrence. The outbreaks are part of forest dynamics and ecosystem processes. Insect and disease events have increased in duration and intensity over time. Factors that influence increased duration and intensities are climate, stand structure, composition and density, and fire suppression.

Diseases

Aerial photo interpretation of the vegetation types in the two subwatersheds indicate no major root rot pockets to date. Laminated root rot is a natural component of the mountain hemlock ecosystem and has probably developed in conjunction with the mountain hemlock vegetation over time. It is assumed that laminated root rot does occur in this zone, but not in proportions that are currently easily identifiable. The recommendation is to avoid root rot pockets when they are found during the survey of a proposed activity.

Armillaria root rot is another rot that is historically associated with the mixed conifer vegetation groups. The same philosophy may be applied to armillaria as to laminated root rot. The recommendation is to avoid armillaria pockets when found so as not to help the spread of the disease any further.

Mistletoe may be found within the mountain hemlock and mixed conifer types. This disease has probably also evolved historically in conjunction with these vegetation types.

**Wildlife**

The Forks/Bridge subwatersheds support a variety of wildlife and wildlife habitat. There are an estimated 200 species of wildlife suspected to utilize habitat within the Forks/Bridge subwatersheds. These species may utilize the subwatersheds for breeding, foraging, and/or resting habitat. There are an estimated 146 species which use the riparian areas of these subwatersheds.

Habitat quantity and quality can affect wildlife. The subwatersheds are quite contiguous and unfragmented. However, fire suppression and increased disturbance by recreation use has lowered habitat suitability for many species.

The following TE&S species and selected species have suitable or potential suitable habitat within the Forks/Bridge subwatersheds: Peregrine Falcon (E), Bald Eagle (T), Northern Spotted Owl (T), California Wolverine (T), American Pine Marten, Fisher, Pileated Woodpecker, Black-Backed Woodpecker, Flammulated Owl, Great Gray Owl, White-Headed Woodpecker, Northern Goshawk, Spotted Frog, and Cascade Frog. Of these species, only the American Pine Marten and the Cascade Frog have been sighted within the Forks/Bridge subwatersheds.

There is an estimated 2,822 acres of suitable nesting, roosting, and foraging habitat for the northern spotted owl, and an estimated 4,760 acres of unsuitable habitat. The remainder of the habitat within the subwatersheds is considered dispersal habitat. A small portion of the subwatersheds were surveyed in 1991, with no responses. Surveys for other TE&S species and selected species have not been conducted.

The Forks/Bridge subwatersheds support summer, transitory, and calving habitat for elk. Deer also use this area as transitory range. The elk tend to migrate to and from summer to winter range in a north to west (summer) and south to east (winter) pattern, using riparian areas and ridges as corridors.

Neotropical migratory birds (NTMB's) use a variety of structural stages and vegetation types in the spring to forage and breed. These birds migrate to North America from their wintering grounds in Central or South America. Year round avian and mammal species travel in and out of the subwatersheds in search for food, mates, and juvenile dispersal. There are no identified travel routes for most of these species.

## Sensitive Plants

Portions of the Forks/Bridge subwatersheds have been surveyed for TE&S plants. A project survey has covered about 5% of Bridge and 1% of Forks subwatersheds. The following plants are known or have been reported to occur within the subwatershed boundaries:

Pumice Grapefern - Botrychium pumicola

This Central Oregon endemic plant is found on volcanic alpine mountaintops and in lodgepole frost pockets in montane forests. An historic, unverified report shows that a portion of one grapefern population may fall just within the Forks subwatershed boundary; description of the populations location is not precise. A second grapefern population was reported from near or just inside the Bridge subwatershed boundary in 1951; this population has not been re-located.

Additional potential habitat exists in alpine and montane areas of the subwatersheds, in open pumice fields and treeless ridges or in frost pockets surrounded by forest. The project area contains a considerable amount of potential habitat; there is a moderate probability that more populations of the pumice grapefern exists in the subwatersheds.

Status: On the Regional Forester's Sensitive Plant List. On the Oregon Dept. of Agriculture (State) List 1, proposed to be listed as threatened. Federal Category 2; more study needed.

Newberry Gentian - Gentiana newberryi

This plant has been found at nine locations in the subwatersheds. More habitat exists in subalpine meadows and other moist openings. There is a high probability that more populations remain to be discovered.

Status: On the Regional Forester's Sensitive Plant List. State List 2; more study needed.

A prefield review of the area identified potential habitat for the following species, all on the Regional Forester's Sensitive Plant List:

Tall Agoseris - Agoseris elata

Low probability. Dry edges of moist ecotones adjacent to moist meadows and streams, between 3,000 - 4,800 feet.

Shasta Arnica - Arnica viscosa

Low probability. Steep scree and talus slopes, lava flows. Usually found at or above treeline.

Estes Artemisia - Artemisia ludoviciana ssp. estesii

Low probability. Within creek floodplains in sandy pockets among rocks and river gravel, between 2,000 - 5,200 feet.

Gorman's Aster - Aster gormanii

Low probability. Open rocky slopes, rocky outcrops or ridges, steep rocky washes. Known from the west side and crest of the Cascades.

Brewer's Reedgrass - Calmagrostis breweri

Moderate probability. Moist subalpine meadows, streambanks and lake margins above 4,000 feet.

Rough Harebell - Campanula scabrella

Low probability. Talus slopes on high Cascade peaks at 7,000-9,000 feet.

Snowline Cymopteris - Cymopteris nivalis

Low probability. Rocky ridges and talus slopes, volcanic gravels.

Bolander's Hawkweed - Hieracium bolanderi

Low probability. Unstable substrates, open, exposed sites in mixed conifer.

Water Lobelia - Lobelia dortmanna

Low probability. In shallow water at the margins of streams or standing water in wet meadows.

Adder's Tongue - Ophioglossum vulgatum

Low probability. Moist to wet meadows among low shrubs, sedges and grapeferns.

## Social Domain

The nearest city is Bend, Oregon which is approximately 13 miles east of the analysis area. Access from Bend is by three routes:

1) on the Cascade Lakes Highway (Forest Highway No. 46) and then on Road 4600 370 to the west side of the area; 2) on County Road 4601 and then on Forest Road 4603 into the eastern portion of the area; or, 3) on County Road 4601 and Forest Road 4601 to the north side of the project area. Several trails provide access to portions of the interior of the area.

