Hills Creek Watershed Analysis

Willamette National Forest
Rigdon Ranger District
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Table of Contents

Figures

Tables

INTRODUCTION

Location

The Hills Creek Watershed Analysis area is located in the Western Cascades, roughly 45 miles southwest of Eugene, Oregon (Figure 1). The watershed extends from the headwaters of Hills Creek just below Diamond Peak down to the base of the Hills Creek arm of the Hills Creek Reservoir.

Management Direction

This document is tiered to current management direction as established by two sources:

1. The Willamette National Forest Land and Resource Management Plan (USDA Forest Service, 1990); this document is referred to in this analysis as the Willamette LRMP.
2. The Final Supplemental Environmental Impact Statement (SEIS) on Management of Habitat for Late-Successional and Old-Growth Related Species Within the Range of the Northern Spotted Owl (USDA, USDI, et al. 1994), popularly known as the Northwest Forest Plan. A Record of Decision (ROD) was published in April, 1994, amending the Willamette LRMP.

In this analysis, "Forest Plan" will be the terminology used to mean the Willamette LRMP as amended by the Northwest Forest Plan.

The Hills Creek watershed is not a key watershed. This analysis has been completed in compliance with this direction and to provide decision-makers with a more comprehensive body of information upon which to base their land management decisions.

Document Format

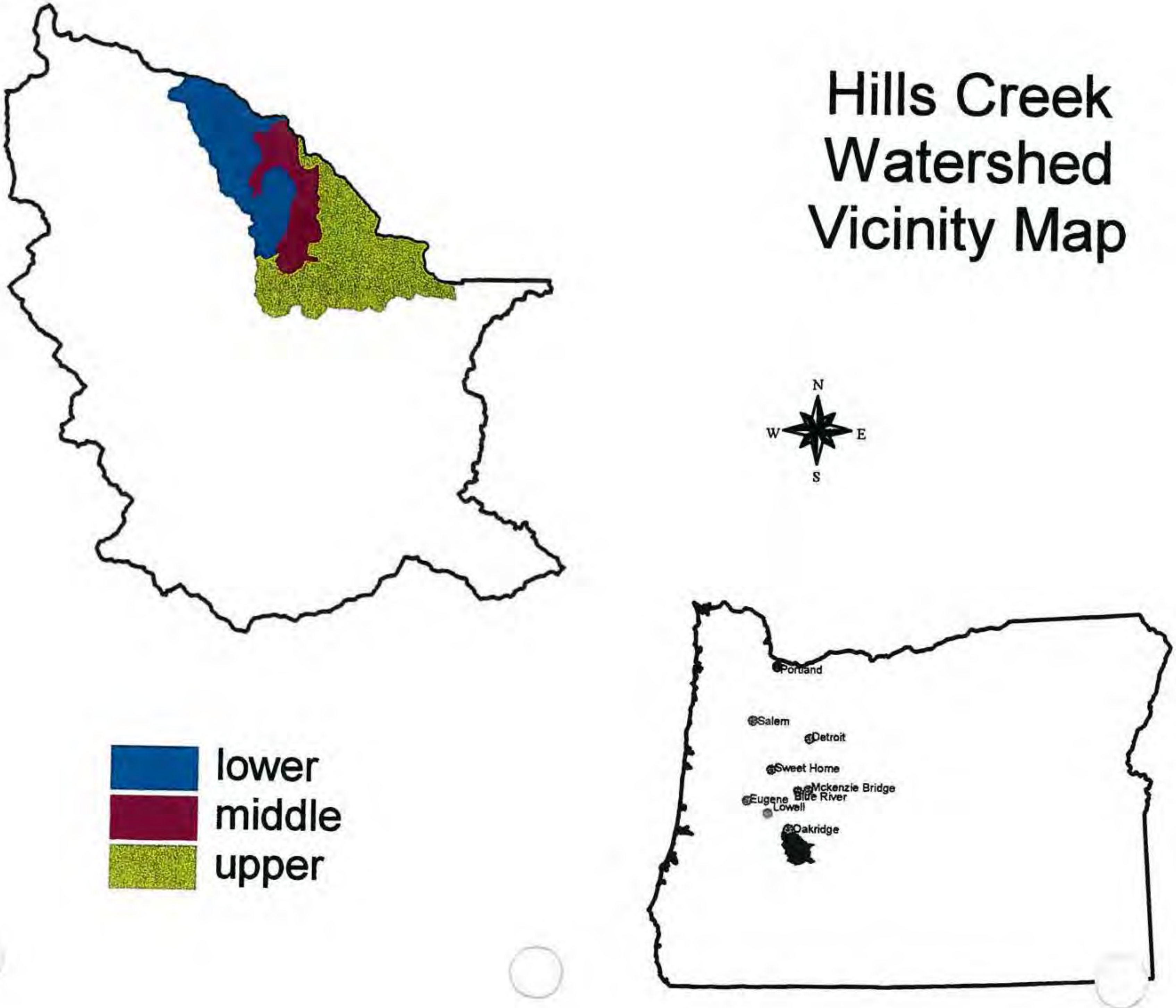
This analysis tells how this watershed came to have the characteristics it contains, of the important processes occurring within it and how landscape processes and patterns changed over time. The intent of this analysis is to provide current resource information set within the context of applicable standards and guidelines, focusing on those activities and issues identified through scoping. As shown in the Table of Contents, this document is comprised of the following components:

