Bend Watershed Analysis

Deschutes National Forest

September 30, 1998

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BEND WATERSHED ANALYSIS TEAM

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Marc Wilcox has a B.S. degree in Natural Resource Economics and a M.S. degree in Hydrology from the University of Nevada. He was a hydrologist for the Gila National Forest for three years and Forest Hydrologist for the Medicine Bow National Forest for sixteen years. In Region 2, he was on the regional BEAR (Burned Area Emergency Rehabilitation) team and has worked on rehabilitation projects in Colorado, Wyoming, South Dakota, and Nebraska. He is currently the Forest Hydrologist for the Deschutes National Forest.

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Bill Peterson has a B.S.F. degree in Forest Science from the University of New Hampshire and a M.F. degree in Silviculture from Oregon State University. His experience with the Forest Service includes seven years as forest llanning team leader, economist, and monitoring coordinator for the Malheur National Forest and two years as EIS team analyst for the Interior Columbia Basin Ecosystem Management Project. He is currently the District Silviculturist for the Bend/Fort Rock Ranger District of the Deschutes National Forest.

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Marv Lang attended Olympic College and the University of Washington and received a B.S. degree in Forest Management. He has twenty-one years of experience with the Forest Service with seven years in Fire and fourteen in Recreation. He has a passion for gardening, cinnamon rolls, and the color blue. He is currently a Recreation Forester for the Bend/Fort Rock Ranger District of the Deschutes National Forest.

Gini Stoddard has a B.S. degree in Natural Science from Western Oregon State College. Her broad resource background with the Forest Service includes hydrology, soil science, archaeology, and vegetation inventories, plus experience with integrated resource databases. She has been a GIS Analyst for the past six years, previously on the Malheur National Forest and the Interior Columbia Basin Ecosystem Management Project. She is currently a GIS Analyst for the Bend/Fort Rock Ranger District of the Deschutes National Forest.

Charles Vickery has a B.S. degree in Geology from Central Washington University. With twenty years of experience in Fire Management with the Forest Service, he is the author of "The Alpine Lakes Prescribed Natural Fire Plan" for the Wenatchee National Forest which was one of the first in Region 6 allowing the Forest Service to manage fire in the Wilderness/alpine lakes ecosystems. He was the Assistant Fire Mangement Officer for the Bend/Fort Rock Ranger District of the Deschutes National Forest and is currently Fuels Specialist for the Supervisor's Office of the Umatilla National Forest.

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Characterization of the Watershed

INTRODUCTION

Watershed analysis is a planning process for understanding the ecosystem at a watershed scale. The context of a watershed is used because it is a defined land area with its own unique set of physical, biological, and social features, recurring ecological processes, and historical land use patterns. While the focus is on issues causing greatest concern for the watershed as a whole, the purpose of the analysis is to determine when and where management activities such as restoration, fishery protection, and enhancement efforts are essential and what conditions require such actions. Success in sustaining healthy ecological functions and the productivity of natural resources would be enhanced by the understanding gained through watershed analysis.

CHARACTERIZATION OF THE WATERSHED

The Bend Watershed is mostly recognized as a source of high quality water originating in cool clear springs in the Happy Valley area and snowmelt of nearby Broken Top. The most visible water features are Tumalo Creek, Tumalo Falls, Bridge Creek, and Bull Spring. Its most recognizable land features are Ball Butte, Tumalo Mountain, Happy Valley, Shevlin Park, the Bridge Creek Fire area, Bearwallow Butte, and private lands owned by Crown Pacific. Historic Skyliner Lodge is a focal point for summer and winter recreation activities close to Bend and easily accessed by Road 4601.

Located west of Bend and northeast of Mt. Bachelor at the northern end of the Bend/Fort Rock Ranger District on the Deschutes National Forest, the highest elevations in the watershed are Ball Butte (8,091 ft.) in the northwest corner and Tumalo Mountain (7,775 ft.) in the southwest corner. Topography gradually slopes in an easterly direction towards Tumalo Creek (4,900 ft.). Known geologically as the broad High Lava Plains, the eruption of Mt. Mazama over 7,700 years ago deposited 2 feet of pumice and ash here.

The entire watershed covers approximately 61,660 acres and of the 24,266 acres of private land, Crown Pacific owns 22,611 acres. In August 1998, a land exchange was finalized for 34,319 acres of Crown Pacific land to be exchanged for 31,256 acres of Forest Service land. In the Bend Watershed, 3,992 acres of Crown Pacific land were exchanged for 2,782 acres of Forest Service land. The purpose of the exchange was to achieve mutual long-term management of restoring and maintaining ecological function on more contiguous areas of federal land rather than on an intermingled pattern of existing ownership which often results in the disruption of ecological processes.

The 4 subwatersheds making up this watershed are Bull (26,219 acres), Tumalo (15,609 acres), Forks (15,609 acres), and Bridge (4,223 acres). Forks and Bridge are Tier 2 Key Watersheds. In the Northwest Forest Plan, the Aquatic Conservation Strategy defines Tier 2 Key Watersheds as directly contributing to conservation of at-risk anadromous salmonids, bull trout, and resident fish species. As the highest priority for watershed restoration, Tier 2

Key Watersheds may not contain at-risk fish stocks but are important sources of high quality water. Directly adjacent to the north on the Sisters District are Squaw and Three Creek Subwatersheds which are also Tier 2 Key Watersheds.

More than two-thirds of the Bend Watershed is within the eastern extent of the range of the northern spotted owl. Wilderness and Roadless Area designations are found in the Forks, Bridge, and Bull subwatersheds. The Northwest Forest Plan allocations are Congressional Withdrawal, Administrative Withdrawal, and Matrix. The Deschutes National Forest Plan Management Areas are Wilderness, Dispersed Recreation, Front Country, Scenic View, Deer Habitat, Old Growth, Special Interest Area, and Bend Municipal Watershed. The City of Bend Municipal Watershed manages over 3,000 acres under agreement with the Forest Service (See Exhibits 1-6).

LANDSCAPE AREAS AND FLOWS

A comprehensive picture of the interactive processes of significant elements within the watershed was defined by the team as Landscape Flows. These elements are essentially the migration of wildlife and the movement of human activities, water flow, and climate. Water from glacial snowmelt and spring-fed streams flows in a southwesterly direction from the Cascade Range to Tumalo Creek. Canals divert water to Bridge Creek and Tumalo Creek at different locations. People move through the watershed on the west side using Road 370 to travel to Todd Lake, the Broken Top Trailhead, and to Three Creeks Lake from Bend via the Cascade Lakes Scenic Byway. To the east, people use Road 4601 to visit Skyliner Lodge and the Tumalo Falls Overlook. Wildlife migrate along a west-east axis with some migratory routes between the Sisters Late-Successional Reserve to the north and the Cultus-Sheridan Late-Successional Reserve to the south.

Major transportation corridors and access points for recreation activities can often become a source of conflict with wildlife migratory movements, an increase in the risk of fire, and can also result in the fragmentation of wildlife habitat areas. Recognition of these patterns is one way of seeing how the ecosystem works, what potential conflicts exist, and where current or future problem areas are located (See Exhibit 7).

The team then divided the watershed into 6 Landscape Areas based upon the following criteria: predominant physical, biological, and social characteristics, resource conditions, road densities, primary issues, and associated key questions. Representing an integrated view of inherent ecological functions and capabilities of the land to support changes from historic and current conditions, the Landscape Areas are further described by resource in Chapters III and IV. The 6 Landscape Areas are: Wilderness (5,032 acres), Cold Forest/Unroaded (3,632 acres), Bridge Watershed (4,223 acres), Front Country/Transition (18,279 acres), Private/Dry Forest (23,857 acres), and Dry Forest (6,637 acres) (See Exhibit 8).

WATER RESOURCE

Although snowmelt and precipitation are the major sources of stream discharge, springs are also a significant contributor. Tumalo Creek and its tributaries are unusual for Upper Deschutes River Basin streams in that they respond immediately to rain on snow events with

Exhibit 1
Bend Watershed Analysis
DESCHUTES NATIONAL FOREST

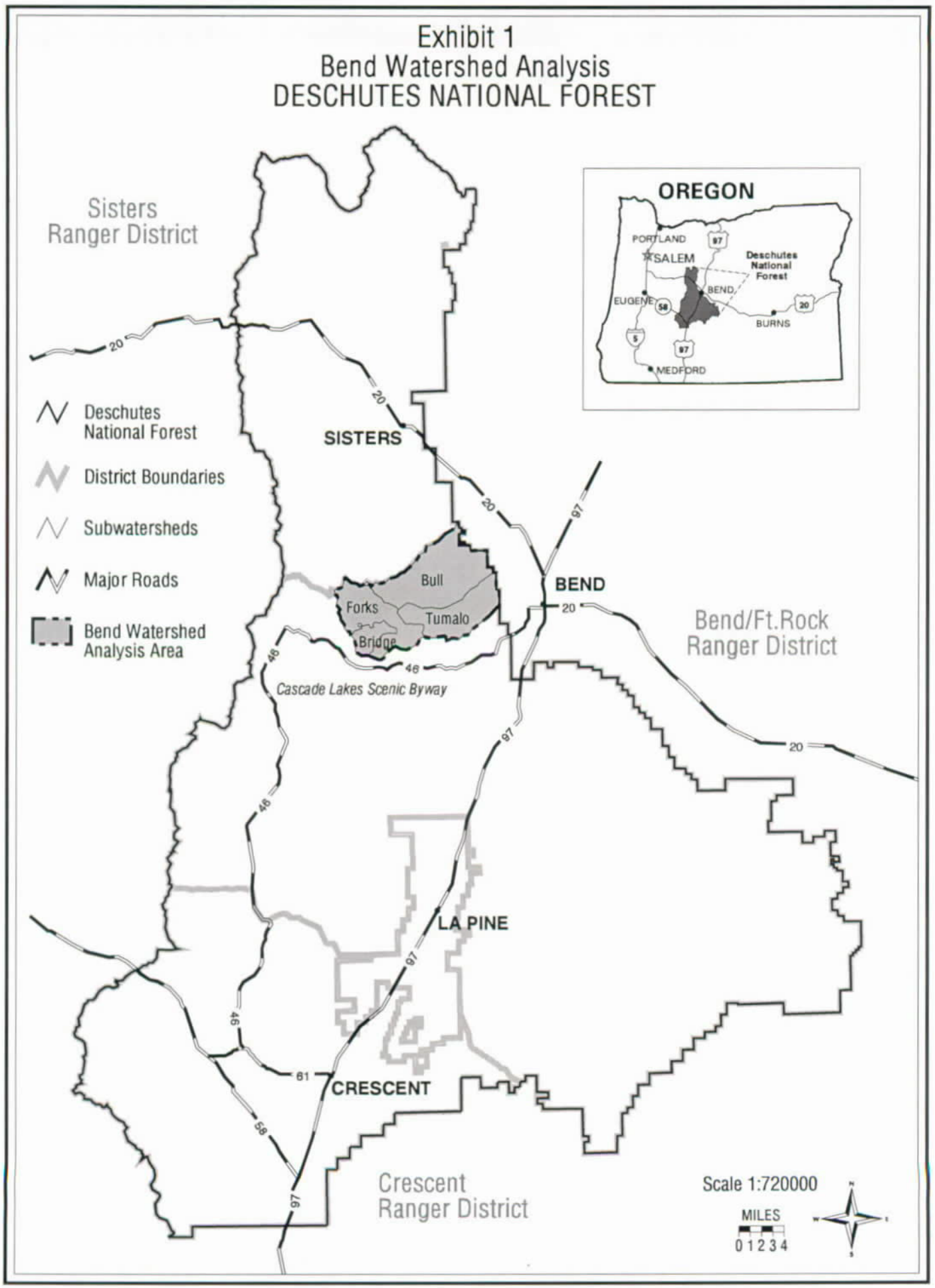


Exhibit 2
Bend Watershed Analysis
SUBWATERSHEDS

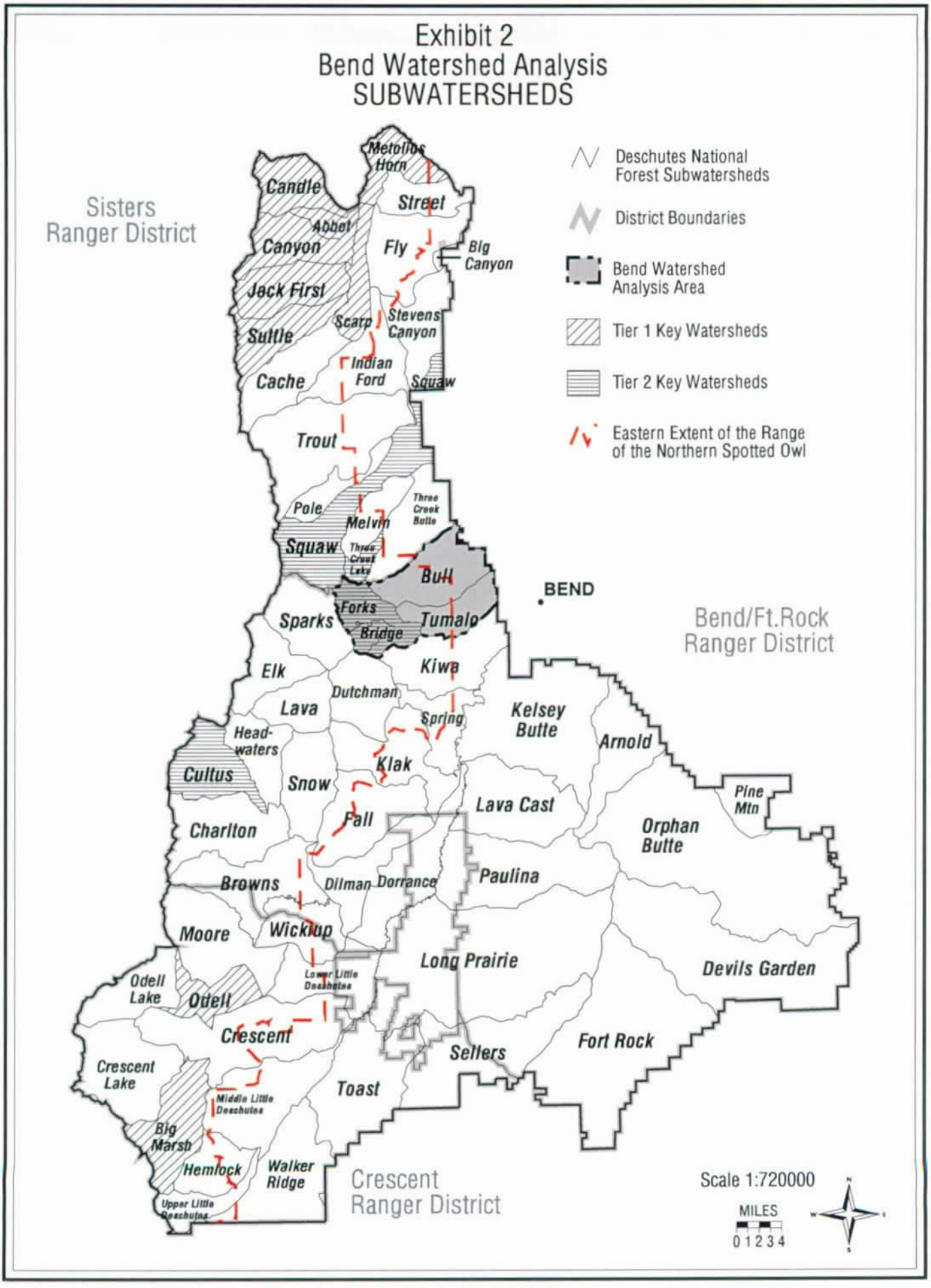


Exhibit 3
Bend Watershed Analysis
BEND WATERSHED ANALYSIS AREA

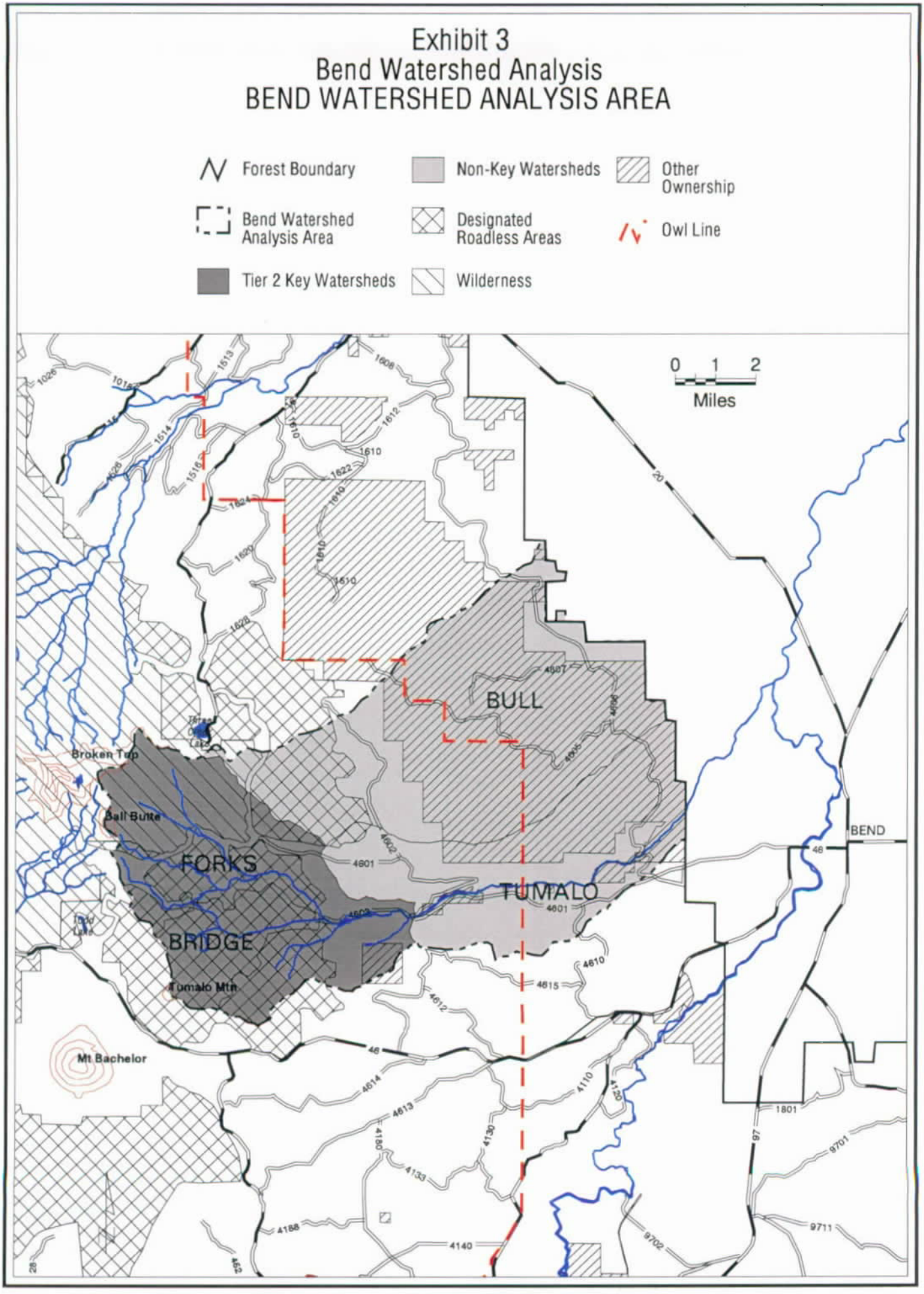


Exhibit 4
Bend Watershed Analysis
TOPOGRAPHICAL VIEW

Forest Boundary

Major Roads

Bend Watershed Analysis Area

Selected Other Roads

0 1 2

Miles

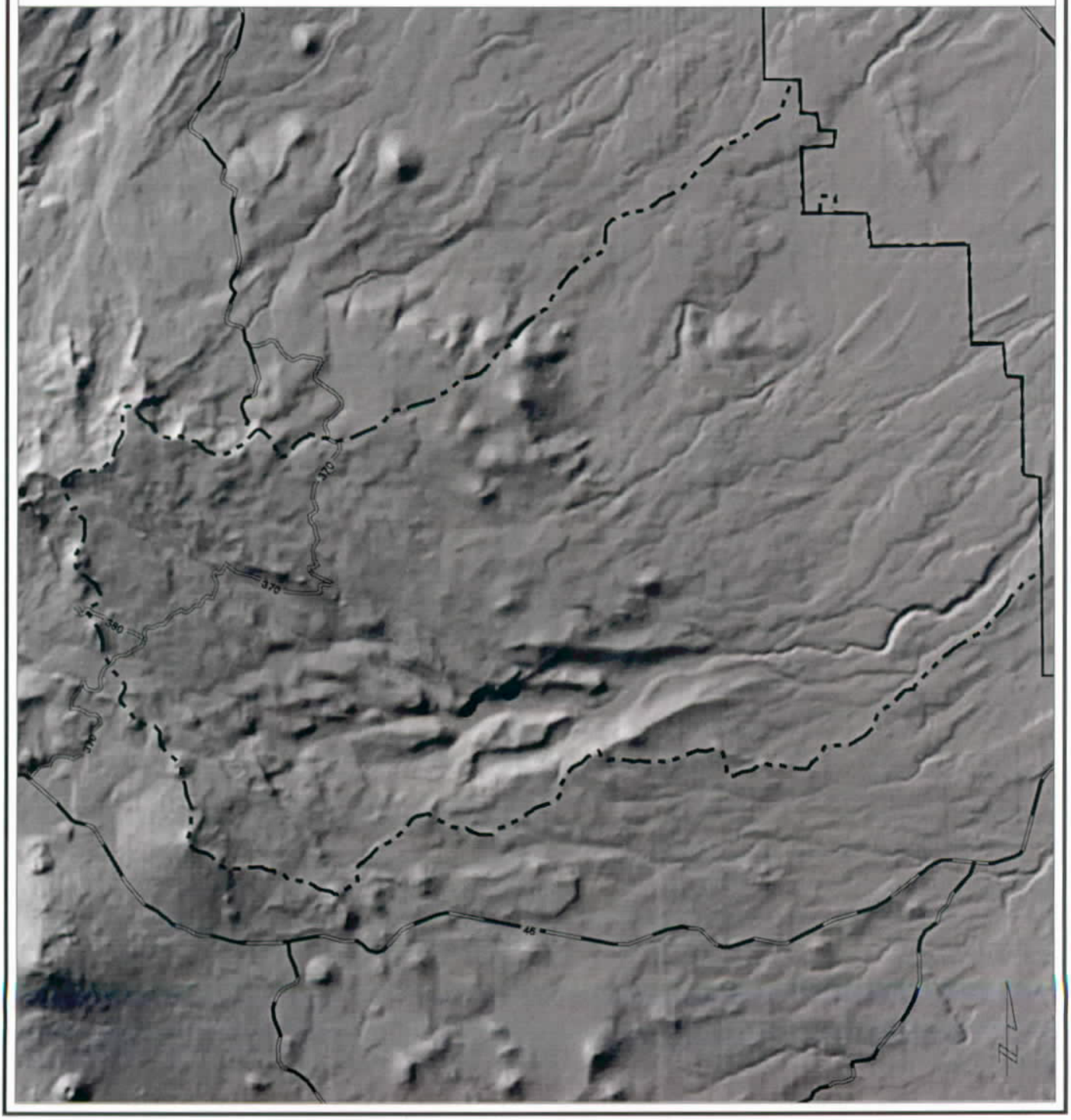


Exhibit 5
Bend Watershed Analysis
NORTHWEST FOREST PLAN ALLOCATIONS

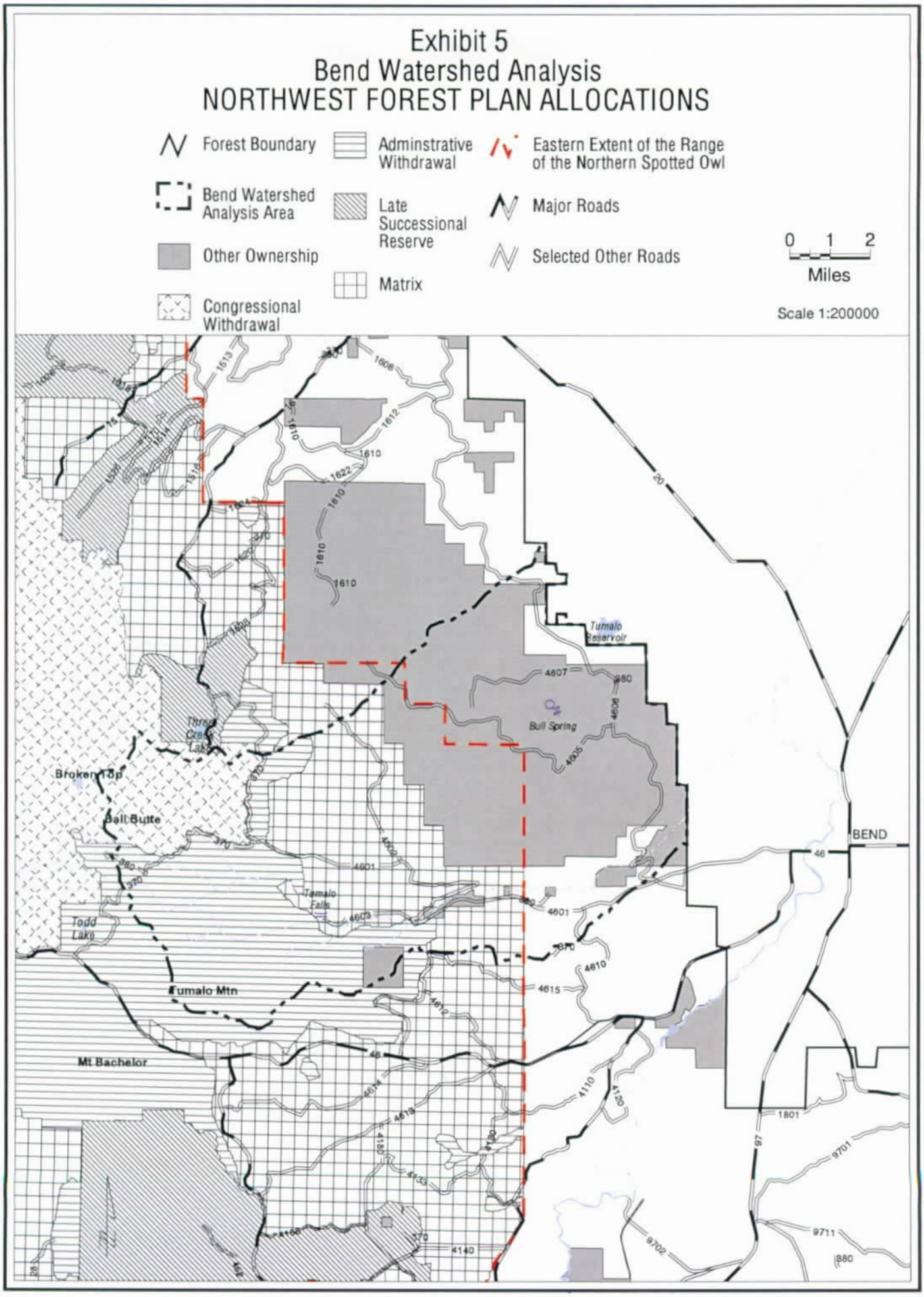


Exhibit 6
Bend Watershed Analysis
DESCHUTES FOREST PLAN MANAGEMENT AREAS

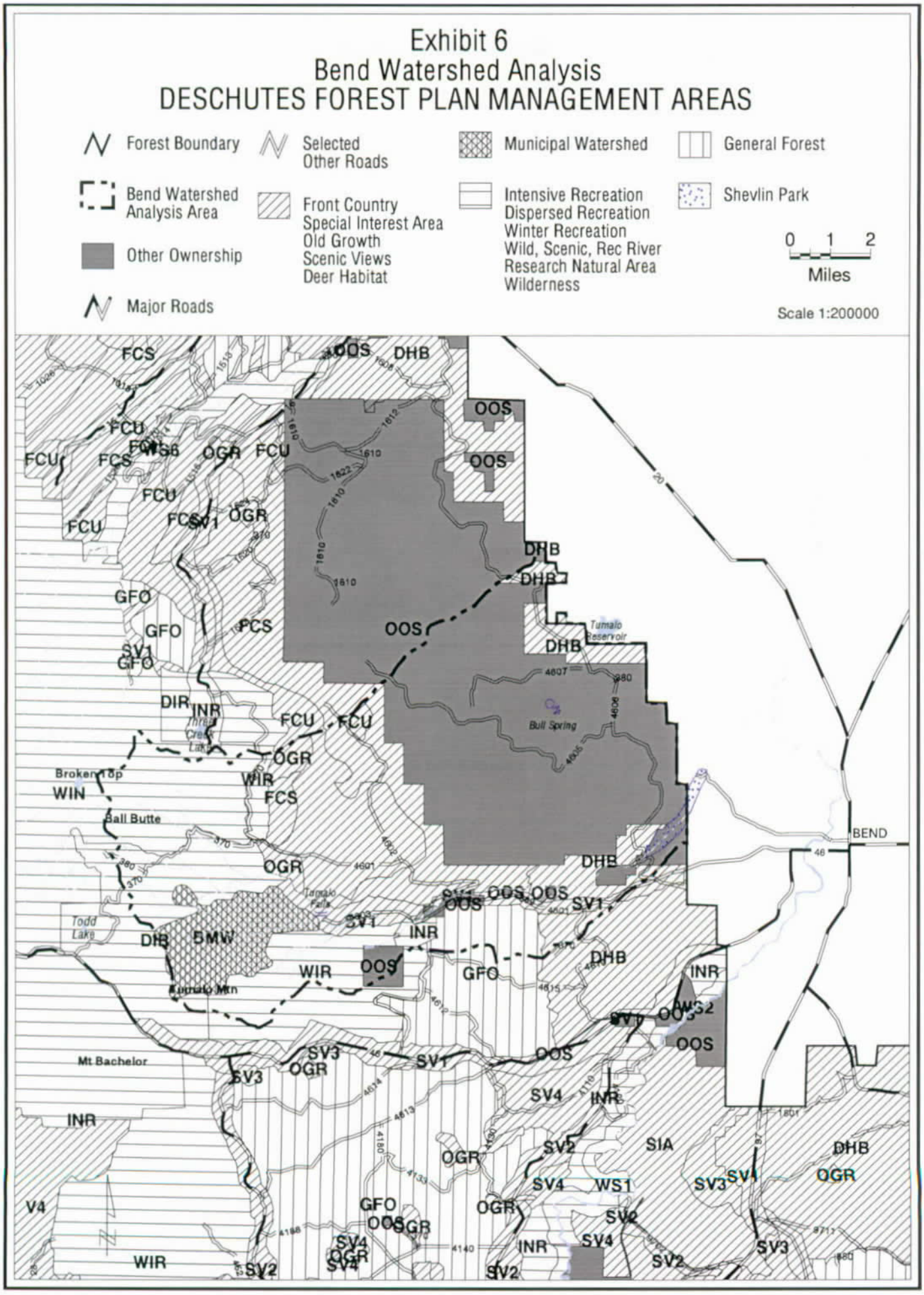


Exhibit 7
Bend Watershed Analysis
LANDSCAPE FLOWS

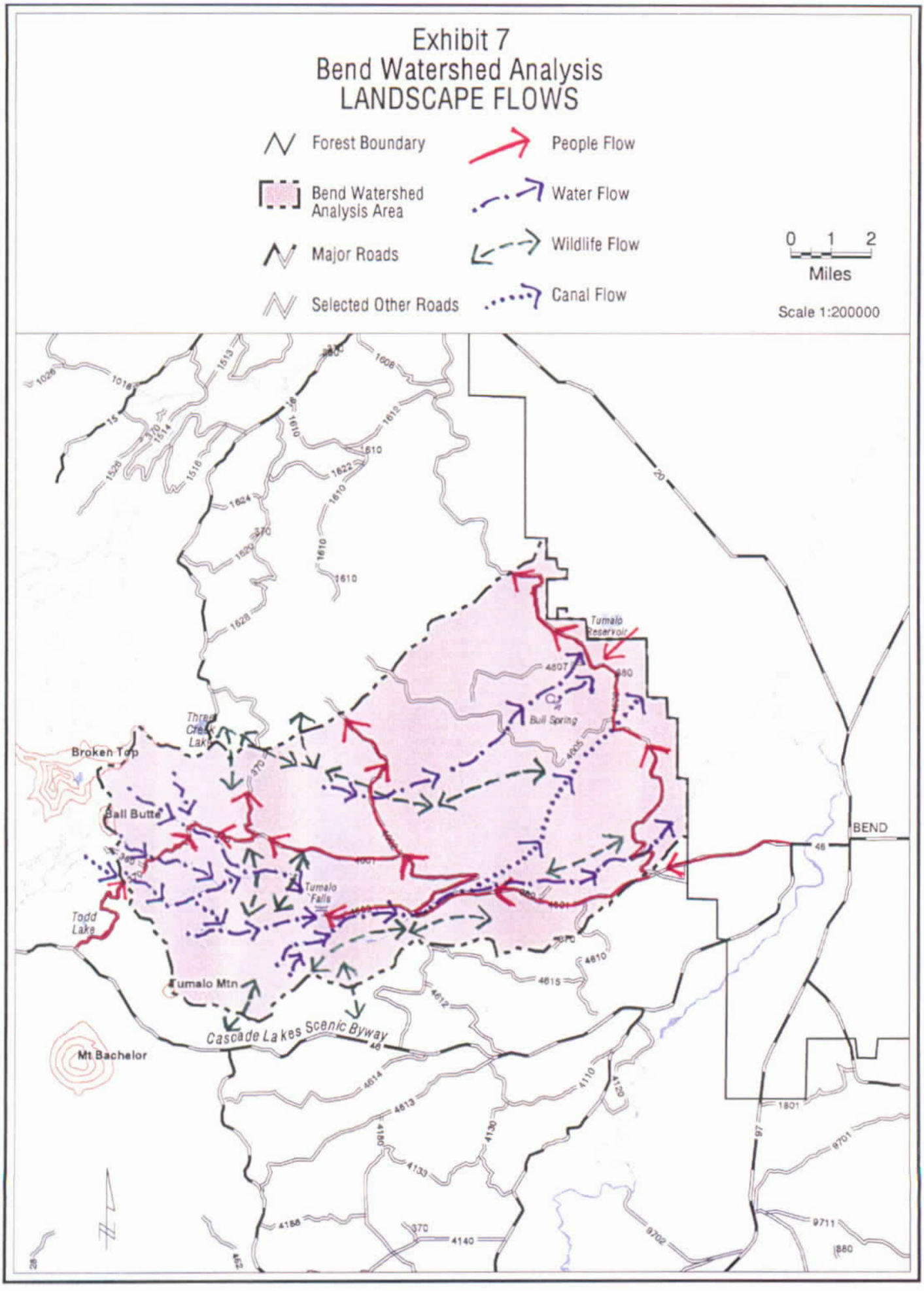
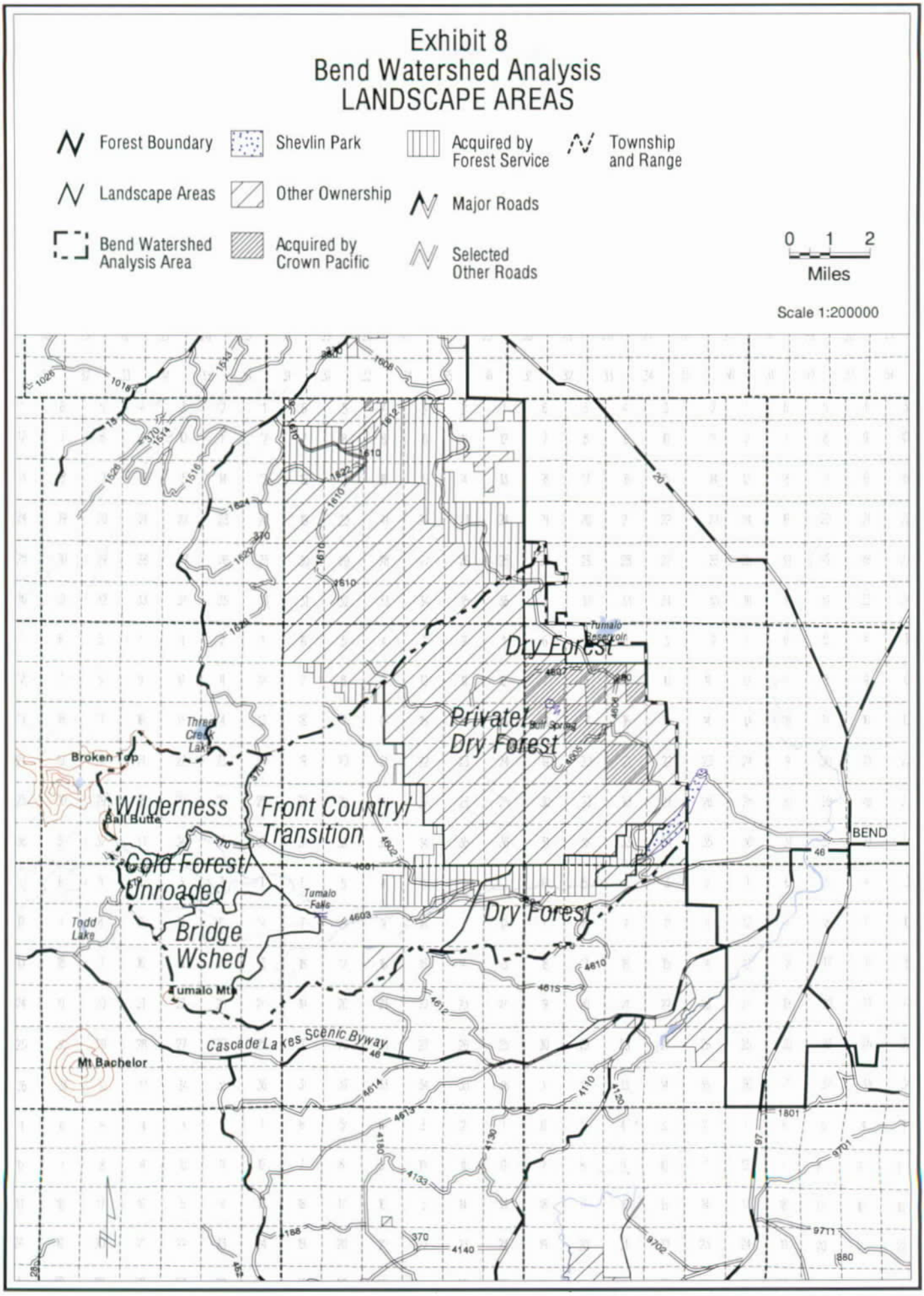