### Trails

Several summer trails exist within the analysis area. The trails are popular as day use routes easily accessed from Bend. Some trails form a loop route attractive to mountain bikers, some are short connecting links to other trails outside the analysis area, while other trails are short walks to scenic attractions. The Bridge Creek Trail runs east and west through the middle of the area and is used by hikers only. The Spring Creek Trail runs north and south, connecting with the Bridge Creek Trail, and is also used primarily by hikers. The Metolius-Windigo Trail is currently located on road 370 on the western and northern edge of the area. Primary use on this trail is horse traffic. The Tumalo Falls Trail is a 3 mile trail to the falls from the parking lot along the North Fork of Tumalo Creek. The first section of the Tumalo Falls Trail is popular as an easy day hike to the top of the falls. Parts of this section and the retaining wall were constructed in 1991. An additional 1/4 mile of trail from the lower falls (near the retaining wall) on up towards the upper falls was constructed for mostly easy day hiking and biking during 1990. An additional 3.0 miles was constructed in 1992 along the north fork, accessing the Spring Creek trail near Happy Valley. Bikers use the South Fork ski trail from Tumalo Falls to the Swampy Lakes area.

For summer activities in this area the terms "separate use" and "user conflicts" generally refer to the potential incompatibility of mountain bike and horse or hiker use.

Historical summer trail development and use patterns as well as soil and vegetative type have contributed to current trail locations and to the lack of trails in some areas.

Winter Trails also exist within the Forks/Bridge subwatersheds. Access is from the sno-parks at Dutchman Flat, Swampy Lakes, Meissner, Edison, or Wanoga; and the parking area at Skyliner. The existing trails are a portion of an overall

District-wide winter trail system for skiers and snowmobilers. The South Fork Trail is used by skiers for access between Tumalo Falls and Swampy Lakes. Road 4603 is used by skiers to access Tumalo Falls and the South Fork. The Flagline Trail is a ski route that connects the Dutchman Flat area to the Swampy Lakes area. Several other trails in he Vista Butte ski area are within this study area also. Snowmobilers use Trail 6 and adjacent play areas through the southwestern portion of the Bend Municipal Watershed (BMWS to access the high country from the Wanoga Sno-Park. The new Trail 5 is used by snowmobilers for this purpose. Road 370 is snowmobile Trail 8 in the winter and provides access from the Cascade Lakes Highway to the high country snowmobile areas.

For winter uses in this area the terms "separate use" and "user conflict" refer to the potential incompatibility of cross country skiers and snowmobilers.

The majority of the analysis area falls within the BMWS, Dispersed Recreation, and Winter Recreation as determined in the Forest Plan. The management direction for recreation within the BMWS provide for dispersed non-motorized recreation and for snowmobiles on a designated route. Currently a motorized vehicle closure exists for most of the area. The other management areas allow for non-motorized summer use and motorized winter use, with the exception of various closures to motorized use in the winter. (eg. Swampy Lakes).

The Recreation Opportunity Spectrum (ROS) class for the area is predominantly semi-primitive non-motorized in the summer and semi-primitive motorized in the winter. The ROS class of semi-primitive motorized can apply on seasonal routes and areas such as snowmobile trails.

The desired recreation experience level on trails in the Tumalo watershed is semi-primitive with a couple of exceptions. The Tumalo Falls Trail from the parking area to the first falls and any future loops from this vicinity back to the parking area is considered an easy access trail with the potential to become barrier free. The trail from the first falls to the upper falls is considered to be a semi-primitive trail suitable for hikers and mountain bikers.

Developed Recreation

There are two developed sites in the Forks/Bridge subwatersheds. They are: Tumalo Falls Trailhead, and Skyliner Lodge.

Tumalo Falls Trailhead is a small non-fee picnic/observation facility with a capacity of 60 people at one time (PAOT). It is located at the end of Road 4603 near the Tumalo Creek trailhead and the City of Bend water intake. Developed facilities at this site include one vault toilet, three fireplaces, four tables, bulletin boards, three interpretive signs, and one trash container.

The primary users of this area are locals who come up during the summer months for a picnic and hikers/mountain bikers who use the North Fork trail. Some use of the toilet occurs during the late fall through early spring months by cross-country skiers who have skied up the road past the locked gate. At this time, overnight use of this facility is allowed but not encouraged.

Maintenance of the area has traditionally been accomplished by way of a volunteer agreement with a city employee residing at the water intake house and periodic Forest patrols.

The other developed facility (except for ski shelters) in the study area is Skyliner Lodge. This is a large log structure built in the 1930's depression era which is on the National Register of Historic Places. It was used for many years by the Skyliners ski club. Future restoration of the facility could bring more visitors to the area. It is currently under a special use permit to OMSI and is managed year around as an outdoor education facility.

Scenic Views

Since the Bridge Creek burn, the portion of the project area from Skyliner Lodge to Tumalo Falls has been extensively opened up visually. Now the form of the canyon walls and their silhouette against the skyline are dominant visual features. The slopes are beginning to fill in with vegetation made up of shrubs, some aspen, and the planted ponderosa pine, lodgepole, white pine, Douglas-fir, and spruce. This variation gives a mottled textural appearance. The green of the vegetation and the earth-tone brown of the soil are the colors. The view ranges from foreground to background.

The immediate area around Tumalo Falls also lost most of the vegetation through the fire. The falls still dominates the view but the view is more open and it does not have the color and textural variety it once had. New riparian vegetation is slowly coming back however. The trail to the upper viewpoint passes through the burn.

The remainder of the watershed is heavily vegetated with a variety of species. The strongest visual elements are the form of the large trees and the various textural patterns of the shrub and ground-cover vegetation. The water element is important too for this area. There are several waterfalls and rapids in the various streams that offer strong visual variety. There are occasional meadows and other natural openings.

Roads

Road 4601 from the paved portion to Road 4603 is a single lane gravel road. Where road 4601 changes from pavement to gravel, the pavement leads to Skyliner Lodge. This gives the appearance that the Skyliner entrance is the main road, and road 4601 continuing on is the side road. There is a 42-foot, single lane concrete bridge across Tumalo Creek. The bridge has an expected remaining life of 15 years. There is a Pacific Power and Light (PP&L) power line and a U.S. West telephone line attached to the downstream side of the bridge. The water mains for the City of Bend cross under the road and bridge. The surfacing on this section of road is minimal and there are drainage and erosion problems.

Road 4603 is a single lane road with undefined turnouts. The horizontal alignments has non-geometric curves and the vertical alignment has grades which are steep enough to cause washboarding and the sight distance is below standard. The surfacing is worn away to the extent that the road cannot be properly graded. There are large stumps on the road shoulders which are concealed by brush. There are two city water lines, a PP&L powerline, and a U.S. West telephone line buried along and under the road. At the upper end,

there is a single lane concrete bridge crossing Tumalo Creek and leading into the parking lot where the road comes to a dead end at the city water intake. The parking lot is a surfaced open area without a specific parking layout. The City of Bend uses this route to access their water intake and have a caretaker living on the site. The road is also used as a cross-country ski trail. There is a gate at the entrance to the road which is used to preclude wheeled vehicles during the winter months. At present, the road does not meet Highway Safety Act standards.