- **Characterization** describes the unique or important features within the watershed.
- **Issues and Key Questions** describes the predominant issues faced in land management activities and identifies the questions that need to be answered to provide decision makers with meaningful resource information.
- **Reference/Current/Trend Conditions** describe historical, current and (where possible) trend conditions of the natural resources pertaining to the issues identified.
- **Synthesis** which interprets and describes links between issues, and their significance.
- **Recommendations** that provide land managers with options to consider.
- A **glossary** provides definitions for technical and agency-specific terms.

- **An appendix** provides information supporting this analysis.

FIGURE 1

Hills Creek Watershed Vicinity Map



CHARACTERIZATION

Land Management Plan

The Forest Plan provides management direction by setting standards and guides that are forest-wide as well as those specific to management areas. There are fifteen management areas established by the Forest Plan represented within the watershed (Figure 2, Table 1). Each management area is designated whether or not harvest is allowable, and if allowed, what types and rates of harvest. In addition to these management areas, Riparian Reserves were established by the Northwest Forest Plan; generally, only management activities which benefit riparian reserves are allowed in these areas.

Table 1. Management Area Acres

Management Area Description	Harvest	Acres	RR acres	Net Acres
Wilderness	N	532	45	487
Dispersed Rec	N	116	24	92
Scenic, Modification Middleground	R, S	427	52	375
Scenic, Partial Retention Middleground	R, S	208	17	191
Scenic, Partial Retention Foreground	R, S	26	0	26
Scenic, Retention Middleground	R, S	2	0	2
Scenic, Retention Foreground	R, S	456	70	386
Developed Recreation	S	27	1	26
General Forest	D,Y, S	16,783	3,162	13,621
Late Successional Reserve (LSR)	D, S	15,981	3,231	12,750
LSR-100 Acre	D, S	615	105	510
Special Interest Area	D, S	24	2	22
Special Wildlife Habitat	D, S	1,541	186	1,355
Pileated & Pine Marten	D, S	470	0	470
Total Matrix Allocations		17,902		14,600
Total Reserved Allocations		19,306	6,895	22,608
Water		358		
Private		799		
TOTAL WATERSHED		38,365		