Exhibit 8
Bend Watershed Analysis
LANDSCAPE AREAS



large increases in flow. This may be partially due to the somewhat impermeable glaciated soils underlying a relatively thin layer of Mazama ash. Also contributing and of greater significance are the steep slopes which exceed 60 degrees in some areas. Perennial and ephemeral streams drain snowfall accumulations from Broken Top and Tumalo Mountain and travel in an easterly direction, collecting into Tumalo Creek which eventually flows into the Deschutes River approximately 8 miles north of Bend. There are several small lakes in the watershed with the largest totalling 16 acres in size. The Bend Municipal Watershed is a significant and primary feature occupying most of the Bridge Subwatershed. The City of Bend diverts water from Bridge Creek fro a significant portion of its drinking water.

Water Quantity

The drainage basin encompasses 47.3 square miles above the gaging station in Shevlin Park. Tumalo Creek fluctuates between about 75 cubic feet per second in the winter months to a normal run-off of 300 to 400 cfs in May and June, with an average annual mean flow of around 100 cfs.

Water Quality

The streams are cool and generally clear, with maximum summer temperature in Tumalo Creek in the mid-50's (Fahrenheit). The tributary streams have similar temperatures or are cooler. Turbidity increases during periods of snowmelt and thunderstorm events. Stream banks and sloping hillsides along Bridge Creek and Tumalo Creek within the Bridge Creek Fire area that are unstable contribute sediments at these times. The water quality of Bridge Creek is among the best in the United States for a surface water system (Reference: Prowell, Roger, City of Bend Watershed Report for 1997, Bridge Creek Watershed, p. 5). Water extracted from Bridge Creek for municipal use is filtered only via gravitational methods and chlorinated before delivery.

Diversions

During the past 100 years, the natural hydrology within the watershed has been greatly altered. Water from Crater Creek, a tributary to Soda Creek which is within an adjoining watershed, is diverted through a small canal to the Middle Fork of Tumalo Creek. Tumalo Irrigation District owns the water rights. Flow from springs destined for the Middle Fork of Tumalo Creek are diverted into Bridge Creek. This is the source of a large portion of the drinking water for the City of Bend. The Columbia Southern Canal has historically withdrawn irrigation water during the summer months from Tumalo Creek downstream of Skyliner Bridge, often reducing instream flows to less than 5 cfs. Due to this flow modification, the stream below the diversion is on the Oregon Department of Environmental Quality 303(d) list for water quality impaired streams. In 1998, water was not diverted because the Tumalo Irrigation District was able to utilize the diversion below Shevlin Park for its water needs. This is a policy that is likely to continue, although the upper diversion will still remain in case a future need arises.

SOIL RESOURCE

The soil resource is dominated by ash and pumice from Mt. Mazama on the surface and glacial till or other localized volcanics in the subsurface. Subsurface material is generally coarse textured and has very low cohesion properties. Subsurface materials on the eastern edge of the watershed include basaltic lavas and glacial outwash. Greater amounts of cinders, colluvium, and residual buried soils are present in the subsurface of the western half of the watershed, as are lands barren of soil material. The inherent productivity of the soil resource is primarily moderate (23,912 acres = 39 percent) and low (24,768 acres = 40 percent), with a lesser amount of high site class lands (12,980 acres = 21 percent). Lands classified as unsuited for timber management, for both social as well as physical site capability reasons, are located at higher elevations (generally within Wilderness) and on the eastern fringe (Soil Resource Inventory Map Unit #36).

Soil productivity is directly influenced by annual precipitation, elevation, aspect and soil profile depths, each of which can be limiting within the watershed. Annual precipitation ranges from 15 to 40 or more inches on an east to west trending scale, elevations range from approximately 3,500 to 8,000 feet, aspects are predominantly easterly in nature, and soil profile depths to bedrock range from moderately deep (greater than 60 inches) to shallow (less than 24 inches). Erosional processes are primarily surface in origin, although some slopes within the watershed are steep enough to exhibit mass wasting. Summer thunderstorm events are the most likely to influence surface erosion of the low cohesion soils present.

AQUATIC SPECIES

Rainbow trout and non-native eastern brook trout can be found in many of the streams. Bull trout could have been present in Tumalo Creek at one time. Tumalo Lake contains eastern brook trout and there are no fish in the other lakes. Redband trout were once native to the watershed but may have hybridized with introduced rainbow trout. Although rainbow trout stocking ended in the 1970's, final analysis of genetic sampling to determine the degree of hybridization is still pending. Eastern brook trout, native to the east coast of North America, were introduced over 50 years ago and have established a self-sustaining population. Fish sampling is limited within the watershed, but in Tumalo Creek within the Bridge Creek Fire area, approximately 75 percent of the fish population are eastern brook trout. Eastern brook trout typically outcompete rainbow trout. The flow regime appears to favor the fall spawning eastern brooks over the spring-spawning rainbows, as high flows that can dislodge freshly laid eggs in the gravel are more frequent in the spring during the snowmelt period. Aquatic invertebrate communities are moderately diverse and abundant. There are no known species on the Regional Forester's Sensitive Species List inhabiting the Bend Watershed.

Habitat Conditions

Diversion of water for irrigation purposes and municipal use have altered flow regimes in Bridge Creek and Tumalo Creek. The Bridge Creek Fire of 1979 burned through and caused heavy short-term impacts to the riparian zones of Tumalo Creek (3 miles), South Fork (0.5 miles), and Bridge Creek (1 mile). Salvage operations removed wood from streams and along stream banks. Along with recruitment of gravel to the streams, elevated quantities of

fine sediment have been added from stream bank and adjacent hillside erosion. In contrast, the riparian zones outside of the fire damage area remain in good condition with stands of large spruce, fir, and mountain hemlock.

Restoration of Tumalo Creek began in the early 1990's. Whole trees were placed and anchored into the channels within the Bridge Creek Fire area. Willow, cottonwood, and Engelmann spruce were planted along the banks. The wood structures shifted during high flows in 1995 and 1996 from rain on snow events. This caused stream bank erosion and created a few very large log jams. Loss of canopy along the stream after the fire has resulted in slightly increased although still relatively cool water temperatures. The stream has likely become more biologically productive due to additional exposure to sunlight with the loss of the streamside canopy. Eventually, as the canopy becomes re-established, biological productivity will return to pre-fire levels.

The streams are bountiful in gravels, cobbles, and boulders for spawning, rearing, and aquatic macroinvertebrate habitat. Cool water temperatures and shade have limited the food supply and fish growth. Habitat below the Columbia Southern Canal diversion is under-utilized when water is being withdrawn. Historically, the streams were heavily shaded, cool and clear with good gravels and abundant large wood. Habitat above the falls was not utilized by fish.

Fish Composition and Distribution

Fish introductions by man have allowed distribution of rainbow and brook trout to occur above Tumalo Falls which would have ordinarily acted as a natural fish barrier. Rainbow trout have also been documented in Tumalo Creek, near the headwaters of Bridge Creek, and in the South Fork of Tumalo Creek. Brook trout have been documented in Tumalo Creek, the Middle Fork past the confluence with Bridge Creek Canal, the North Fork up to Happy Valley, Tumalo Lake and the creek that drains it, the South Fork up to the junction of the 2 channels, and in Bridge Creek up to the diversion dam. They are also found in many of the small springs and beaver ponds in the flood plain. Fish are unable to migrate futher upstream on Bridge Creek because of the dam.

In recent surveys conducted within the Bridge Creek Fire area of Tumalo Creek in August 1998, bull trout were not observed. Historically, redband trout and possibly sculpin and bull trout were distributed up to migrational barriers or large gradient increases. The majority of occupied habitat was Tumalo Creek up to Tumalo Falls, Bridge Creek up to the first falls, and the South Fork of Tumalo Creek. Redband trout are currently on the Regional Forester's Sensitive Species List. As of June 13, 1998, bull trout of the Columbia Basin were listed as threatened by the U.S. Fish and Wildlife Service.

VEGETATION

Upland Forest Vegetation

In the Bend Watershed, there exists a great variety in forest types. Variations in climate, soils, elevation and topography have combined to provide diverse forest assemblages that differ in species composition, structure and density.

Existing vegetation within the watershed follows an elevational and associated moisture gradient that ranges from high elevation, sparsely vegetated, "krummholz" forest types on rocky zones, down through moist forests composed of dense mountain hemlock stands, into mid-elevational zones of mesic lodgepole pine and mixed conifer landscapes, and finally to xeric forested stands of ponderosa pine. Disturbance processes also follow this elevational transect with the greatest change from the native ecological regimes increasing in the descent through the elevational zones. Riparian communities pass through the elevation gradient and provide connection to these different landscape features.

Additionally, the degree of change from the native or natural forest setting generally follows this elevational gradient with the most pristine composition high in the watershed, and the highest degree of departure from the pristine, becoming apparent in the approach to high-density population centers such as the nearby city of Bend. Alterations in the native forest, both in terms of the the forest architecture and ecological function, are the result of human intervention within the past century, mostly fire suppression, timber harvest, road building, and general human access. Fire suppression has creaaated more potential for larger and more intense fires.

Plant Association Group (PAG)

The major forest communities and the typical species found within them are listed from dry to moist to cold environments. Note that 95 percent of the total watershed acreage can be grouped into 5 major forest vegetation types (Source: Forest-wide PAG layer).

Forest Vegetation Structure

At a very general description, forest structure at the landscape level is dominated by the following: early conditions within the Bridge Creek Fire area on approximately 3,400 acres, mid-structure stands within the previously manipulated ponderosa pine and mixed conifer zones outside the Bridge Creek Fire area, and late structure in the passively managed lodgepole pine and mountain hemlock zones (Source: Photo Interpretation/Most Similar Neighbor (MSN) Database Analysis, 1998).

Forest Vegetation Density

The existing stand densities that occur across the entire watershed ranges from low to high density with each of the 3 density classes nearly evenly split. However, densities tend to be less variable and tied to Landscape Zones found in the watershed (See Chapters III and IV for more information).

Insects and Pathogens

Insect activities have been recorded from aerial reconnaissance annually for the past 2 decades. Maps of current insect agents at work within the watershed indicate the most apparent insect agents are bark beetles and defoliators (Source: 1997 Aerial Survey). Forest pathogens are well represented throughout the watershed also and include but are not limited to root rot, stem decay, and dwarf mistletoe.

TERRESTRIAL WILDLIFE SPECIES

Habitat

Types of wildlife species present in any given area are determined by characteristics of the environment. For example, variations in elevation, topography, vegetation structure and type, latitude, climate, and precipitation are all factors which, in combination with countless other variables, form the assemblage known as habitat. In addition to the physical environment, nearly all species on the planet are subject to some level, whether direct or indirect, of human interaction. The intensity and type of human interaction and/or habitat alteration will largely determine the ability of a species to persist even in a structural environment for which it is most aptly suited.

Habitats and human interactions within the Bend Watershed vary widely. Portions of the watershed have changed only slightly in comparison to historic conditions. These areas continue to support wildlife requiring even the most pristine of habitats. Other areas within the watershed have been altered dramatically by fire suppression, timber harvest, road construction, and general human access. The scope of changes in habitat structure has been significant enough to create unsuitable conditions for species historically found in the same area.

Both scope and intensity of altered environmental conditions as well as basic habitat types within the watershed generally follow the elevation gradient. At lower elevations, areas once dominated by large stands of mature ponderosa pine now consist primarily of small and medium diameter cultivated stands of the same species.

Mixed conifer and lodgepole pine stands in the middle elevations of the watershed area have experienced varying levels of insect outbreak, timber harvest, and stand replacement fire that reduced late and old structure. However, stands are largely intact and fragmentation is low to moderate. Fire suppression has led to unnaturally dense stands subject to a higher level of instability. Road densities range from light to heavy and recreation activity is significant in some areas.

The upper elevations have undergone relatively little change in comparison to historical conditions. These acres are dominated by late structure mountain hemlock forests as well as alpine meadow and rock. Roading is minimal or nonexistent and recreation access and activity is considered light. A lack of timber harvest, and significant natural stand altering events has minimized the effects of fragmentation.

Species Diversity

Wildlife species composition varies widely throughout the watershed both seasonally and spacially. Significant changes in elevation allow a wide representation of habitat types including high desert shrub, upland wet and dry forest, riparian, and alpine communities. In excess of 200 wildlife species are estimated to inhabit the watershed. Since fragmentation and disturbance are minor at the middle and upper elevations, immigration, emigration, and exchange of genetic information are relatively unobstructed. High road densities and intensive timber harvest in the lower elevations of the watershed have created movement barriers for many species.

The following threatened, endangered species (TES) and selected wildlife species have suitable or potentially suitable habitat within the watershed: peregrine falcon, bald eagle, northern spotted owl, wolverine, Townsend's big-eared bat, Preble's shrew, black-backed woodpecker, northern goshawk, great gray owl, pileated woodpecker, flammulated owl, marten, fisher, lynx, spotted frog, and Cascades frog.

No portion of the watershed has been surveyed for TES wildlife species. Among TES species, bald eagle and peregrine falcon are the least likely to occupy the watershed due to a lack of suitable foraging habitat. Wolverine and Townsend's big-eared bat are probable occupants, while the lynx is a possible occupant, but the probability is low.

There are an estimated 1,126 acres of suitable nesting, roosting, and foraging (NRF) habitat for the northern spotted owl (a likely occupant), and an estimated 9,300 acres of dispersal habitat within the watershed. Remaining acres are classified as unsuitable for this species.

The watershed functions as summer, transition, and winter range for both deer and elk. Areas near water also serve as suitable fawning and calving habitat. Both deer and elk migrate between summer and winter ranges in a west-east direction.

FIRE/FUELS

There are currently a variety of vegetation types and fire regimes within the Bend Watershed that represent the effects of historically repetitious fire with variable spread rates and intensities. A modern day sampling of fire occurrence data from 1970 to 1997 reveals 142 detectable ignitions which is roughly equivalent to 5 fire starts annually. Most of these fires were ignited by natural causes (104 fires or 73 percent). The area could still be accurately described as a "fire environment" with a human component that is increasing the likelihood of fire starts in the area.

The 1979 Bridge Creek Fire was a human caused event which burned most of the vegetation within its boundaries over a total of 3,400 acres. This fire has minimal mosaic patches which are scattered only along a small portion of the fire boundaries. The intensity of the fire may have contributed to the short-term hydrophobic character of the pumice soil in some areas. Structures were placed on slopes following the fire to reduce downhill flow velocities and sedimentation rates into Tumalo and Bridge Creeks. Although some south aspect slopes

adjacent to the creeks remain partially bare of vegetation, the majority of the slopes have revegetated enough to make them relatively stable.

In recent history, this is the only large scale fire event ever to occur within the Bend Watershed. A potential risk exists for a similar event given the right combination of weather patterns and fuel conditions. Although the probability is low due to the right conditions occurring only on about 6 days throughout the entire year, these identified conditions would still require monitoring during the summer months.

RECREATION

Primary access routes are Road 370 to Todd Lake and to the Broken TopTrailhead from the Cascade Lakes Scenic Byway, Road 4601 to Skyliner Lodge and Tumalo Falls Overlook, and the northern portion of Road 370 which joins the Three Creeks Road from Sisters. The Skyliner recreation area is only 10 miles from Bend and apart from paved roads, routes accessing recreation facilities varying in standards and maintenance levels with some roads minimally maintained for high clearance vehicles at moderate to low levels. Other access routes along the Cascade Lakes Scenic Byway are Road 4615. Road 4612, and several other minor roads which includes access from private lands.

The developed recreation facilities providing access to the watershed are trailheads, snoparks, and Skyliner Lodge which operates through a special use permit to the Oregon Museum and Science Industry for environmental education. Primary trailheads that access the area are Tumalo Falls, Skyliner Lodge, Shevlin Park (Bend Metro Parks and Recreation), Todd Horse Camp, Broken Top Trailhead, and Phil's Trail, a popular mountain biking trail. Primary snoparks are Meissner, Wanoga, Swampy, and Dutchman. The Recreation Opportunity Spectrum classifies the watershed as mostly Semi-Primitive (non-motorized in the summer and motorized in the winter) and Roaded Natural.

An extensive network of summer and winter trails provide opportunities for hiking, mountain biking, equestrian riding, nordic skiing, snowshoeing, dog sledding, and snowmobiling. Areas closed to motorized use in the winter are the Three Sisters Wilderness, Tumalo Winter Closure, Swampy/Meissner Closure, and the Bend Municipal Watershed. The unroaded areas are closed to motorized use in the summer. Dispersed camping is mostly hunting related and is popular along Road 370 and Road 4601. Big game hunting season begins with archery season in August and goes through November when snowfall usually becomes substantial.

Chapter II
Issues and Key Questions

Chapter II
Issues and Key Questions

Issues were identified by the team as a way to focus on the primary elements of the ecosystem that are most relevant to the watershed in terms of management objectives, human values, and resource conditions. Also formulated were key questions from indicators commonly used to measure or interpret critical ecosystem elements. The issues and key questions were then used by the team to identify resource management concerns and trends as a way to provide a basis for the management recommendations in Chapter VI.

ISSUE 1. SUSTAINING WATER QUALITY AND RIPARIAN HEALTH

Background:

The water quality of the Bend Municipal Watershed is among the best in the United States for a surface water system that is generated primarily by a constant flow of cool, clear spring water. Increased recreational use and the greater risk of fire potential as fuels accumulate may affect the future ability of the Bend Municipal Watershed to provide water quality that complies with the standards of the Safe Drinking Water Act of 1986. The desired condition for water quality, riparian health, fish habitat, and stream function in Tumalo Creek is not currently being met within the Bridge Creek Fire area. Even after 20 years following the fire event, recovery is still slow and occurring at a rate that may be improved through selective restoration activities.

Fish habitat and stream function have also been compromised in the lower sections of Tumalo Creek due to flow modifications below the Columbia Southern Canal diversion. This section of the stream is currently on the DEQ 303(d) list for impaired streams as a result of flow modification that has often been less than 5 cfs during the summer months. These conditions improved in 1998 due to the Tumalo Irrigation District's decision to divert all of its water at its diversion below Shevlin Park, leaving an estimated 40 to 50 cfs in the channel throughout the summer months. This policy is expected to continue in future years and could possibly alleviate the conditions that may have allowed elevated temperatures to occur during the summer months.

Key Questions:

1. What is the status of water quality within the Bend Municipal Watershed and what level of use in current activities is appropriate in order to maintain high water quality in the long-term?

The status of water quality is excellent, although the turbidity limits imposed by the City of Bend are exceeded on approximately 20 days annually, primarily during snowmelt season, thunderstorms, or rain on snow events. Restricting recreational activities within the watershed since 1991 has been an effective means of maintaining water quality, although no significant improvement is shown in the turbidity data. The majority of trail areas do not contribute sediment directly to perennial streams, although there are a number of stream

crossings that do not have boardwalks or bridge crossings. Very little water bar installation or maintenance has occurred on the Bridge Creek Trail since mountain bike use was eliminated, creating areas that are still moving sediment downslope and into the stream in some cases. If future monitoring shows degradation of water quality, limits would need to be imposed upon the numbers of users and types of activities.

2. What is the status of water quality, fish habitat, and hydrologic characteristics of Tumalo Creek within the Bridge Creek Fire area and does the stream meet Proper Functioning Condition (PFC)?

Several studies and surveys are scheduled to provide information for evaluating current ecological conditions. The Bridge Creek Fire and subsequent salvage of large wood have created relatively unstable, transitional stream conditions typical of disturbed systems of this type. Even though water temperatures are cool and water quality is within acceptable limits, the stream channel has problems with the volume of sediments in spawning gravels, bank erosion and a slightly depressed diversity in macroinvertebrates. The stream is also somewhat out of balance in terms of riffles, pools, and natural width to depth ratios due to the limited amount of root wads and trees in some reaches of the stream channel. Despite a significant amount of coarse woody debris added in 1990 and 1992, the high flows of 1995 and 1996 created a few large log jams and limited numbers of isolated structures within the Bridge Creek Fire area. A PFC survey will be done in the near future. Additional surveys for measuring the hydrologic integrity of Tumalo Creek are planned for 1998 and 1999.

3. What are the flows, fish habitat and hydrologic conditions in Tumalo Creek below the diversion and what flow would be needed to remove Tumalo Creek from the 303(d) listing?

Annual flows within this section of Tumalo Creek have generally been approximately 50 cfs during the winter months, 300 to 400 cfs during spring run-off, and less than 5 cfs during summer irrigation months. Low summer flows have resulted in a reduction of fish habitat and modified hydrological conditions. The 1998 flow during the summer irrigation season was approximately 40 cfs due to a change in policy by the Tumalo Irrigation District to divert its water below Shevlin Park, a policy which is expected to continue into the future.

Fish habitat is variable within this section but generally improves with higher flows. Hydrologic conditions include riffles, cascading habitat, Rosgen B-type channel with low frequency of pools, and a lack of complexity following the removal of stream "debris" by irrigation users. There has been more interest recently from private landowners to improve fish habitat and prevent further stream degradation. It is not known at this time whether the additional 40 cfs remaining in the stream would be adequate enough to remove the stream from the 303(d) listing. Thermograph installation is planned for 1999 to measure water temperatures during the summer months. This stream section has been identified as an area for future work between the State Department of Environmental Quality and irrigation users to improve fish habitat and reduce summer water temperatures.

4. What fire risks exist due to present fuel loadings?

Fire risk is moderate to high for this area although the potential for large fires is mitigated to some degree by the close proximity of the Bend Watershed to the Redmond Air Center. The risk of fire continues to increase over time as the upper extent of natural fire return intervals in these forest types are approached or exceeded and fuels continue to build. Fires that do occur are likely to be stand replacement events capable of exposing extensive areas of bare mineral soil susceptible to erosion from rainfall and snowmelt accumulations.

ISSUE 2. PROTECTING RESOURCE VALUES WHILE MAINTAINING A QUALITY RECREATION EXPERIENCE WITH APPROPRIATE USE LEVELS AND ACCESS.

Background:

Soil quality within the watershed has been affected in some areas by accelerated erosion from recreational uses, primarily foot traffic off of designated trail routes to overlooks or down to the stream course. A few trail locations are susceptible to contributing sediment into stream habitats, including sections of the South Fork and North Fork Trails where such steep grades were not originally designed for mountain bike use or were poorly located. Sections of Road 370 and Road 4601 have soil erosion problems at stream crossings or on steep grades that need to be stabilized or restored. Wildlife populations and habitat may also be adversely impacted from increased recreation use and development within the watershed.

Key Questions:

1. How do we maintain water quality as upland recreation activities increase the chance of water quality degradation via sedimentation?

Water quality can be maintained through seasonal closures to motorized use, restricted access to detrimental uses, development and implementation of an educational program through the City of Bend, State DEQ, Oregon Health Division, and the Forest Service, relocation or rehabilitation of problem trail and road sections, and maintenance of roads and trails at the prescribed minimum level.

2. What management actions are necessary to minimize the risk for detrimental impacts from Road 370, Road 4601, and continued recreation use and development of trail systems?

Risks for detrimental road-related impacts can be minimized through surface treatment and spot hardening, enforced road closures with seasonal closures to allow dry season use only, selective water bar locations, and relocation or rehabilitation of problem grades. Future development of trails needs to involve resource specialists in the site analysis and design phases of the planning process in order to be more effective in recommending ways to protect the site from detrimental impacts. The continued monitoring of recreation uses and associated impact levels are critical and necessary in order to repair and restore damaged areas quickly.

3. What kinds of recreation use conflicts between users or with resources need to be prevented or resolved?

Current recreation users are primarily mountain bikers, hikers, and horseback riders. Recreation experiences can be improved and conflicts prevented between mountain bikers and horseback riders by providing separate user trails. Providing access to information would increase user awareness and promote trail etiquette. Conflicts between mountain bikers and hikers usually occur in downhill and straightaway situations. Designing trails with lower grades, multiple curves, or trail turnouts can be used to control the high speeds of mountain bikers. Downhill traffic can also be restricted in certain cases. Resource impacts from recreation use are primarily associated with soil erosion and increase of fine sediment in streams resulting from the loss of vegetation.

4. What limits to recreation use would protect wildlife habitat?

Wildlife habitat protection would occur by limiting motorized use through seasonal closures. Restricting inappropriate uses from certain areas needs to be enforced by trail signing and rerouting.

ISSUE 3. SUSTAINABILITY OF FOREST CONDITIONS WHERE RESILIENCY IS BEING LOST.

Background:

Forest resilience to insects and disease agents has diminished outside the Bridge Creek Fire area as stand densities have increased and shade tolerant species populate warmer and drier sites, a result of practices such as fire exclusion and selective harvesting. Vegetative conditions include an extensive area of unfragmented forest at mid and upper elevations, a loss of large tree structure at lower elevations, and forest encroachment in meadow areas. Mid-elevational, dry mixed conifer stands are the most significantly affected by an increase in density, including a potential loss of large trees from increased competition, and a greater risk of stand replacement fire. The Bridge Creek Fire of 1979 has created the only significant break in connectivity within these mid-elevational stands.

Outside of firewood harvests, past management activities within the mid-elevational, lodgepole pine stands have been relatively minimal and with a skeleton road access system in place, few stand management treatments have been implemented in the past 20 years. Lower elevational ponderosa pine stands (mostly on private lands) have been heavily harvested in the past, with railroad era clearcuts creating large blocks of middle-aged forests that are found today. Most treatments have occurred within the stands located on lands owned and managed currently by Crown Pacific. Currently, most of these stands are more resilient to insect agents where densities have been reduced although they are still somewhat at risk to fire disturbance due to their uniform crown cover and shrub component. Increased access provided by a much greater road network on private lands can lead to faster fire suppression response times on the ground.

Key Questions:

1. How do we maintain an existing unfragmented landscape in the mid-elevational stands while reducing the risk of insect epidemics and stand replacement fire events such as the Bridge Creek Fire of 1979?

Difficulties exist in maintaining an unfragmented landscape that was naturally disturbed through fire cycles and insect and disease agents. Realistically, most proposed situations would actually end up trading one kind of fragmentation for another. Active management would create smaller, patch size openings and passive management would result in larger areas of disturbance from insects and disease or from stand replacement fires such as the Bridge Creek Fire. The fragmentation caused by a fire at that scale and level of disturbance opens up the potential for another fire to occur there in the future.

In some cases, the desire for passive management of these stands to maintain important values such as wildlife habitat and positive recreation experiences. Currently, the stands are relatively healthy although the risk of loss due to stand replacement fire events would continue to increase over time.

2. Where can conifer encroachment in wetlands be reduced while still maintaining healthy watershed function?

Reduction can occur in aspen pocket areas and isolated wet meadows in upland areas.

3. What stands would benefit from stocking level (density) reduction to promote stand resilience?

Drier forest types, such as dry mixed conifer and ponderosa pine stands would reap the greatest benefits from stocking level reduction, expressed primarily in activated vigor of residual trees. Moist or upper elevational cold forest types would receive the least benefits. Lodgepole pine may actually benefit from increased density, especially in more mesic zones although these types are considered to have fewer economical benefits. Stands within the mid-elevational zone appear to have the least amount of changes from natural disturbance regimes although the risk of larger scale fire disturbances is increasing. Current trends in land management with continued fire suppression would create a greater number of older forests with fewer openings than may have existed historically.

Unanswered Questions for Issue #3:

1. How far are we from historic regimes for meadow succession?

2. To what degree are we outside of normal conditions?

3. What kinds of effects on wildlife habitat have been caused by forest encroachment?

4. What is the probable future of this landscape in 10, 50, 100 years?

Chapters III and IV
Historic and Current Conditions

Chapters III and IV
Historic and Current Conditions

HYDROLOGY

The Forks and Bridge subwatersheds within the Bend Watershed are sources of high quality water, providing municipal drinking water and irrigation water. Recognized as Tier 2 Key Watersheds in the Northwest Forest Plan, they have the highest priority for restoration activities and require watershed analysis to be completed prior to long-term management activities occurring. Special standards and guidelines which apply are found on page C-7 of the Record of Decision for the Northwest Forest Plan.

Annual precipitation ranges from approximately 40 inches in the western portion of the watershed to 15 inches at the eastern edge. Perennial streams are Bridge Creek, Spring Creek, Tumalo Creek, South Fork, Middle Fork, and North Fork of Tumalo Creek, an unnamed stream which drains Tumalo Lake, Bull Springs, and several other unnamed springs. Intermittent streams include Bottle Creek and Rock Creek. Streams drain the higher elevations of Broken Top and Tumalo Mountain to the west where the heavy snowpack melts and generally flows in an easterly direction through glaciated valleys. The water collects in Tumalo Creek and eventually enters the Deschutes River approximately 8 miles north of Bend. Very little surface water exists in the eastern portion of the watershed.

Although perennial streams are more numerous in the western portion of the watershed than in other areas on the Bend/Ft. Rock Ranger District, most of the area is still considered to be a groundwater recharge area. Numerous springs provide cool, clear water. Snowmelt and precipitation are major contributors to surface water discharges. Tumalo Creek and its tributaries are unusual for Upper Deschutes River Basin streams in that they respond immediately to rain on snow events with large increases in flow. This may be partially due to the somewhat impermeable glaciated soils underlying a relatively thin layer of Mazama ash. Also contributing and of greater significance are the steep slopes which exceed 60 degrees in some places. The few lakes within the watershed are small and shallow.