Road 370 and road 4601 west of the 4601-4603 junction are not part of the transportation system which access the Falls area. They are part of this analysis area because of the recreation use which occurs along these routes. It has been determined through the forest planning process that both roads will be managed for a more primitive experience suitable for high clearance two wheel drive vehicles. The Forest Service will continue to maintain the roads for resource protection but will not improve them to allow easy access for passenger cars.

Easements, Agreements, and Permits

Road 4601--Easement to Crown Pacific.

Both 4601 and 4603--Permits and Consent Agreements to PPL and US WEST.

The City of Bend presently has special use permits for the water lines.

## ISSUES IDENTIFIED

Each phase of this analysis process is strongly dependent on interdisciplinary cooperation to keep the analysis focused on relevant issues. During the initial phases of the watershed analysis process, the team shared information to provide the entire team with a more complete "picture" of the watershed. The key landscape trends, causes, and risks are identified and integrated between the physical, biological, and social arenas, or "domains". From these "team teachings" the team listed issues that were later developed into key issues and key elements at risk within the watershed. The initial listing is as follows:

- Increased recreation use could negatively impact riparian areas and wet meadows, which in turn could impact water quality.

- Increased recreation use will increase the risk of wildfires.

- Water quality in Bridge Creek, which is the key domestic water supply for Bend.

- Sedimentation in Tumalo Creek, as a result of the Bridge Creek fire (1979), is above desired levels.

- Seasonal conflict between horse users and vehicles on Road 370.

- Gravel washed out on low water crossings on Road 370.

- Protect investment made in the plantation in the Bridge Creek burn.

- Concern over ability to sustain late structural stages in mixed conifer.

- Potential disturbance to wildlife with increased recreation activity (i.e.goshawk, wolverine {sensitive, C2}, northern spotted owl {threatened}, big game).

- Loss of wildlife habitat from lack of fire events and suppression is causing riparian encroachment.

- Natural disturbances contribute to diversity of wildlife habitat and should continue.

- Loss of spruce, cottonwood, and aspen habitat along Tumalo creek from Bridge Creek fire.

- Protect amphibian and invertebrate habitat.

- Lack of wildlife data in area as a knowledge base for management.

- Protect riparian wildlife habitat.

- Maintain connectivity of wildlife habitat.

- Protect and maintain Newberry gentian (GENE) habitat.

- Past plant surveys in area were governed by trail location proposals; doesn't encompass entire watershed.

- Conflict with GENE and dispersed camping/parking.

- Travel management concerns; i.e. protection of resources through road closures and/or obliterations; vs. user freedom/preference.

- Horse and mountain bike use displaced from trails (Bend watershed), identifying a need for alternative trail opportunities.

- Site degradation associated with dispersed recreation.

From this list, the team developed 5 key issues that helped keep the analysis focused:

- Long-term restoration, protection and maintenance of riparian and hydrologic functions.

- Demand in recreation use could further impact social, physical, and biological processes.

- Natural hydrology has been altered to supply irrigation and domestic water.

- Sustainability and resilience of Mt. Hemlock and mixed conifer vegetation.

- Displacement of horse and mountain bike trail users within the municipal watershed has resulted in a demand for alternative trail opportunities.

## KEY TRENDS, CAUSES, AND RESOURCES AT RISK

The team identified in matrix form; 1) key resource trends, 2) their causes, 3) the ecological processes involved, 4) the primary and 5) related resources at risk based in their analysis. Table 3, located at the end of the document summarizes the discussion.

Key resources at risk were combined and summarized into the following list:

Physical Domain

A) Soil quality
B) Water quality
C) Air quality
D) Wetlands

Biotic Domain

A) Wildlife
B) TE&S plant species
C) Vegetation
D) Native fish species

Social Domain

A) Recreation experiences/opportunities

The following narrative identifies key risk areas by domain.

Physical Domain

Soil Quality

Soil quality in the subwatersheds is high due to the limited disturbance from human activities. Except in compacted areas where human actions or natural disturbances (e.g. landslides) have occurred, soil processes; i.e., percolation and infiltration; have not been disrupted. There has been limited harvest activities which has reduced impacts from road building and mechanized machinery.

Soil quality is less in areas where human activities occur, such as: on or near trails or roads, near recreation facilities (Tumalo Falls trailhead, Skyliner Lodge area), Bridge Creek burn area, and stream banks (user-made trails causing a loss of vegetation cover). These activities affect water percolation and infiltration in a negative way by increasing water runoff.

Erosion caused by, among other things, increased recreation may have a negative effect on water and soil quality adjacent to roads, trails, and recreation facilities. The use of snowmobiles during low snow conditions and in sensitive areas is an example.

Water Quality

Water quality within the Bend Watershed is an area of concern to the City of Bend, particularly within Bridge Creek. An expensive water filtration plant would have to be constructed by the city if compliance with the Safe Drinking Water Act is not continued. The City of Bend and the Deschutes National Forest have agreed in a Memorandum of Understanding to protect water quality within the Bend Municipal Watershed (see Appendix A). The trend has been that the water quality has exceeded the standards.

The reaches of Tumalo Creek within the burn area continue to contribute sediment to the stream. The most active stream bank erosion occurs primarily during the spring snowmelt. The trend is for continued stream bank erosion above the pre-fire era. Over time the trend would eventually be reversed as the vegetation becomes established and matures.

Air Quality

No trends in air quality can be documented through monitoring within the Tumalo watershed except in the nearby city of Bend, where average carbon monoxide concentrations have decreased, visibility has increased slightly, and inhalable particulates show no significant change between the periods of 1988-1992.

In general, impacts to air quality from campfires and motor vehicle exhaust can be expected to increase with projected increases in visitation to central Oregon and population for the Bend metropolitan area. Vehicular traffic along the Cascades Loop Highway and by local residents also continues to increase making an increase in carbon monoxide concentrations a possibility. Technological improvements in wood burning devices and automobile emissions may help offset these trends. In the recent past the amount of slash burning has decreased, due both to lower timber harvest levels and the increased utilization of materials in lieu of burning. During the summer months, smoke from an increasing number of large wildfires has become a more common occurrence within the watershed and the surrounding countryside. Additionally, air quality concerns may limit the ability of land managers to implement prescribed burning as a fuel treatment and silvicultural tool.