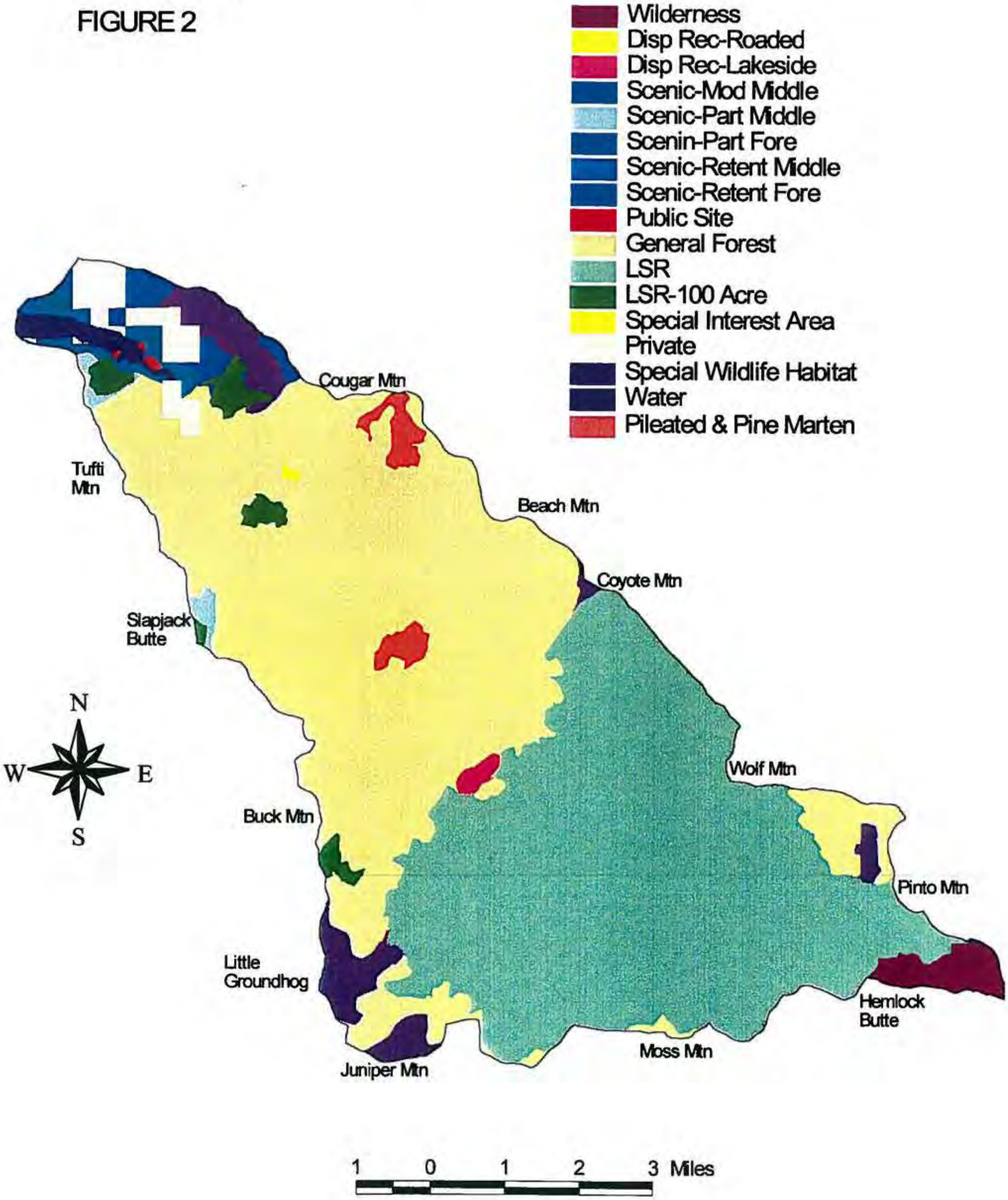
Table Notes:

1. In Harvest: Y = regeneration harvest allowed, S = salvage is always a consideration and is determined by site-specific analysis, N = no harvest allowed, R = reduced harvest, D = density management allowed in younger stands, if such action benefits the resources or management objectives.
2. Net Reserved Allocation acres includes riparian reserves.
3. Not all riparian reserves have been identified; actual riparian reserve acres will be greater.

For purposes of this analysis, allocations have been classified into two broad categories:

- Matrix: Includes General Forest and all Scenic allocations, less the imbedded Riparian Reserves. There are 14,600 acres of matrix in this watershed (38%).
- Non-matrix Lands: Includes allocations of non-harvest areas, thus allowing only management actions that benefit the resource : Wilderness, Recreation , LSRs, Special Interest Areas, Wildlife and Riparian allocations. The Hills Creek watershed is 58% (22,608 acres) non-matrix lands.

Land Management Plan
Hills Creek
FIGURE 2



Human Uses

Recreation:

Recreational-use within the Hills Creek watershed is moderate and strongly, associated with Forest Service roads FS 21 and FS 23. Hunting, hiking, fishing, biking, and camping are the predominate recreational activities within this watershed. In so far as camping, the greatest use occurs in the upper arm of Hills Creek reservoir and along the lower 4 miles of Hills Creek, as well as dispersed campsites at CT bridge and Cozy Cove. Hunting camps are scattered throughout the watershed with the most popular at Vivian Lake trailhead and at the mesic (standing water) area in the Warfield drainage.

Fishing is popular within this watershed and the most popular areas are at any bridge or stream crossing. Generally, most fishing takes place from Hills Creek Reservoir upstream to about the junction of Road 23 and 5875.

Historic and Pre-historic human uses (Archaeology):

For those who inhabited the western edge of the North American continent during the thousands of years prior to the influx of Euroamericans, the Cascade Mountains were part of the landscape of daily living. Mountain meadows, forests, streams and lakes held a wealth of resources for those knowledgeable in their ways and seasons. White (1975) suggests the Kalapuyans occupied the valley edges in conjunction with the Douglas-fir ecotone during the late spring and summer to engage in hunting, tool manufacture and hide preparation. The Molallas wintered in sites located along streams in the lower elevations, usually west of the Cascades, and they exploited the higher country for roots, berries and larger game (deer, elk and bear) at other times of the year. They also fished for salmon, steelhead, trout, eels and other species in suitable streams and lakes.