The potential for mass wasting is low because of the absence of indicators of past or recent landslides. Erosional processes are generally from lateral scour of streambanks and sideslope rill, especially during thunderstorms and snowmelt. There is some channeling of water on Road 370 and on trails during storm events and snowmelt resulting in overland flow of sediments. The diversions of water for the municipal water supply and irrigation and the Bridge Creek Fire are the most significant factors that have changed current hydrologic conditions from historic conditions.

HISTORIC CONDITIONS

Water quality in the streams has historically been excellent with cool temperatures moderated by flow from springs. Summer temperatures ranged from the low 40's to the mid-50's Fahrenheit. Erosional processes were limited primarily to lateral migration of channels, adjustments of channels to log jams, and rill from hillslopes during thunderstorms and

snowmelt periods. Stream banks were well vegetated and stable. Stream types were primarily Rosgen B types, high in gradient and dominated by riffle habitat. There were some reaches of C type where gradients were lower and pools were abundant. Instream large wood was abundant in the lower gradient reaches but less in the high gradient reaches where it was moved out at high flows. Vegetation ranged from mixed conifer in the higher elevations to primarily ponderosa pine in the lower elevations. Seral stages were mid to late adjacent to streams. There was a component of deciduous species such as mountain alder, willow, cottonwood, and aspen.

Prior to the diversions, Tumalo Creek would have had more instream flow for much of the year. The withdrawal for the City of Bend Municipal water supply is offset by the input from the Crater Creek Canal for only about 3 months out of the year. Tumalo Creek below the present Columbia Southern Canal diversion had higher summer flows and provided better fish habitat. More volume would have been provided to Sparks Lake due to increased summer flows from Crater Creek and Soda Creek, which is in an adjacent watershed, prior to the Crater Creek diversion.

CURRENT CONDITIONS

Wilderness Landscape Area

Surface water resources within the Wilderness Landscape Area are limited to an unnamed small perennial stream, the upper portion of the North Fork of Tumalo Creek, and the upper reaches of the intermittent Bottle Creek and Rock Creek. The channels are generally high gradient from 5 to 30 percent dominated by riffles, habitats, and are Rosgen A and B types. In July 1996, streamflow was measured at 3.7 cfs on the unnamed perennial stream. Water temperatures are cool, generally less than 57 degrees Fahrenheit. Headwaters originate in alpine fir or subalpine fir surroundings and then descend through forests of mountain hemlock, subalpine fir, and lodgepole pine.

Cold Forest/Unroaded Landscape Area

Surface water resources include the North Fork and Middle Fork of Tumalo Creek, a small reach of Tumalo Creek, and an unamed spring-fed tributary of the North Fork. The channels are generally entrenched and of moderate gradient from 3 to 5 percent with some reaches over 10 percent. Waterfalls are numerous, sinuosity is low and the Rosgen Stream type is predominately B with some reaches of A and C. Sideslopes are moderate to steep with box canyons. Instream wood is abundant in the lower gradient reaches. Habitat types are dominated by riffles and bedrock is common in the substrate. Streamside vegetation includes old growth mountain hemlock, lodgepole pine, whitebark pine, Engelmann spruce, and subalpine fir. Streamflow data is limited although instantaneous readings measured 91 cfs in Tumalo Creek on July 1993, and 9.4 cfs in the North Fork on September 1996. Summer water temperatures range from the mid-40's to the low 50's Fahrenheit.

The Middle Fork receives additional flow from the Crater Creek Canal but loses flow by the diversion of spring water into the Bridge Creek Canal. The water rights in the Crater Creek Canal, in operation since 1914, are owned by the Tumalo Irrigation District. The maximum flow in the canal is 20 cfs which generally runs from July to October and provides 3,000 to

4,000 acre-feet of water annually. The volume of water diverted to the Bridge Creek Canal generally runs 15 to 17 cfs throughout the year.

The flow diversions and Road 4601-370, which cross all the aforementioned channels, are the most significant human caused effects to the water resources within the Cold Forest/Unroaded Landscape Area. The crossings at the North Fork and the unnamed stream are fords where there is limited introduction of sediments into the streams. There are no current grazing allotments nor history of logging.

Bridge Watershed Landscape Area

The Bridge Watershed Landscape Area essentially mimics the Bend Municipal Watershed. Surface water resources include Bridge Creek, Spring Creek, and the Bridge Creek Canal. The summer natural flow of Bridge Creek is normally 5 to 10 cfs but is augmented with the diversion from the springs via the Bridge Creek Canal near the headwaters. The discharge from the springs is normally 17 to 20 cfs, most of which ends up in the canal. The earthen canal, completed in 1955, is approximately 0.5 mile long and for the most part occupies a natural draw. The canal is headcutting near its origin, adding sediments to the stream.

The City of Bend withdraws up to 11.4 million gallons daily (17.5 cfs) from Bridge Creek for drinking water production, totalling 1.6 to 1.7 billion gallons annually. This amounts to 50 to 60 percent of the city's total drinking water production. The water is withdrawn from Bridge Creek approximately 0.1 mile upstream of the confluence with Tumalo Creek, and is piped several miles to storage tanks where it is chlorinated before distribution to the city. There is no filtration system. Surplus water is released prior to chlorination back into Tumalo Creek on the western edge of Shevlin Park.

The water quality of Bridge Creek is among the best in the United States for a surface water system (Prowell, 1998, personal communication). Water filtration is not required if 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 been met or exceeded in over 98 percent of the samples since testing began in 1988, exceeding the minimum requirement of 90 percent. Turbidity is monitored continually, and is normally only 0.2 to 0.3 Nephelometric Turbidity Units (NTU). The City does take water over 1 NTU from time to time, especially when demands are high in early to mid-spring, but they usually try not to exceed 2.5 NTU as a matter of policy. There are several factors that decide when to preclude surface water use, such as user demand, chlorine demand, chlorine residual in the system, and an estimate of how long the turbidity event will last. There are approximately 20 days annually when the turbidity is elevated above 1.0 due to snowmelt, thunderstorms, or temporary bank erosion from the channel adjusting to a newly fallen tree. Water temperatures range from 34 to 50 degrees Fahrenheit.

Bridge Creek has numerous falls and generally has a gradient of 7 to 8 percent, and predominantly riffles. There is one 1.2 mile reach that is lower in gradient (2 percent) where pools are more numerous. The sideslopes are generally moderate but steeper near the mouth where the Bridge Creek Fire consumed the streamside and upslope vegetation. Within the Bridge Creek Fire area, which includes the first mile of Bridge Creek, overland flow of sediments into the stream during storm events is still a concern. The unburned reaches of the

stream descends through an undisturbed forest of medium to late seral stage mountain hemlock, sub-alpine fire, whitebark pine, Douglas fir, and lodgepole pine. The Rosgen stream type is B.

Spring Creek, a small tributary to Bridge Creek, had a discharge measured at 0.62 cfs in August 1995. The overall gradient is 8 percent and the habitat types are dominated by riffles. The sideslopes are moderately steep, and are vegetated with medium to late seral stage Douglas fir and mountain hemlock. The lower 0.2 mile was impacted by the Bridge Creek Fire of 1979. The falls at the mouth of the creek presents a migrational barrier to fish. Water temperatures range from the mid-40's to the mid-50's during the summer.

Tum Lake is a small 2-acre lake that is shallow and has no fish. Water quality data is not available at this time.

Front Country/Transition Landscape Area

Surface water resources include Tumalo Creek, South Fork of Tumalo Creek, the first 0.1 mile of Bridge Creek, the lower reaches of Bottle and Rock creeks, Tumalo Lake and an unnamed creek that drains it, the upper reach of Bull Springs, and several small springs that are tributaries to Tumalo Creek.

Tumalo Creek is the major water resource within the Front Country/Transition Landscape Area. The stream flows through an entrenched channel with numerous scenic waterfalls until descending into a wide, glaciated valley composed of underlying glacial tills. The dominating feature within this area is the Bridge Creek Fire area. The fire burned 3.0 miles of floodplain vegetation along Tumalo Creek within the glaciated valley, destroying the root masses that provided stream bank stability. Before the fire, stands of large Engelmann spruce, subalpine fir, and ponderosa pine lined the stream. The loss of vegetation from the fire also decreased evapo-transpiration rates and increased snow accumulations, providing more runoff into the stream. The trend is for increased evapotranspiration as the vegetation becomes reestablished. Currently, the landscape within the burn is dominated by early seral stage pine trees and brush species. The combination of the loss of streambank stability and increased runoff (peak flows and total water yield) has resulted in stream bank erosion and lateral migration of the channel in some locations. There are accelerated bar formations and braiding of the channel.

Tumalo Creek is a Rosgen stream type B above the confluence with Bridge Creek, but below the confluence, the stream fluctuates between types B and C. The channel is becoming braided in some areas, and the width/depth ratio is increasing. Fish habitat has been decreased and fine sediment input has increased. Pool habitat comprises about 7 percent of the habitat types within the burned area, while riffle habitat makes up 86 percent (1996 Stream Survey, Deschutes National Forest).

Discharge in Tumalo Creek fluctuates from about 50 cfs during late summer to about 300 to 400 cfs during the spring snowmelt period or rain on snow events. The average flow between 1936 to 1986 was 102 cfs with a maximum off 1140 cfs and a minimum of 25 cfs. The gaging station near Skyliner Bridge has been discontinued since 1987.

Water temperatures within Tumalo Creek range from the mid-40's to the upper 50's during the summer months. Turbidity increases during thunderstorms and snowmelt periods. Macroinvertebrates monitoring has indicated that diversity and abundance of populations is slightly impaired, likely due to the presence of fine sediments. Several private residences are located adjacent to Tumalo Creek on the eastern edge of the Front Country/Transition Landscape Area, some of which withdraw water for domestic use.

The South Fork of Tumalo Creek experienced riparian damage from the fire in the lower 0.5 mile but has recovered well and is not experiencing lateral migration or braiding. The lower reach which is within the Bridge Creek Fire has a gradient of 1 percent and is a Rosgen stream type C with habitat types dominated by pools (59 percent). The upper reach has a gradient of 5 percent and is a Rosgen stream type B with habitat types dominated by pools (65 percent). Large wood is abundant throughout the stream. Within the Bridge Creek Fire area, the vegetation is of early seral stage pines and mountain alder. Further upstream, the seral stages are medium to late stands of subalpine fir and Engelmann spruce. August water temperatures range from the low to upper 40's. Flow was recorded at 6.4 cfs on September 30, 1992.

Tumalo Lake is a shallow 16-acre lake located on both private and Forest Service lands. The Swampy Lakes are several small and shallow ponds that have no fish. Water quality is unavailable for these lakes.

Dry Forest Landscape Area

Tumalo Creek and a few intermittent channels are the surface water resources within the Dry Forest Landscape Area. The Columbia Southern Canal operated by the Tumalo Irrigation District withdraws water from Tumalo Creek near the western fringe of this landscape area. The canal is normally in operation from mid-April to mid-October and averages about 40 cfs withdrawal, although flows in the canal have been as high as 190 cfs. There is considerable water loss in the canal from percolation (approximately 20 cfs). Tumalo Creek below the diversion is on the Oregon S ıte Department of Environmental Quality 303(d) list for water quality impaired streams due to flow modification.

The stream channel is a Rosgen type B with gradients 2 to 3 percent and habitat type dominated by riffles. The valley is narrow and sideslopes are steep with streamside vegetation dominated by Engelmann spruce, Douglas fir, and ponderosa pine in the mid to late seral stages. Mountain alder is also prevalent. Within the eastern portion of this landscape area, the dominant vegetation becomes mid-seral stage ponderosa pine with some white fir, lodgepole pine, and juniper. The stream banks are relatively vegetated and stable. This landscape area has been modified by timber harvest activities. Some riparian harvest of timber has occurred in the past.

Private/Dry Forest Landscape Area

Stream characteristics, stream bank stability, water quality, and water quantity for Tumalo Creek are similar to those within the Dry Forest Landscape Area. Landscape modification from timber harvest activities is evident. All of the Bull Springs channel is found on private

land. No stream surveys have been conducted on this small spring. The flow eventually goes subterranean at the eastern edge of this landscape area.

SOIL RESOURCE AND EROSIONAL PROCESSES

The soil resource within the Bend Watershed is dominated by ash and pumice from Mt. Mazama, glacial till, and other reworked volcanics. The eastern edge of the watershed also includes glacial outwash in the subsurface profiles. Lesser amounts of cinders, colluvium, and residual buried soils (paleosols) weathered from basaltic lavas or from ash tephras older than Mazama are present as subsurface components throughout portions of the watershed. Alpine lands barren of fine soil are located at the highest elevations of the Forks and Bridge subwatersheds. Glacial activity occurred in the upper elevation portions of the watershed, including the Tumalo Creek Canyon and the Tumalo Highland Plateau. The scarp on which Triangle Hill and Bearwallow Butte are located appears to be associated with a large volcanic caldera that now comprises the Tumalo Highland Plateau. Volcanic activity associated with this caldera and glaciation are two of the primary influences on landform formation and duration within the watershed.

The following table summarizes the soil stratum profiles within the Bend Watershed:

Table 1. Soil Stratum/Landtypes of the Bend Watershed

Landtype	Acres	Percent
alpine meadows	2,990	5%
juniper scab flats	167	0.3%
lodgepole frost pockets	206	0.3%
ash/paleosol/cinders	2,679	4%
ash/paleosol/lavas	5,926	9.6%
riparian or ephemeral drainages	3,190	5.2%
barren lands	2,892	4.7%
ash/till	33,736	55%
ash/outwash	8,744	14%
ash/residuum or colluvium	1,046	1.6%

Physiographic and Climatic Factors Influencing Inherent Soil Productivity

Annual precipitation, elevation, aspect, and soil profile depths all directly influence the productivity of the soil resource and combine to provide a variety of vegetative plant associations within the watershed. Annual precipitation ranges from 15 to 40 + inches and elevations range from approximately 3,500 to 8,000 feet, both on an east to west trending scale. Aspects are predominantly easterly in nature but include steep north and south slopes within the Tumalo Creek drainage, and soil profile depths to bedrock range from moderately deep (60 inches +) to shallow (less than 24 inches). The combination of these factors provides primarily moderate and low inherent productivities with a lesser amount of high site

class lands in some areas. Lands considered to be unsuited for timber management are present, including lands at higher elevations (generally within Wilderness) and on the eastern fringe (Soil Resource Inventory map unit #36). Table 2 provides a summary of the inherent productivity of the soil resource based upon the cubic foot site class production figure associated with each Soil Resource Inventory map unit.

Table 2. Inherent Productivity of Soils in the Bend Watershed

productivity class	acres	percent
high	13,634	21%
moderate	25,116	39%
low	22,906	35%
unsuited	2,717	4%
barren	393	0.6%

Erosional Processes

Erosional processes within the watershed are primarily surface in origin, although some slopes in the upper portions of the Forks and Bridge subwatersheds are steep enough to exhibit mass wasting. Summer thunderstorm and rain on snow events can produce sediment transport despite the rapid infiltration rates of the surface mineral soil component. These infiltration rates are offset in part by the low cohesion properties of the ash and pumice mineral soil and, in the mountain hemlock and portions of the mixed conifer plant associations, by a thick and relatively impervious organic litter layer. Soil particles are readily detached by raindrop impact and overland flow energies, especially in areas where bare mineral soil is exposed and slopes and impervious litter layers contribute to overland flow accumulations and rates.

Areas of Concern

Soil quality within the watershed could be reduced by continued recreational development and use. Some trail and road locations within the watershed are susceptible to contributing sediment into perennial stream habitats. Soil quality on upland forest sites could be reduced by harvest and fuels reduction activities in the future. Soil quality is currently at or slightly below inherent quality levels within most of these areas. Upland soils within the private boundaries have received the most disturbance and reduction in soil quality from past activities. Although soil stability and productivity within the Bridge Creek Fire area is improving slowly, south facing slopes on the Bridge Creek drainage remain susceptible to erosion from wind or thunderstorm events.

HISTORIC CONDITIONS

Soil Characteristics

Soil profiles within the watershed generally had distinct horizons stratified according to the timing of material deposition and the amount of weathering of the mineral components of the

stratum. The majority of the watershed has a moderately deep cap layer of wind deposited ash and pumice overlying glacial till or reworked volcanics. Glacial till is absent from the eastern most portion of the watershed where either a layer of residual soil weathered from basaltic lavas or glacial outwash underlies the ash cap. The ash cap material has weathered into a mineral soil A, A/C and C horizon profile, with the A and A/C horizons generally comprising the rooting zones of the forest vegetation.

The bulk density and soil strength of the surface mineral horizons and rooting zones of the soils present within the watershed are naturally low due to the inherent characteristics of the ash and pumice material comprising these fractions. Physical disturbances capable of compacting mineral soil or mixing the natural stratification of soil horizons were historically limited, although landslides had the potential for increasing the soil strength of the rooting zone by exposing higher density subsurface materials such as glacial till or by accumulating material in a denser mass downslope. Evidence of this mechanism operating on a measurable scale within any of the subwatersheds is limited. Glaciation was the primary historic disturbance within the watershed prior to deposition of the ash cap material. This sequence of events formed a higher density subsurface soil layer comprised of till or outwash material underneath a relatively unconsolidated and low bulk density surface layer of ash.

Soil productivity within the watershed was influenced primarily by precipitation levels and soil temperatures, both of which are directly related to the elevational changes from the western highlands to the eastern fringe. Annual precipitation ranges from over 40 inches in the higher country to less than 15 inches on the eastern fringe. Soil temperatures directly influence the length of active biological growth during the growing season and range from frigid to cryic. Slope aspect and soil stratum also influence site productivity, examples of which include the lower productivity of soils on landforms comprised of cinders and those located on some of the southern aspects within the subwatersheds. Table 2 previously summarized the inherent productivity of the soil resource within the Bend Watershed.

Erosional Processes

Erosional processes within the watershed were primarily surface in origin, although some slopes in the upper portions of the watershed are steep enough to have exhibited mass wasting. Landforms and cyclic climatic patterns probably generated rain on snow and thunderstorm events that accumulated significant overland flows capable of eroding the low cohesion soil material on the surface. Slope stability within a given subwatershed was primarily influenced by the level of fire disturbance that had occurred in the years prior to a significant rainfall run-off event, most notably the extent of surface mineral soil exposed as a result of biomass consumption from fires. Although fire was a part of all the plant associations present within the watershed, the frequency and behavior of these events varied enough to provide different degrees and extents of slope susceptibility to erosional processes.

Natural fire cycles in the mixed conifer and mountain hemlock plant associations often led to stand replacement fires capable of consuming the majority of live and dead organic matter on the soil surface. These conditions left bare mineral soil susceptible to wind and water erosion in the immediate years following a fire. These areas also coincide with some of the steepest slopes in the watershed, increasing the rate and extent of erosional events when they did occur. Fire cycles within the ponderosa pine plant associations were likely lower intensity

fires that occurred at return intervals of 5 to 20 years. These type of fire events did not generally consume all of the organic cover on the soil surface and resulted in the exposure of less bare mineral soil following each event. Slopes in these areas are also more gradual and less susceptible to accumulating high energy overland flows.

CURRENT CONDITIONS

Harvest and Road History

The soil resource on federal lands within the Bridge and Forks subwatersheds is in a relatively low impact condition due to limited amounts of past management activities and road development. The construction of roads and trails have converted a relatively small percentage of the soil resource into nonproductive areas dedicated for transportation and recreation. The Bridge subwatershed has no roads within its perimeter, while the Forks subwatershed has a low overall road density because portions are either Roadless Areas or have had very low levels of past activities. Approximately 1,344 acres or 9 percent of the Forks subwatershed has had documented harvest activities within the past 30 years, the majority of which are associated with the Bridge Creek Fire salvage. The Bridge Creek Fire salvage area is the largest area of soil disturbance on lands under federal jurisdiction within the watershed. Although units adjacent to Tumalo Creek and a few units on steeper slopes along the canyon walls had salvage material yarded with helicopters to minimize soil disturbance, the majority of units incurred greater amounts of soil compaction and the mixing of naturally stratified soil horizons from tractor yarding.

The Bull and Tumalo subwatersheds have incurred the most extensive soil impacts within the watershed as a result of railroad era logging during the 1930's and 40's and various prescription harvests during the late 1970's and 80's. Photo reconnaissance of 1943 photos reveals significant coverage of railroad era operations, including rail spurs and skid trails, on all lands that were dominated by ponderosa pine. Many of the railroad spurs remain today as part of the road transportation system. Impacts are present on lands under both private and federal ownership, although it appears that the extent of impacts on the privately owned lands containing ponderosa pine forests is greater.

Road density calculations reveal an extensive network of roads throughout the 17,400 acres of private forest land within the Bull subwatershed and the 6,400 acres of private forest land within the Tumalo subwatershed. Skid trail patterns and densities visible in 1995 photos support the occurrence of intensive ground-based operations on the majority of acres under private ownership over the past 20 years. Single end suspension cable yarding did occur on steep slopes within portions of the Bridge Creek Fire salvage area. The federal acres on the highland plateau of the Bull subwatershed were not railroad logged and have had a few harvest entries since 1970. The federal acres in the Tumalo subwatershed were intensively harvested by railroad era logging and have had limited amounts of recent thinning and selective harvests.

Soil Impacts

The soil resource has been impacted to varying degrees from these past management activities as a result of compaction, displacement of surface organics, and loss of the mineral

soil A horizon. The productivity of the soil resource as a result of these conditions has been altered to some extent, although the majority of sites continue to support second growth forests and herbaceous vegetation. Since the slopes in the majority of impacted areas are relatively gentle and organic litter layers relatively thin and non-contiguous, the effect of the various impacts may be offset to some degree through the minimization of overland flow energies on the surface and the increase in the percent of rainfall that is able to infiltrate the soil surface. Despite these conditions, road systems, skid trails, and landings are extensive enough to contribute to concentrated overland flows capable of eroding productive surface horizon material from many upland sites. Most of the private and federal acres that are impacted from past activities are outside the immediate canyons of perennial streams, although there are the acres on steep slopes within the Bridge Creek Fire area that form the canyon sides of Tumalo Creek. Helicopter and cable yarding of salvage material limited the amount of impact that was incurred on these sites and the majority of these acres have also been stabilized to varying degrees by planted trees and regenerated shrubs.

The type and extent of past management activities within a subwatershed is useful in identifying areas that will most likely have detrimental conditions as a result of compaction from machine traffic or exposure of mineral soil. Areas with harvest activity records can be further stratified into condition classes based upon the type of harvest system used, the volume of material removed and the density of skid trails remaining on the landscape. The following table summarizes the extent of harvest activities since 1970 within each of the 4 subwatersheds included in this analysis.

Table 3. Acres of Documented Past Management Activities Within Each Subwatershed Since 1970

Subwatershed	total acres	acres impacted	% of subwatershed
Bridge	4,223	200	5%
Bull	26,221	111 / 17,429 *	1% / 66%
Forks	15,612	1,344	9%
Tumalo	15,605	690 / 5,332 *	4%

* acres impacted includes those on federal land / private land in the subwatershed. Impacts on federal acres do not reflect railroad era logging, which are estimated to have covered 30 percent of the land currently under federal jurisdiction in the Tumalo subwatershed. Private land acres impacted reflects primarily railroad era logging impacts and cumulative selective harvest entries in the past 20 years.

Condition Classes

The existing condition of the soil resource is stratified into 4 condition classes as determined by the percentage of a given area considered to be in a detrimental state. Detrimental conditions include compaction, displacement, burn damage and/or puddling to such a degree that site productivity is reduced. Condition Class A includes areas with detrimental damage of 0 to 10 percent, Class B: 11 to 20 percent, Class C: 21 to 40 percent and Class D: >40 percent. The following table summarizes the existing condition classes within each of the 4 subwatersheds using past activity databases and photo interpretation. The figures are

estimated acres and are not yet digitized. Condition Class D areas are roads only and are overlap acres.

Table 4. Existing Condition Classes Within Each Subwatershed

Subwatershed	Class A (ac./%)	Class B (ac./%)	Class C (ac./%)	Class D (ac./%)
Bridge	4,023 (95%)	200 (5%)	-	-
Bull	7,652 (29%)	1,140 (4%)	17,540 (66%)	228 (1%)
Forks	14,268 (91%)	631 (4%)	713 (5%)	38.6 (<1%)
Tumalo	1,059 (7%)	8,549 (55%)	5,997 (38%)	164 (<1%)

Erosional Processes

Erosional processes within the watershed are dominated by overland flows during higher volume rain events. The area is most susceptible to these erosive forces during rain on snow events when run-off volumes can become very significant in a short period of time. The Bend Watershed and the Tumalo Creek drainage were heavily tested during a 3 day, February 1996 rain on snow event that produced high volume run-off from the melting of an estimated 4 feet of snowpack. Sediment movement that did occur was the result of overland flows since no landslides occurred within the watershed during this event. Rates of erosion appear to be only slightly elevated from historic levels as a result of past harvest activities and the road systems that are in place. The minimal amount of erosion that did occur is attributable to the low levels of impact present within the upper subwatersheds, specifically the low density of roads and the lack of harvest units in which skid trails or landings contribute to the volume and energy of accumulated run-off.

The greatest movement from overland flow processes has occurred within the Bridge Creek Fire area over the past decade, where exposed mineral soil having very low cohesion properties and slopes exceeding 30 percent elevate the risk of soil movement during rain events. Sheet erosion within the Bridge Creek Fire area contributes the majority of sediment that reaches Tumalo Creek, although evidence of rill or gully erosion following the 1996 event was minimal. Revegetation of this area has occurred in the nearly 20 years following the fire to levels capable of minimizing soil loss during major run-off events.

While the type of erosional processes have not been altered within the watershed, the construction of roads and trails, along with the suppression of fire, have likely changed the extent of soil movement during run-off events. Overland flows probably have increased in some areas adjacent to constructed roads and within areas where road densities are high. Sediment transport from upland areas to perennial streams is occurring and is primarily related to existing roads and recreational trails that are within the immediate canyons in which these streams are located. These areas are not extensive and are related to a few specific roads and trails discussed in Chapter V. Road 370 and Road 4601, as well as the North Fork Trail, are the primary contributors of sediment, although total amounts are limited to some extent in terms of volume and time.

Although quantitative measurements are difficult, the suppression of fire within the watershed has also affected sediment movement both positively and negatively. While suppression has limited the amount of the soil resource directly exposed to erosional mechanisms, the increased depths and aerial extent of litter and duff layers in some areas as a result of reduced fire consumption likely contributes to a reduced rate of infiltration during rainfall events and a subsequent increase in the amount and erosive energy of overland flows.

Fire suppression over the last 80 years may have actually decreased the extent of sediment movement within the watershed from that which occurred historically. Although the Bridge Creek Fire created the most extensively disturbed area within the watershed due to the high consumption rate during the event and the salvage activities that followed, there are no other areas of significant size that have had a stand replacement event in the last 80 plus years. As a result, the total amount of bare mineral soil susceptible to rain and wind erosion is likely less than at a given point of time in the historic past if historic fire return intervals in the various plant associations are considered.

The volume of sediment movement as a result of past harvest activities and the road and trail systems that are in place have not been quantified in all the subwatersheds, but are reflected by sediment measurements at the City of Bend Municipal Watershed intake. Turbidity levels at the downstream end of the Bridge Creek Fire area most likely increased in the immediate years following the fire, although no samples were recorded. Bedload sedimentation measurements within this reach of Tumalo Creek do support a trend of increased deposition of sediment during the years following the fire. The rates of sediment movement from within the fire area are likely to decrease as vegetative growth stabilizes adjacent watershed slopes.

Soil conditions within the Forks and Bridge subwatersheds have not been altered significantly from those present historically due to their primary designation as Wilderness, Municial Watershed, or Roadless area. This has resulted in the minimal development of roads and has limited soil disturbance activities such as timber harvesting. A section of private ownership in the southeastern portion of the Forks subwatershed has been harvested during the summers of 1997 and 1998 and represents the most recently impacted area in these 2 subwatersheds. The Bridge Creek Fire area is the only other one of appreciable size that has been impacted from harvesting activities in these subwatersheds. The primary soil disturbance activity in these subwatersheds has become the construction and use of recreational trails and the low maintenance of high elevation roads such as Road 370 and Road 4601. Both activities have resulted in isolated areas of soil compaction and vegetative removal. Use trends are expected to increase over time, likely with an associated increase in resource impacts.

The Tumalo and Bull subwatersheds have had more harvest activities in the past and have an extensive supporting transportation system developed within them. The area impacted as a result of these activities appears to have been enough in some areas to alter soil productivity through the loss of surface mineral soil via erosional mechanisms and the compaction of mineral soil A and A/C horizon material. Lands aquired by the Forest Service under the land exchange with Crown Pacific, especially those on the north side of the Tumalo Creek Canyon, are highly impacted from past activities and have relatively high road densities.

The majority of harvest activity on federal lands in the Tumalo and Bull subwatersheds occurred during the railroad era harvests of the 1920's and 30's, leaving middle-aged, second growth ponderosa pine stands that are not expected for commercial harvests within the next 10 years. Very little recent activity is apparent within the ponderosa pine stands on federal land in these subwatersheds. Soil conditions would be expected to remain at moderately disturbed levels, improving slowly as litter and duff accumulated underneath a maturing forest. Soil conditions on private forestlands would also be expected to remain near existing conditions, although impacts from selective harvests have been a greater component of management on private forest land in the past 20 years and have incurred higher levels of soil disturbance. Harvest activity on these lands would be expected to continue at current levels into the future. Lands aquired by Crown Pacific from the Forest Service in the land exchange are likely to have an increase in harvest activity within the next 10 years.

Soil Needs Assessment

-- Forest lands within the Tumalo and Bull subwatersheds in condition class C or D are in need of the amelioration of compaction levels to maintain site productivity and reduce sediment movement off site and into perennial streams.

-- In order to reduce the risk of resource damage in the short-term, the design and maintenance levels of recreational trails within the watershed need to keep pace with changes in the type and amount of use.

--Trails constructed without properly designed grades and locations for their intended uses have an elevated risk of creating resource damage via erosional and sedimentation pathways.

-- In some areas, trails originally constructed for hiking that are now used by mountain bikes are in need of relocation and redesign. Proposals for new construction or acquisition of trails need to include resource specialist and trail user input on location, design and maintenance levels.

-- Monitoring of resource conditions along trail corridors needs to continue in order to track impacts that are a result of use or management designations.

-- The appropriate use and maintenance levels of these roads need to be assessed at the project level in order to reduce resource impacts which are currently occurring as a result of erosion and sedimentation.

-- Soil restoration associated with compaction from past mechanized harvest operations should occur in upland areas within the Tumalo Creek drainage, especially forestlands acquired by the Forest Service from Crown Pacific. Activity areas identified as being in condition class C or D under the existing condition analysis are included in these recommendations.

-- Trail relocation and redesign resulting from changes in use is needed on the South Fork Trail where mountain bike use is eroding the trail tread and exposing tree roots. The need for these actions is immediate because trail conditions are deteriorating at an accelerated rate and a perennial stream is located adjacent to this trail.

-- The acquisition of portions of an existing trail leading from Shevlin Park to Road 4601 should include an assessment of current use restrictions and trail tread design before any changes occur. The trail is currently functioning in a low impact, low user conflict condition.

-- The use and maintenance levels of Road 37υ and Road 4601 are the highest priority identified for the transportation system within the Bend Watershed. Current erosional damage is contributing sediment to perennial and ephemeral stream channels and should be addressed in the immediate future. Despite seasonal closures, impacts to the sensitive soils and high meadow vegetative resources continue to occur as use of Road 370 continues to increase. Recent breaches of off-road restrictions and gated closures reflect the need to assess the management of this road in a sensitive, high elevation location.

-- The grade of Road 4601 as it climbs out of the Tumalo Creek drainage is also in need of reassessment. Current grades exceeding 10 percent in a direct line upslope have created rill and gully erosion on the road bed with direct movement of sediment into the Tumalo Creek drainage. Relocation of this grade with appropriate switch backs to reduce grades should occur in the immediate future.

-- Some spur road and skid trail restoration and obliteration is recommended on slopes within the Bridge Creek Fire area.

AQUATIC SPECIES

HISTORIC CONDITIONS

Composition and Distribution

Redband trout may have been the only fish species occupying waters within the Bend Watershed. There are no historical records of any other fish species. Their distribution was most likely throughout Tumalo Creek up to Tumalo Falls, in Bridge Creek to the first falls approximately 0.3 miles upstream from the confluence with Tumalo Creek, the South Fork close to the headwaters, and in an unnamed creek draining Tumalo Lake which has no fish.

In recent years, there have been unverified reports of bull trout sightings. Whether bull trout are indigenous to the watershed or not is a controversial issue. According to the Oregon Department of Fish and Wildlife, highly fluctuating flows and lack of deep pools are the limiting factors keeping bull trout and mountain whitefish from residing in Tumalo Creek. There were and still are several habitat features favorable to bull trout. Cool water temperatures throughout the season are within a range tolerated by bull trout. Cooler water temperatures occur during the fall months (less than 9 degrees Centigrade) which are critical to induce spawning in bull trout. Water temperatures approaching 2 to 4 degrees Centigrade in mid to late fall are the optimum temperatures for embryo survival and increased size of alevins. There are adequate gravels for spawning in some reaches, especially within the Bridge Creek Fire area although the fine sediment volumes are higher than desired. Fine sediment volumes prior to the fire were likely lower, although no data is available. The large accumulations of instream wood are a preferred habitat feature for bull trout. Within the

Bridge Creek Fire area, numerous side channels and beaver ponds provide rearing habitat and refugia from high flows.

Besides the lack of deep pools, another characteristic of Tumalo Creek and its tributaries that would be unfavorable to inhabitance by bull trout is the occasional fall storm event that could dislodge embryos in the gravels.

The introduction of eastern brook trout in the watershed jeopardized the existence of bull trout, if they were indeed indigenous. The 2 species compete for food resources and commonly hybridize. Offspring are usually sterile.