Wetlands

There is a change in the composition of wetlands occurring from encroaching conifers. The riparian vegetation adjacent to Tumalo Creek and Bridge Creek within the burn area had substantial Engelmann spruce stands prior to the fire in 1979. Presently the riparian vegetation is dominated by alder, and the floodplain has been replanted with ponderosa pine and lodgepole. This has established an even-aged ponderosa and lodgepole pine stand. Within the floodplain, the desired condition is to restore the area to spruce.

Road 382, a spur of road 370, crosses a wet meadow as it heads toward the North Fork. The trend is for continued degradation of soils and vegetation within the meadow. There are some dispersed camping areas in Happy Valley adjacent to road 370 that are impacting meadow areas. There are also stream crossings in this area that are in disrepair, resulting in riparian degradation. The trend is for continued riparian degradation. Page C-32 of the Standards and Guidelines for the President's Forest Plan states under Road Management RF-2e., requires management activities to meet Aquatic Conservation Strategy objectives

by "minimizing disruption of natural hydrologic flow paths, including diversion of streamflow and interception of surface and subsurface flow". This will continue to degrade the meadow areas, and could expand with increased recreation use.

**Biotic Domain**

Wildlife

Fire regime changes, subsequent increased vegetation stocking levels, and fuels buildups all contribute to changes in habitat. Increases in stocking level usually occur in the smaller diameter trees that are also younger in age than the surrounding forest. These trees have survived due to the lack of disturbance factors that have helped to keep stocking levels under control. The trees surviving within the mixed conifer and mountain hemlock types are shade tolerant species. All these factors combined create a situation of intense competition between the older, large diameter trees and the younger, small diameter trees. The older trees are the ones that lose their vigor quicker, are more susceptible to insect and disease attacks, and are generally less healthy due to a combination of stress factors. Habitat lost with increased stocking levels and loss of the large tree component will be raptor habitat. Snag habitat with lowered recruitment snag potential will affect the cavity nester species. As habitat changes occur, there may well be a change in the species composition from species that utilize old growth forest structures to species that utilize a younger structured forest.

TE&S Plant Species

Fire exclusion has also had an impact on the availability of habitat for TE&S plant species. Several of the known and suspected species, including Newberry gentian, depend on meadow openings in the forest canopy. Naturally occurring fires create new openings and probably retained existing openings, creating habitat for these plant species. These fires also played a role in preventing tree encroachment into these openings, including moist meadows.

Recreation activities and facilities also impact TE&S plant habitat. Contained in the analysis area are many points where the highest probability habitat for sensitive plants and the most appealing areas for recreation and dispersed activities coincide. Prime examples are the subalpine meadows of Newberry gentian. Dispersed camping is occurs on several known populations. Also of concern are the open, wind-swept pumice ridges that comprise a major part of the pumice grapefern's habitat. Even the tread of hikers could pose a threat in this fragile environment. Overall, foot traffic, recreational vehicles, bikes, and horses can compact soils, de-vegetate areas, and introduce noxious weeds. These impacts cumulatively reduce habitat for sensitive plants and affect plant diversity in general.

Building of trails or roads through moist meadows or riparian habitat has the potential to reduce or restrict overland flow. This in turn could affect seed dispersal, genetic diversity, and founding of new populations for some sensitive plant species that depend on overland flow for seed dispersal.

Vegetation

The Forks/Bridge subwatershed vegetation is relatively pristine in that it is not very fragmented (from timber harvest, wildfire, etc.). Natural disturbance regimes that occur would be frequent fires, periodic insect outbreaks, and diseases that evolve as part of natural ecological processes.

Fire plays an important role in the development of eastside forest ecosystems. Naturally occurring fires tended to be of low intensity and short duration. Beginning around the turn of the century, wide spread fire suppression began, changing this natural fire regime and has thus become a contributing factor to altered disturbance regimes and plant successional pathways.

Changes in periodic fire regimes have allowed for fuels and down woody debris to build up and be present on the forest floor. Heavy fuel loads pose an increased risk and hazard for fires that may burn with extreme intensity and cover large areas. The Bridge Creek Fire is an example of one such fire. High intensity fires contribute to reduced scenic quality, loss of wildlife habitat, reduced recreation opportunities, loss of structural and vegetative diversity, loss of native seed sources for re-vegetation, air quality degradation, and detrimental impacts to the soil resource.

Lack of periodic fires has allowed the lodgepole pine forests to develop into dense overstocked conditions that existed to a lesser degree in historic forests. This highly dense overstocked condition favors epidemic levels of bark beetle outbreaks over large areas whereas historic conditions favored endemic levels of bark beetles in smaller pockets.

Overstocking in the mixed conifer type can also be contributed in some part to a change in the natural fire regime. These dense stands of mixed conifer provide conditions that are conducive to budworm outbreaks. Recent epidemic outbreaks have occurred over large areas given the dense overstocked conditions now present, versus historically small endemic outbreaks.

Laminated root rot is associated with the mountain hemlock type, and armillaria root rot is found in association with the mixed conifer type. It is assumed that these root rots probably exist within the vegetation types, though not in proportions that are easily identified. No major root rot pockets have been found within the Forks/Bridge subwatersheds.

Root rot pockets create openings within the forest that provide habitat for species that utilize openings. Root rot pockets are also areas of high fuel concentrations and contribute to the down woody debris component. Fire hazard may be increased within and surrounding these openings due to the increased fuels. Habitat may be lost within these openings if an intense fire event occurs.

Along with the change in natural fire regimes is the change in the risk of fire due to increased human use of the area. Due to the increase in the local population and the areas close proximity to Bend, the risk of human caused fires within the Forks/Bridge subwatersheds is high (see Social Domain section).

The Bridge Creek fire devastated essentially all of the vegetation within the burn area. The burn area was grass seeded and tree species planted as artificial means of re-vegetating the area. Brush species, mainly ceanothus,

regenerated naturally as it is shade intolerant, and is chest high in some areas. The brush species compete intensely with the tree species for food and nutrients. The tree species are now approximately 12-15 feet in height and are higher than the brush. However, due to the open stocking, the brush species are still prevalent. Over time as the brush become more shaded out from the growing trees, they will naturally die off. For the present time, the brush component is a major concern from a competition standpoint. This brush competition should be managed so that more food and nutrients are made available for uptake by the tree species. If the brush component is not actively managed, there is a risk of another fire event that would carry through the plantation, killing the trees and losing the time and money investments made to replant the burn area.

The Bridge Creek plantation should be monitored periodically for insect and disease activities. If insect or disease activities are found then appropriate action should be taken to reduce or eliminate the problem to help protect the investment already made in the plantation.

The Engelmann spruce bottomlands within the Bridge Creek burn area were destroyed by the fire. These are unique bottomlands and are in need of further restoration activities to bring this component back into the ecosystem.