Periodic burning was widely reported in western Oregon, and practiced by both the Kalapuyans and the Molalas. The Kalapuyans burned for many reasons. As hunter-gatherers, some of their reasons had to do directly with collecting food. They set fires to drive deer for hunting and as part of their methods of collecting tarweed (Madia) seeds and grasshoppers. They regularly set fires to keep the ground under oak trees brush-free to facilitate collecting acorns, a crucial dietary staple for them. According to Minto, an early Oregon settler:

"Fire was the agent used by the Calapooia tribes to hold their camas grounds and renew their berry patches and grass-lands for game.on the west face of the Cascades the Molallas claimed dominion, and fire was their agency in improving the game range and berry crops (1908:152-153)."

Over 45 archaeological sites have been found in the Hills Creek watershed to date. The majority of these sites are located in lower elevation terraces or meadows and prairies which were much more extensive before Euroamerican settlement.

In 1893, the Cascade Range Forest Reserve was established under the auspices of the U.S. Department of the Interior. The Reserve covered a large portion of the Cascade Range.

Initially it was a closed area, but by 1897 the land was reopened to settlers, miners, stockmen and lumbermen for their use. In order to enforce the regulations of the U.S. Department of the Interior and later the Department of Agriculture in 1905, forest rangers were hired to patrol the area. Rangers working in the area were engaged in activites that included patrolling, acting as game warden, surveying, erecting cabins, trail building, timber marking, log scaling, locating sites for mills and hotels, fire fighting, and being a deputy U.S. Marshal.

Twentieth century development of the Upper Willamette was expedited by the advent of the railroad, the contemporary road system, and the logging truck. In 1912, a railroad line opened as far as Oakridge. By 1930, motorized vehicles like the log truck, were in common usage. As a result, the forest became more accessible for development of its resources, including lumber and recreation.

Stratification of the Watershed

The watershed has been stratified for analysis into three regions based on dominant soil characteristics, landform, and vegetation patterns (Figure 3). Each of these strata are described in terms of dominant geology, landform, storm response, channel type, fire processes and terrestrial habitat types and patterns. Each stratification factor is discussed in the section below, followed by a section which describes the unique features of each stratum.

Stratification Factors

Geology, Soils and Landform

Bedrock geology for Hills Creek watershed ranges from sheared and altered pyroclastics (tuffs and breccias) to extrusive lava flows. The pyroclastics weather to fine-grained soil while lava flows weather to granular soil. Landforms range from remnants of alpine glaciation in the upper reaches to earthflows and dissected terrain in the middle and lower reaches respectively.

Storm Response

Storm Response models relative differences in hydrologic processes due to natural landscape characteristics and is calculated as a function of soils, elevation and aspect. The model considers the water yield of different soil types, water availability as determined by the relative accumulation of snow and melt rate as determined by aspect relative to warm-air storm fronts. See Appendix for specific model definition.

Storm response describes the magnitude and timing of storm runoff. High storm response indicates a relatively large amount of surface runoff delivered quickly to the stream network, while low storm response indicates a lesser amount of runoff delivered at a slower rate through subsurface and surface pathways. Overall, 63% of the watershed has high storm response, 20% is moderate and 17% has low response.