Stream invertebrate communities were relatively diverse, abundant, and widespread, and composed of species typical of cool, eastern Cascade streams.

Habitat Conditions

The habitat conditions were similar to current conditions, with the exception of the effects of the fire, roads, and the flow diversions. Waterfalls prohibited fish distribution into the headwaters. Shade and instream wood were abundant, substrates were cobble, gravel, and small boulder dominated, streambanks were vegetated and stable, and habitat types were dominated by riffles. Fine sediment volumes in the spawning gravels were likely lower than current conditions, as streambanks had higher stability and there were no road crossings.

Water temperatures were probably lower than current conditions because all stream reaches were shaded with large conifers and the cool springs currently feeding the municipal water supply would have cooled the Middle Fork. Bridge Creek and the upper reach of the Middle Fork would have been the exceptions. The water temperatures of Bridge Creek have been cooled from the input from the spring water and the upper reach of the Middle Fork above the spring source has been cooled from the input from the Crater Creek Canal.

The diversity of boulders, gravels, organic debris, and stream velocities provided various habitat types for invertebrate communities.

CURRENT CONDITIONS

Composition and Distribution

Self-sustaining stream populations of rainbow trout and eastern brook trout overlap and are widespread in the watershed, found even above migrational barriers. Populations were likely established above the barriers either from official stockings conducted by the Oregon Department of Fish and Wildlife or by private citizens seeking to increase the area of distribution. Populations are generally distributed in streams up to where low flow or high velocities due to high gradient becomes limiting. The dam on Bridge Creek at the municipal water intake is a migrational barrier. There are no fish found in any of the lakes except for Tumalo Lake which contains eastern brook trout. A majority of the fish in the watershed are small in size (less than 8 inches) resulting in relatively light fishing pressure (See Exhibit 9).

The rainbow trout may actually be redband trout, a Forest Service Region 6 Sensitive Species. Redband trout are an inland version of the coastal rainbow trout. Rainbow trout were stocked in the watershed annually from 1948 until 1972, and may have hybridized with the native redbands, diluting the genetic purity. Specimens of rainbow trout were collected from Tumalo Creek in 1994 for genetic analysis with results still pending.

The eastern brook trout, native to the east coast of North America, were widely introduced to the western United States early in the 20th century. The Tumalo Creek drainage was stocked with eastern brook trout for the first time in 1948. Specifically, they are not a trout but a char, being closely related to the bull trout. Brown trout are suspected to inhabit Tumalo Creek at the eastern edge of the watershed. Brown trout are exotic to North America, having been introduced from Europe late in the 19th century. They were introduced to the Deschutes River over 50 years ago and have spread their distribution into Tumalo Creek.

The eastern brook trout are very prolific and can overpopulate a stream or lake resulting in numerous fish of a small size. There is evidence for this occurring in the burned area of Tumalo Creek based upon electrofishing sampling. Very few of the fish exceeded 6 inches in length. Sampling has indicated that brook trout make up approximately 75 percent of the population within the Bridge Creek Fire area while the other 25 percent are rainbow trout.

The stream invertebrate community is likely similar to historic conditions. There has likely been an increase in species that graze on algaes within the Bridge Creek Fire area with the opening of the canopy.

Wilderness Landscape Area

There are no known fish populations in the Wilderness Landscape Area.

Bridge Watershed Landscape Area

Rainbow trout have been documented in Bridge Creek and have likely been distributed up to the junction with the Bridge Creek Canal. Eastern brook trout are speculated to inhabit Bridge Creek and would have a similar distribution.

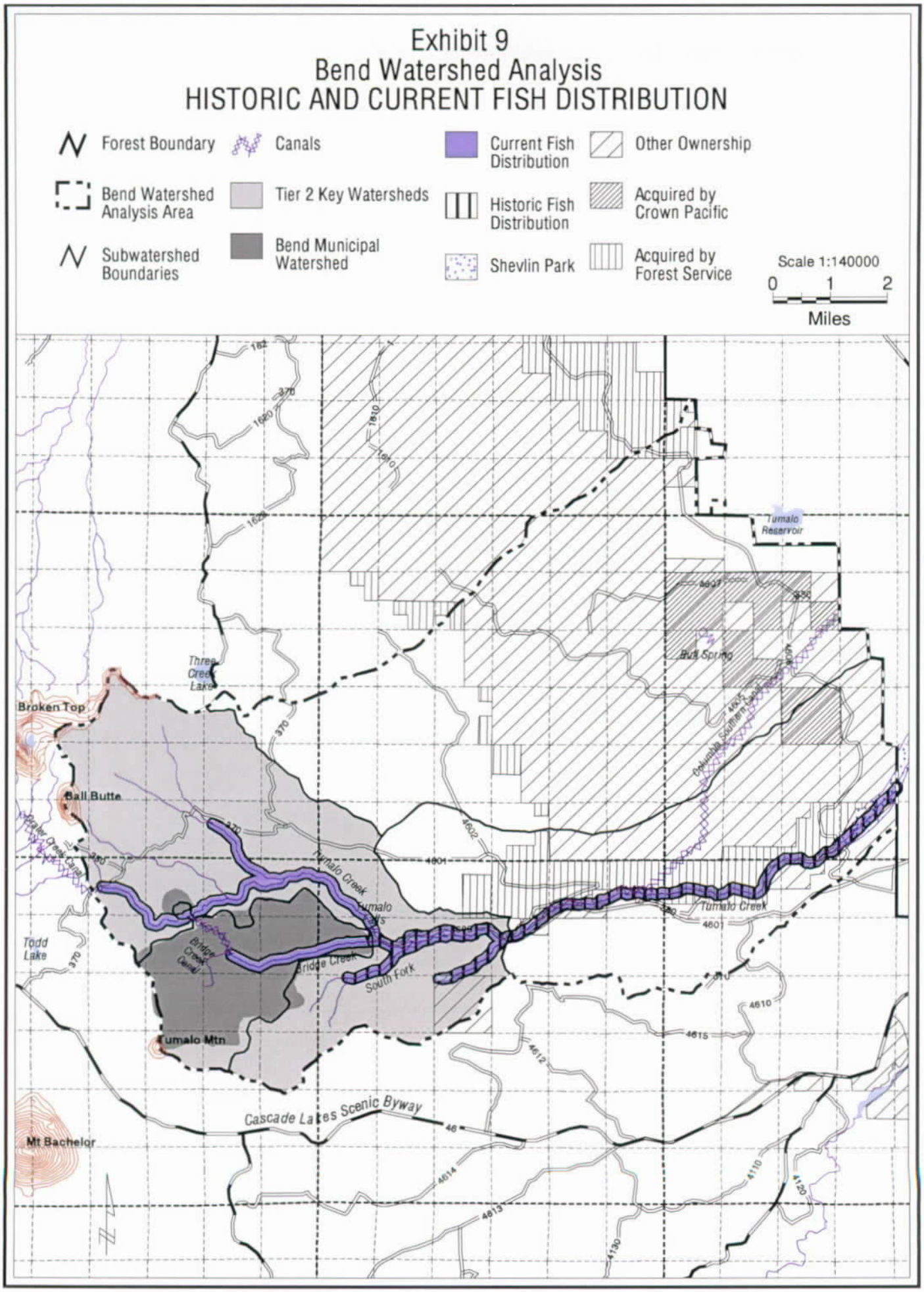
Cold Forest/Unroaded Landscape Area

Eastern brook trout inhabit the North Fork of Tumalo Creek close to the Wilderness boundary, a small spring-fed tributary to the North Fork, Tumalo Creek, and the Middle Fork of Tumalo Creek upstream to the confluence with Crater Creek Canal.

Front Country/Transition Landscape Area

Eastern brook trout and rainbow trout occupy Tumalo Creek, the South Fork of Tumalo Creek upstream close to the headwaters, and Bridge Creek upstream to the dam at the municipal water intake. Trout, primarily eastern brook trout, are also found in the several beaver ponds formed in small tributary streams to Tumalo Creek within the Bridge Creek Fire area. Eastern brook trout also reside in Tumalo Lake and the small stream that drains it.

Exhibit 9
Bend Watershed Analysis
HISTORIC AND CURRENT FISH DISTRIBUTION



Dry Forest Landscape Area

Eastern brook trout and rainbow trout inhabit Tumalo Creek. There may also be brown trout in the downstream reaches of Tumalo Creek.

Private/Dry Forest Landscape Area

Eastern brook trout and rainbow trout inhabit Tumalo Creek. There may also be brown trout. The other small streams within this landscape area do not contain any known fish populations.

Habitat Conditions

Within the streams, the numerous falls and the paucity of pool habitat are the major habitat features that limit the fish populaitons. Stream reaches are generally riffle dominated, having only 5 to 10 percent pool habitat. Streamflows have been altered for downstream irrigation purposes, but there are some favorable instream habitat conditions. With the exception of the area burned by the Bridge Creek Fire, the riparian zones are relatively intact with mature stands of mixed conifer and brush providing shade, overhead cover, and instream large wood recruitment. There are adequate amounts of gravels, cobbles, and boulders for spawning, rearing, and macroinvertebrate habitat. Water temperatures are relatively cool, generally less than 55 degrees Fahrenheit, even in the summer. The cooler temperatures likely limit growth rates of fish. Instream large wood is fairly abundant, decreasing in higher gradient reaches where it is displaced with high flows.

Wilderness Landscape Area

The perennial streams within this landscape area are relatively small and high in gradient and do not provide fish habitat.

Bridge Watershed Landscape Area

Shade and potential instream wood recruitment was nearly eliminated in the lower 0.5 mile of Bridge Creek by the 1979 fire and subsequent wood salvage. The natural flow of Bridge Creek is increased substantially from the input from the canal (up to 17 cfs) which has increased fish habitat. Waterfalls and the lack of pools limit the fish population. Instream large wood is relatively abundant with over 200 pieces per mile which provides fair to good hiding cover.

Cold Forest/Unroaded Landscape Area

The habitat conditions are relatively undisturbed with the exception of a few trail and road crossings and flow alterations within the Middle Fork of Tumalo Creek. Fish habitat is limited by the presence of waterfalls, high gradient and a lack of pools.
The upper reach of the Middle Fork receives additional flow during the summer from outside the watershed via the Crater Creek Canal which originates on the flanks of Broken Top. The increased volume improves fish habitat but also introduces fine sediments. The diversion of spring water into the Bridge Creek Canal, flow that would naturally enter the Middle Fork,

decreases fish habitat within the Middle Fork. However, this loss of flow is largely offset by the flow from the Crater Creek Canal during the summer months. Poor drainage and stream crossings along Road 4601-370 (fords) contribute some fine sediments to watercourses.

Front Country/Transition Landscape Area

Fish habitat conditions were greatly altered by the Bridge Creek Fire which burned approximately 3 miles of riparian habitat along Tumalo Creek and another 0.5 mile on the South Fork of Tumalo Creek. The tall pine, spruce, and fir have been replaced by brush species such as mountain alder. Despite the loss of shade, the water temperatures remain relatively cool, rarely exceeding 55 degrees Fahrenheit. Stream bank erosion and widening of the channel is evident in several areas on Tumalo Creek with the loss of the vegetation after the fire. Despite the lower gradient in this reach, pool habitat still makes up only about 7 percent of the habitat types. Instream large wood was increased with stream restoration projects to replace what was taken out after the fire salvage operation, which included both the removal of instream wood and streamside standing trees. Flood events in 1995 and 1996 created movement of the instream wood, resulting in large log jams and pushing much of the wood onto the fringes of the stream. While some of these log jams provide excellent hiding cover for fish, much of the wood is not available to create habitat except during high flow. There are abundant gravels and cobbles for spawning and macroinvertebrate habitat, but the sediment sampling of the substrate has indicated volumes of fine sediments above the desired levels, which are less than 20 percent.

Instream flows to Tumalo Creek are decreased with the withdrawal of water from Bridge Creek for the municipal water supply. During the summer months, this is largely offset by the input from the Crater Creek Canal.

The small creek that drains Tumalo Lake is also within the fire perimeter. The creek does not provide much fish habitat due to its small size, high gradient, and lack of pools. The volume of Tumalo Lake, nearly entirely on private land, has been increased with the construction of a small dam at the outlet, increasing available fish habitat.

Dry Forest Landscape Area

Tumalo Creek is well shaded with mixed conifer at the western edge, switching to primarily ponderosa pine moving downstream to the east. The stream flows through a canyon with steep sideslopes. Lack of pool habitat is limiting for fish populations, comprising less than 3 percent of the habitat types. Instream large wood is relatively abundant (over 300 pieces per mile), providing hiding cover and micro-pools for fish. Substrates are dominated by cobbles and gravels. Some past riparian zone harvest of conifers is evident. Portions of this landscape area adjacent to Tumalo Creek are within private ownership.

The Columbia Southern Canal diversion, located at the western edge of this landscape area, reduces fish habitat in Tumalo Creek for nearly 6 months annually. Approximately 40 cfs is withdrawn on average. Summer flows may be reduced to less than 5 cfs when the canal is in operation. The diversion acts as an upstream migrational barrier to fish within Tumalo Creek while in operation. Fish seeking spawning areas cannot pass over the diversion dam which is also unscreened, allowing for loss of fish down the canal. Total annual loss is unknown.

Private/Dry Forest Landscape Area

Stream characteristics are similar to those in the Private/Dry Forest Landscape Area.

VEGETATION

Plant Associations

Vegetative composition is an important component in understanding, analyzing, and evaluating the physical, biological, and social processes occurring within the watersheds. Interactions among processes of climate, geomorphology, plant succession, and disturbance events yield changes in vegetative composition and trend (species, structure, density). Climate, soils, and topography generally remain constant over time. Succession and disturbance continually work in concert to change the vegetation condition, both in terms of structure and distribution, as well as in processes and ecological function.

Plant associations are an organizing framework for establishing known vegetation species ranges and were used in this analysis. Species distributions and their potential distribution range have been mapped for the entire watershed. These plant associations vary from high elevation, cold, sparsely vegetated upper regions dominated by rock and alpine meadows to warm, dry ponderosa pine stands found throughout the lower elevation.

Broadly categorized into plant association groups (PAGs), 7 general communities of forest vegetation emerge. These are: ponderosa pine dry/wet (PPD/W), mixed conifer dry (MCD), mixed conifer wet (MCW), lodgepole pine dry/wet (LPD/W), mountain hemlock dry (MHD), meadow/riparian (MDW/RIP), and rock/alpine meadow (ROCK/ALP) (See Table 5 and Exhibit 10).

Table 5. Plant Association Groups by Subwatershed

Major PAG	% of Total Landscape	Dominant tree species coverage	Bridge Subws	Forks Subws	Bull Subws	Tumalo Subws
PPD/W	39%	ponderosa pine	0%	0%	57%	60%
MCD	14%	ponderosa pine	11%	12%	13%	9%
MCW	14%	white fir	4%	17%	10%	22%
LPD/W	13%	lodgepole pine	5%	19%	14%	7%
MHD	15%	mt. hemlock	75%	35%	4%	0%
MDW/RIP	3%	mdw/riparian	1%	15%	1%	2%
ROCK/ALP	2%	rock/alpine shrub	3%	1%	0%	0%
Totals	100%		100%	100%	100%	100%

Historic or Reference Conditions

The following discussion summarizes the differences between the current forested vegetation conditions and those conditions thought to exist under native disturbance cycles in previous centuries. Where possible, explanations of reasons for those differences are given.

The historic vegetation condition in this section is based on estimates of reference conditions, in order to establish a general picture of probable landscape conditions under native disturbance regimes. This is set to conditions that most likely existed prior to European settlement, when fire dominated conditions are thought to have existed (circa 1850-1910). This procedure, termed historic range of variability (HRV) analysis, was completed using the Vegetation Dynamics Development Tool (VDDT, Hann et al. 1997) successional pathway model to establish likely reference points.

Structural Stage Classification: Forest structures and species composition (often termed seral stage) provide a basis for describing both the existing condition of the landscape, as well as the theorized condition under more native disturbance cycles (e.g., conditions under which the landscape is believed to have evolved prior to fire suppression, timber harvesting, and road building for example). In order to simply the analysis, 3 structural stages have been assigned and are described as follows:

Early structural stages are those newly establishing stands, such as the many acres of pine plantations that are reclaiming the Bridge Creek Fire area. Middle structure stages are those stands that are neither young nor old, but are middle aged, such as the "second growth" ponderosa pine stands that dominate the environment on the lower portions of the watershed, closest to the urban interface with Bend. Late structure stages are the oldest stands, often remnants from an earlier era. An example of late structure stands are mountain hemlock stands that occupy much of the upper portions of the watershed area, particularly the Bridge and Forks subwatersheds.

In this procedure, plant community associations and stand structures are projected into the future, for 10, 50 and 100 year projections, and mid-point estimates of species composition and structural classification are made. Simulations of HRV conditions include the most common native disturbance agents (fire, insects, disease pathogens), but more recent disturbance agents (timber harvest, thinning, exotic species) are suppressed (See Appendix for more information).

Table 6. Historic Structural Stages by Plant Association Group (Percentage)

Major PAG	% of Total Landscape	Dominant tree species coverage	Open Areas	Early Structure	Mid Structure	Late Structure
PPD/W	39%	ponderosa pine	0%	10%	10%	80%
MCD	14%	ponderosa pine	0%	10%	20%	70%
MCW	14%	white fir	0%	20%	45%	35%
LPD/W	13%	lodgepole pine	0%	30%	45%	25%
MHD	15%	mt. hemlock	0%	15%	55%	30%
MDW/RIP	3%	mdw/riparian	100%	0%	0%	0%
ROCK/ALP	2%	rock/cinder	100%	0%	0%	0%
Totals (Range)	100%	all species	5% (5%)	14% (10-20)	27% (20-35)	54% (40-65)

Exhibit 10
Bend Watershed Analysis
PLANT ASSOCIATION GROUPS

Forest Boundary

Bend Watershed Analysis Area

Mountain Hemlock

Mixed Conifer Wet

Mixed Conifer Dry

Lodgepole Pine Wet

Lodgepole Pine Dry

Ponderosa Pine Wet

Ponderosa Pine Dry

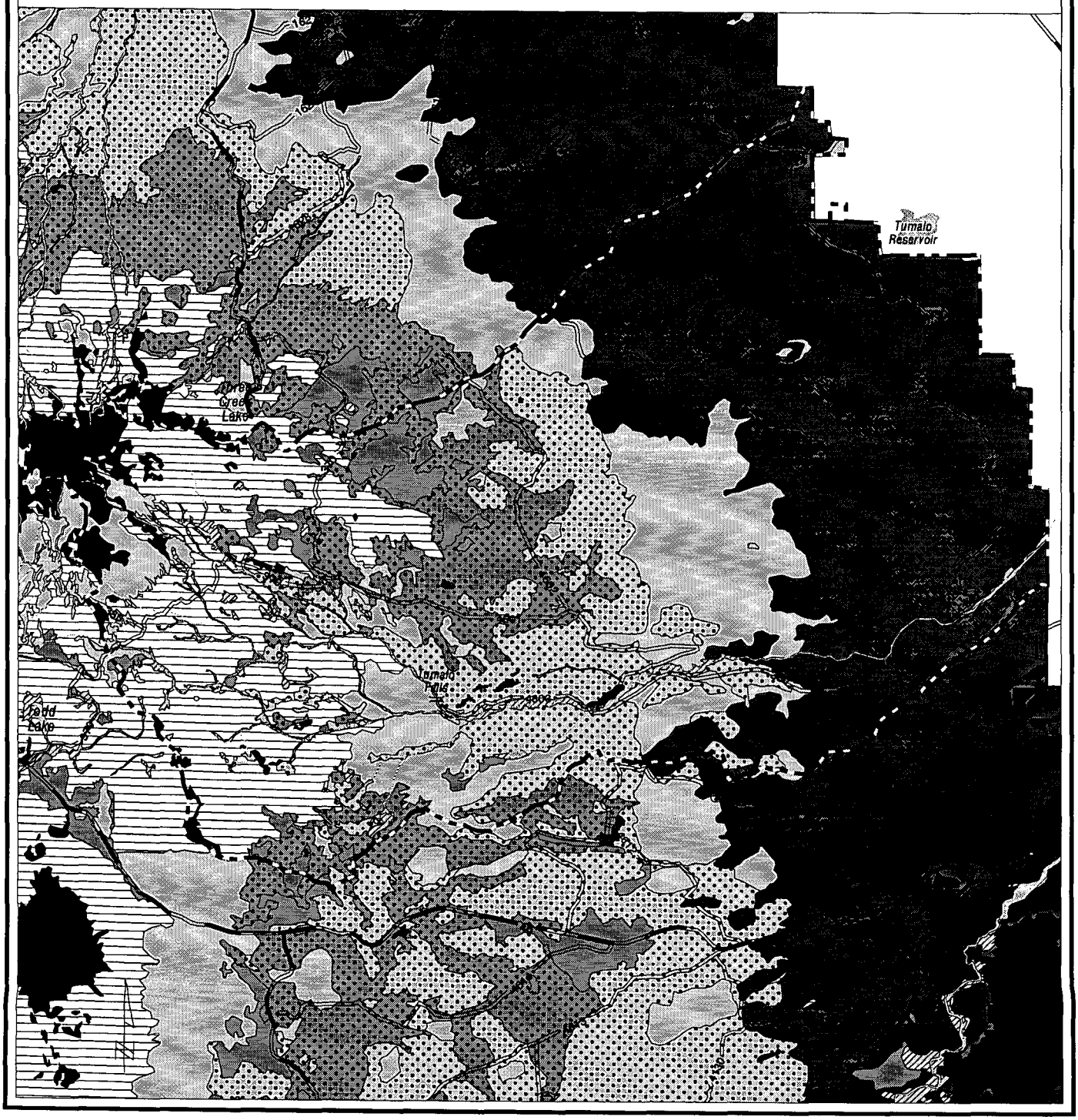
Riparian and Meadows

Lava, Rock and Cinder

0 1 2

Miles

Scale 1:140000



Disturbance Processes

The following discussion centers around the role of disturbance in shaping vegetation patterns, processes, and ultimately trends in the watersheds. Forest vegetation disturbance provides a process to interrupt the ongoing process of succession. There are many disturbance agents present within the watershed area. See Table 7 for dominant historic disturbance by PAG.

Fire: The role of fire in shaping the vegetation within the watershed is described in the Fire History summary.

Insects and Pathogens: Insects have the potential to cause substantial vegetative changes, resulting in the emergence of new landscape patches and patterns. Ponderosa pine and mixed conifer stands are imminently susceptible to defoliator insect attacks, as well as to those by bark beetles. Although there is no certainty of these events occurring, there is a greater predisposition for outbreaks to occur, relative to other forest vegetation types, both in terms of structure and composition. Thus, if an outbreak of defoliator or bark beetle species occurs at an epidemic level, then large patches may be created across the landscape, as the ponderosa pine and mixed conifer dominated vegetation zones are the dominant plant associations within the lower portions of the watershed.

Table 7. Dominant Historic Disturbances by Plant Association Group (PAG) *

Potential Vegetation (Major PAG)	Dominant Disturbance Factors	Disturbance Regime Intensity	Average Disturbance Size/Patch Created (ac)	Primary Geomorphic Zone	Typical Elevation Zone
Water	Floods	Low	1-100		3500'-8000'
Riparian & Meadow	Fire	Low	1-50	Valley bottoms & hanging basins	5500'
Alpine Meadow & Sparsely Vegetated	Fire	Low	1-50	Glaciated Uplands	7000'
Ponderosa Pine Dry/Wet	1) Fire 2) Insects and Disease	1) Low 2) Low	1) < 5 2) < 5	Upland Lava Plains	3500'-5500'
Lodgepole Pine Dry/Wet	1) Fire 2) Insects and Disease	1) High 2) High	1) 50-1000 2) 10-1000	Plateaus & Basins at Elevations	5000'-6800'
Mixed Conifer Dry	1) Fire 2) Insects and Disease	1)Moderate 2) Low	1) 20-300 2) 1-5	Volcanic Highlands & Toeslopes	4200'-5600'
Mixed Conifer Wet	1) Fire 2) Insects and Disease	1) High 2)Moderate	1) 100-500 2) 100-500	Volcanic Uplands & Glacial Bottomlands	5000'-6200'
Mountain Hemlock	1) Fire 2) Insects and Disease	1) High 2) Low	1) 50-150 2) 50-200	Volcanic Uplands at Elevations	5700'-7500'

*Low severity disturbance regime: 1-25 year return interval, 0-20 tree mortality;
Moderate severity disturbance regime: 26-100 yr return interval, 21-70% tree mortality;
High severity disturbance regime: >100 year return interval, >70% tree mortality

Root pathogens, in addition to insects, have also contributed to landscape patterns and patches. As a root disease center expands, trees on the edges of openings become susceptible to infection and ultimate mortality. Over time, these openings may be colonized by species more resistant to the root disease, thus regenerating a new stand of different composition. Often, species presence, seed production and pathogen specificity limits the re-establishment of the created opening. Lodgepole pine and western white pine are shade-intolerant species typically more resistant to root pathogens than the shade-tolerant firs, thus allowing a mechanism that promotes species diversity over successional advance. Root disease pockets are casually observed in aerial photography within the mountain hemlock zone.
Fire patterns currently will differ greatly from historic patches and patterns, simply as a result of chronically increasing stand densities and fuel loadings.

Mountain Pine Beetle

The effects from mountain pine beetle activity has been the most significant agent of mortality in recent years. Large expanses of lodgepole pine stands have succumbed to these insect attacks, and mapping has occurred from the 1980's to present, with shifting "hot spots" occurring each year. Lodgepole pine dry and wet plant association groups have been hardest hit, and interspersed mortality has shown up in the ponderosa pine dry, mixed conifer dry, and some high density mountain hemlock PAGs as well.

Cultural stand treatments can reduce the risk of epidemic beetle attacks before they occur. This necessitates the reduction of density levels to ensure that individual tree health and vigor is maintained. Stand regeneration to a new forest structure can also reduce the potential for beetle attack, and is most appropriate in lodgepole pine stands nearing the end of their natural lifecycles, whether from pathogens or high density stress. Salvaging dead lodgepole pine resulting from such beetle outbreaks can reduce the larger increase in fire hazard, but will not stop the outbreak, as stand conditions that favored the outbreak have not been altered elsewhere (Eglitis, 1996)

Western Pine Beetle

Large diameter ponderosa pine are particularly vulnerable to epidemic attacks by the western pine beetle, especially within mixed conifer dry PAGs. These trees are stressed by a variety of factors, yet this can be tied to competition for scarce resources. The vulnerability of loss from epidemic levels of bark beetles is correlated to growth rates and life cycles of ponderosa pine trees.

Older trees with thin crowns and slow growth rates are most likely to be attacked and killed by the western pine beetle, and are typically found in highly dense stands.

Fir Engraver

The fir engraver is a bark beetle that attacks most fir species in the western United States. Most susceptible are the true fir species found within the mixed conifer dry and wet PAGs. Mass attacks occur coincident with drought conditions, and precipitation zones are key to undertanding fir mortality management risk. Annual precipitation of 20 to 25 inches defines an extreme risk of white fir attacks by the fir engraver. These are typically fir trees at the lower end of their elevation range, and generally conform to the mixed conifer dry PAGs. In typical, non-drought years, most fir engraver attacks occur in conjunction with root disease agents. Silvicultural treatments that maintain trees in a healthy, vigorous state will often minimize stand mortality risk, and manage the fir engraver at endemic population levels.

Douglas Fir Beetle

The Douglas fir beetle, a large bark beetle, is similar to the mountain pine and western pine beetles in life cycle. This beetle infests trees damaged by windfall, fire, or other disturbance event, and attacks Douglas fir trees, particularly those found within the mixed conifer dry PAGs. Outbreaks are typically sporadic and of short duration, yet are likely to kill large

numbers of trees. Damage is greatest in dense stands of mature Douglas fir trees (Eglitis 1997).

Western Spruce Budworm

Douglas fir and white fir are the tree species most at risk to western spruce budworm infestations. Conditions that favor outbreaks are large expanses of nearly pure host trees, primarily those with multi-layered canopies and host stands on warm, dry sites. Silvicultural practices that maintain trees in a healthy and vigorous condition will tend to reduce the risk to epidemic levels of budworm activity. Stand management techniques that reduce pure host tree composition and move to more seral species also helps in minimizing the risk of epidemic budworm attacks.

Armillaria Root Disease

Armillaria root disease can exist as a saprophyte on dead woody material for decades or as a lethal tree parasite. Armillaria spreads from colonized stumps or infected trees to nearby healthy trees. Tree species have varying amounts of resistance to the disease due to natural biochemistry. Resistance fades, however, when the tree is under stress, creating pockets of mortality, or in some cases wiping out an entire stand over time. Stress elements include overstocking, drought, and soil compaction.

Effects from armillaria are mixed. It creates canopy gaps and snags that are representative of a late-successional forest during the early phases of the disease. These conditions are considered ideal for the prey base of the spotted owl. As mortality increases in distribution and abundance, an opening is created that is no longer at a scale suitable for owl foraging. Unless resistant species are established or introduced, the opening is likely to persist for decades.

Annosus Root Disease

Annosus root disease spreads from colonized stumps from windborne spores that germinate following disturbance, typically logging. Secondary attacks by bark beetles often follow initial infections. Disease centers usually focus around old infected stumps, but also can be from wounds on live trees. Host trees are pine, mountain hemlock, and true fir.

White Pine Blister Rust

This fungal disease was introduced into North America in the early 1900's from Europe, with host species for white pine blister rust being the five-needled pines (includes western white pine and whitebark pine). Ribes species (gooseberry plants) are the alternate hosts for the disease, providing the mechanism for blister rust infections. This blister rust is currently infecting western white pine trees that are a minor component of stands within the mixed conifer and mountain hemlock zones of this watershed.

Dwarf Mistletoe

Dwarf mistletoe is found within the mountain hemlock, mixed conifer, lodgepole pine, and ponderosa pine types and are ubiquitous within the watershed. Native to this region, these parasites have increased in distribution and abundance as a result of fire suppression and selective harvest practices over the past several decades. With the advent of effective fire suppression efforts during the past century, the distribution and intensity of mistletoe has no doubt substantially increased over time.

Heavy infections of mistletoe slow tree growth, compounding over time to the point where it may not be possible to grow stands that exhibit characteristics of large, old trees. Silvicultural treatments that are effective in reducing or controlling dwarf mistletoe include thinning, retaining mistletoe-free trees, pruning, mistletoed overstory removals, and species replacement.

Other Agents of Change

Several other disturbance agents of concern exist within the watershed, including Douglas fir tussock moth, pandora moth, laminated root rot, and windstorm, but are not discussed in this section. The reader is encouraged to review the Cascade Lakes Watershed Analysis and/or the Cultus/Sheridan LSR Assessment (Deschutes National Forest, 1995/1996) for more detailed descriptions.

Landscape Area Descriptions of Current Conditions

The existing vegetation condition in this section has been summarized from a recent aerial photo interpretation effort, using photography taken in 1995. Vegetation assignments were made, on a stand basis, for tree species, structural or developmental stage, and stand density. This photo-interpretted data was used to classify the entire watershed area into one landscape summary, from which to describe the major conditions and trends. Similarly, reference conditions were estimated in order to establish a general picture of probable landscape conditions under native disturbance regimes, prior to European settlement (circa 1850-1910). This procedure, termed historic range of variability (HRV) analysis, was completed using a successional pathway model to establish likely reference points. For information on methods used to characterize the landscape environment, see the appropriate chapter in the appendices of this report.

Current Cover Types and Structural Stages

To establish a picture of the current condition of forested vegetation, cover type and structural stage is added to the underlying PAG foundation. The utility of this approach is for: 1) further exploration of current landscape in terms of existing species composition and structure; and 2) to establish a baseline of the most likely past structures and general composition (e.g., Historic Range of Variability or HRV estimates) to see how far the landscape has departed from our understanding of the natively-evolved landscape of the past. Note that the second item requires that a good deal of assumptions be made (See Table 8 and Exhibit 11).

Table 8. Existing Forest Structural Stages by Plant Association Group (Percentage)

Major PAG	% of Total Landscape	Dominant tree species coverage	Open Areas	Early Structure	Mid Structure	Late Structure
PPD/W	39%	ponderosa pine	3%	6%	81%	10%
MCD	14%	ponderosa pine	1%	5%	85%	9%
MCW	14%	white fir	0%	33%	60%	7%
LPD/W	13%	lodgepole pine	0%	1%	84%	15%
MHD	15%	mt. hemlock	4%	3%	21%	72%
MDW/RIP	3%	mdw/riparian	3%	1%	8%	7%
ROCK/ALP	2%	rock/cinder	100%	0%	0%	0%
landscape totals	100%		6%	8%	66%	20%

Vegetation Summary by Landscape Areas:

The following narrative characterizes the entire four sub-watershed area into 6 Landscape Areas, in a summary of existing vegetation condition.