Decrease In Native Fish Species Populations

A probable cause in the decline of native fish (redband and possibly bull trout) populations in the Forks subwatershed is the introduction of brook trout about 50 years ago. Hatchery rainbow trout were stocked by state agencies until the 1970's. The stocked fish competed with natives for food and habitat, and may have interbred with the native redband. Another factor to depressed populations may be the withdrawal of flow for irrigation needs downstream of the subwatersheds, which reduce available habitat in Tumalo Creek.

The Bridge Creek Fire and following management activities depleted available fish habitat and may be another contributing factor to the decline of native fish populations. Salvage logging of the burn area in the early 1980's included clearing of instream large woody material, and all dead standing timber along the stream banks of Tumalo Creek and South Fork. These actions eliminated much of the fish cover and changed the stream dynamics, contributing to the present streambank erosion and widening of the channel. Restoration projects were undertaken in 1990-92 that placed over 200 large wood structures in the stream, and planted several hundred trees and shrubs. The woody material was smaller on average (10-14"dbh) than that which would have occurred naturally; many of the trees cleared from the channel were 24-36" dbh. The desire to use whole trees limited the size of trees that the heavy equipment could effectively handle safely. The ponderosa pine that were planted after the fire may require another 75-100 years before they will provide large wood recruitment to the channel. The life span of the habitat structures is estimated to be 30-40 years, leaving a window of 35-70 years that the stream would again be deficient in large woody material, presenting the opportunity of duplicating large wood restoration 30-40 years from the present.

Although the fish populations likely declined after the fire, monitoring of the fish populations since habitat restoration was completed has shown an increase in abundance.

## Social Domain

The social domain within the Forks/Bridge subwatersheds includes a variety of human interactions and sentiments for the natural resources found there. There are several types of trends that are changing historical uses and impacts on the landscape.

### Recreation Experiences/Opportunities

The increase in recreation density is changing the recreation experience, causing user conflicts, resource impacts, and facility deterioration. With the increased use of the watershed, the opportunities for semi-primitive and other less developed levels of recreation are diminishing.

Crowding at recreation facilities, including trails, is diminishing the recreation quality and experience for some users.

The increase in the number of residents and visitors puts at risk the resources that attracted many people to the area: open space, solitude, and unspoiled beauty. As the population has increased so has the use of public lands. This has brought about the need for restrictions to reduce user impacts, and to place more emphasis on site management. Road and area closures, and trail restrictions are common management tools. As the population of Deschutes County increases, there are likely to be more restrictions placed on the use of public lands. An existing example of this is the Memorandum of Understanding between the Forest Service and the City of Bend, providing the framework for managing and prohibiting motorized activities in the BMWS. Also, there is a self-issue permit system in place in the BMWS.

Any disturbance, especially by mechanical means, also increases the risk that noxious weeds will be introduced into the subwatersheds. Weed seeds may be brought in either on the equipment used in trail or road construction, or by users of the roads and trails. Seeds can be carried by horses or in their feed, or in the tire tread of either motorized vehicles or bikes. Noxious weeds, especially spotted knapweed, have the potential to spread quickly and could crowd or eliminate sensitive plant habitat with just a few years' growth.

In general, use in the Forks/Bridge subwatersheds is increasing proportionally to the population and popularity of Bend. The more popular activities include: nordic backcountry skiing, snowmobiling, hiking, and mountain biking. Use data as well as visual observations supports the need for additional trail systems as well as the need to deal with the carrying capacity issue for this area. Use is limited at this time only by parking access. The trend is toward increased use of trails by all user groups with emphasis on those mentioned above.

More specifically, trail use by areas is important to highlight. The Tumalo Falls area and relatively new North Fork trail, open to mountain bikes and hikers, has been monitored since it's opening in 1993. Use has more than doubled from the 1994 to the 1995 seasons. The numbers of bikes and hikers, respectively, has remained about the same but overall use is up. The good weather in 1995 as compared with 1994 as well as the word of mouth popularity are likely reasons for the increase. The Tumalo Falls area receives more and

more use as the land recovers and becomes more scenic since the fire in 1979. In 1993, an additional regular boost in hiking use comes from OMSI operating out of Skyliner Lodge. The Tumalo Falls area is only 13 miles from Bend and receives approximately 98% day use capacity.

The significant use increase in this area tends to result in conflicts between uses. As more and more people access the area trails at one time, conflicts, even socially based conflicts, will increase. Use on the Bridge Creek trail was also up in 1995 for similar reasons, but is limited to hiking as it is in the BMWS. Illegal mountain bike use continues to occur but has decreased each year since the BMWS was closed to bikes in 1990.

Other trails in the area include the winter nordic trails accessed by Swampy Lakes and Meissner Sno-parks. Most of these winter trails are used by mountain bikes in the summer. Use continues to increase along with the popularity of mountain biking and the area as a recreation destination point. Local mountain biking groups are active in creating and maintaining new trails. There is some off trail use by bikes, horses and hikers, mostly related to hunting use, but is also scattered throughout the year.

Winter use trends are increasing like summer uses, but the most significant increases are seen in the snowmobiling and back country/telemarking use. Most of the use and resulting conflicts occur in the Dutchman/Tumalo Mountain area. Though Dutchman is not in the analysis area, it is an intregal link to activities occurring in the Forks/Bridge subwatershed. This area is a shared use area, as well as being a congested area where different uses converge, especially around Dutchman Flat. As snowmobile technology advances, they are able to travel more places and in varied snow conditions than in the past, creating additional tension, especially between motorized and non-motorized users and in more remote, steeper terrain such as Tumalo Mountain. With marginal snow years, the Dutchman Flat area receives greater use, as in early and late season, again adding to an already congested area. Issues related to this conflict include air quality, noise, safety and carrying capacity.

Developed recreation in the analysis area is limited due to the existing management allocations and related standards and guidelines. Along with developed sites mentioned previously, recreation facilities also include dispersed campgrounds at Tumalo Falls. All of these facilities are receiving increased day use, while overnight use remains more constant. The 370 road serves dozens of individual dispersed campsites which are utilized during the summer months. The access to the 370 road is managed by a gate at either end of the road which is opened up after the snow melts and the road surface dries out. This road is maintained for high clearance vehicles only but receives use by all types of vehicles.

There appears to be a trend in these areas towards a significant increase in day use while the overnight use at these dispersed sites increases slightly. Similar trends are seen in the Three Sisters Wilderness area just adjacent to the north. The day use is primarily tied to picnicking, sightseeing and trail use.

There is little change in the management of the roads accessing this area. Some lead to and go through meadow areas. As use increases, there is more opportunity for situations where vehicles leave the road surface and park or

drive in meadow areas. The condition of the roads themselves deteriorates with time and use with limited maintenance.