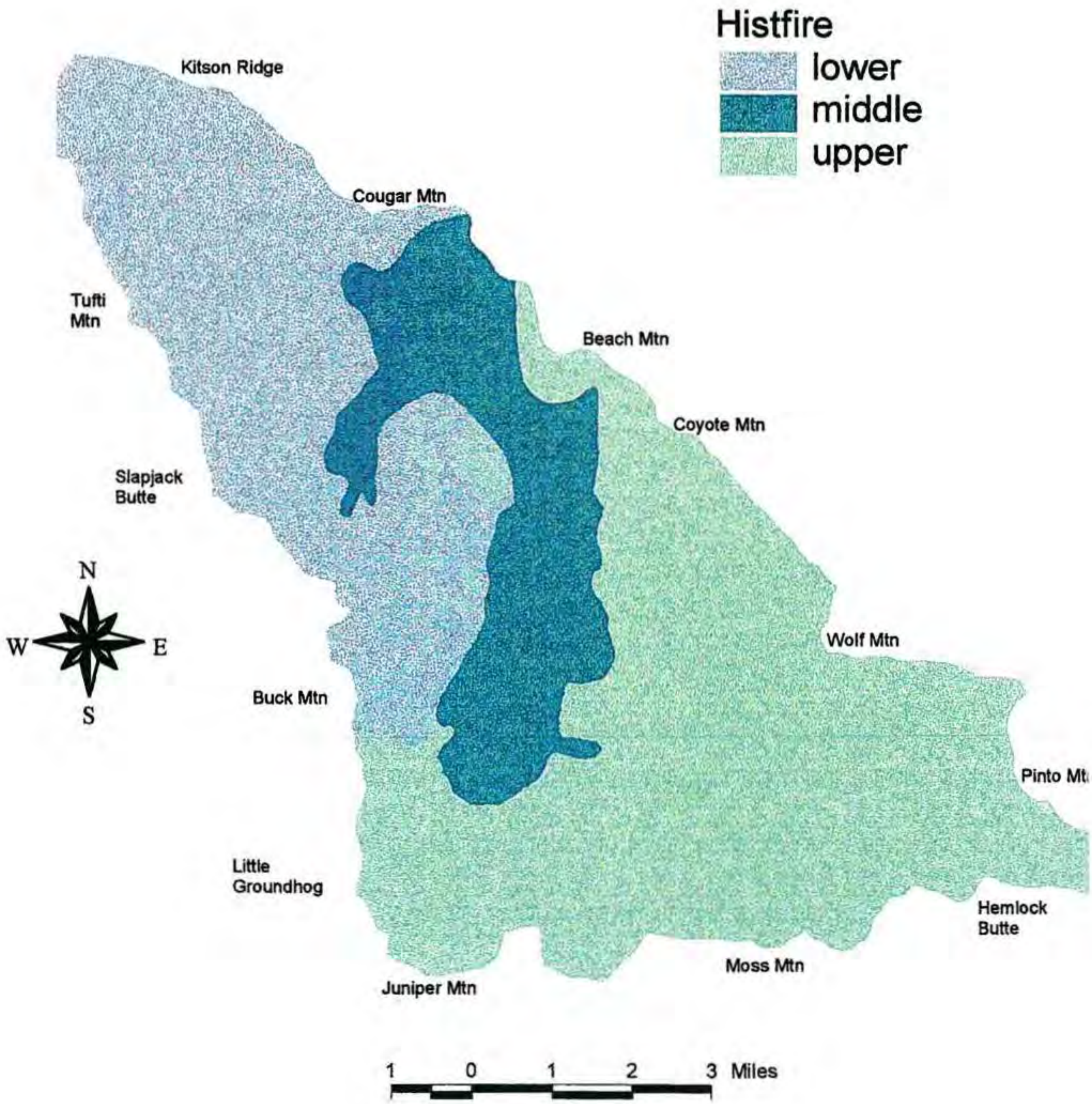
Channel Type

Stream channel segments in the watershed are characterized as Source, Transport, and Response based on their gradient, confinement and valley form (Montgomery and Buffington, 1993).

Source segments generally occur high in the drainage network and on steep slopes. They represent the initial formation of the fluvial system and act as sources of water, sediment, and other materials to segments downstream. Fluvial processes are weakly developed and hillslope processes (such as mass wasting) strongly influence these segments. The dominant disturbance regime in this part of the network is one of relatively high intensity, low frequency events such as debris flows. Generally, these segments are not fish bearing.

Transport segments function as a link between source and response segments of the system and they often occur in middle reaches of the network. They are created and maintained by a combination of hillslope processes (i.e. mass wasting), fluvial processes such as sediment transport and storage, and floodplain formation. Generally, these segments are inhabited by resident trout species.

Strata
Hills Creek
FIGURE 3



Stratification Factors (continued)

Response segments are generally in lower portions of the drainage network dominated by fluvial processes (i.e. bank erosion, floodplain development, side channel formation, pool and bar formation). The disturbance regime in this part of the system is a combination of high frequency, low intensity events (i.e. bankfull flows) and low frequency, high intensity events (i.e. major floods).

Fire Processes

Historically, periodic fire was the dominant disturbance regime that shaped the vegetative landscape patterns including patch dynamics and stand characteristics. Fire patterns are strongly linked to topography, precipitation patterns and forest types. Specific fire patterns of the watershed are discussed in the strata descriptions below.

Historical fire patterns were determined using records from the 1940's (photos), which detected only stand replacing fires. These records show two distinct periods of high fire activity; one mid-19th century, and one early in the 20th century (Figure 4 and Table 2). Although there were roughly the same number of incidents during each episode, fires of the 19th century averaged slightly larger in terms of patch size. Data used is limited to a narrow temporal view, and is inadequate to establish the full range of natural variability.