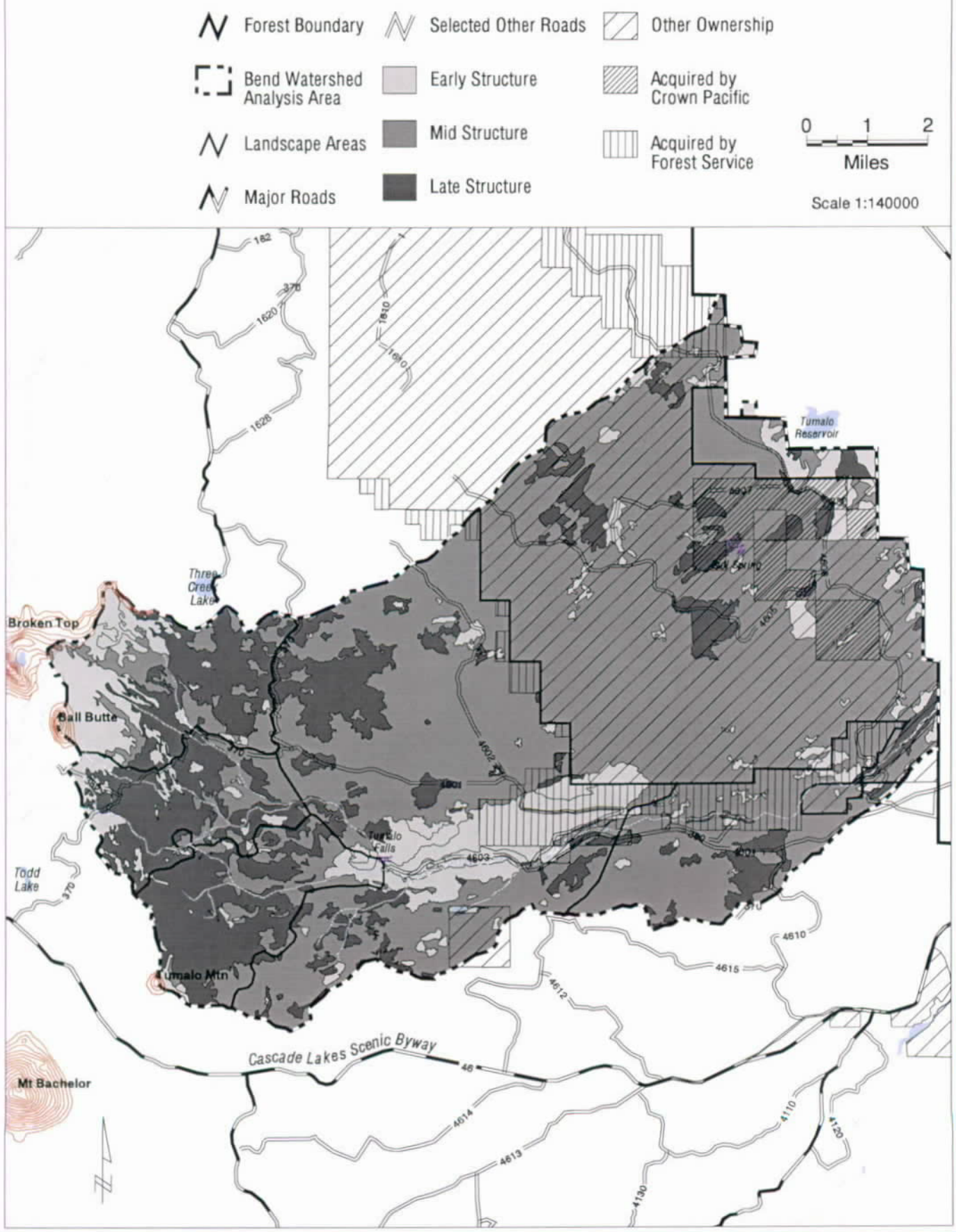
Landscape Area 1: Wilderness - Fire suppression has allowed more stands to age without substantial disturbance. As a result, many more acres have advanced to late structural stages. Additionally, meadows have been encroached upon by lodgepole pine and mountain hemlock trees, in the absence of disturbance.

Landscape Area 2: Cold Forest/Unroaded - Similar to Landscape Area 1, stands continue to advance in age in the absence of disturbance. For the mountain hemlock stands, less openings remain relative to the historic condition, and about twice as much late/old structural stages are added through the years. Fire suppression remains the major reason for this long-term shift to old, dense forest types.

Landscape Area 3: Bridge Creek - Much like Landscape Area 2, the dominant forest structure is one of late/old composition. Meadow encroachment by conifers continues in the absence of disturbance. The relatively recent Bridge Creek burn is the one exception to this continuous advancement of forested stands, as roughly 5 percent of this landscape area was recycled to open and early stages about 20 years ago.

Landscape Area 4: Front Country/Transition - Predominantly mid-structural stages throughout, this area represents a dramatically different composition of forest vegetation than the primitive watershed conditions (above) and heavily manipulated portions (below). The Bridge Creek Fire set succession back to open and early conditions on over 15 percent of this portion, and remnant old forest conditions exist on another similar acreage. However, a full two-thirds of the landscape area resides in middle-aged, medium-sized forest stands, due to a combination of factors. Previous, selective harvesting of large, old trees during the past century has reduced the acreage of late and old structured stands in the ponderosa pine and mixed conifer dominated stands. Perhaps more impactive has been the suppression of fire

Exhibit 11
Bend Watershed Analysis
VEGETATION STRUCTURAL STAGE



and subsequent insect epidemics of mountain pine beetle that have recycled many acres of late/old lodgepole pine stands, allowing an understory of mountain hemlock and/or white fir to flourish. It is thought that periodic fires would have replaced these stands, perhaps at an infrequent, but high intensity, fire cycle. In the continued absence of fire, these hemlock, and to a lesser degree true fir, stands will continue to advance successionally, and a greater proportion of the landscape will grow into late/old structure, if insect and disease agents remain endemic.

Landscape Area 5: Private/Dry Forest - This portion of the landscape has seen tremendous change from the historic condition, as the majority of acres are in the mid structural stages at present. Timber harvest and thinning has profoundly reduced the average size and density of trees throughout this area, with virtually a 10-fold reduction in late and old forest structure, particularly in ponderosa pine stems. Continued fire suppression and harvest/thinning will continue to reduce the acreage in early and old forest structures, dependent upon target tree stocking densities and stand rotation lengths.

Landscape Area 6: Dry Forest - Much like Landscape Area 5, this area has seen profound reductions in the amount and distribution of late/old structural stages, to the tune of about a five-fold reduction.

Table 9. Existing Conditions for each Landscape Area by Structural Stage

Landscape Area Number and Name		Area (in acres)	Open Areas	Early	Mid	Late
1	Wilderness	5,032	33%	4%	25%	39%
2	Cold Forest	3,632	16%	2%	21%	61%
3	Bridge Creek	4,223	3%	7%	29%	61%
4	Moist Forest	18,278	2%	16%	66%	16%
5	Private Dry	23,857	3%	5%	84%	8%
6	Public Dry	6,637	4%	7%	77%	13%
Total Landscape		61,689	6%	8%	66%	20%

Stand Density Classes:

Stand density has also been classified for the landscape, although there is currently no readily available method to reference existing conditions to the historic. Nonetheless, in the absence of fire disturbance, stands have avoided successional set-backs and have generally gained higher densities across the entire watershed. Table 10 and Exhibit 12 provide an estimate of current stand density acres by density classification (See Vegetation Appendix for more information).

Table 10. Existing Conditions for each Landscape Area by Stand Density Class

Landscape Area Number and Name		Area (in acres)	Low Density	Moderate Density	High Density	Total
1	Wilderness	5,032	77%	17%	6%	100%
2	Cold Forest	3,632	39%	16%	45%	100%
3	Bridge Creek	4,223	25%	15%	60%	100%
4	Moist Forest	18,278	33%	20%	47%	100%
5	Private Dry	23,857	38%	45%	17%	100%
6	Public Dry	6,637	35%	49%	16%	100%
Total Landscape		61,689	38%	32%	30%	100%

Summarizing Conditions to Landscape "Zones"

The following discussion on vegetation collapses the 6 landscape areas into 3 distinct landscape zones, each dominated by a different forest vegetation composite. For each landscape zone, the major plant communities are discussed, along with a quantitative estimate of their coverage within the zone. Use of the 3 zones is done in an effort to broadly characterize the 4 watershed areas into discrete biophysical environments that offer strikingly different conditions of vegetation and wildlife habitat, as well as distinct opportunities for management.

In summary, the 6 landscape areas are readily collapsed into 3 landscape zones, based on their inherent similarities or differences. As they are all dominated by late/old structures of mountain hemlock and mountain hemlock-lodgepole pine mixtures, landscape areas 1, 2, and 3 are combined into Landscape Zone A. Landscape Area 4 remains a distinct identity and is labelled Landscape Zone B. Landscape Areas 5 and 6 have similar plant associations and species mixtures (decidedly ponderosa pine) and management history (extensive timber harvests), and are combined into a singular Landscape Zone C.

The tables below show the landscape area data collapses, and are provided for a definitive summary of the current condition in estimates of historic condition.

Table 11. Existing Conditions for each Landscape Zone by Structural Stage

Landscape Zone	Landscape Area(s)	Acres	Open	Early	Mid	Late
A	1, 2, 3	12,915	18%	4%	25%	52%
B	4	18,278	2%	16%	66%	16%
C	5, 6	30,496	3%	5%	82%	9%
Totals	All	61,689	6%	8%	66%	20%

Exhibit 12
Bend Watershed Analysis
VEGETATION STAND DENSITY

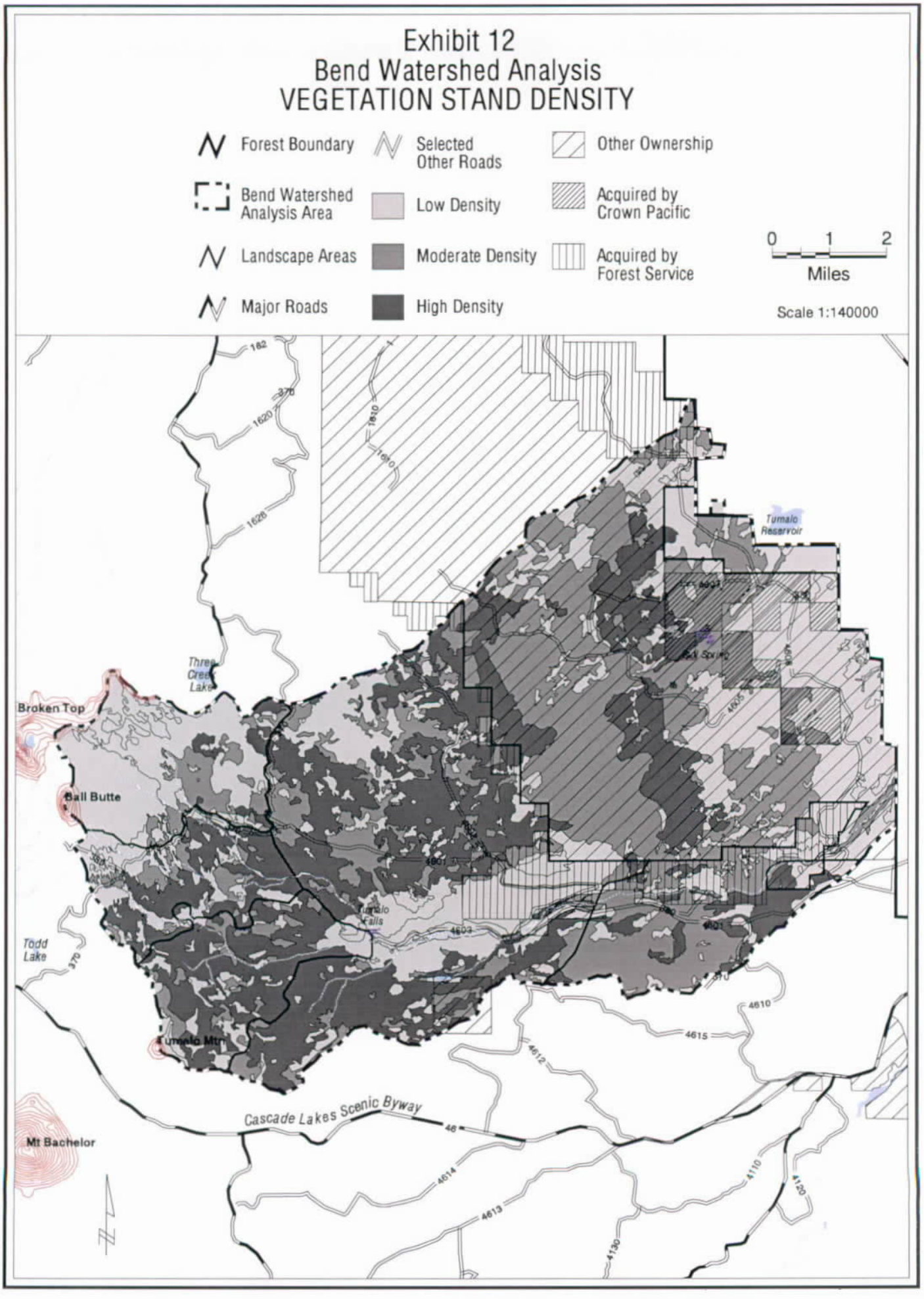


Table 12. Historic Conditions of each Landscape Zone by Structural Stage (HRV Estimate)

Landscape Zone	Landscape Area(s)	Acres	Open	Early	Mid	Late
A	1, 2, 3	12,915	19%	13%	41%	27%
B	4	18,278	1%	22%	41%	36%
C	5, 6	30,496	1%	11%	13%	75%
Totals	All	61,689	5%	14%	27%	54%

* Landscape Zone A: comprised of the following plant association group proportions: MHD = 66%, MDW = 15%, MCD/W = 8%, LP = 7%, ROCK/RIP = 4%;

Landscape Zone B: comprised of the following plant association group proportions: MCW = 38%, LP = 38%, MCD = 16%, MHD = 7%, RIP/ROCK = 1%;

Landscape Zone C: comprised of the following plant association group proportions: PP = 79%, MCD = 15%, MCW = 5%, RIP/ROCK/SHRUB = 1%;

Landscape Zones in Detail

Zone A (Wilderness, Cold Forest/Unroaded, Bridge Watershed Landscape Areas)

Mountain Hemlock (MHD PAG: 66 percent of zone)

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 trees species where mountain hemlock will still be the dominant or co-dominant tree. The 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 to 21 inches, are multi-sized and multi-storied. Old growth encompasses both older forests of early seral species, such as fire dependent species, and forests in later successional stages dominated by shade-tolerant species. Mountain hemlock is not considered a highly-desired commercial timber species and is found throughout the dispersed recreation and Bend Municipal Watershed management areas. This PAG is found on all aspects within an elevation band of about 6,000 to 7,500 feet.

Sparsely Vegetated (incl. ROCK, RIP, Alpine Shrub/Meadow PAGs: 19 percent of zone)

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 these are areas of rock and grass. Shrubs and trees found within this area will often 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, at elevations above 7,000 feet.

Also note that riparian areas flow through the sparsely vegetated types, the mountain hemlock types, the mixed conifer types, and the Bridge Creek burn. At higher elevations, mountain hemlock will encroach upon meadow openings as a part of the native ecological process, namely forest succession. At lower elevations, lodgepole pine will readily advance into meadow areas. In both cases, the lack of disturbance events such as fire, makes the way for succession to proceed.

Lodgepole Pine (LPD and LPW PAGs: 7 percent of zone)

The lodgepole pine PAG's are located mainly within an elevation band of 5,800 to 6,800 feet with some stands located as low as 5,200 feet. This is considered high elevation lodgepole and given the natural disturbance and succession processes, the lodgepole will probably be replaced over time by mountain hemlock and/or true 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 to 9 inches dbh), multi-sized, low density stands and pole size dbh's in single storied stands. Many of these structures appear to be of second growth vegetation characteristics.

Mixed Conifer (MCD and MCW PAGs: 8 percent of zone)

The mixed conifer type is composed of a mix of species cover that includes white fir, Douglas fir, mountain hemlock and lodgepole pine. Occasionally, western white pine and, to a much lesser degree, western larch trees, either individually or in patches, are found in this zone. These plant associations occur both on north and south aspects and will show differences in stand densities, crown and canopy cover, and species mixtures between aspects. Ponderosa pine is found within the mixed conifer zone at the lowest elevations, which are typically 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 to 21 inches dbh) and canopy covers of 25 to 75 percent 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. Old growth structures encompass both older forests of early seral species, such as fire dependent species, and forests in later successional stages dominated by shade-tolerant species. Included within this mixed conifer zone are timber harvest units that have been planted or naturally regenerated. The mixed conifer has an elevation range of 5,200 to 6,800 feet with some patches found as high as 7,800 feet.

Zone B (Front Country/Transition Landscape Area)

Mixed Conifer (MCD and MCW PAGs: 54 percent of zone)

The mixed conifer type becomes the dominant plant association found within this landzone and is composed of a mix of species cover that includes white fir, Douglas fir, mountain hemlock and lodgepole pine. Occasionally, western white pine and, to a much lesser degree, western larch trees are found here. These plant associations occur both on north and south aspects and will show differences in stand densities, crown and canopy cover, and species

mixtures between aspects. Ponderosa pine is found within the mixed conifer zone at the lowest elevations, which are typically 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 to 21 inches dbh) and canopy covers of 25 to 75 percent 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. Old growth structures encompass both older forests of early seral species, such as fire dependent species, and forests in later successional stages dominated by shade tolerant species. Included within this mixed conifer zone are timber harvest units that have been planted or naturally regenerated. The mixed conifer has an elevation range of 5200 to 6800 feet with some patches found as high as 7800 feet.

Lodgepole Pine (LPD and LPW PAGs: 38 percent of zone)

The lodgepole pine PAG's are located throughout this zone at generally an elevation band above 5,000 feet. Similar to Zone 1, this is considered high elevation lodgepole pine and given natural disturbance and succession process, the lodgepole will probably be replaced over time by true fir species or mountain hemlock. The majority of the lodgepole type is mapped as pure lodgepole stands and includes mixes of lodgepole and fir species within other stands. The lodgepole pine stands are of various sizes (averaging 5 to 9 inches dbh), multi-sized, low density stands and pole size dbh's in single storied stands. Many of these structures appear to be the remnant stands following mountain pine beetle outbreak activity over the past few decades.

Mountain Hemlock (MHD PAG: 7 percent of zone)

Mountain hemlock dominance drops away in this zone, as it becomes less of a dominant forest type. The closed canopies of pure mountain hemlock give way to the mixtures of lodgepole pine-hemlock, and lodgepole pine-true fir. The majority of the mountain hemlock type exhibits a range of diameters at breast height (dbh) from 9 to 21 inches, are multi-sized and multi-storied. Old growth encompasses both older forests of early seral species, such as fire dependent species, and forests in later successional stages dominated by shade tolerant species.

Riparian (RIP and ROCK PAGs: 1 percent of zone)

Riparian features and rock outcrops make up the remainder of acres within this zone. Within this analysis area, riparian zones include meadows, lakes, and perennial stream courses. The riparian flows through the mountain hemlock, the mixed conifer, the Bridge Creek Fire area, and the ponderosa pine communities. Associated with the mixed conifer and riparian communities along the Bridge Creek Fire area are Engelmann spruce bottomlands.

Zone C (Private/Dry Forest, Dry Forest)

Ponderosa Pine (PPD and PPW PAGs: 79 percent of zone)

The ponderosa pine PAG's are located entirely within this zone at generally an elevation band generally below 4,800 feet. The majority of the ponderosa pine type is mapped as pure ponderosa pine stands and will include mixes of lodgepole pine and white fir species sporadically. The ponderosa pine stands are of rather uniform size (averaging 7 to 12 inches dbh) and structure (mid-structural stage). As the majority of this zone is in private, industrial forestry ownership, these are typically of low density and are single storied stands. Many of these structures appear to be the remnant stands following commercial timber harvesting in the first half of the 20th century.

Mixed Conifer (MCD and MCW PAGs: 20 percent of zone)

The mixed conifer type fades to being the minor plant associations found within this landzone. It is composed of a mix of species cover that includes white fir, Douglas fir, mountain hemlock and lodgepole pine. Occasionally, western larch trees are found in these communities. These plant associations occur both on north and south aspects and will show differences in stand densities, crown and canopy cover, and species mixtures between aspects. Structurally, the mixed conifer type is composed of mixes of small diameter to large diameter trees (5 to 21 inches dbh) and canopy covers of 25 to 75 percent 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. Old growth structures encompass both older forests of early seral species, such as fire dependent species, and forests in later successional stages dominated by shade tolerant species. Mixed conifer stands within this land zone have an elevation range of 4,800 to 5,500 feet with some patches found as high as 6,000 feet.

Riparian (RIP, ROCK and Shrub PAGs: 1 percent of zone)

Riparian areas within this zone flows through ponderosa pine and mixed conifer dominated plant communities. The canyon that Tumalo Creek flows through in the lower portion of the watershed area is a good example of riparian vegetation that is confined to a narrow zone. Species diversity increases within this zone, and tree species expand beyond the common ponderosa pine to include Douglas fir, western larch, and quaking aspen. These types of plant associations are readily seen in walking through the lower portion of the canyon at Bend's Shevlin Park.

Landscape Patterns and Patches

Meadow and rock areas are easily identified patches within the subwatersheds. Most meadows 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 a pronounced geologic feature. In addition, rock outcrops are readily visible within the Bridge Creek Fire area.

Definitive vegetation landscape patterns and patches are somewhat difficult to define within the subwatersheds. Infrequent native fire regimes have allowed for much of the vegetation types to begin development of old growth structural characteristics. This is especially so for undisturbed portions of the watersheds above 6,000 feet elevation. 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.

Overall within the watershed, 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. Timber sale units located in the southeast portion of the Forks watershed have created openings within the mixed conifer forest type that is drier and supports more ponderosa pine. These openings have been planted or are naturally regenerated.

More Recent Historic Information

Bridge Creek Fire: The fire started on July 24, 1979 and burned a total of 3,400 acres. Of this approximately one-half of the acres are within the Forks and Bridge subwatersheds, which are relatively pristine. Current mapping describes the potential vegetation for this area as mixed conifer. The intensity of the fire moved the vegetation from a mixed conifer mid/late/old growth stage to an early seral stage. Due to the variety of tree species planted and the intensity of grass seeding, de facto plant associations are difficult to define. For this reason, the fire has been split out as its own group with no associated vegetation PAG attached (Pre-WEAVE, 1995).

Additional Fire Information - Rehabilitation efforts began immediately. Aerial grass seeding of annual rye grass was accomplished by mid-August, 1979. Ten pounds of grass per acre were seeded over the entire area except within the Bend Municipal watershed which 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 percent 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, Engelmann spruce, mountain hemlock and lodgepole pine. Native hardwood species were planted into the riparian areas including thinleaf alder, willow, aspen, black cottonwood, currant, red elder and serviceberry.

TERRESTRIAL WILDLIFE SPECIES

HISTORIC AND CURRENT CONDITIONS

Landscape Zone A (Wilderness, Bridge, and Cold Forest/Unroaded Landscape Areas)

The Wilderness and unroaded areas provide contiguous habitats affected mainly by natural disturbances (insect outbreaks, fire, etc.). Habitats within these Landscape Areas are similar to historic conditions, with the exception of more dense stand conditions, an increase in LOS acres and a lack of small openings all of which have resulted from fire suppression. The most prominent change in direct human interaction in this portion of the watershed is the increase in recreational use. Although use may be considered light in relation to other areas of the District, the level of human activity may be significant enough to displace some species, such as wolverine, that avoid any type of human presence.

Landscape Zone B (Front Country/Transition Landscape Area)

This zone represents the middle elevations between the intensively managed Landscape Zone C and the relatively unmanaged, primitive Landscape Zone A. Here, forested vegetation is a mixture of mountain hemlock, lodgepole pine, and mixed conifer stands. Forest structure is predominately mid-structural stage (66 percent), with 16 percent of the Zone in early, and 16 percent in late and old structure. Historically, there was probably much less mountain hemlock represented and more of an equitable distribution of structural stage percentages. Fragmentation is low throughout most of the zone (and may be lower than what occurred historically) with the Bridge Creek Fire and scattered timber harvest units accounting for most breaks in forested continuity. Road densities are higher than Zone A, but still much lower than Zone C. Recreation activity is moderate to high and includes such activities as hunting, fishing, hiking mountain biking, cross country skiing, and snowmobiling.

Landscape Zone C (Private/Dry Forest and Dry Forest Landscape Areas)

The lower elevations of the watershed consist primarily of ponderosa pine wet and dry communities, with lesser amounts of mixed conifer, lodgepole pine, and juniper stands. Historically, this area was dominated by ponderosa pine, the majority of which (54 percent) was in late and old structural condition with understory species and densities governed by low intensity, short return fire intervals. Tree spacing was variable, with most mature stems being in small (1/2 to 2 acre) clumps. Under the current condition, a vast majority of acres (82 percent) are mid-structure with little variation in stem spacing. Road densities are highest in this portion of the watershed, with densities exceeding 4 miles per square mile. Recreation intensity is light to moderate. Much of this zone consists of mule deer winter range.

PETS and Selected Species Analysis

Wildlife species represented in this assessment include those given federal status (Threatened, Endangered, and Sensitive status species) that are known to inhabitat or potentially inhabit the watershed. Also included are selected species known to occur or

potentially occur in the watershed, which include those species managed as indicator species (MIS) on the Deschutes National Forest, or characterized as Species of Concern (SOC) by the U.S. Fish and Wildlife Service. Species at risk but not given a management status may also be included. Species included in the assessment are as follows:

Table 13a. Bend Watershed - Listed Species and Federal Status

Species		Federal Status
American Peregrine Falcon	*Falco peregrinus anatum*	E
Northern Bald Eagle	*Haliaeetus leucocephalus*	T
Northern Spotted Owl	*Strix occidentalis caurina*	T
Canada Lynx	*Lynx canadensis*	C (PT)
California Wolverine	*Gulo gulo luscus*	S, SOC
Townsend's big-eared bat	*Corynorhinus townsendii*	S, SOC
Preble's shrew	*Sorex preblei*	S, SOC
Oregon spotted frog	*Rana pretiosa*	C

Table 13b. Bend Watershed - Selected Species

Species		Status
Black-backed woodpecker	*Picoides arcticus*	MIS
White-headed woodpecker	*Picoides albolarvitus*	
Pileated woodpecker	*Dryocopus pileatus*	MIS
Northern goshawk	*Accipiter gentilis*	MIS, SOC
Great Gray Owl	*Strix nebulosa*	SM
Golden Eagle	*Aquila chrysaetos*	MIS
Marten	*Martes americana*	MIS
Pacific fisher	*Martes pennanti pacifica*	MIS
Cascades frog	*Rana cascadae*	SOC

E= Endangered, T= Threatened, S= USFS Region 6 Sensitive, C= USFWS Candidate for Listing, PT= Potential Listing as Threatened, MIS= Deschutes National Forest Management Indicator Species, SOC= USFWS Species of Concern.

American Peregrine Falcon

Historic Condition - There are no known historic nesting sites within the watershed. Habitat suitability was probably similar to that found today. A lack of suitable foraging areas, such as those provided by areas of open water, would have limited historical use by this species.

Current Condition - No active nest sites or individual sightings are known. Although several cliff sites, exposed within the Bridge Creek Fire area, may serve as suitable nesting substrate, the lack of forage habitat would limit the watershed's capacity to support breeding pairs.

Trends - There are no trends specific to this watershed, but regional populations may be increasing. Pesticide bans along with juvenile hacking programs have led to higher reproduction rates and juvenile survival.

Northern Bald Eagle

Historic Condition - Historic bald eagle use within the watershed is not known. As with peregrines, a lack of open water foraging habitat would have restricted nesting and home range use. Deer winter range at the lower elevations may have served as winter or transitional forage sources but use would have been sporadic and dependent on deer distribution and severity of the winter.

Current Condition - Suitability for nesting is similar to historic condition. There are no known active nesting or roosting areas within the watershed. Lower elevation habitat may be used as forage sites during winters with significant deer mortality.

Trends - Highgrading of large diameter ponderosa pine at the eastern edge of the watershed has reduced the opportunity for winter roosting.

Northern Spotted Owl

Historic Condition - Historic distribution and populations numbers within the watershed are not known, however, populations would have been likely to inhabit areas dominated by mature or old growth conifer stands with complex structure including multiple canopy layers, large green trees and snags, heavy canopy cover, and ground level coarse woody material. Suitable nesting, roosting, and foraging (NRF) habitat would have been found in stands of mixed conifer, ponderosa pine with white fir understory, or mountain hemlock with sub-alpine fir where the overstory consists of large trees (generally greater than 20 per acre) 25 inches dbh or greater.

Estimates for historic range of variability (HRV) for stand types and structural stages within the watershed show that approximately 43 percent (26,500 acres) of the watershed would have supported plant association groups (PAGs) normally found in spotted owl habitat (See Table 14). Of this 43 percent, about 54 percent (14,300 acres) is estimated to have been in late and old structure with multiple-storied canopy. Not all of these acres would have been suitable at any point in time (due to insect activity, fires, blowdown, lack of suitable nest trees, etc.), but it could be assumed that at least 50 percent (7,200 acres) was suitable NRF habitat.

Actual fragmentation patch size and pattern would have varied widely, depending upon levels of precipitation, insect outbreaks, and lightning and Native American-caused fire ignition rates. Agee (1993) describes fire return intervals within the East Cascades as

variable, but averaging between 10 to 60 years, depending on aspect and elevation. Fire intensity was normally low as these frequent fires removed understory ladder fuels and consumed material on the forest floor. An accumulation of fuels after a relatively long fire free period would have increased the potential for large acre events, but such large fires were more the exception. At higher elevations, fragmentation in mountain hemlock would have consisted of scattered pockets of root rot averaging several acres in size, in addition to infrequent (300 to 500 years) large acre stand replacement fires. In summary, spotted owl habitat within the watershed historically would have been largely contiguous, with small breaks in the canopy ranging from infrequent to frequent, and large breaks (greater than 100 acres) being infrequent.

Table 14. Historic Conditions - Vegetation Type and Stand Structure

Major PAG	% of Total Landscape	Dominant Species	HRV Structural Stage Estimates (%) Open Areas	Early	Mid	Late/Old
PPD/W	39	pond. pine	---	2,405	2,405	19,606
MCD	14	pond. pine	---	864	1,728	6,045
MCW	14	white fir	---	1,728	3,886	3,022
LPD/W	13	lodgepole	---	2,405	3,609	2,005
MHD	15	hemlock	---	1,388	5,089	2,776
OTHER	5	rock/rip./ meadows	154	---	---	---
Landscape Totals (Range %)	100		154 (5%)	8,363 (10-20%)	16,656 (20-35%)	33,312 (40-65%)

Current Condition - There are no known active or recently active spotted owl nesting areas within or adjacent to the watershed. Also, surveys have not been conducted within the watershed. Suitable NRF habitat has been identified within the watershed and totals 1,200 acres. Characterization of NRF habitat in the current condition is much more restrictive than for the historic condition due to the availability of more site specific data, therefore, direct comparisons in estimated acres of NRF are not necessarily valid. However, comparisons in structural stage vegetation by PAG is available and serves as fairly good data for comparison.

To assess historic versus current conditon habitat for spotted owls, late and old structural stage acres by suitable PAG will be used. Table 15 shows a total of 8,044 late and old structure acres within the mixed conifer dry (MCD), mixed conifer wet (MCW), and mountain hemlock dry (MHD) vegetation types. In comparison, under the estimated historic condition 11,843 acres of late and old structural habitat existed in PAGs known to be suitable for spotted owl nesting, roosting, and foraging. This represents a net loss of 3,799 acres of potentially suitable habitat, all of which is accounted for within the mixed conifer PAGs. Given the tolerances for the accuracy of HRV analysis (+/- 15 percent), the change may be as

little as 3,200 acres or as much as 4,400 acres. Main causes for the disparity in suitable habitat include timber harvest as well as the Bridge Creek Fire.

Table 15. Current Conditions - Vegetation Type and Stand Structure

Major PAG	% of Total Landscape	Dominant Species	Structural Stage Estimates (Acres) Open Areas	Early	Mid	Late/Old
PPD/W	39	pond. pine	773	1,443	19,851	2,450
MCD	14	pond. pine	86	432	7,341	777
MCW	14	white fir	0	2,858	5,186	605
LPD/W	13	lodgepole	0	86	6,736	1,203
MHD	15	hemlock	370	275	1,943	6,662
MDW/RP	3	mead/rip.	1,554	20	150	130
ROCK	5	rock/cind.	3,084	---	---	---
Landscape Totals	100		5,813	5,103	41,203	11,827

Spotted owl dispersal habitat encompasses approximately 9,300 acres within the extent of acres governed by the Northwest Forest Plan on Forest Service lands. A majority of dispersal acres occur within the Front Country/Transition Landscape Area, but stands suitable as dispersal within the central and northern portions of the Front Country/Transition Landscape Area are more scattered than those found in the southern portion of the same Landscape Area as well as areas within the Cold Forest/Unroaded and Bridge Landscape Areas. Breaks in dispersal habitat continuity throughout the watershed were attributed to small-diameter stands, low canopy closures, timber harvest units, and the Bridge Creek Fire.

A majority of the watershed is managed under guidelines provided by the Northwest Forest Plan (NWFP). Owl Management allocations within the watershed include Congressionally Withdrawn, Administratively Withdrawn, and Matrix (See Table 16). There are no acres of Critical Habitat (LSR) designated within the watershed, however, the Three Creeks and Sheridan LSRs lie in close proximity to the north and south, respectively (See Exhibit 5).

Table 16. Bend Watershed - Northwest Forest Plan Allocations

NWFP Allocation	NWFPAcres Within the Watershed	NRF Habitat Acres
Congressionally Withdrawn Lands	4,407	0
Administratively Withdrawn Lands	11,795	774
Matrix	11,370	352
Riparian Reserve	663	---
Totals	**28,235**	**1,126**

Trends - Past timber harvest along with the Bridge Creek Fire area have reduced and fragmented portions of the watershed that may have been suitable NRF habitat. Barred owls continue to extend their range east, and are better adapted to more fragmented environments. They may also cross geneticaly with spotted owls and in doing so dilute the spotted owl gene pool.

Given the amount of federal protection for spotted owl populations and their habitat, species numbers and distribution is expected to level off or begin to show an increase in the future.

Canada Lynx

Historic Condition - High quality lynx habitat in the western mountains consists mainly of a mosaic of early structural habitats with high snowshoe hare densities, and late-strucural stands with down woody material for cover and denning. Forest types known to be used by this species include mixed conifer, aspen, lodgepole pine, spruce, and subalpine fir communities. Historically, suitable lynx habitat probably existed within the watershed at or above the MCW plant association group. A lack of fire suppression would have provided a more equitable distribution of structural conditions, creating more favorable habitat for snowshoe hare populations. There have been no historic sightings of lynx reported within or adjacent to the watershed. Fur trapping which occurred in the late 1800's and through the first half of this century would have targeted lynx as a commercial species, and trapping, in conjunction with disturbance factors and changes in habitat, may have extirpated lynx from much of its historic range.