The risks associated with the existing trends for trails can be separated into social and resources risks (erosion, impacts to wildlife and plants, increased risk of wildfire, etc.).

Social risks include the safety and conflicts related to different uses attempting to utilize the same trail system, as well as the result of increasing use levels on a particular trail or area. The issue of carrying capacity weighs heavily in this situation. As different types of use keeps increasing, verbal confrontations, physical wrecks, and safety problems sometimes result. The most volatile mix of uses tends to be non-motorized vs. motorized, which occurs only in the winter. Summer conflicts tend to revolve around mountain bikes and hikers, mountain bikes and horses, or horses and hikers. The combination of over-use coupled with certain types of use can create a volatile situation.

Resulting management actions may include use regulations or closures to certain uses on a particular trail. These actions would be based on good monitoring of the situation and problem identification. Identification of the appropriate carrying capacity and types of uses allowed on a trail would be done along with potential mitigation measures to remedy a situation when it reaches the identified threshold. These social based risks are largely based on the attitudes of the users. Education is the number one tool used to remedy social conflicts.

Resource risks as related to trail use are easier to measure than social risks but need to be monitored as well to determine when other resources are at risk. Resources at risk are vegetation, soils and water quality. Air quality comes into play when motorized use is present. Effects on wildlife are a concern especially when motorized use is a factor. The actual impact on soil is mostly limited to the trail tread itself. User trail created in addition to a system trail are a concern because they are generally steep and tend to lead to water. Erosion of soil into a water course may have an affect on water quality as does the related trampling that tends to occur when a trail is located near water. The disturbance of riparian vegetation and potential decrease in water quality are significant concerns given the aquatic conservation strategy standards as defined in the President's Plan.

Those risks associated with developed or dispersed sites tends to be focused near the developed site and usually are near water of some kind for scenic and other values. Impacts are usually greater near the site and decrease rapidly with the distance from the site. Generally, trails are associated with developed sites, whether planned or user created. Dispersed sites tend to be user created and therefore don't very often meet standards. The impacts that tend to occur with these sites are usually related to soil compaction and erosion and riparian or water quality issues.

There are also social risks related to developed sites usually tied to personal safety and law enforcement issues. Regulations, tend to be stricter in more developed sites in order to maintain a safe situation.

Scenic views are changing very little in this area given the absence of harvesting and other management activities. The most significant change occurring is the regeneration of trees in the Bridge Creek burn area. The trees are getting tall enough that views opened up by the fire will be gradually disappearing over the next 10 years. Other changes are minor and are related to the natural growth of trees and encroachment of meadows. Risks associated with scenic views are minor in comparison with other resource values and tend to be related to views and viewpoints which draw people. There will be increased impacts similar to developed sites as view points are made more accessible. The reverse is true as well in the case of the Bridge Creek burn growing in, obscuring views that now exist.

## GOALS AND OPPORTUNITIES BY DOMAIN

The team next identified goals and restoration opportunities for the watershed by domain based on the trends, causes, and risks. The goals and opportunities identified in this section are not management direction, nor do they represent a comprehensive list of the goals and opportunities that may exist for the watershed. They are simply intended to be used in defining restoration opportunities and to validate the contribution of new projects in the watershed in meeting watershed goals.

PHYSICAL DOMAIN

**Key Elements at Risk - Soil Quality**

Goal: Reduce soil erosion and compaction.

Opportunities

1. Monitor/rehabilitate roads, trails, and other ground disturbing activities.

2. Locate new facilities and trails to reduce negative impacts to soil resources.

3. Monitor/rehabilitate Tumalo trailhead and Skyliner Lodge areas from user impacts.

**Key Elements at Risk - Water Quality**

Goal: Maintain and improve water quality.

Goal: Maintain water quality in the BMWS to comply with the Safe Drinking Water Act of 1986.

Opportunities

1. Coordinate water quality monitoring and studies with the City of Bend.

2. Conduct studies to determine extent of problem(s) associated with possible surface and ground water contamination.

3. Install underground water pipeline from Middle Fork Springs to current city water intake.

4. Control, design, relocate and monitor facilities (roads, trails, etc.) to minimize impacts to wetlands.

5. Improve stream crossings along road 370.

6. Reduce the risk of stand replacing wildfires.

**Key Elements at Risk - Air Quality**

Goal: Comply with Clean Air Act as ammended in 1977.

Opportunities

1. Continue to monitor air quality (Bend is the closest monitoring station).

2. Restrict campfires within Forks subwatershed.

**Key Elements at Risk - Wetlands**

Goal: Reduce resource damage caused by increased recreation use.

Goal: Protect, enhance and restore riparian vegetation.

Opportunities

1. Control, design, relocate and monitor facilities (roads, trails, etc.) to minimize impacts to wetlands.

2. Improve stream crossings along road 370.

3. Plant and enhance native riparian vegetation within Bridge Creek burn (hardwoods, spruce).

4. Actively manage dispersed campsites.

5. Close road 382 to protect wet meadow.

BIOTIC DOMAIN

**Key Elements at Risk - Wildlife Habitat**

Goal: Protect and enhance TE&S animal species habitat.

Goal: Maintain connectivity of forest canopy, wildlife corridors, and elk thermal cover.

Goal: Provide habitat to maintain healthy populations of snag dependent species.

Goal: Protect riparian areas for wildlife habitat and diversity of species.

Opportunities

1. Survey and monitor TE&S animal species and other wildlife species.

2. Close, and/or obliterate roads.

3. Retain large diameter trees, snags, and down coarse woody debris.

4. Reduce the risk of catastrophic events (e.g. wildfire).

**Key Elements at Risk - TE&S plant species**

Goal: Protect and enhance TE&S plant species habitat.

Opportunities

1. Survey to determine extent of Newberry gentian population.
2. Provide meadow restoration and enhancement activities.
3. Survey to determine if Pumice grapefern, and other possible TE&S species exist and document population(s).

**Key Elements at Risk - Vegetation**

Goal: Maintain a healthy, vigorous forest environment.

Goal: Maintain and protect investments made in the plantation (Bridge Creek burn).

Goal: Reduce the risk of stand replacing fires.

Opportunities

1. Manage to provide for endemic levels of insects and diseases (to reduce stocking levels).
2. Manage brush component of Bridge Creek plantation.
3. Reintroduce fire as a component of the ecosystem.
4. Monitor Bridge Creek plantation for animal damage and insects and diseases.
5. Restore Engelmann spruce bottomland vegetation.

**Key Elements at Risk - Native Fish Species**

Goal: Enhance native fish populations.