Table 2. Historic Stand-replacing Fire Event Summary

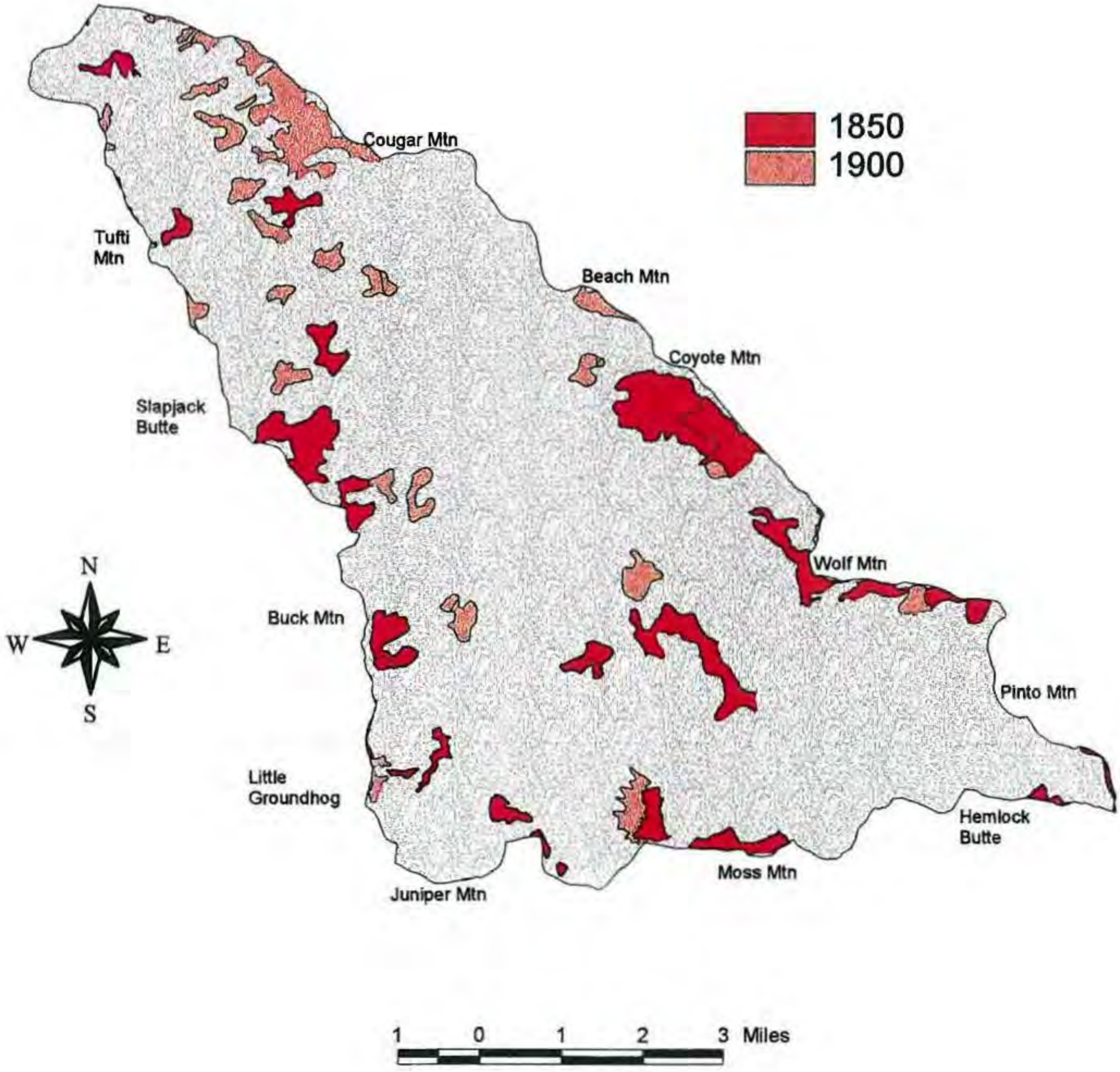
	Number	Total Acres	Average Patch Size	Maximum Patch Size
1850	31	2,983	96	756
1900	36	1,962	55	618

Fire suppression efforts were initiated in the 1910s, and have resulted in a substantial decrease in size of fire events until the 1970's; between the 1900 fire episode and 1944, there were only three detectable fire events in the watershed. There have been three significant fire events in the watershed since that time: the Buck Fire in the early 70's, the Shady Beach fire in 1988 and the South Zone event in 1996 (Figure 5).