Current Condition - The current status of lynx within the watershed is unknown. Suitable habitat does exist, but is thought to be marginal due to a lack of early structural vegetation in the high country. No recent sightings for this species have been reported. Some formal surveys have been conducted by the Forest Service but results are not yet available.

Trends - Since much of the potential lynx habitat within the watershed is within the Wilderness and unroaded areas, habitat conditions are expected to remain static during the forseeable future. However, as the presence of humans in these environments continues to increase disturbance will increase as well.

California Wolverine

Historic Condition - Although historic population densities are unknown, wolverine were probably more abundant prior to European settlement. Historic distributions in the 3 Pacific western states extended from Canada, south throughout the forested portions of Washington, from central Oregon west to the coast. and throughout central and northern California. Heavy trapping in the early 1900's reduced or extirpated local populations.

Current Condition - The wolverine is a shy, secretive species that requires large tracts of undisturbed subalpine communities where human presence is minimal. Recent sightings around Broken Top, Tam McArthur Rim, Benchmark Butte, Crane Prairie, and Cultus Lake indicate a moderate to high probability that wolverine inhabit the watershed, at least in a transitory fashion. Helicopter surveys for den sites conducted during the winter of 1998 by the Oregon Department of Fish and Wildlife did not rsult in any sightings.

Trends - Wolverine populations were drastically reduced by trapping during the first half of this century, and may have been extirpated from much of its former range. Although potential habitat is considered fairly stable, increased recreation use poses a threat to wolverine distribution.

Townsend's Big-Eared Bat

Historic Condition - Historic condition of big-eared bat habitat and distribution was probably similar to current conditons.

Current Condition - There are no known caves within the watershed nor have there been sightings reported for this species.

Trends - No trends within the watershed are identified for this species.

Preble's Shrew

Historic Condition - Preble's shrew habitat was historically limited within the watershed due to a lack of riparian meadow and marsh/upland meadow interface. No historic sightings have been reported.

Current Condition - Suitable habitat for this species is lacking throughout the watershed. Although no formal surveys have been conducted, the likelihood of occurrence is low.

Trends - No trends within the watershed are identified for this species.

Oregon Spotted Frog

Historic Condition - Historically, this species probably did not inhabit the watershed given the lack of suitable habitat, which includes marshy conditions with seasonally slow moving, warmer water transitionally found at lower elevations around the Deschutes River and Cascade Lakes. No historic sightings have been reported.**Current Condition** - Areas within

and adjacent to the Bend Watershed were characterized as non-habitat (Newton et al. 1998) for Oregon spotted frogs.

Trends - No trends within the watershed are identified for this species

SELECTED SPECIES

Cavity Nesters

Approximately 39 species of cavity nesting bird species occur or are expected to occur within the Bend Watershed. Snag, down log, and green tree replacement numbers are not currently known. Due to past management treatments, insect and disease outbreaks, and wildfire, gaps exist in both the distribution of available dead wood habitat and future snag and down log replacement trees.

Black-Backed/Three-Toed Woodpecker

Historic Condition - Although habitat suitability indices were not conducted, numbers and distribution of these birds were probably greater historically, due mainly to the existence of more snags across the landscape including snags unharvested from stand replacing events. Also, suitable habitat is estimated to be greater historically. Acres of LOS lodgepole pine were estimated to be over 2,000 acres, compared to 1,200 acres in the current condition (See Tables 13a and 13b).

Current Condition - As stated above, suitable habitat is currently estimated to be 1,200 acres. An additional 6,700 acres of mid-structure lodgepole pine serves as marginal or suitable, depending on available snag numbers. Much of the mid-structure lodgepole pine is within unroaded areas, and will likely be allowed to cycle naturally, providing prime habitat for these species. Three-toed woodpeckers were sighted within the Bridge Creek Fire area 2 to 3 years post-fire. No sightings of black-backed woodpeckers have been reported within the watershed.

Trends - In areas where salvage logging of standing dead trees has not occurred, populations of black-backed woodpeckers may be increasing. Lodgepole pine stands allowed to cycle naturally will continue to provide habitat for both of these species.

Pileated Woodpecker

Historic Condition - Suitable habitat for pileated woodpeckers, which is composed mainly of LOS mixed conifer wet stands and mountain hemlock, is estimated at 5,800 acres. Historical habitat suitability within mixed conifer dry vegetation types was probably lower because more frequent, low intensity fires tended to remove more down logs and understory canopy.

Current Condition - No pileated woodpecker sightings have been reported within the watershed. The nearest sighting was recorded about 4 miles south, near Kiwa Butte in 1995. Current habitat is available in LOS stands within the mountain hemlock and mixed conifer

wet PAGs, and totals 7,300 acres. While some habitat has been lost to timber harvest and the Bridge Creek Fire, habitat for this species within the watershed has probably increased in suitability since fire suppression has allowed accumulations of down logs as well as understory intrusions of white fir within some stands historically lacking any significant understory vegetation.

Trends - Removal of large diameter trees within the MCD PAG has reduced acres of suitable habitat. However, fire suppression in combination with retaining Wilderness and unroaded areas has probably increased overall suitable habitat within the watershed.

White-Headed Woodpecker

Historic Condition - Documented provincial declines in numbers indicate historical populations to be greater than under the current condition. Historically, LOS ponderosa pine habitat (suitable for this species) had a wide distribution and high acre totals (19,600 acres) prior to timber harvest activities in the 1940's.

Current Condition - No sightings have been recorded within the watershed. Current acreage of suitable habitat totals a paltry 2,500 acres. Where large diameter ponderosa pine still exist at lower elevations, fire suppression has led to understory intrusions by various tree species that essentially create unsuitable conditions for white-headed woodpeckers.

Trends - The dramatic decrease in LOS pine has greatly reduced acres of habitat suitaable for this species. Unless large areas are allowed to return to late and old character, the future of this species within the watershed is uncertain.

Raptors

Northern Goshawk

Historic Condition - Historically, the abundance and quality of suitable habitat for northern goshawks was higher than currently exists. An estimated 28,600 acres of habitat was available in the ponderosa pine wet and dry, and mixed conifer dry PAGs under historic conditions.

Current Condition - Surveys have not been conducted, however, goshawk sightings have been reported within the Bridge Creek Fire area and just south of the watershed along Road 4615. The nearest known active nest is located along the Middle Fork of Tumalo Creek about a mile south of the watershed. Habitat distribution has diminished, mainly due to timber harvest and roading at mid and lower elevations. Suitable nesting habitat, for example, now totals only 3,800 acres in comparison to the 28,600 acre estimate given for historic condition.

Trends - Loss of habitat within the ponderosa pine and mixed conifer PAGs has restricted habitat available to goshawks. Areas now considered suitable are at high risk to stand replacment events due to the dense nature of these stands.

Golden Eagle

Historic Condition - Preferred habitat consisting of open forest and desert shrub conditions was probably lacking, with the exception of the occasional large-scale fire that would have created openings suitable for foraging. Most historic use likely occurred at the eastern fringe where ponderosa pine stands mingle with juniper and desert shrub.

Current Condition - A lack of large diameter pine along the eastern fringe of the watershed has reduced nesting habitat suitability in that area. Active nesting, however, has been reported along the cliffs within the Bridge Creek Fire area. It is not known whether these birds are using this area for foraging, or venture out to the desert for food.

Trends - Habitat trends for the golden eagle within the watershed are uncertain, and can only be clarified after identifying locations of forage areas. If the birds are foraging primarily within the Bridge Creek Fire area, stand succession will soon reduce foraging effectiveness.

Flammulated Owl

Historic Condition - Similar to that of the white-headed woodpecker and northern goshawk, habitat for flammulated owls was extensive historically. Suitable habitat included ponderosa pine PAGs with LOS characteristics, as well as mixed conifer PAGs with LOS and some degree of ponderosa pine presence. Preferred microhabitat characteristics for this species range from relatively open mature stands to dense stands of multi-layered, second growth and mature forest. Historic habitat is estimated to be approximately 28,700 acres. Although an estimate of historic numbers of flammulated owls is unavailable, one can assume that populations were higher under historical conditions since so much more suitable habitat was available.

Current Condition - Surveys have been conducted within the watershed, and consist of a calling route 2.5 miles long, extending along Roads 4601 and 4602 from Tumalo Creek to Bearwallow Butte. Flammulated owl responses along this route were reported as recently as June 1998. The sampling area is relatively minute and more extensive surveys would give more information on the distribution of this species, but the response rate for such a small portion of survey would indicate that flammulated owls are probably relatively well distributed in areas with potential habitat. Approximately 3,800 acres of suitable habitat currently exist within the watershed, only 13 percent of estimated historical acres. Habitat losses can be attributed to timber harvest of large diameter ponderosa pine and associated species, insect and disease outbreaks, and the Bridge Creek Fire.

Trends - Loss of LOS within the mixed conifer dry and ponderosa pine PAGs has seriously reduced habitat and distribution for this species. Untreated areas remaining in mixed conifer stands represent the only viable habitat left in the watershed.

Great Gray Owl

Historic Condition - It is questionable whether the watershed ever supported breeding pairs of great gray owls since the preferred habitat (wet and dry meadows interspersed with lodgepole pine) was probably very limited in scope and distribution.

Current Condition - Fire suppression has most likely led to a conversion of open meadow to pine stand in some areas, further restricting the habitat and potential for breeding pairs. No sightings have been reported, although no formal great gray owl surveys have been conducted.

Trends - Meadow forage habitat is decreasing due to lodgepole pine encroachment. Other forest openings are lacking in otherwise suitable areas because of fire suppression.

Mammals

Marten

Historic Condition - Suitable habitat consists of late structure lodgepole pine and mixed conifer wet stands, and to some degree mid-structure lodgepole. Habitat is estimated to have totaled about 8,600 acres historically. Historic levels of habitat fragmentation, which reduces habitat suitability for marten, most likely varied for any given century, but would have been more prone to isolated large acre events in lodgepole pine, and less so within mixed conifer dry plant associations.

Current Condition - Marten sightings have been reported within the Bend Watershed, although formal surveys have not been conducted. Sightings have also been reported immediately north and south, indicating a high probability of marten presence within the watershed.

Acres of suitable marten habitat (8,500 acres) are similar under current conditions, but optimal habitat in the form of LOS lodgepole pine has decreased, being replaced by mid-structure lodgepole pine and mountain hemlock. In some areas, lodgepole pine stands that would normally be set back in structural stage by agents of stochasticity have been allowed to reach maturity, while in others timber harvest has occurred or small diameter mountain hemlock has replaced lodgepole pine. Snags and down logs in mixed conifer stands are also accumulating, further increasing habitat suitability in stands that may have been of marginal suitability historically. In addition, current levels of overstory fragmentation within mixed conifer and lodgepole pine PAGs are probably not outside HRV in scope or distribution since timber harvest within these associations has been relatively light. The Bridge Creek Fire area, which covers about 4,000 acres within the mixed conifer association, may exceed the average acre total for a single stand replacing event under historic conditions, but the total acreage if averaged across the watershed, is probably not outside the range of historic variability.

Although, as stated above, total acres of marten are similar to historic conditions, high densities of open roads have eroded habitat suitability within many areas where stand

conditions are favorable for marten. This not only creates a disturbance factor, but also increases the likelihood of dead wood removal in the form of public firewood cutting.

Trends - Retention of roadless character within the mixed conifer wet and lodgepole pine PAGs has allowed stands to cycle naturally, providing large areas suitable for marten. Fire suppression within lodgepole pine, however, has led abnormally high fuel accumulations that create a high risk to large scale stand replacement fire.

Fisher

Historic Condition - In the Pacific Northwest, fishers are considered obligate late-successional mammals. Preferred forest structure, characterized by diversity in tree size and shapes, light gaps in the canopy with associated understory vegetation, snags, fallen trees and limbs, and limbs close to the ground, is considered more important than tree species **(Ruggerio et al. 1994)**. With this in mind, suitable habitat most likely consisted of LOS stands in the mixed conifer wet and mountain hemlock wet and dry PAGs. Analysis of HRV shows about 5,800 acres of habitat historically.

Current Condition - There have been no fisher sightings reported or formal surveys conducted within the watershed. Fur trapping during the early 1900's decimated populations within Oregon and Washington. Extirpation from some areas is likely, while in others population densities have yet to recover and may not recover without substantial reintroduction efforts.

Current suitable habitat is estimated at 7,300 acres, an increase over historical conditions. Reasons for the increase include fire suppression within the mountain hemlock association. High road densities also have a negative impact on fisher habitat. Although not as wilderness dependent as wolverine, fishers are usually characterized as a species that avoids humans **(Douglas and Strickland 1987, Powell 1993)**.

Trends - Increased recreation and human disturbance will have a negative effect on this species. Retention of roadless areas will aid in maintaining some viable habitat.

Neotropical Migrant Birds

This category includes a relatively large list of birds, among which are individual species that utilize a wide array of habitat types. Some are habitat specialists while others require more general conditions. Therefore, an assessment of specific habitat acres would not accurately portray historic and current conditions in the proper context of watershed analysis. The method used here compares changes in availability of structural stage acres by PAG.

Historic Condition - For HRV, all structural stages were represented for all PAGs found within the watershed (See Table 17). An estimate of HRV for riparian and/or meadow habitat was not available but total acres probably exceeded that under the current condition, mainly due to the presence of fire. Species relying on LOS within any PAG were most likely more abundant historically, while species tied closely to mid structure in all but the

MHD PAG had less available habitat. Early structure was more abundant within the MCD, LP, and MHD PAGs mainly because fires were not suppressed.

Table 17. Historic and Current Conditions - Stand Structure by PAG

Major PAG	Structural Stage (%) *Early* HRV	*Early* Current	*Mid* HRV	*Mid* Current	*Late/Old* HRV	*Late/Old* Current
PPD/W	6	10	10	81	80	10
MCD	10	1	20	85	70	9
MCW	20	33	35	60	35	7
LPD/W	30	1	45	84	25	15
MHD	15	3	55	21	30	7
Landscape-Totals	**14**	**8**	**27**	**66**	**54**	**20**

Current Condition - Several changes have occurred within the watershed concerning habitat availability. First, and most notable is the loss of LOS ponderosa pine and mixed conifer dry habitat. The effect on several species has already been discussed (white-headed woodpecker, flammulated owl, northern goshawk). Populations of other species that rely heavily on this habitat type (e.g. Lewis' woodpecker, pygmy nuthatch) may be severely restricted. In contrast to reductions in LOS ponderosa pine and mixed conifer dry stands, mid structure acres within both of these PAGs has increased dramatically. This situation is less beneficial, however, since no neotropical migrants suspected to occupy the watershed are mid-structure obligate (**Thomas 1979**). For many species, second growth forest may serve as either nesting or foraging habitat, whereas mature and old forests provide both nesting and foraging habitat within the same stand.

Trends - Trends vary by species and vegetation type dependence within the watershed. On a larger scale, habitat alterations south of the border where most of these birds winter has created population decreases. Logging during the breeding season on the summer range has the potential to reduce local populations.

Big Game

Historic Condition - Deer populations across the East Cascades were described by John C. Fremont as low or nonexistent during his journey though this country in 1826 and 1827. Between 1926 and 1933, the mule deer population in Oregon was estimated at 39,000 to 75,000 animals (Bailey 1936). Populations increased in the 1930's and 1940's before peaking in the late 1950's and early 1960's. Much of the increase in deer numbers is attributed to conversion of grassland to more palatable brush species through heavy grazing

and fire suppression, creation of more forage habitat by logging, and extensive predator control (Gruel 1986).

Since the mid 1960's, mule deer populations in Oregon and across the Intermountain West began to decline as clearcuts converted back to forest, shrub stands became decadent, grazing pressure decreased, and traditional wintering areas were overcome by urban development.

Anecdotal information suggests that deer populations within the watershed were historically low, and probably never underwent the radical boom and bust observed for herds at lower elevations. Over the last 100 years, aside from intensive logging on private ground, the habitat has remained fairly static. While human access has increased in the middle and lower portions of the watershed, much of the higher ground is relatively inaccessible for most of the public.

Elk densities within the watershed were also historically very low or nonexistent. State biologists did not notice elk presence in the area with any regularity until the 1970's, and significant increases in the herd were not seen until early 1990's.

Current Condition - Deer populations for the Upper Deschutes Herd Management Unit have undergone dramatic change in the 1990's. For example, in 1991, the summer herd was estimated at just under 16,000 animals. Heavy and prolonged snow accumulations in 1992 caused massive winter mortality, and the herd was estimated in 1993 at 11,300 animals. Since then, herd numbers have been slowly rebuilding. The 1998 summer herd is estimated to be 13,300 deer.

Summer herd elk numbers for the Upper Deschutes Unit are currently estimated at about 1,200 with the total number increasing annually.

Seasonal big ranges within the Bend Watershed include summer, transition, and winter range (See Table 18). The Deschutes National Forest Land and Resource Management Plan (1990) designates appro..imately 6,292 acres within the watershed for management as Deer Winter Range (M-7). Winter range for most of the Upper Deschutes herd that summer in the Bend Watershed is centered on private land in and around Bull Springs. Seasonal movements for deer occur in an east-west-east direct (generally following the elevation gradient). Elk exhibit several movement patterns. A portion of the herd may winter west of the Cascade crest, while the remainder move down above Bull Springs or head south to winter near the Inn of the Seventh Mountain.

Table 18. Deer Seasonal Ranges

Subshed	Deer Range (acres) Summer	Winter	M-7 Designated	Transition
Bridge	4,223	0	0	0
Forks	5,609	0	0	0
Bull	6,897	12,203 (PVT) 1,688 (FS)	1,892	3,132
Tumalo	4,571	5,170 (PVT) 2,907 (FS)	4,400	469 (PVT) 1,758 (FS)
Watershed Totals	**21,300**	**21,968**	**6,292**	**5,359**

Deer cover/forage ratios were analyzed for the watershed (See Table 19). Each subwatershed shows a ratio skewed toward cover, and well outside the 60/40 ratio recommended by **Thomas (1979).** Since timber harvest activities on private land could not be assessed, cover forage values were analyzed for Forest Service lands only.

Table 19. Deer Cover/Forage Ratios

Subshed	Deer Habitat Type (acres) Cover	Forage	Cover/Forage Ratio
Bridge	3,621	603	86/14
Forks	8,744	3,522	71/29
Tumalo	6,481	1,766	78/22
Bull	7,179	1,437	83/17
Watershed Totals	**26,025**	**7,328**	**78/22**

Road densities in some areas exceed the desired condition for habitat security in some areas of the watershed, particularly in the Bull and Tumalo subwatersheds, and portions of the Forks subwatershed (See Table 20). Overall road density exceeds 3.0 miles per square mile for the watershed. Roads 370 and 4601/4602 provide the bulk of hunter access into Roadless and Wilderness areas.

Table 20. Road Densities

Subwatershed	Road Miles	Subwatershed Square Miles	Road Densities (miles/square mile)
Bridge	0	6.6	0
Forks	26.7	24.4	1.1
Tumalo	112.8	24.4	4.6
Bull	156.8	41.0	3.8
Watershed Totals	**296.3**	**96.4**	**3.07**

Trends - For deer, the trend is probably a slow, small increase in herd numbers residing within the watershed. The habitat's carrying capacity is low due to a lack of openings good forage habitat, especially on Forest Service lands. As the Bridge Creek Fire area matures into more dense stands of second growth forage acres will be reduced even further.

Elk numbers continue to increase throughout the Upper Deschutes Management Unit, but growth is expected to slow as the herd nears carrying capacity. Although the notion is not supported in the literature, increases in elk populations can have a negative effect on deer numbers on the same range.

Amphibians

Cascades Frog

Historic Condition - Cascades frog are believed to be closely associated with water throughout their life history and are found in ephemeral and permanent water sources including meadows, marshes, ponds, and creeks (**Brown 1997**). Breeding usually occurs in shallow, warmer water provided in flooded meadows, marshes, creeks, and smaller ponds. Historic populations availability of suitable habitat for this species within the watershed are not known, but since populations of Cascades frog throughout its distribution have shown a slow, downward trend in recent decades, it can be assumed that historic numbers may have been higher.

Current Condition - Cascades frog sightings have been reported in Spring Creek, Happy Valley Creek, Bridge Creek, and various sections of Tumalo Creek. Breeding populations also exist to the north (Three Creeks Lake) and to the south (Todd Lake) of the watershed (Brown 1997). Considering the number and frequency of sightings, this species is probably fairly common along stream reaches within the watershed.

Trends - Continued sightings with relatively high frequency within the watershed indicate that distribution and population numbers are probably stable.

FIRE/FUELS

HISTORIC CONDITION

Prehistoric Fire

Evidence since the cessation of volcanic activity in the area suggests significant interactions between climate, vegetation, and fire which continued into present times. Pollen analyses conducted in the western Cascades (Leopold et al. 1982), revealed regional vegetation patterns during the Holocene Period. They imply a very dynamic relationship between vegetation and fire due to a much warmer and drier climate. This indicates that the range of the dry meadow and shrub/grass plant associations were much more extensive and large range fires were very frequent.

Aboriginal Burning

There are historical accounts of aboriginal peoples using fire in the Deschutes River Basin for hunting, to improve seed and berry crops, and as a weapon of war (Stewart, 1936). Paiute and Tenino tribes resided in the valley. Klamath and Modoc were frequent visitors and used fire for the same reasons.

Early Settlement

The first white people to appear were trappers in 1825. In the early 1840's, immigrants passed through attempting to find shorter routes to the Willamette Valley and by the 1880's, began to establish residence there (Bork, 1984). Settlers often used fire to clear land for livestock and crops (Pyne, 1982. Shinn, 1978). Evidence from fire atlas show several large human caused fires in the upper valley in 1908, 1910, and 1914. These were increasingly dry years and these fires may be due to ignorance and culture. A letter from a District Ranger on the Klamath National Forest written in 1918 to his supervisor attributed this increase in fires to prospectors, hunters, "renegade whites and Indians", and "pure cussedness" class of people, in which he suggested shooting as a prevention tool (Harley, 1918).

CURRENT CONDITION

Present Day Fires

Today in the Bend Watershed, there are a variety of vegetation types and fire regimes representing the effects of the historically repetitious fire with variable spread rates and intensities. A modern day sampling of fire occurrence data from 1970 to 1997 reveals 142 detectable ignitions which are roughly equivalent to 5 fire starts annually. Many of these fires were ignited by natural sources (104 or 73 percent). The area could still be accurately described as a "fire environment" with an increasingly human component.

Fire Ecology

Mountain hemlock/alpine zones: Large fires are relatively infrequent in these high elevation sites but lightning patterns and frequency show that ignitions are common. Fire

intensity is dependent upon weather and development of fuel complexes capable of supporting crown fire. These heavy fuel complexes take a long time to develop and are usually small. Therefore, high intensity fires are infrequent and usually less than 50 acres. Low intensity fires are frequently ignited but rarely exceed 100 acres.

Mixed conifer zones: Fire frequency on these sites ranges from 10 to 50 years. *Abies concolor* forests in Crater Lake National Park were found to have a return frequency of 9 to 42 years by McNeil and Zobel (1980). This would certainly indicate fire of low intensity due to the frequency. The extent of these fires was not great. At Crater Lake, McNeil and Zobel found few fires that burned their entire study area of 7.5 square kilometers. According to Bork (1984), there are no existing trees scarred by fire across a 125 hectare area at Pringle Falls.

Moist lodgepole pine zones: Fire in these stands characteristically burned with low to moderate intensities occasionally torching out in crowns. The fire behavior is dependent upon stand condition and climate. Patchy fuel continuity prevented disturbance at a landscape scale (Hopkins, 1994).

Dry lodgepole pine zones: These stands are visited by fire every 40 to 60 years with low to high intensity. The magnitude of natural fires could range from slow burning, smoldering duff and litter across the forest floor, to an occasional crown fire. The former being the most common due to low natural fuel loads. Though most any fire in a stand will be fatal due to the fire intolerant nature of the *Pinus contorta*. Fire studies in Crater Lake National Park and at Wickiup Springs on the Fremont National Forest showed extensive low intensity fires and even large fire events adjacent to these stands that did not enter or affect the stands, suggesting these could have acted as a natural barrier except under unusual fire weather (Agee, 1993).

An important related disturbance is mountain pine beetle (Dendroctonus ponderosae) attacks. In stagnant or low vigor stands, these attacks can be significant and set the stage for stand destruction by creating heavy loads of down and dead material intermixed with developing regeneration. In the absence of fire, this insect may provide the disturbance that seems to be a natural part of stand development over time.

Ponderosa pine zones:

The expansive stands of ponderosa pine that once dominated much of the area were a result of low to moderate intensity fires visiting the stands every 7 to 30 years (Bork, 1984). Stand replacement events were rare but occurred in 80 to 300 year intervals, leaving paths of replacement regeneration. These patches varied in size from 10 to 100 acres (Hopkins, 1994).

The Bridge Creek Fire

The 1979 Bridge Creek Fire was a human caused event which burned most of the vegetation within its boundaries. This fire has minimal mosaic patches which are scattered only along a small portion of the fire boundaries. The intensity of the fire may have contributed to the short-term hydrophobic character of the pumice soil in some areas. Structures were placed

on slopes following the fire to reduce downhill flow velocities and sedimentation rates into Tumalo and Bridge Creeks. Although some of the south aspect slopes adjacent to the creeks remain partially bare of vegetation, the majority of the slopes have been revegetated enough to be considered relatively stable.

In recent history, this is the only large fire ever to occur within the Bend Watershed. A potential risk exists for a similar event given the right combination of weather patterns and fuel conditions. Although the probability is low due to the right conditions occurring only on 6 days throughout the summer, these identified conditions would still require monitoring during the entire year.

Fire Management Action Plan for the Bridge Creek/Tumalo Creek Watershed (Revised 1998)

Purpose: The purpose of this plan is to define the joint responsibilities of the Deschutes National Forest and the City of Bend in fire prevention and suppression of fires in the Bridge Creek/Tumalo Creek Watershed.

Present Management Situation: The legal Bridge Creek/Tumalo Creek comprises an area approximately 7,000 acres, more or less of which 4,510 acres are currently contributing to the City of Bend domestic water supply. Within the contributing watershed, 88 acres are noncommercial forest lands, 32 acres are riparian, and 4,223 acres are Forest Service Lands. the Deschutes National Forest Land Management Plan preferred alternative allocates 4,200 acres to the Domestic Watershed 1 Option. The Northwest Forest Plan allocates this area as Administratively Withdrawn. Approximately 7 percent of the area is considered high hazard fuels, 26 percent are moderate hazard fuels, and 67 percent are low hazard fuels.

An agreement between the City of Bend and the U.S. Forest Service was made in 1926 describing the major use of the watershed as production of potable water. This agreement stipulates that the Forest Service has the primary responsibility for fire suppression and joint responsibility for prevention.

Within the legal watershed, 365 acres were either partially or totally consumed by the Bridge Creek Fire and 5.1 mm board feet of timber were removed in a salvage sale after the fire. All of the slash from this operation has been treated. Fuel loading in this area is now less than 10 tons per acre.

A primary suppression disadvantage is the layout of existing roads in the watershed. Road 4603 ends at the City of Bend Water Intake on Bridge Creek. Road 370 goes through the headwater at the north end of the watershed. Road 4601 and Roads 700 and 800 border the north rim of Tumalo Creek. Trail 23 traverses the watershed from north to south by starting at Happy Valley and crossing Tumalo Creek, it then follows Spring Creek for approximately a mile before turning south and crossing Bridge Creek. After passing Swampy Lakes Shelter, the trail ends at Road 80 off of Road 4615. It's the most heavily used trail. Trail 24 traverses the east-west axis of the watershed starting at the Bend City Water Intake, following Bridge Creek west, and ending on Road 370. According to the Land Management Plan's preferred alternative, there are no immediate plans for new roads in the watershed.

Detection is also a problem because there are no lookout stations within the watershed. The nearest lookout with visibility into the area is Lava Butte which is located 14 miles to the southeast of the watershed.

The key resource values within the watershed are water, wildlife, and dispersed recreation. To date, management activities have been limited primarily to City water improvements, fire protection, primitive trail development, and dispersed recreation.

Communication: The Deschutes National Forest Fire Dispatcher can be called at Commerce 9903 and 548-6011. Telephone numbers for key personnel of both responsible agencies are found in the Appendix.

Action Plan in Case of Fire: Due to the inaccessibility of the watershed, an observation plane and smokejumpers from Redmond Air Center will be put on stand-by and dispatched at the request of the Duty Officer, after receiving a "fire report". The District Ranger will be notified that an initial attack is underway. If the jump plane and/or smokejumpers are not available, Prineville BLM Helitack will be dispatched. Ground forces will also be dispatched to the nearest trailhead and will start walking to the fire or be flown to the fire via helicopter from Tumalo Falls. The number of air and ground forces depends upon the Action Class of the day, as specified in the Forest Mobilization Plan. Fire retardant use must be approved by the Duty Officer.

There are areas within the watershed where mechanized equipment can be used advantageously, but such use in some areas could create unacceptable environmental impacts. Permission must be granted by the District Ranger for any heavy equipment use in the domestic watershed. In case of a large fire or one with large fire potential, a Resource Advisor, or the District Ranger, if available, will be ordered. The Resource Advisor will ensure that the fire suppression action does not create unacceptable environmental impact upon the watershed. The Resource Advisor will also coordinate, if needed, a Burned Area Rehabilitation Team which will be assembled to provide expertise for analyzing damage and recommending rehabilitation procedures.

Responsibilities: The U.S. Forest Service has the primary responsibility for suppressing fire in the watershed. They will train the city fire guard with local U.S. Forest Service fire courses that pertain to his/her duties. They will provide aerial detection on high hazard days, and after lightning storms, and will initiate and enforce fire closures. The City of Bend will provide a fire guard to patrol the watershed by foot 5 days a week. This seasonal employee will hike the trails and survey areas in the watershed where people are frequently found.

References: FSM 2500 - Watershed Management, 2509.13 - FSH Burned Area Emergency Rehabilitation Handbook, 2523 - Emergency Rehabilitation of Watersheds Following Wildfire, 5106.14 - Fire Control/Watershed Management.

RECREATION

HISTORIC CONDITION

Wilderness Landscape Area

Recreation use in the Three Sisters Wilderness dates back to before the turn of the century. During this era, thousands of sheep and cattle grazed the meadows and openings on both sides of the Cascade crest. Establishment of the National Forest in 1906 initiated the move toward reduction of livestock numbers and establishment of grazing seasons consistent with the resource capability. Administration was largely custodial in nature from the time the area was included in the National Forest System until the termination of World War II. Trails and administrative facilities suitable for the fire prevention and suppression activities were constructed and maintained during this time.

The Three Sisters Primitive Area was established by the Chief of the Forest Service in 1937 under the authority of Regulation L-20. It consisted of about 191,000 acres of rough, primitive country along the backbone of the Central Oregon Cascades. In 1939 Regulation L-20 was revoked and Regulations U-1 and U-2 were adopted to provide for establishment and management of Wilderness areas. The Secretary of Agriculture directed that areas established under Regulation L-20 be reclassified under Regulations U-1 and U-2. The Three Sisters Wilderness was established on February 6, 1957. With the passage of the Wilderness Act on September 3, 1964, the area became a part of the National Wilderness Preservation System. The Oregon Wilderness Bill of 1984 expanded the Sisters Ranger District portion of the Three Sisters Wilderness Area to include some roadless areas in the vicinity of Snow Creek and Black Crater Lake.

The need to educate users in good Wilderness practices resulted in assignment of the first Wilderness Ranger to the northern portion in 1964. Additional rangers were added over time. Their duties were to furnish information, collect data, clean up campsites and maintain trails. The first of several Forest discussions on coordination and management between the Deschutes and Willamette National Forests occurred during the 1970's. This was also the time when research began to address solutions to management problems. One of the outcomes was the development of the Limits of Acceptable Change (LAC) Process. This gave managers a way to measure and monitor the physical and social impacts of recreation use. Current management direction is provided primarily by the Wilderness Strategies Project EA which was completed and signed in 1990 by a team from the Willamette and Deschutes National Forests.

Most of the current trail system evolved from earlier sheep driveways, firemen way trails, packer routes, and fishermen trails, all of which were refined over time. The trailheads evolved with the road systems as roads were developed closer to the Wilderness boundary. Some of the early trail building and maintenance was done by the Civilian Conservation Corps (CCC). More recently, money for improvements has been provided through the Capital Investment Process which allows all Forests to compete for a pot of money managed at the regional level. Current regional policy is to avoid building new trails. Although changes in the system can be made, there should be no net gain in the miles of trail within the Wilderness.

Cold Forest/Unroaded Landscape Area

Recreation within the Cold Forest/Unroaded Landscape Area was historically similar to the Wilderness Landscape Area, with early use centered around access for sheep and cattle grazing. A ranger station present in Happy Valley in the early 1900's provided horse supported supervision of grazing and trail use in the area. Trail development evolved around horse access to the high country lakes. During the early 1960's, Road 370 was developed as a highway project between Cascade Lakes and Sisters, although the project was never completed.

Bridge Creek Watershed Landscape Area

Located within this Landscape Area is the Bend Municipal Watershed which in 1997, was the source of approximately 50 percent of the city water supply in 1997. Although trail development within the watershed has been relatively minimal, access and use within the watershed was not limited until after the Bridge Creek Fire in 1979. Trails include the Bridge Creek hikers trail and the winter snowmobile trail #6.

Front Country/Transition Landscape Area

Recreational use within this landscape area was primarily centered around access for wilderness grazing and seasonal hunting. Horse trails that were formed in this area were most likely converted to roads at some point during the last 50 years. Trail systems that are present include the Swampy Lakes and Virginia Meissner areas, both of which evolved around the designation of old roads/horse trails for nordic skiing and, more recently, mountain bike use. Skyliner Lodge and Ski area were also prevalently used during the mid-1900's for winter recreation. Development of houses along Tumalo Creek began in the 1950's and continues to a limited extent today.