Goal: Provide and restore fish habitat.

Opportunities

1. Restore large woody material to Tumalo Creek over the long-term.
2. Plant native riparian vegetation along streams.
3. Eradicate exotic fish species.
4. Continue to coordinate efforts with ODFW.

**Key Elements at Risk - Recreation Experiences/Opportunities**

Goal: Provide a variety of recreation opportunities.

Goal: Reduce user conflicts caused by an increase in recreation use and variety of uses.

Goal: Provide recreation opportunities that are compatible with wildlife use, meadow habitat, and soil quality.

Opportunities

1. Improve and/or relocate trail and road facilities. Manage existing facilities to relieve existing conflicts.

2. Actively manage dispersed camp sites.

3. Provide and maintain trail opportunities and related facilities. Plan facilities to avoid conflicts between different user groups. Address carrying capacity and types of uses allowed.

4. Monitor user demographics and numbers to develop marketing strategies to identify needs and preferences.

5. Monitor mountain bike use of trails to determine future management.

6. Monitor the condition of recreation facilities and trails and develop an operations and maintenance plan.

7. Maintain facilities and redesign/construct new facilities where needed, such as: more non-motorized trail opportunities, including the implementation of Tumalo Trails Phase II.

8. Increase law enforcement presence, providing user contacts with an emphasis on etiquette, low impact methods, and other wise forest use information.

9. Develop a viewshed strategy for trails and road corridors to provide views to interesting features (rock outcrops, variety of vegetation, etc.)

10. Maintain high visual quality along roads and trails.

11. Manage size of parking areas to reflect appropriate levels of use.

12. Obliterate and rehabilitate user trails.

13. To reduce conflict, manage developed sites as day use only.

14. Maintain partnership with the City of Bend to manage and monitor use in and around the BMWS.

Table 1. FORKS/BRIDGE SUB-WATERSHEDS
PAG and Forest Structural Stages
Current Condition

| Plant Association Group | Eco-Unit Summary | | Forest Structural Stages | | | |
|---|---|---|---|---|---|---|
| | PAG Acres | PAG % of Area | Early Acres | Middle Acres | Late Acres | Old Acres |
| Sparsely Vegetated * | 4,928 | 25% | NA | NA | NA | NA |
| Mountain Hemlock | 5,441 | 27% | - | 272 | 2,992 | 2,176 |
| Lodgepole Pine | 3,133 | 16% | - | 627 | 2,506 | - |
| Mixed Conifer | 4,377 | 22% | 86 | 256 | 2,415 | 1,620 |
| Bridge Creek Burn ** | 1,935 | 10% | 1,935 | - | - | - |

TOTAL: 19,814

Note: This acreage includes approximately 500 acres of private land within the Forks subwatershed. Structural stages are defined by diameter sizes in the Deschutes National Forest WEAVE process book and corresponding Integrated Satellite Imagery (ISAT).

* Sparsely vegetated includes rock and grassy areas.

** Bridge Creek burn acreage excludes rock areas as these rock areas are accounted for within the sparsely vegetated class. Current condition PAG was not determined for the burn area because of its early seral stage and the type of species planted within the burn area.

Table 2. FORKS/BRIDGE SUB-WATERSHEDS
Historic Disturbance Characteristics

| Potential Nat. Vegetation Plant Assoc. Groups | Dominant Disturbance Factors | Disturbance Regimes (Severity) | Average Disturbance or Patch (Acres) | Typical Landform Setting | Typical Elevation Range | Aspects |
|---|---|---|---|---|---|---|
| Sparsely Vegetated | NA | NA | 100-500 | Above Timberline | 6,800'+ | All |
| Mountain Hemlock | 1) Fire<br>2) I & D | High<br>Moderate | 50-150<br>50-200 | Below Timberline<br>Flat to Steep | 6,000' - 6,800' | All |
| Lodgepole Pine | 1) Fire<br>2) I & D | Moderate<br>Moderate | 50-100<br>10-1,000 | Flat to Steep | 5,200' - 6,800' | All |
| Mixed Conifer | 1) Fire<br>2) I & D | Low<br>Moderate | 50-500<br>100-500 | Mid to Steep | 5,200' - 6,800'+ | All |

Low severity regime: 1-25 year return interval, 0-20% vegetation mortality
Moderate severity regime: 26-100 year return interval, 26-70% vegetation mortality
High severity regime: >100 year return interval, >70% vegetation mortality

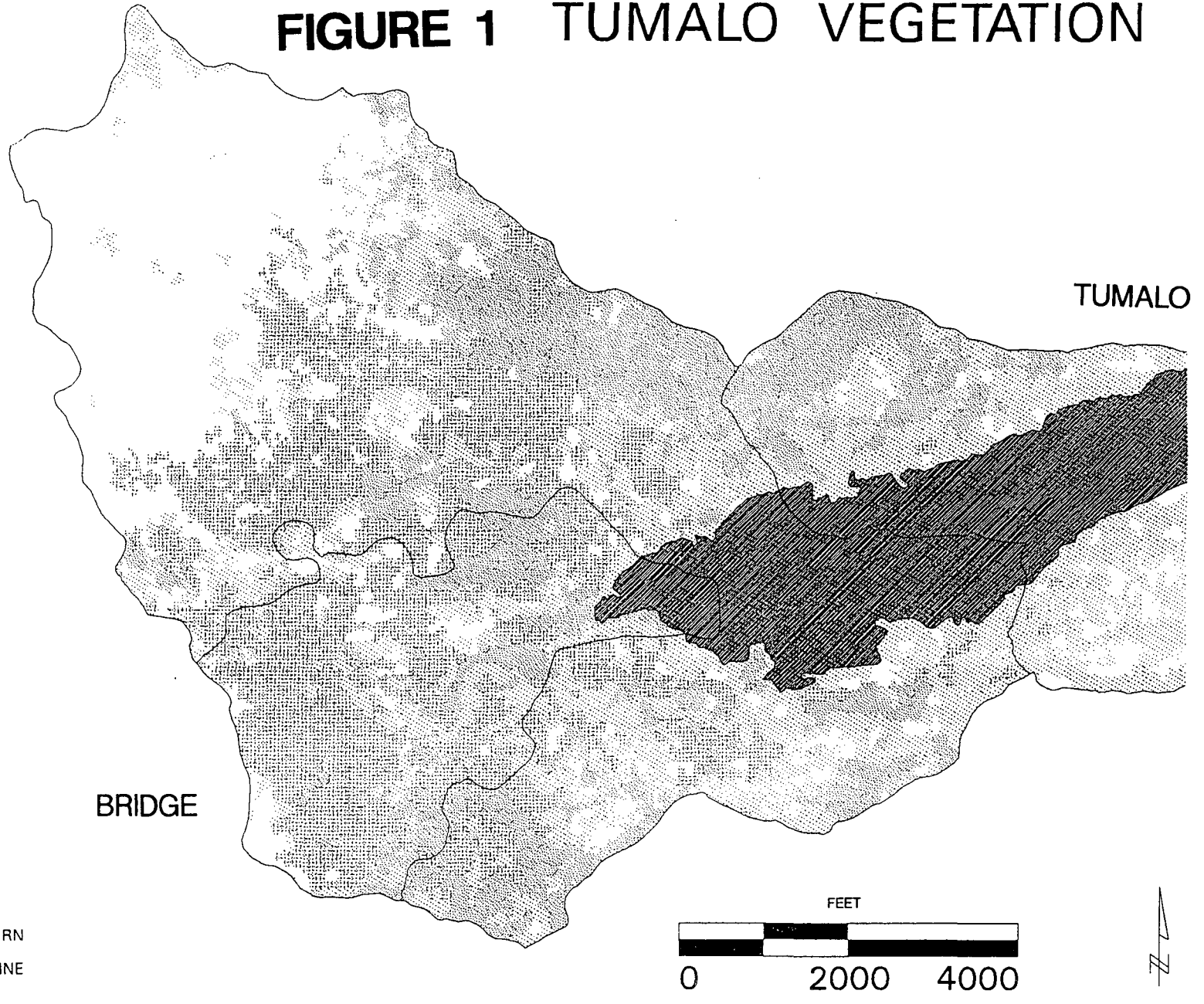
Table 3: Summary of Key Watershed Trends, Underlying Causes, and Associated Resources at Risk