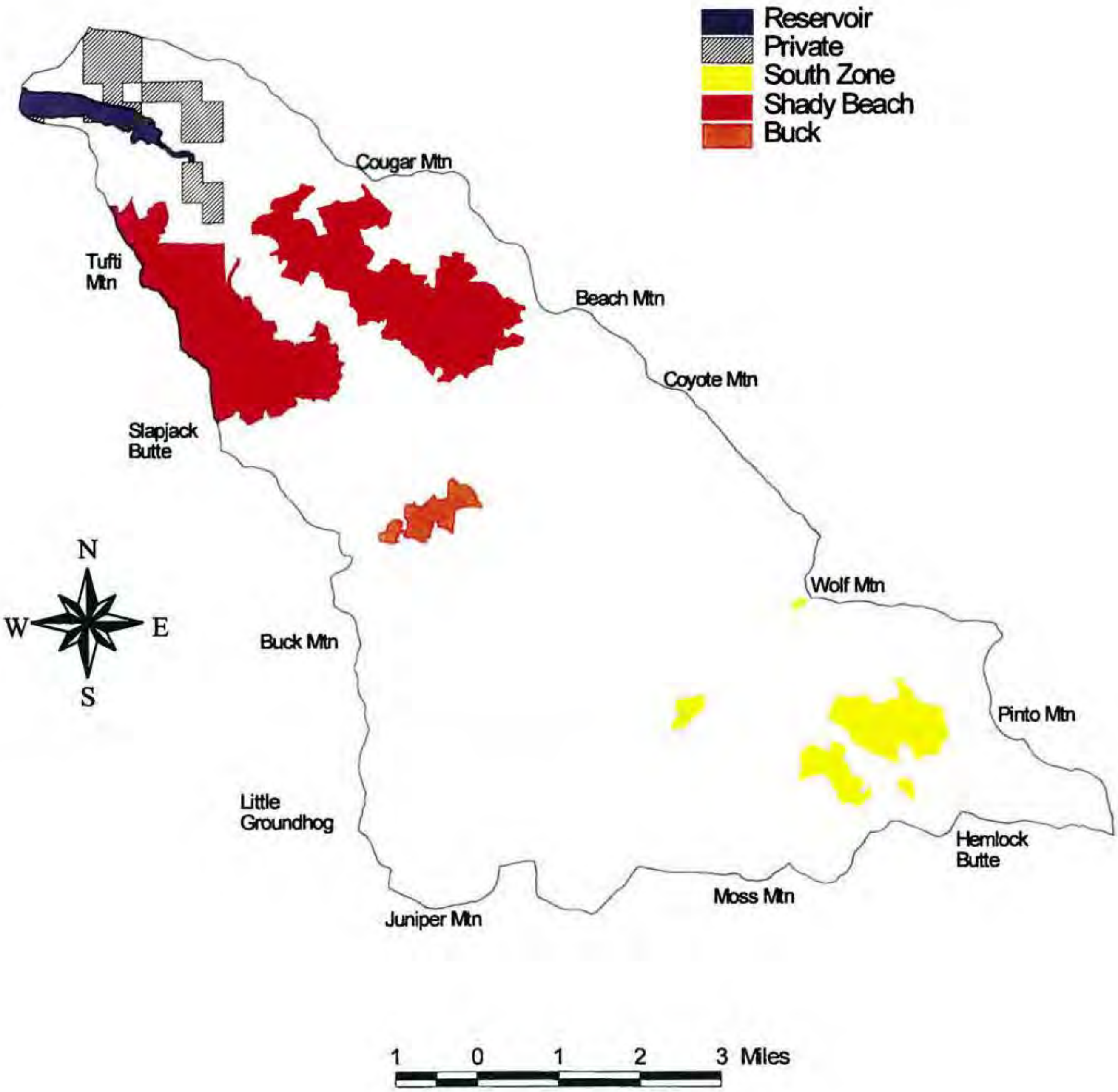
Fire History

Hills Creek

FIGURE 4



Recent Fires
Hills Creek
FIGURE 5



Habitat Types

For purpose of this analysis, habitat has been categorized into broad habitat types based on topographic position and dominant vegetation types. Four habitat types occur within the Hills Creek Watershed:

High elevation upland forest: This habitat type is dominated by mountain hemlock, pacific silver fir and noble fir, occurring above approximately 4,000 feet. A number of species, such as gray jays and marten are closely tied to this habitat type. In addition, this habitat is used during summer by many wildlife species that winter in the lower elevation habitat type.

Low & mid-elevation upland forest: This habitat type is dominated by western hemlock and Douglas-fir. This habitat type is utilized by a wide array of wildlife species, most notably the spotted owl, and provides important wintering grounds for numerous species.

Rare and non-forested: Non-forested special habitats and rare forested associations are important for biodiversity of plant and animal species. Eighty-five percent of flowering plants in the central western Cascades are found in non-forested areas such as rock outcrops and meadows (Hickman, 1976).

Riparian: Riparian habitats provide connectivity within the landscape and are integral for dispersal and genetic interchange of both riparian and many upland species. Riparian stands along the larger stream courses are characterized by a larger hardwood component which contributes greatly to the diversity of wildlife species utilizing the riparian habitats.