Private/Dry Forest Landscape Area

Recreation use of this area was most likely limited to seasonal hunting and access to higher country areas. Ownership by Crown Pacific allows public access and use of roads, although overnight use is prohibited.

Dry Forest Landscape Area

Recreational use of this area primarily centered around Tumalo Creek and access to higher country for firewood and hunting. The development of mountain biking trails within this landscape area began in the 1980's and now includes an extensive number of trail miles.

CURRENT CONDITION

Wilderness Landscape Area

Recreation use within the Wilderness area remains within the designated encounter limits set under Forest Plan Standards and Guidelines for the Wilderness Management Area, although maintaining standards for physical impacts and social encounters may be difficult as use

increases. Overall, within the Three Sisters Wilderness, overnight use is down (Hall and Shelby, 1992) but day-use increased from 42 percent in 1982 to 76 percent in 1995. The average group size for day-use is 2.6 people per party and the average for overnight is 3.0 per party. Use within the Wilderness has doubled from 1982 to 1991 and has continued to increase at a rate of about 4 percent per year. The portion of the Wilderness within the Bend Watershed is used at low to moderate rates, primarily due to the lack of surface water features and developed trails.

Wilderness regulations require that all users carry a self-issue permit. These permits are found at the trailhead bulletin boards along with other pertinent information.
Human uses include hiking, horseback riding, hunting, skiing, mountain climbing, nature study, photography and the study and use of Wilderness skills. Wilderness outfitter guides are available for those people who need their services. There is currently a moratorium on allowing additional outfitter guides in Wilderness, however, the Willamette and Deschutes National Forests are proposing to do a needs assessment in Fiscal Year 1999 to determine if additional guiding is needed.

Fire has been one of the natural forces that created and maintained ecosystems of the Cre_t Wildernesses. In 1996, a team from the Deschutes and Willamette National Forests wrote a Prescribed Natural Fire Program Plan for the Mt. Jefferson, Mt. Washington and Three Sisters Wildernesses. This plan paves the way for the reintroduction of natural fire in the Wilderness. However, a "risk assessment" and "management ignited supplement" must be done before the plan can be implemented.

Cold Forest/Unroaded Landscape Area

Recreation use within this Landscape Area has increased steadily in the past 5 years as trail systems have developed to accommodate uses displaced from the Municipal Watershed and the popularity of the area has increased. Multiple use of trails in this area is occurring even though some trail segments have been constructed for a specific use. Mountain biking occurs on most trails and conflicts between mountain biking and other uses have the potential to become safety or recreational experience problems. Management may need to restrict trails to specific designated uses if resource related impacts or the safety of users are compromised. Managing trails for the purpose of preventing overuse or inappropriate types of uses should be determined by monitoring resource conditions and user experiences.
An anticipated increase in recreation use could result in decreased water quality and hydrologic function. In general, effects to stream channels from recreation use would be due to road, trail, and dispersed camping use. Lack of maintenance is considered a significant problem because it would allow increasing amounts of sediment to be deposited into streams within this and the Front Country/Transition Landscape Area.

Bridge Watershed Landscape Area

Access and use of the watershed area was severely limited by the City of Bend in response to pressures from the Oregon Health Division which enforces EPA regulations. Municipal water supplies obtained from this watershed are currently not filtered and the Oregon Health Division required the implementation of limited use in order to allow this non-practice to continue. Mountain bike use and overnight camping were eliminated in 1995. Use of

existing trails is currently limited to day-use hiking only. Little rehabilitation of trails has occurred since the closure to mountain bikes, and areas that were rutted or gullied from the lack of water bars and mountain bike use remain so today.

A snowmobile trail that travels through the watershed continues to be open for winter use. There is limited use of winter snowmobile trails in the summer since these trails utilize meadows and other openings and are considered inappropriate and not intended for summer use. Resource damage often occurs when OHV users ignore posted signs restricting OHV use from these trails.

Front Country/Transition Landscape Area

This Landscape Area includes the developed recreation sites at Tumalo Falls Trailhead and Skyliner Lodge. The Tumalo Falls Trailhead is in poor condition since the parking area is poorly drained and the surface lacks good traction. Parking spaces are not well defined and vehicular barriers are deteriorating. Erosion from the parking lot tends to flow down a steep pitch to the bridge and creek crossing. A vault toilet which is located within 75 feet of the creek currently fills up during the winter. This may be caused by a leak in the vault or poor drainage allowing snowmelt to enter the vault from above. The City of Bend Municipal Watershed facilities, including a stewards house and intake building, are located adjacent to the trailhead parking area.

Skyliner Lodge is a CCC-era structure built in the 1930's. Over 60 years old, it is in fair condition and has been improved and well maintained in recent years. The barrier-free entry was recently completed and funded by a grant from the Regional Forester's Challenge Cost-Share Program. The Oregon Museum of Science and Industry operates a Cascade Science School here providing outdoor education for young people and has been responsible for several changes on the site, including the addition of yurts as sleeping shelters.

Road 4603 accessing the Tumalo Falls Trailhead is in moderate condition and presents several safety issues, including a lack of good sight distance and the loss of the original surfacing material. These conditions usually occur where the road is either two-lanes or in some cases, only one-lane. Overgrown brush on either side of road also hinders sight distance. The 2 bridges at both ends of Road 4603 are in marginal condition and need to either be replaced or reconstructed.

The Swampy Lakes Trail system continues to receive winter nordic use and summertime hiking and mountain biking use. The addition of the Swede Ridge access trail has completed a loop opportunity for users accessing this system from the Tumalo Falls or Skyliner Lodge trailheads.

Dispersed camping is popular along Roads 370, 4601, and 4602. Typical impacts from dispersed car camping includes the denuding and trampling of vegetation, soil compaction, and related erosion, and the removal of vegetation either dead or alive for firewood. Current access to the road systems is somewhat limited by gates. Road 370 is usually under snow until early August and gates control traffic use until the road is dry enough to support vehicular traffic. Normal use season is August through October. Road 370 and Road 4601 are in particularly poor condition due to heavy use and minimal levels of road maintenance.

The trend is for a gradual decline of the road's condition. Heavy maintenance would be required to bring it to an acceptable standard.

Private/Dry Forest Landscape Area

Recreation use within this landscape area continues to occur under accepted Crown Pacific conditions of day-use only. Horseback riding trails near Tumalo Reservoir and a mountain bike trail from Shevlin Park to the Bridge Creek Fire area are used and maintained by the public. The Road 4606 system is primarily located on Crown Pacific land and overnight use is prohibited there.

Dry Forest

Recreation use of this landscape area is primarily tied to the mountain bike trail system emanating from the Phil's Trail Trailhead. Other activities include road driving and dispersed camping.

Trail Conditions

In general, trails wthin the watershed are in good condition since approximately 40 percent of the summer trails have been constructed in the last 7 years. Pre-existing trails are also in good condition. In most cases, trails are located in upland vegetation areas away from riparian areas. Trails following Bridge Creek and Tumalo Creek are low in gradient and in good conditon due to the many drainage structures built. Some of the water bars on the Bridge Creek Trail need to be replaced and the drainage structures on all of the trails need annual cleaning. Typically, user trails developing over time lead to viewpoints or go the water's edge and have the potential for erosion and sediment contribution to perennial streams. Both Bridge and Tumalo Creek are in good condition relative to user trail development.

Erosion Processes

The existing trail conditions do not contribute significantly to the sedimentation directly into the streams. There are portions of trails, especially on steeper pitches where water may run down trails and off of the trail periodically. The typical situation is to have the water exit the trail and deposit sediment within 10 feet of the trail's edge. For both Bridge and Tumalo Creek trails, although the trails parallel the streams closely, sedimentation going directly into the streams rarely occurs.

Increasing use on the trails has increased soil disturbance within the trail tread, creating further dishing or trenching of many trails. At some point, the trenching will increase beyond the point where a water bar or drain dip can effectively divert the water off the trail. As volume and velocity of the water increases, the potential for an increase in sediments reaching water courses also increases. Normally, this could take 30 years or more to occur if the trail was well designed and constructed to specifications, although this could occur in less time due to the trend of increased use and type of uses. Implementing mitigation measures could slow down the anticipated negative impacts.

The access roads in the area are already in a condition that would require repair, heavy maintenance or reconstruction. Specifically, Road 370 and its tributaries and Road 4601 on the east end steeper slopes are already eroding at an accelerated rate and additional traffic would continue this trend. The majority of erosion that is occurring does not cause direct damages to any streams, although Road 370 crosses the North Fork of Tumalo Creek without any bridge structures. Other roads within the area are less steep and in better condition.

Human Impacts

The trend of increased recreation use in the watershed area has been established over the last few years as the population in central Oregon and its popularity as a destination resort and recreation area have grown. Most of the day-use activities are hiking, mountain biking, and horseback riding. Restrictions prevent domestic animals, bikes, overnight camping, and campfires in the City of Bend Municipal Watershed area. These restrictions will remain unless the status of the watershed as a surface water system changes in the future. Mountain biking is the fastest growing use with horseback riding also on the increase with the development of the Todd Creek Horse Camp. As the population of the area continues to grow, so will the interest in hiking due to the easy access to the area from the city of Bend.

Although hunting has decreased throughout the watershed, dispersed camping still occurs. Off-trail use is high during hunting season but fairly low during the summer season. Most of the off-trail use occurs in the winter due to snowmobilers having more access. Most of the trail users are nordic skiers with backcountry skiers going off-trail to avoid snowmobilers. Daily use counts have increased approximately 5 to 10 percent per year over the last several years over most of the area.

Resource Concerns

Additional resource concerns related to trail use and recreational experiences include trails that go through wet meadow areas; trail short-cutting resulting in erosion; camping adjacent to lakes or streams; the proliferation of user created trails on certain routes including peak climbing; the depletion of the dead and down woody component resulting from the use of campfires; and camping in or on the edge of meadows.

Chapter V
Trends and Interpretation

Chapter V
Trends and Interpretation

TREND RATINGS

The team identified trends occurring within each landscape area that relate to the watershed's primary issues and key questions. A trend rating system was developed which measures the short-term risk to the ecosystem by describing the source of the problem or occurrence and the resources affected. The trends are rated as high, moderate, or low based upon the amount of expected change from current and historic conditions. The ecological integrity of each landscape area was also given a rating based upon how much of a departure was evident from historic regimes. Further support is from the description of the conditions affecting the ecosystem. Both the trend ratings and ecological integrity ratings were then used to develop the management recommendations in Chapter VI.

Wilderness Landscape Area

Trend #1: More old forest currently exists than under native disturbance regimes.

Cause: Lack of disturbance, including fire suppression efforts.

Resources Affected: All resources are affected to some extent, most notably vegetation, as forest structures continue to advance in age (ever increasing risk of stand replacement event) and wildlife habitat (lack of early forest structure, as openings become filled with trees). Stand conditions will eventually become less stable, a result of insect, disease, and other disturbance agents. In addition, fire risks over time will build as fuel loadings increase and these increased risks include the spread of fire from the Wilderness into the Front Country/Transition Landscape Area directly to the east.

Trend Rating: Moderate

Rationale for Rating: Although the late and old forest structure continues to increase proportionately on the landscape, these conditions have not departed greatly from the native forest conditions prior to fire suppression. Increasing forest biomass will eventually result in higher intensity fires and greater consumption of fuels, yielding more difficult control efforts. However, for the near future, this area will remain a high priority for fire suppression efforts in order to protect surrounding resource area values.

Trend #2: Increased recreation use is resulting in more trail impacts which include the loss of trail tread integrity from heavy traffic and horse use.

Cause: Increasing population numbers and marketing of the area, development of new trails, trailheads, and horse camps making the area more accessible to the public.

Resources Affected: Vegetation, Soils, Water Quality, Wildlife, Recreation Experience

Trend Rating: Low-Moderate

Rationale for Rating: Use will continue to increase in the area at a moderate rate and will be affected primarily by access from Road 370. The development of Todd Horse Camp may increase recreation use of this area by those accessing the Wilderness by horse.

Trend #3: The extent of fire, including frequency of occurrence and amount of acreage, has decreased within the plant associations located in the Wilderness area.

Cause: Fire suppression efforts.

Resources Affected: All resources are affected to some extent, most notably vegetation (increased risk of stand replacement events), water quality (increased overland flows), and wildlife (habitat changes, lack of structural diversity). The risk of fire movement from here to the Front Country/Transition Landscape Area to the east is increasing.

Trend Rating: Moderate

Rationale for Rating: Although the frequency and extent of fires is decreasing, the majority of forest conditions remain within the normal fire return interval of the mountain hemlock plant association. Increased litter and duff levels raise the risk of higher intensity and longer duration burns at the soil surface as forest conditions approach the upper end of this return interval. Fire suppression efforts are likely to remain a priority for this area due to the high fuel load condition of the Front Country/Transition Landscape Area located to the east and the close proximity to Bend and to the Bend Municipal Watershed.

Cold Forest/Unroaded Landscape Area

Trend #1: More old forest exists currently than probably existed under native disturbance regimes.

Cause: Lack of disturbance including fire suppression efforts.

Resources Affected: All resources are affected to some extent, most notably vegetation, as forest structures continue to advance in age (ever increasing risk of stand replacement event) and wildlife habitat (lack of early forest structure, as openings become filled with trees). Stand conditions will eventually become less stable, a result of insect, disease, and other disturbance agents. In addition, fire risks over time will build as fuel loadings increase and these increased risks include the spread of fire from the unroaded areas into the Front Country/Transition Landscape Area directly to the east.

Trend Rating: Moderate

Rationale for Rating: Although the late and old forest structure continues to increase proportionately on the landscape, these conditions have not departed greatly from the native forest conditions prior to fire suppression. Increasing forest biomass will eventually result in

higher intensity fires and greater consumption of fuels, yielding more difficult control efforts. However, for the near future, this area will remain a high priority for fire suppression efforts in order to protect surrounding resource area values.

Trend #2: Recreation use is increasing.

Cause: Trail development and user-created trails, demand from the mountain biking community for more single-track trails, increased marketing of the area, and an increased population base. There is also an increase in winter recreation use of back country and off-trail use for both motorized and non-motorized activities.

Resources Affected: Recreation Experience

Rating: Low-Moderate

Rationale for Rating: As trail access and opportunities have increased, so have the number of users. The largest increase has come from mountain bike users. Horse use has also increased with the development of Todd Horse Camp and the adjacent Metolius-Windigo Trail.

Trend #3: The road surface and stream crossings of Road 370 are gradually deteriorating over time.

Cause: Automobile use during wet weather conditions and low level of road maintenance.

Resources Affected: Soils, Hydrology, Water Quality

Trend Rating: High

Rationale for Rating: Existing gates on each end of Road 370 limit use to August through October, although breaches of the gates and on the road surface occur on a regular basis. While limiting the season of use is generally beneficial, weather and drainage conditions during the open months can quickly deteriorate. The road has a natural surface which is susceptible to sediment movement from overland flows and rutting from vehicular traffic. Low maintenance levels have allowed rutting and gullying to persist. The road fords a perennial and 2 ephemeral streams, raising the occurrence of fine sediment contributions to these streams.

Bridge Watershed Landscape Area

Trend #1: EPA drinking water quality standards and state DEQ turbidity levels are being met.

Cause: The Bridge Watershed Landscape Area is well vegetated and comprised of soils with a high rate of infiltration of precipitation. As a result, the majority of instream water is from

springs that provide water of high biological and chemical quality, as well as very low turbidity. Recreational use is regulated and there is a general lack of development and disturbance within the watershed.

Resources Affected: Hydrology

Trend Rating: Low

Rationale for Rating: The Safe Drinking Water Act of 1986 requires 90 percent of fecal coliform samples to meet Environmental Policy Act standards. Since testing began in 1988, over 98 percent of the samples have met or exceeded the standard. While the state DEQ requires that municipal water supplies can only be delivered unfiltered when nephelometric turbidity units (NTU) are less than 5, the City of Bend tries not to exceed 2.5 NTU as a matter of policy. The City water supply has exceeded this level approximately 20 days annually over the last 10 years and does not draw water from Bridge Creek when this occurs.

Trend #2: More old forest exists currently than probably existed under native disturbance regimes.

Cause: Lack of disturbance, including fire suppression efforts.

Resources Affected: All resources are affected to some extent, most notably vegetation, as forest structures continue to advance in age (ever increasing risk of stand replacement event) and wildlife habitat (lack of early forest structure, as openings become filled with trees). Stand conditions will eventually become less stable, a result of insect, disease, and other disturbance agents. In addition, fire risks over time will build as fuel loadings increase, and these increased risks include the spread of fire from this watershed into neighboring areas.

Trend Rating: Moderate

Rationale for Rating: Although the late and old forest structure continues to increase proportionately on the landscape, these conditions have not departed greatly from the native forest conditions prior to fire suppression. Increasing forest biomass will eventually result in higher intensity fires and greater consumption of fuels, yielding more difficult control efforts. However, for the near future, this area will remain a high priority for fire suppression efforts in order to protect resource area values directly related to the City of Bend Municipal Watershed, as well as resource values of the surrounding area.

Trend #3: Recreation use is continuing to change in terms of type and number of users.

Cause: Increasing popularity of mountain biking on existing trails in the 80's and 90's.

Resources Affected: Soils, Vegetation, Wildlife Habitat, Water Quality, Recreation Experience

Trend Rating: Moderate

Rating Rationale: Hiking and minimal livestock use were the traditional uses in the past in the Bridge Creek Watershed. With the increasing popularity of mountain biking in the 80's and 90's, the City of Bend Municipal Watershed decided to regulate this type of use and prohibited both mountain biking and domestic animals from the area under its management. Hiking is the only permitted recreation use allowed here.

Front Country/Transition Landscape Area

Trend #1: Recreation use is increasing in the Skyliner Lodge area.

Cause: Developed trail system and associated facilities, proximity to Bend, and increased development in adjacent residential areas

Resources Affected: All resources affected

Trend Rating: Moderate-High

Rationale for Rating: Historically, the Skyliner Lodge area was the major winter recreation destination prior to the development of Mt. Bachelor Ski Resort. The ski hill area has been used for sno-play and Skyliner Lodge has been occupied by the Oregon Museum and Science Industry. Increased growth in Bend, including the outlying residential areas along Skyliner Road, have added to the increased recreation use in the area for both summer and winter.

Trend #2: More stands are overstocked to the point of instability.

Cause: Fire suppression, lack of vegetation management, and natural forest succession.

Resources Affected: All resources are affected to some extent, most notably vegetation, as forest structures continue to gain density in the absence of disturbance. Wildlife habitat is affected as the distribution and abundance of a variety of landscape conditions decreases, including the lack of early forest structure, as openings become filled with trees; and the loss of old forest structures due to insect attacks, root pathogens, and stand-replacing fires. Stand conditions eventually become less stable with the increased stocking and the inter-tree competition that this brings, resulting in insect, disease, and possibly fire disturbance agents that work to rebalance the stands across the landscape. As most stands become overstocked and unstable relative to the native disturbances that once punctuated this Landscape Area, more area is involved in the more intense disturbance cycles when they do occur (e.g., the Bridge Creek Fire of 1979 which grew to approximately 3,400 acres).

Trend Rating: High

Rationale for Rating: Although the late and old forest structures are not very dominant on the landscape, these conditions have not greatly departed from the fire climax forest conditions prior to fire suppression. Many lodgepole pine stands that once burned as they

matured are now similarly killed by mountain pine beetles as they advance in age. In the absence of stand management activities, these types of forest stands are slowly replaced by late seral white fir and mountain hemlock stands and may eventually appear to have old growth characteristics. The greatest change, however, is with the increased stand densities throughout this landscape area, especially in the ponderosa pine communities. Fire suppression and selective harvesting have decreased the amount of large, old ponderosa pine structure and created many more small trees per acre. Many stands once dominated by ponderosa pine overstories and frequent light intensity fires now have fewer pine overstory trees and roughly 10 times the number of trees in the understory relative to the pre-fire exclusion era. This shift from essentially single-storied pine to fir dominated stands carrying greater understory biomass has resulted in greater stand instability and higher intensity fires when they do occur.

Trend #3: Insect and disease pathogens will continue to operate on the landscape.

Cause: Fire suppression, lack of vegetation management, and increasing stand densities

Resources Affected: Forests continue to gain density in the absence of fire and vegetation manipulation disturbances. As these stands become older and denser, they provide ideal habitats for opportunistic insect and disease agents. Wildlife habitat is negatively affected when the distribution and abundance of landscape conditions decreases in variety such as the lack of early forest structure, loss of openings and loss of old forest structure due to insect attack, root pathogens, and stand replacement fire. Stand conditions eventually become less stable with the increased stocking and the inter-tree competition that this brings, resulting in insect, disease, and possibly fire disturbance agents that work to rebalance the stands across the landscape.

Trend Rating: Moderate

Rationale for Rating: As the forests continue to gain density in the absence of management disturbances, insect and disease pathogens respond to the new habitat conditions. In the maturing lodgepole pine stands, optimum host habitat to support mountain pine beetle outbreaks occurs when stands exceed 30 trees per acres of trees 9 inches in diameter. Root rot becomes more widespread when ponderosa pine dominated stands are harvested and replaced by dense stands of true fir species. Since these conditions are not greatly departed from the native disturbance regimes, a moderate rating is given. Although there are more acres that carry greater stand instability relative to the generally understood historic condition, the overall magnitude of insect and disease agents is not greatly different than pre-settlement conditions.

Trend #4: There is a tree species shift from pine to fir and hemlock.

Cause: Fire suppression and forest succession from fire climax to climatic climax species.

Resources Affected: All resources are affected to some extent, most notably the vegetation condition across the landscape, as the subtle change in species occurs over the course of decades. Wildlife habitat is affected as ponderosa pine dominated stands become replaced by true fir stands and the species respond to this shift. Similarly, lodgepole pine dominated stands are slowly replaced by true fir and/or mountain hemlock.

Trend Rating: Moderate

Rationale for Rating: Although this is not necessarily desirable, the shift from early seral stands (ponderosa pine, lodgepole pine) to late seral forest types (white fir, mountain hemlock) results in a redistribution of stand conditions and habitats. If these shifts result in the minimization or elimination of scarce habitat conditions, then the species that use these habitats become less abundant. While this is a long-term process, the shift in species should be recognized as a moderate trend rating as it results in not only changes in species composition, but also in habitat conditions, insect and disease agent activities, and ultimately differing disturbance patterns and processes. The shift from essentially single-storied pine stands to multi-storied pine and fir has led to greater natural fuel loadings, resulting in higher fire intensities when fires do occur.

Trend #5: Tumalo Creek channel and bank stability are decreasing within the Bridge Creek Fire area.

Cause: Bridge Creek Fire in 1979, subsequent salvage of large wood, and aerial seeding of long-lived, shallow rooted non-native grass species.

Resources Affected: Fisheries, Vegetation, Wildlife, Water Quality, Hydrology

Trend Rating: High

Rationale for Rating: The flood plain of the reach of Tumalo Creek through the Bridge Creek Fire area was highly disturbed by the fire event and subsequent salvage of trees. Very little wood remained within the system following the fire and salvage operations. The aggressive revegetation by non-native grasses seeded after the fire and the salvage of nearly all significant trees along the stream has left many portions of the bank susceptible to undercutting and scouring. Recent rehabilitation efforts has returned coarse wood to the stream system. The floods of 1995 and 1996 moved much of the wood into several large log jams. The stream has become braided and degraded since the Bridge Creek Fire of 1979. Alder has revegetated portions of the flood plain throughout this reach, although historic references did not identify this species as a significant component of this system.

A common occurrence after fire is an increase in water yield due to decrease in evapotranspiration and from loss of vegetation. Concurrently, root systems of streamside vegetation are decomposing. These 2 factors coupled with the removal of instream wood during salvage operations and the reseeding of the flood plain with non-native shallow rooted grass species have led to stream bank instability and an overload of the sediment carrying capacity of the stream. This is demonstrated by accelerated bar formation and braiding of the

channel in the past 10 years. The stream channel is not currently in a stable condition. There has been some decrease in fish habitat and likely slight increases in turbidity, water temperature, and fine sediments.

Trend #6: Road beds on Roads 370, 4601, and 4603 continue to deteriorate and erode.

Cause: Increased automobile use during wet weather conditions, low levels of maintenance and poor road grades or road locations.

Resources Affected: Water Quality (Road 370 and Road 4601), Recreation Experience

Trend Rating: High

Rationale for Rating: Existing gates on each end of Road 370 limit use to August through October. While limiting the season of use is generally beneficial, weather and drainage conditions during these months can quickly deteriorate. Road 370 is a natural surface road susceptible to sediment movement from overland flows and rutting from vehicular traffic. Low maintenance levels have allowed rutting and gullying to persist. Road 4601 has been surfaced with a variety of rock and cinders in some areas and remains a natural surface road in others. The primary area of deterioration is a section currently owned by Crown Pacific that climbs directly uphill through the Bridge Creek Fire area at an estimated 10 percent grade. Sediment movement from this grade is capable of reaching Tumalo Creek. This segment would be acquired by the Forest Service under the Crown Land Exchange if it receives final approval.

Trend #7: Fish are being lost down the Columbia Southern Canal from Tumalo Creek.

Cause: Lack of screens at canal diversion.

Resources Affected: Fisheries

Trend Rating: Moderate

Rationale for Rating: The canal diversion has been unscreened since its inception over 80 years ago. An undocumented but suspected significant number of fish have been transported out of the stream during this period, possibly including the native redband which is on the Regional Forester's Sensitive Species List. The Oregon Department of Fish and Wildlife has been negotiating with the Tumalo Irrigation District to screen the canal, perhaps as early as 1999. The canal diversion was not used in 1998 and may be kept only as an emergency diversion in the future.

Trend #8: Upstream fish passage at the Columbia Southern Canal diversion is not currently possible when flow is being withdrawn.

Cause: Fish are unable to negotiate the diversion dam.

Resources Affected: Fisheries

Trend Rating: Moderate

Rationale for Rating: Rainbow and brown trout seeking spawning areas are limited to below the diversion where spawning gravels are limited. Spawning areas above the diversion are not being used to their potential.

Trend #9: Recreation use is increasing.

Cause: Proximity to Bend and development of trail systems.

Resources Affected: Wildlife, Fisheries, Soil, Water Quality, Vegetation, Recreation Experience

Trend Rating: Moderate

Rationale for Rating: Both the Tumalo Reservoir area and the area south of Skyliner Road have numerous mountain biking trails. This low elevation area provides access to horses primarily in the Tumalo Reservoir area and to mountain bikes in the lower Skyliner area for about 8 months out of the year. Both are very close to and accessible from Bend.

Private/Dry Forest Landscape Area

Private forest lands are expected to be managed for timber production into the foreseeable future. Wood production may be trending toward a sustained yield policy that would include maintaining some structure within treated stands. Rehabilitation of existing soil impacts are not expected to occur. Timber activity on lands acquired from the Forest Service is likely to increase from current levels under federal jurisdiction. Recreation access and day-use policies are not expected to change from existing Crown Pacific policies. Many vegetative and fire related trends are similar to those found in the Dry Forest Landscape Area.

Dry Forest Landscape Area

Trend #1: Tumalo Creek is included on the Oregon Department of Environmental Quality 303(d) list for water quality impaired streams with the parameter being flow modification.

Cause: Withdrawal of flow for irrigation via the Columbia Southern Canal.

Resources Affected: Aquatic species including Fish, Riparian Vegetation, and Hydrology

Trend Rating: High/*Low

Rationale for Rating: Withdrawal averages 40 cfs during the irrigation season from April to October. During some periods, 50 percent or more of the flow of Tumalo Creek is diverted affecting 8.5 miles of stream. Diminished flow leads to decreased fish habitat, dry ravel of banks, and a loss of riparian vegetation.

*Rating would be Low during periods when Tumalo Irrigation District does not use this canal. Recently, an additional pipe was constructed at a downstream site, resulting in discontinued use of the Columbia Southern Canal during most years. The District wants to keep the canal intact for emergencies and for drought years.

Trend #2: Middle-aged forest and shrub vegetation are continuing to advance in age.

Cause: Natural forest succession process.

Resources Affected: Wildlife, Vegetation, Recreation Experience. As stands continue to recover from previous selection harvests, they will advance in age and size. Depending upon health, vigor, fire events, and future tree harvest activities, it is possible that these stands will eventually grow into large, old structural stage composition. Recreation and wildlife values that are connected to old forest conditions would be increased.

Trend Rating: Moderate

Rationale for Rating: The late and old forest structures that are associated with the pre-settlement ponderosa pine forests today are greatly lacking from this Landscape Area. Since most of this land was privately owned, many acres have been harvested during the 1930's and 40's and selectively harvested in the past 20 years. Structural conditions have greatly departed from the fire climax forest conditions prior to European settlement with the large, old ponderosa pine stands once dominating this landscape now covering only a small percentage of the area. There will, however, be a continual advancement in size, density, and structure of these middle-aged stands in the absence of stand replacement fire or insect and disease disturbances.

Trend #3: Urban interface areas are increasingly demanding fire protection.

Cause: Increased fire risk as a result of homogeneous, mid-seral stand and shrub structures, the continued development of adjacent urban forest lands, and increased recreational use.

Resources Affected: Social Impacts, Fire Resources

Trend Rating: Moderate

Rationale for Rating: Existing fire protection policies include inter-agency and multi-partnership agreements for the suppression of fire and the reduction of risks associated with fuel loadings and vegetative structures. These policies are expected to continue into the

Table 21. Trend Ratings for each Landscape Area

Landscape Area	Trend	Cause	ResourcesAffected	Rating
Wilderness	**Trend #1:** Acres of old forest greater than under native disturbance regimes	Lack of disturbance including fire suppression efforts	• Vegetation • Wildlife Habitat	Moderate
	Trend #2: Increased recreation use	Population increase, marketing of area, accessibility to area by developed trails, trailheads, horse camps, etc.	•Vegetation •Soils •Water Quality •Wildlife Habitat •Recreation Experience	Low-Moderate
	Trend #3: The extent of fire, including the frequency of occurrence and the amount of acres, has decreased within the plant associations located in the Wilderness area.	Fire suppression efforts	•Vegetation •Water Quality •Wildlife Habitat	Moderate
Cold Forest/Unroaded	**Trend #1:** Acres of old forest greater than under native disturbance regimes	Lack of disturbance including fire suppression efforts	•Vegetation •Wildlife Habitat	Moderate
	Trend #2: Increased recreation use	Increased trail development	•Vegetation •Soils •Water Quality •Wildlife Habitat •Recreation Experience	Low-Moderate
	Trend #3: The road surface and stream crossings of Road 370 are gradually deteriorating over time.	Automobile use during transitional weather conditions and low level of maintenance	•Soils •Hydrology •Water Quality	High

Bridge Watershed	**Trend #1:** EPA drinking water quality standards are being met.	The Bridge Watershed Landscape Area is well-vegetated with a high rate of infiltration of precipitation, leading to a majority of run-off from springs which provide high quality water. Recreational use is regulated and there is a general lack of development and disturbance which preserves water quality.	•Hydrology	Low
	Trend #2: Acres of old forest greater than under native disturbance regimes	Lack of disturbance including fire supression efforts	•Vegetation •Wildlife Habitat	Moderate
	Trend #3: Increased recreation use	Increased activities in the Wilderness and increased winter motorized use in the area	•Recreation Experience	Moderate
Front Country/Transition	**Trend #1:** Increased recreation use in Skyliner Lodge area	Developed trail system and associated facilities, proximity to Bend, increased residential development in adjacent areas	•Vegetation •Soils •Water Quality •Wildlife Habitat •Recreation Experience	Moderate-High
	Trend #2: More stands are stocked to the point of instability.	Fire suppression, lack of vegetation management, and natural forest succession	•Vegetation •Wildlife Habitat	High
	Trend #3: Insect and disease pathogens will continue to operate on the landscape.	Fire suppression, lack of vegetation management, and natural forest succession	•Vegetation •Wildlife Habitat	Moderate
	Trend #4: There is a tree species shift underway from pine to fir and hemlock.	Fire suppression and forest succession from fire climax to climatic climax species	•Vegetation •Wildlife Habitat	Moderate
	Trend #5: Decrease in channel and bank stability of Tumalo Creek within the Bridge Creek Fire area	Bridge Creek Fire in 1979, subsequent salvage of large wood and aerial seeding of long-lived, shallow rooted non-native grass species	•Vegetation •Water Quality •Hydrology •Wildlife Habitat •Fisheries	High

Front Country/Transition	**Trend #6:** Continued road bed deterioration and erosion on roads 370, 4601, and 4603	Increased automobile use during transitional weather conditions, low levels of maintenance and poor road grades or road locations	•Water Quality •Recreation Experience	High
	Trend #7: Loss of fish from Tumalo Creek down Columbia Southern Canal	Lack of screens at canal diversion	•Fisheries	Moderate
	Trend #8: Upstream fish passage eliminated at Columbia Southern Canal diversion	Fish unable to negotiate diversion dam	•Fisheries	Moderate
	Trend #9: Increased recreation use	Land exchange with Crown Pacific	•Vegetation •Soils •Water Quality •Wildlife Habitat •Fisheries •Recreation Experience	Moderate
Private/Dry Forest	Lands under private ownership			
Dry Forest	**Trend #1:** Tumalo Creek is included on the Oregon DEQ 303(d) list for water quality impaired streams. The parameter is flow modification.	Withdrawal of flow for irrigation via the Columbia Southern Canal	•Riparian Vagetation •Hydrology •Fisheries	High/*Low
	Trend #2: Middle-aged forest and shrub vegetation continues to advance in age.	Natural forest succession process	•Vegetation •Wildlife Habitat •Recreation Experience	Moderate
	Trend #3: Increasing demand for fire protection from the urban interface	Increased fire risk as a result of homogeneous, mid-seral stand and shrub structures, the continued development of adjacent urban forest lands, and increaased recreational use	•Fire Resources •Social Impacts	Moderate

ECOLOGICAL INTEGRITY RATINGS

The ecological integrity of each landscape area was given a rating by the team based upon how much of a departure is evident from historic regimes. These ratings are supported by a description of the conditions affecting the ecosystem and any relevant management policies.