| TRENDS | CAUSES | ECOLOGICAL PROCESSES | PRIMARY RESOURCES AT RISK | RELATED RESOURCES AT RISK |
|---|---|---|---|---|
| **PHYSICAL DOMAIN** | | | | |
| **Soil Improvement:** | | | | |
| except in compacted areas from human activities. | -Limited harvest activities | -Soil transport<br>-Percolation | -Soil productivity<br>-Water quality<br>-Road, trail, and rec. facilities | -Fish habitat<br>-Veg. health & growth<br>-Recreation quality/ experience<br>-Scenic quality<br>-Amphibian habitat |
| **Soil Quality:** | | | | |
| Reduction of soil quality through compaction, displacement, and mixing. | -Road building/const. activities<br>-Machine activities (harvesting)<br>-OHV use<br>-Human/livestock trampling | Water percolation and infiltration<br>-Decreased root penetration<br>-Disruption of soil microbes<br>-Rapid surface flow<br>-Soil/gas exchange | -Soil<br>-Water quality | -Native vegetation<br>-Veg. growth and productivity<br>-Scenic quality |
| Trails: | -Foot/bike/horse<br>-User made trails | | -Soil quality | Scenic quality |
| Rec. Facilities: | -Lack of maintenance<br>-Precipitation events<br>-Loss of veg. cover | | | |
| Sedimentation: Tumalo Creek | -Bridge Creek Fire<br>-Precipitation events<br>-Loss of veg. cover | | | |

| TRENDS | CAUSES | ECOLOGICAL PROCESSES | PRIMARY RESOURCES AT RISK | RELATED RESOURCES AT RISK |
|---|---|---|---|---|
| **Water Quality:** | | | | |
| Pollution | -Recreation use | -Change in biotic | -H2O quality | -Fish habitat |
| H2O flow in | -Loss of veg. cover | composition of | | -Amphibian habitat |
| Tumalo/Bridge Cks. | -Streambank erosion | microorganisms | | -Human health |
| Increased water temps. | due to channel | -Change in water | | -Recreation experience |
| Decreased quality in | radiation, clearing | chemistry | | -Aquatic food chain |
| burn | & lack of veg. due | -Warming from soil | | |
| | to fire | radiation | | |
| | | | | |
| **Air Quality:** | | | | |
| Overall Watershed | -Internal combustion | -Temperature inversion | -Human health | -H2O quality |
| | engines | -Wind transport | -Scenic quality | -Rec experience |
| | -Woodstoves | -Weather patterns | | -Ability to do prescribed |
| | -Campfires | -Fire regime affected | | burning |
| | -Fugitive dust | -Secondary | | -Woodstove use |
| | -Topog. features | successional pathways | | |
| | -Slash burning | -Human disease | | |
| | -Wildfires/fuels | susceptibility | | |
| | treatments | | | |
| | -Field burning west of | | | |
| | the Cascades | | | |
| | -Increased human | | | |
| | population | | | |

| TRENDS | CAUSES | ECOLOGICAL PROCESSES | PRIMARY RESOURCES AT RISK | RELATED RESOURCES AT RISK |
|---|---|---|---|---|
| **BIOTIC DOMAIN** | | | | |
| **Decrease in native fish species (Red Band & Bull Trout)** | -Intro. of exotic fish species<br>-Irrigation diversions | -Competition between natives and exotics<br>-Interbreeding due to downstream hatchery fish influence | -Native fish populations | -Reduced quality of fishing experience |
| **Change in fire regime** | -Fire suppression<br>-Lengthy analysis process caused by conflicting resource goals and social values<br>-Air quality objectives | -Change in fire regime<br>-Change in lodgepole successional process<br>-Change in plant successional processes:<br>a) more lodgepole<br>b) more shrubs<br>c) more white fir | -Loss of larger tree to insects<br>-Bend Municipal Watershed<br>-Water quality<br>-Connectivity<br>-Soil quality | -Ability of trees to respond to thinning<br>-Loss of WL habitat for late successional species (large snags & nest trees)<br>-Scenic diversity<br>-Hiding cover for big game<br>-Recreation experience<br>-Aquatic species |
| **SOCIAL DOMAIN** | | | | |
| **Recreation Activity/Use is:**<br>-Changing the rec experience<br>-Causing an increase in user conflicts<br>-Causing resource damage<br>-Increasing risk of wildfires<br>-Crowding | -Immigration to C. OR.<br>-Promotion of C. Or. as a recreation destination area<br>-Variety/quality of rec. opportunities available in C. OR.<br>-OMSI facility at Skyliner Lodge | -Human caused fires<br>-Flow of noxious weeds<br>-Change in vegetation successional patterns | -Opportunity for Primitive and less developed levels of rec. in ROS (Recreation Opportunity Spectrum) | -Personal freedom<br>-Unique plant and animal habitat<br>-Air/H2O/veg/soil quality |

# FIGURE 1 TUMALO VEGETATION



# FIGURE 2 TUMALO FOREST STRUCTURAL STAGES