Wilderness Landscape Area

Ecological Integrity Rating: High

Responsible Conditions:
Unfragmented late structural forests; the majority of stands are currently within the upper parameters of historical fire regimes, although a stand replacement event is likely. Disturbance agents are still within historic range of variability (HRV) parameters. Recreation is within the limits of the designation level with moderate to low levels of use. Minimal impacts such as soil erosion and compaction to roads and facilities are occurring.

Relevant Management Policies: Wilderness Area Policy

Cold Forest/Roadless Landscape Area

Ecological Integrity Rating: High

Responsible Conditions: Unfragmented late structural forest. High use and impacts on Road 370. Recreation use is approaching the upper limits of a Semi-Primitive recreation experience with moderate to low levels of use.

Relevant Management Policies: Prescribed Fire in a Non-Wilderness, Designated Roadless Area

Bridge Watershed Landscape Area

Ecological Integrity Rating: High

Responsible Conditions: Late structural forest. Municipal Watershed Area. Species are fairly intact except for early trappings. The area supports a pristine ecosystem-dependent species.

Relevant Management Policies: City of Bend Municipal Watershed, Designated Roadless Area

Front Country/Transition Landscape Area

Ecological Integrity Rating: Moderate

Responsible Conditions: Fragmentation is fairly minimal. LOS is still present but less than 50 percent of historic, fire climax regimes. Most of the instability in the watershed is found

in this area in which many stands have experienced species and structural conversions and human access is relatively high. Despite these conditions, there are no urgent or immediate forest problems. The northwest corner is Roadless with areas in other parts of the landscape area having high road density. Recreation use is approaching the limits of a Semi-Primitive recreation experience for those using trails from Tumalo and Swampy Lakes. Tumalo Creek has low integrity in terms of width ratio, pool frequency, fish habitat, depth, streambank stability, and instream structure.

Relevant Management Policies: Designated Roadless Area, Front Country Management Area

Private/Dry Forest Landscape Area

Ecological Integrity Rating: Low

Responsible Conditions: Heavily fragmented, high road density, lack of LOS structure, canals, dewatered Tumalo Creek, high levels of soil disturbance including compaction, and loss of organics from past harvest operations.

Relevant Management Policies: Crown Pacific Land Management Policies

Dry Forest Landscape Area

Ecological Integrity Rating: Low

Responsible Conditions: Decreased flow in Tumalo Creek, high road density, past harvest impacts, limited structural variety, lack of LOS structure (varying degrees of fragmentation), somewhat modified landscape as compared to the Private/Dry Forest Landscape Area (private lands have about 10 percent of late and old forest structure left intact and public lands have about 20 percent left).

Relevant Management Policies: Wildland/Urban Interface, General Forest, Deer Winter Range, and Scenic View Management Areas

ECOSYSTEM CONDITIONS

The team identified and described the current and desired conditions affecting the ecosystem of the watershed by landscape area. The social and ecological functions express the essence, use, and resource opportunities of each of these landscape areas.

Wilderness Landscape Area

Current Condition: There are limited water resources, no existing water quality problems, and no known fish populations. The ecosystem is relatively pristine with clear, cold water and extensive tracts of intact LOS structure that is minimally fragmented. Wolverine populations are suspected. There is very little early structural stage which presents a problem

for those wildlife species needing dispersal openings. There is no roading which allows for an intact system and high potential for maintaining good connectivity.

Late and old structure mountain hemlock stands are present in nearly double the amount expected under natural fire disturbance regimes. The landscape has a predominantly high country nature that includes numerous alpine meadows between forested stringers. Fire starts are suppressed, although a Prescribed Natural Fire Plan has been partially completed.

Desired Condition: Water quality is maintained for existing streams and surface waters. Wilderness experiences that are highly desired by recreation users are maintained. Wildlife habitat moves towards a condition where small openings needed by certain species and more heterogenous opportunities are created. Fire continues to be suppressed, but a Prescribed Natural Fire Plan is in place in order to reintroduce fire under appropriate conditions. Dispersed day-use and unstructured hiking opportunities increase for both hikers and horse use.

Social and Ecological Function:

- Potential wolverine habitat.
- Refuge for wildlife.
- LSR connectivity between the Sisters LSR and the Cultus-Sheridan LSR's.
- Low density use in the Wilderness for hikers and horse recreationists.

Trends (short term - 0 to 10 years, long term - 10+ years):

- Late and old forest structures will increase due to lack of disturbance and increased stability.
- More LOS habitat with an inevitable natural disturbance affecting the early stages.
- A slight increase in more day-use vs. overnight camping.
- Frequent fire starts insignificant in size and duration.
- Prescribed Natural Fire Plan and implementation.

Cold Forest/Unroaded Landscape Area

Current Condition: Conditions are similar to those in the Wilderness Landscape Area. The biggest differences are a greater abundance of surface water and changes to the natural hydrology. The amount of water in the Middle Fork of Tumalo Creek has increased with input from the Crater Creek Ditch. Where Road 370 crosses the stream, drainage is poor and there is an increase of sediment in the streams. Springs that feed the Middle Fork of Tumalo Creek are diverted from into Bridge Creek. Increased turbidity has resulted in some areas as a result of these changes. Brook trout are found in the streams. Potential wildlife species include wolverine, fisher, marten, and spotted owl.

This Landscape Area has the greatest amount of late structural forest with approximately 2 to 3 times more than historically expected under fire disturbance regimes. Bikes are allowed as a non-motorized use in the summer and snowmobiles are allowed as a motorized use in the winter. More summer and winter use occurs here than in the Wilderness with mostly

snowmobiling, skiing, and increasing snowshoeing activities. There is a moderate to high density level of summer and winter trails.

Desired Condition: Crater Ditch is eliminated in order to restore historic and natural water flows to Soda Creek and Sparks Lake. Improve ditch maintenance if water rights cannot be purchased. Natural stream stability of existing streams continues to be maintained. Non-motorized recreation use is emphasized as a day-use activity. Road 370 erosion problems are corrected and it is maintained as a primitive road with high clearance conditions. Road 370 remains open for the short-term and provides access to selected trailheads in the long-term. Appropriate use levels and restrictions for bike riding and winter snowmobile use are maintained in order to meet water quality standards. Forest vegetation encroachment upon natural openings is controlled.

Social and Ecological Function:

- Provides high quality water for irrigation use in the Bend area.
- Increase in day-use recreation activities.
- Significant summer range for big game.
- Serves as a refuge for LOS-dependent species that are intolerant of fragmentation and high road densities.
- LSR connectivity, similar to the Wilderness Landscape Area in terms of unfragmented condition.
- A reservoir of pristine conditions.

Trends:

- Vegetation has a continued increase in late and old structural stands.
- Semi-Primitive Non-Motorized use occurs.
- Increased day-use, accessible by new trails and trailheads from the Cascade Lakes Scenic Byway or Road 370.
- Snowmobile and mountain bike use are increasing at a faster rate than other recreation uses.
- Same as present levels for hiking.
- Less hunting, dispersed camping, road hunting.
- Development of loop trail system completed.
- More winter motorized activities and fewer hunting activities in the long-term.

Bridge Watershed Landscape Area

Current Condition: Bridge Creek was originally a small stream but channel size has increased with the diversion of water since 1955. Erosion and increased turbidity increased after the fire but have now stabilized. Rainbow trout and non-native brook trout are found in the streams. Potential wildlife species include wolverine, fisher, marten, and spotted owl. Diversity of vegetative species, including more spruce, is present. Recreation use is heavily regulated. This area includes the upper extent of the Bridge Creek Fire area. Water quality is currently meeting standards for coliform and turbidity.

Desired Condition: Winter snowmobile use is limited. Forest vegetation encroachment upon natural openings is controlled. Recreation use is not heavily regulated due to water quality requirements for the City of Bend Municipal Watershed. Future management actions taken by the City of Bend result in less of a need to regulate use. Sedimentation and erosion problems in the canal are elimininated in order to protect water quality.

Social and Ecological Function:

- Serves as a refuge for LOS-dependent species that are intolerant of fragmentation and high road densities.
- Provides 50 to 60 percent of the drinking water to the city of Bend.
- Late- Successional Reserve connectivity.
- Elk summer range.
- Wilderness experience in a non-wilderness area close to Bend that is a hiker only, quality experience for solitude within an ecosystem similar to the west side of the Cascades in a setting that includes falls, creeks, and riparian vegetation.

Trends:

- Decreased regulation of recreation activities dependent upon future actions taken by the City of Bend Municipal Watershed concerning transport of water.
- Water quality is improved in the Bridge Creek Fire area as vegetation increases.
- Water quality standards increase due to the demands for better quality water (currently meeting standards for coliform).
- Fire continues to have full suppression.

Front Country/Transition Landscape Area

Current Condition: Brook trout and rainbow trout are found in the streams, particularly in the portion of Tumalo Creek that became relatively unstable as a result of the Bridge Creek Fire of 1979 and subsequent salvage operations. Water temperatures are within state standards. Some channel instability is occurring causing channel braiding and bank scouring to continue. The Columbia Southern Canal is located on the eastern fringe of this landscape area. The diversion acts as a barrier to fish moving upstream in the summer and causes the loss of fish down the canal. New policies implemented by the Tumalo Irrigation District during the summer of 1998 diverted the water at a point further downstream. This prevented the loss of fish down the canal and created higher flows in the reach below the Bridge Creek Fire area.

There is currently less of a departure in vegetative structure from historic regimes than in other landscape areas. There is more early and mid-forest structure with some fragmentation and varying levels of open road densities. The Bridge Creek Fire of 1979 was a bigger fire than normally would occur but due to the fuels, it was much closer to naturally occurring conditions. Stands that have less resilience are mostly found here. Plantations established within the Bridge Creek Fire area continue to gain density as they mature.

Motorized access and developed recreation sites such as the Tumalo Falls Lookout and Skyliner Lodge are more prevalent within this landscape area. Dispersed use is increasing with more overnight and motorized use than in other areas.

Desired Condition: Tumalo Creek is restored to a more stable stream system and removed from the 303(d) list through collaborative work with the State DEQ and irrigation right owners. The Columbia Southern Canal diversion is screened.

Road densities are reduced. Understory density and fire risk are reduced within some mixed conifer stands and the newly established plantations in the Bridge Creek Fire area. Forest vegetation encroaching upon natural openings is removed. Resiliency is restored to some dense stands especially ponderosa pine once dominated by frequent fire cycles. Engelmann spruce are returned to the riparian zone.

Trail connections between urban and forest areas are improved including the existing Tumalo Trail system and to the Three Creeks area on the Sisters District. Existing informal winter recreation trail system improvements are made rather than constructing any new trails.

Social and Ecological Function:

- Provides a poriton of the linkage between the Three Creeks and Sheridan LSRs.
- Serves as a travel corridor for migrating big game.
- Transition zone from private lands that are fairly developed and heavily managed to Wilderness with a fair amount of roads, some trail systems, and large areas without trails or roads.
- Recreational driving on back roads in a Semi-Primitive wilderness to vista lookout points at Bearwallow Butte and Triangle Butte.
- Many opportunities exist to provide linkages and connections to other parts of the watershed.
- Fairly central transition zone.
- Irrigation water diverted from here.
- Skyliner Road Subdivision and private parcels - growing residential population.
- Outdoor educational center at Skyliner Lodge.

Trends:

- Increased recreation use at the Skyliner Lodge area with the addition of trail linkages.
- Braiding and lateral migration in the Tumalo Creek channel within the Bridge Creek Fire area.
- Continued instability in Tumalo Creek until its natural pattern is established (lots of sedimentation, braiding instability, and unfavorable conditions for aquaic diversity).
- More development occurring in the residential areas along Skyliner Road.
- Increased use on Road 4601 for recreational driving, dispersed camping, day-use hiking and fishing activities due to the close proximity to the city of Bend.
- Skyliner Lodge becoming more of a focal point for recreation in the area.
- Stream flow becoming more "normal" to pre-fire stream flow conditions.
- Increasing stand densities with continued fire suppression.

Private/Dry Forest Landscape Area

Current Condition: Ponderosa pine LOS is lacking. The area is heavily managed and roaded in order to provide commercial wood products and reduce fire risks. Soil disturbance areas are extensive. Deer winter range is in moderate condition. Access for recreaiton driving and hunting is provided by the road system which is closed in the winter. Dipersed horse-related uses occur near and around Tumalo reservoir. Crown Pacic lands have a policy of no shooting allowed, no overnight use, and fire closures.

Desired Condition: Forests are managed to provide more diverse conditions, including an increase in LOS conditions. Tumalo Creek is removed from the 303(d) list by augmenting flow and stabilizing channels to meet State DEQ requirements from the Federal Clean Water Act. Tumalo Irrigation District continues its lower diversion policy implemented in the summer of 1998. Vegetative management activities occur for economic gain, sustainable harvest, long-term sustained yield, fire risk, and to generate commercial value. A mosaic of shrub and forage conditions are interspersed with thermal cover where possible and road densities are reduced to levels below 1.5 to 2 miles/square mile.

Social and Ecological Function:

- Deer and elk winter range.
- Public use allowed for day-use recreation, including mountain bike trail connection from Shevlin Park to the Skyliner area.
- Transitional zone between the city of Bend and primitive forest.
- Crown Pacific tree farm.

Trends:

- Dependent upon stand growth rates, market conditions, and Crown Pacific's long-term land management plans.

Dry Forest Landscape Area

Current Condition: Eastern brook trout and rainbow trout are found in Tumalo Creek with possibly brown trout in the downstream reaches of Tumalo Creek. Topographical features are canyon formations above the streams. There are extensive stands of middle-aged trees and high road densities with a lack of ponderosa pine LOS. A fair amount of trails exist and horse use is increasing around Tumalo Reservoir.

Desired Condition: Road density is reduced. Management is towards LOS pine conditions and for a variety of tree and shrub age classes. An official trail system is developed for dispersed day-use activities and for a connection between existing user trails along Tumalo Creek and the Wilderness. Use of the area as an urban interface dumping ground is reduced.

Social and Ecological Function:

- Deer winter range and migration corridor for big game.
- Irrigation water source.
- Outtake at Tumalo.

- Day-use for mountain bikes and horses.
- Shevlin Park/private land.
- Pumice lands (mining, shooting range, urban land uses, dumping ground, on the fringe).
- Forest/urban interface boundary (fire risks).

Trends:

- Middle-aged forests will continue to advance in age.
- Dense stands will be at risk to insects and fire.
- Private/public land interface.
- Fire awareness/urban interface.

Chapter VI
Management Recommendations
Data Gaps and Analysis Limitations
Monitoring
Aquatic Conservation Strategy

Chapter VI
Management Recommendations, Data Gaps and Analysis Limitations, Monitoring, and Aquatic Conservation Strategy

MANAGEMENT RECOMMENDATIONS

Management recommendations are made by the watershed analysis team as a way to maintain and protect the critical elements and processes identified through the trend ratings and assessment of ecological conditions in Chapter V. Using the issues and key questions, these recommendations reflect the most relevant and desirable conditions for the watershed which are the protection of water quality, enhancement of a quality recreation experience, and improvement of forest health and riparian function.

Wilderness Landscape Area

1. Reintroduce fire in the wilderness ecosystem by developing and implementing a Prescribed Natural Fire strategy.

2. Determine appropriate level of use for this landscape area.

3. Maintain current maintenance level (Level 2) and seasonal closures on Road 370 to limit access, improve safety for users, and reduce impacts to resources due to road deterioration.

Cold Forest/Unroaded Landscape Area

1. Reduce forest encroachment through manipulation of vegetation around meadows.

2. Maintain current maintenance level and seasonal closures on Road 370. Improve stream fords with additional armoring of bank areas that are currently a source of sediment input. Recent breaches of off-road restrictions and gated closures reflect the need to assess how to improve management and use of this road in a sensitive, high elevation location.

3. Reintroduce fire in this landscape area, especially meadow edge burns, by developing and implementing a Prescribed Natural Fire strategy.

4. Assess appropriate recreation use levels to limit social and resource impacts.

Bridge Watershed Landscape Area

1. Vegetative manipulation and thinning around meadows from forest encroachment.

2. Remedy Bridge Creek Canal head cutting.

3. Maintain appropriate recreation access to meet water quality standards.

Front Country/Transition Landscape Area

1. Restore Tumalo Creek to a more stable stream condition within the Bridge Creek Fire area.

2. Screen the diversion entry into the Columbia Southern Canal.

3. Improve trail system connections from Shevlin Park to Tumalo Trail System.

4. Improve trail system connections from Bend to the Skyliner/Tumalo area.

5. Promote additional Engelmann spruce in the riparian zone of Tumalo Creek in the Bridge Creek Fire area.

6. Reduce stand densities and fuel loading where appropriate.

7. Manage access to promote a semi-primitive non-motorized summer recreation experience.

8. Improve safety of snowplay ski-jump hill or relocate snowplay use.

9. Assess the grade and maintenance level of Road 4601 as it leaves Tumalo Creek drainage and relocate with appropriate switch backs to reduce erosional loss from current levels.

10. Trail relocation and/or redesign resulting from changes in use patterns from initial design specifications is needed on the South Fork Trail.

11. Limit overnight use for the areas along Tumalo Creek and Road 4603 between Skyliner Lodge and Tumalo Falls.

12. Provide fish passage at Columbia Southern Canal.

13. Purchase the section of privately owned land that includes Tumalo Lake.

14. Thin and culture to develop late structure and prevent overstocking in the ponderosa pine and mixed conifer dry sites.

15. Salvage some of the standing and down dead in higher elevation lodgepole pine for fuel reduction to reduce fire risk while retaining overstory continuity.

16. Pre-commercial thin tree plantations within the Bridge Creek Fire area along Road 4601 and Tumalo Creek to prevent overstocking.

17. Spur road and skid trail restoration and obliteration on select areas within the Bridge Creek Fire area.

18. Assess need for Nordic hut-to-hut system.

Private/Dry Forest Landscape Area

Crown Pacific lands

Dry Forest Landscape Area

1. Road density reduction through closure and obliteration.

2. Mowing and burning to treat shrub component.

3. Support Tumalo Irrigation District's policy to divert water below Shevlin Park. continuation of this policy may result in the removal of Tumalo creek from the State 303 (d) list.

4. Maintain existing recreation facilities.

5. Assess road to trail conversion opportunities and existing use trail tread design and restriction status of any trails acquired through the Land Exchange.

6. Reintroduce fire in appropriate stands to address urban interface fire protection/awareness needs.

7. Soil restoration on acquired lands on the north side of Tumalo Creek. Activity areas identified as being in condition class C or D under the existing condition analysis are included in these recommendations.

8. Thin and culture in high density, late and old structural ponderosa pine and mixed conifer dry sites.

DATA GAPS AND ANALYSIS LIMITATIONS

In general, data gaps for the soil resource include a direct correlation of site productivity reductions resulting from soil disturbances such as compaction and the loss of natural horizon stratification. Detrimental disturbances totaling more than 20 percent of the aerial extent of an activity area are currently determined to be significant enough to reduce site productivity, although actual changes in long-term biomass production and general forest health are difficult to quantify. The assessment of existing conditions across the watersheds was done using activity databases and remote sensing and are generalized to some degree.

Soil movement and sediment contributions to streams resulting from roads and trails within the watershed has also not been quantified, although observations on the ground have identified the occurrence of these mechanisms. The reduction of erosion and sedimentation is regarded as a priority within this watershed since one subwatershed is a municipal water supply and Tumalo Creek has been highly disturbed following fire salvage operations in 1980.

MONITORING

Continued monitoring of trail conditions within the watershed are recommended. Current monitoring of the North Fork trail has revealed moderate stability of the trail tread under current hiker and mountain biker use. Areas of hiker travel off of the trail to gain vantage points of the stream and falls continue to be impacted and should be monitored into the future. Informal monitoring of the Swede Ridge, South Fork, and Happy Valley trails has identified small sections of tread slough or excessive grades, although only the South Fork appears to need timely restoration.

AQUATIC CONSERVATION STRATEGY

INTRODUCTION

The Northwest Forest Plan provides guidelines for developing an Aquatic Conservation Strategy for the purpose of protecting and restoring aquatic/riparian ecosystems on Forest Service administered lands within the eastern extent of the range of the northern spotted owl. The main objectives are to ensure protection of aquatic systems, maintain connectivity, water quality, water and sediment storage and transport regimes, and maintain and restore fish, wildlife, and plant populations and diversity. In order to meet the Aquatic Conservation Strategy objectives, a proposed project or management action must maintain the existing condition or move it within the range of natural variability of the important physical, social, and biological components of the watershed.

The key components of the Aquatic Conservation Strategy are Riparian Reserves, Key Watersheds, Watershed Analysis, and Watershed Restoration. Riparian Reserves are portions of watersheds where riparian-dependent resources receive primary emphasis and include waterbodies such as lakes and ponds, wetlands, streams, stream processes, and fish habitats. Key Watersheds are a system of large refugia that are crucial to at-risk fish species and stocks and provide high quality water. These refugia include areas of high quality as well as degraded habitat. Within the Bend Watershed, the Forks and Bridge subwatersheds are identified as Tier 2 Key Watersheds which likely do not contain at-risk fish stocks but are important sources of high quality water.

Watershed Analysis is the vehicle for achieving the Aquatic Conservation Strategy objectives. A basis for monitoring and restoration programs is provided through this process and Riparian Reserve widths and conditions are developed and recommended by the watershed analysis team specifically for the Bend Watershed. Watershed Restoration is a long-term program designed to restore watershed health and aquatic ecosystems which include habitats supporting fish and other aquatic and riparian-dependent organisms.

RESOURCE CONSIDERATIONS FOR SETTING RIPARIAN RESERVES

Ecological processes driving floodplain and channel dynamics are essential considerations in setting widths and conditions for Riparian Reserves. The width of the defined stream channel and floodplain, as well as the flow regime characteristics of the system, dictate the minimum tree size needed to provide effective instream wood. The presence of large woody

material within a stream channel is a critical factor in maintaining the system's integrity, including the movement and storage of sediment in the channel. Providing additional sources of large wood and floodplain stabilization is a key component of a designated Riparian Reserve in which vegetative health and structure is promoted and diverse aquatic habitat types are created. Maintaining healthy floodplain vegetation is important in resisting erosive forces of flood events and to filter sediment and nutrients during the high flow events.

Riparian Reserves are a component of the Aquatic Conservation Strategy intended to provide habitat beneficial to fish and riparian-dependent and aquatic species other than fish, enhance habitat conservation for species dependent on the riparian transition zone, improve travel and dispersal corridors for terrestrial animals and plants, and serve as connectivity corridors between Late-Successional Reserves. These Riparian Reserves ensure a moist zone for both amphibians and other wildlife species. Nearly 80 percent of the terrestrial wildlife species are either directly or indirectly dependent upon these areas for meeting their habitat needs. Ungulates use riparian areas disproportionately more than upland terrestrial areas for fawning and calving. Lactating females take advantage of the improved cover and succulent vegetation.

Within the Riparian Reserves, particularly in lodgepole pine and the wet mixed conifer plant association groups, maintaining healthy forest stands with high snag densities and green tree replacements over the long-term is highly desired for sustaining wildlife habitat needs and water quality. Higher management risks within these areas are often desirable in order to allow natural processes to occur unimpeded by unnecessary human intervention.

RIPARIAN RESERVE WIDTHS AND MANAGEMENT REQUIREMENTS

Riparian Reserves, as described in the Northwest Forest Plan and Record of Decision (ROD), have been adopted (USDA, USDI, 1994) for the Bend Watershed. Considered to be special management areas, proposed projects and activities will be prohibited or regulated based upon the ROD Standards and Guidelines and the resource directions described below. The environmental assessments or environmental impact statements prepared for these projects and activities will be used to describe and to determine site specific conditions and mitigation needs.

A small portion of the watershed within the Dry forest Landscape Area lies east of the northern spotted owl line, and therefore fall under the Inland Native Fish Strategy (INFS) management plan (1995). Rather than Riparian Reserves, INFS defines riparian areas and associated lands as Riparian Habitat conservation Areas (RHCA). As with riparian Reserves, riparian-dependent resources receive primary emphasis. With a few exceptions, the widths for RHCAs mimic those of Riparian Reserves from the NWFP. Within this document, RHCAs will be considered as Riparian Reserves.

Recommended Riparian Reserves widths along many of the watershed's streams have been increased slightly due to the presence of moist soil types reflective of riparian hydrology and vegetation. Riparian Reserves were established for lakes, ponds, intermittent and perennial streams, and wetlands associated with soil resources mapped as landtypes 2, 5, and 8 in the 1979 Deschutes National Forest Soil Resource Inventory (See Exhibit 13).

Vegetation

Fire, salvage, and various thinnings are operational tools available to create small openings in riparian areas. Large trees within the distance equal to the height of 2 site-potential trees from the stream channel will be retained since they have the potential for providing shade or live woody material to the stream systems. Wildlife habitat considerations will dictate the remaining condition of the patches needing to be created. Fuel loading in Riparian Reserves are generally greater than in surrounding uplands where active management has occurred, except within established facilities such as developed recreation sites, residential areas or wildland/urban interfaces.

Roads, Grazing and Minerals Management

As per the ROD, site specific conditions and mitigation will be described and determined in the project environmental assessments or environmental impact statements. There will be no net increase in roads.

Lands, General Riparian Area Management, Watershed and Habitat Restoration, Fish and Wildlife Management and Research

As per the ROD, site specific conditions and mitigation will be described and determined in project environmental assessments or environmental impact statements.

Recreation Management

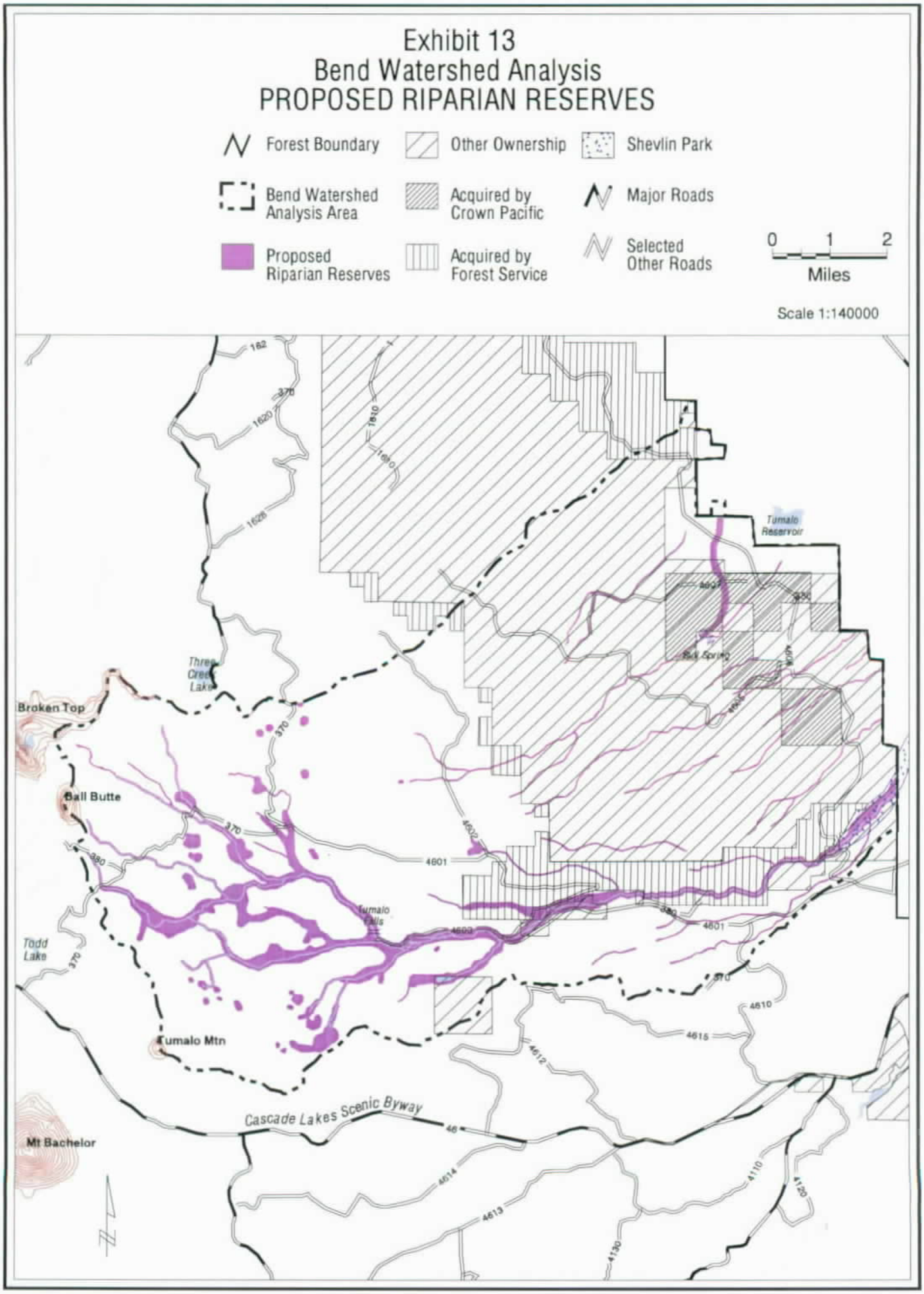
Campgrounds or camping sites will not be developed within the distance equal to the height of 2 site-potential trees of any water body. Existing camping sites that have fire rings or picnic tables closer than 50 feet to water will be reassessed and relocated if necessary based upon site review and comments from affected campers. Vegetative buffers will be used to prevent sediment from washing into adjacent waters and to focus foot traffic onto defined pathways. Circulation patterns and access will be redirected by realigning trails or relocating trailheads, using different surface materials such as wood boardwalks, wood viewing platforms or hard surfaces, trail borders or boundaries using natural elements such as the surrounding fallen woody material, semi-buried stones, or native shrubs or groundcovers. Native plant species that are 12 to 18 inches minimum height are suggested as a way to deter foot traffic. Tree plantings should be of mixed sizes and varied spacing to appear natural. Native plant species are to be approved per site by the District or Forest Botanist.

Scenic views will be strongly considered when relocating camping sites, day-use picnic sites, trails, and viewpoints. Opening views, providing more sun exposure and light, and replanting damaged riparian vegetation areas will improve both the overall scenic quality and the desired recreation experience close to water. Day-use picnic sites will be designated with picnic table locations away from areas where riparian vegetation is damaged or removed.

Fire/Fuels Management

A fire management strategy for the Riparian Reserves will be developed within 5 years that will allow for fire by prescription under both natural and human caused ignitions. The fire

Exhibit 13
Bend Watershed Analysis
PROPOSED RIPARIAN RESERVES



management strategy should allow fire to burn to and through the water influence zone and should be commensurate with the surrounding vegetation zone, providing for structural diversity and, where appropriate, include a confine, contain, and control doctrine. Firelines constructed with mechanized equipment within or across riparian areas should be limited to extreme emergencies only.

RECOMMENDED RIPARIAN RESERVE WIDTHS

The recommended Riparian Reserve widths for the Bend Watershed will adhere to the following standards listed in the Record of Decision for the Northwest Forest Plan (pages C-30, C-31).

For the Bend Watershed, recommended Riparian Reserves on Forest Service land totals 4,522 acres, of which 479 are actually RHCAs within the Dry Forest Landscape Area. The Riparian Reserves are overlapped by other designated areas from the Northwest Forest Plan (Congressional Reserves, Late-Successional Reserves, Administratively Withdrawn), each with their own specific standards and guidelines. Riparian Reserve standards and guidelines apply in these other areas. After calculating the acreage for the other designated areas, 1,047 acres of Riparian Reserve are associated with Matrix lands.

Fish-bearing streams:
Riparian Reserves consist of the stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of 2 site-potential trees, or 300 feet slope distance (600 feet total, including both sides of the stream channel), whichever is greatest. A site-potential tree height is the average maximum height of the tallest dominant trees (200 years or older) for a given site class. The greatest slope distance is 300 feet for most stream reaches within the Bend Watershed. One notable exception is within the canyon area of Tumalo Creek, where the Riparian Reserve width will extend to the top of the gorge, greater than 300 feet slope distance.

Permanently flowing non-fish bearing streams:
Riparian Reserves consist of the stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance (300 feet total, including both sides of the stream channel), whichever is greatest. The greatest slope distance is 150 feet for most stream reaches under this category within the Bend Watershed.

Wetlands greater than 1 acre:
Riparian Reserves consist of wetlands and: the area to the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or the extent of unstable and potentially unstable areas, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance from the edge of wetlands greater than 1 acre, whichever is greatest. Site specific analysis will be needed to determine the greatest slope distance for wetlands greater than 1 acre within the Bend Watershed.

Lakes and natural ponds:
Riparian Reserves consist of the body of water and: the area to the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or to the extent of unstable and potentially unstable areas, or to a distance equal to the height of 2 site-potential trees, or 300 feet slope distance, whichever is greatest. The greatest slope distance is 300 feet for lakes and ponds within the Bend Watershed.

Seasonally flowing or intermittent streams, and wetlands less than 1 acre:
Intermittent streams are defined as any nonpermanent flowing drainage feature having a definable channel and evidence of annual scour or deposition.

This category applies to features with high variability in size and site specific characteristics. At a minimum, the Riparian Reserves must include the stream channel and extend to the top of the inner gorge, the stream channel or wetland and the area from the edges of the stream channel or wetland to the outer edges of the riparian vegetation, and extension from the edges of the stream channel to a distance equal to the height of one site-potential tree, or 100 feet slope distance, whichever is greatest. The greatest slope distance is 100 feet for intermittent streams and wetlands less than 1 acre within the Bend Watershed.

Note: All recommended Riparian Reserve widths are subject to change under site-specific analysis conducted during a NEPA decision-making process.

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Appendices

TUMALO CREEK STREAMFLOW

(Below Columbia Southern Diversion)