Habitat Patterns

Fragmentation, interior forest habitat, and habitat connectivity are landscape patterns strongly affecting plant and wildlife species. Habitat must occur in patterns which not only provide patches of sufficient size to sustain viable populations, but also provide for species dispersal. When landscape vegetation patterns change, there is often an accompanying shift in species composition, distribution, abundance and in the interchange of population genetics.

Interior forest habitat plays a critical part in maintaining healthy populations for many forest-dependent animal species (Forman and Godron, 1986; Bunnell, 1995). Interior forest is any seral stage which occurs in a patch of sufficient size and shape that there is some area which is not influenced by edge effect. Along edges of strongly contrasted habitat types (i.e. old growth adjacent to stand initiation), edge effects could extend up to 400m (8 tree lengths) in the Central cascades. Thus, any patch less that 64 ha contains no interior habitat (Chen et al, 1995). Large blocks of interior habitat provide for sustainability of a larger number of species.

Within this analysis, dispersal needs are addressed for mature and old-growth (MOG) related species, since historically the predominant habitat in this landscape consisted of MOG forest. Much of the analysis is an extension of the concepts of connectivity a review and discussion by by Mellen (1997); concepts in dispersal were drawn from ideas presented by Beier and Lee (1992).

Travel dispersal corridors and the connectivity of the corridor over the landscape is critical for dispersal and genetic exchange to maintain viable populations (Harris, 1984; Lefkovitch &

Fahrig, 1985). Connectivity of habitat need not be spatially contiguous nor temporally continuous as long as through time it is arranged in such a pattern as to allow movement across the landscape. Habitat that effectively provides dispersal across the landscape is habitat that meets the basic needs for survival such as food, microclimate, and security from predators.

Corridors are often thought of as narrow linear passageways, as streams are for fish movements. There is a wide array of terrestrial wildlife and plants present in the watershed, exhibiting a wide array of dispersal abilities and habitat needs. For many of these species, dispersal corridors need to be viewed in a landscape perspective, taking into account different habitat types for different species, the size and distribution of such habitats, and dispersal abilities of species. Animals interact with the landscape at three different scales: within the home range, within a population and between populations, as referenced in Mellen 1997.

Strata Descriptions

Upper

Location and Land Allocations: This area encompasses the steep headwaters of the watershed. This stratum has the most non-matrix allocations, being dominated by late successional reserves (LSRs) and wilderness. The elevation ranges from approximately 2800 to 5800.

Geology, soils and landform: Extrusive flows of basalt and andesite, with granular soil. Alpine glaciation (U-shaped valleys and cirque basins). The mass wasting regime is characterized by relatively small and frequent shallow, rapid landslides.

Riparian Reserves, Storm Response and Channel type: 19% of this stratum is identified as riparian reserves. Most of the streams are source reaches; the remainder are transport reaches. Most of the area is high storm response, except north facing slopes which are moderate to low. Class III and IV Riparian Reserves on steep slopes are sometimes subject to stand replacing fires.

Fire Processes: The steep topography, exposed ridges and habitat types in this area resulted in fires which would be a combination of underburn and stand-replacing. North facing slopes are less likely to experience stand-replacing fires, but the plant communities are more susceptible to fire-caused mortality; south-facing slopes were more likely to incur an intense fire, but had individuals resistant to fire damage. Incised class III and class IV streams sometimes function as a "chimney" during a fire, causing higher intensity burns in these areas.

Habitat Type: This area supports the only high-elevation forest in the watershed; 15% of this stratum is covered in high elevation timber types. This strata also has the greatest number and variety of non-forested special habitats. This combination of high and low elevation species, as well as the richness of special habitats, contributes considerably to the overall biodiversity of the watershed.

Habitat Patterns: The variety of fire intensities and habitat types caused fire processes which created mosaic landscape patterns.

Middle

Location and Land allocations: Encompasses the gentler slopes from the Shady Gap and Beach Mountain area, extending southward into the Groundhog drainage. Allocations are approximately 25% LSR and other non-matrix allocations, and 75% matrix. Elevation range is from 2200 to 4200.

Geology, soils and landform: Pyroclastic bedrock (tuffs and breccias) with fine-grained soil. Earthflow. Mass wasting regime characterized by localized instability associated with slope modification, i.e. stream channels and roads.

Riparian Reserves, Storm Response and Channel Type: 23% of this stratum is identified in Riparian Reserves. Most of the streams are transport reaches, except the mainstem of Hills Creek which is classified as a response reach in the central part of the stratum. Storm response varies distinctly with aspect in this stratum with north aspect being mainly low and south aspect mainly high. Most of the low storm response that occurs within the watershed occurs in this stratum.

Fire Processes: Fires in this area tended to be lower intensity, mostly underburns. Very infrequent large-scale high mortality events, usually coinciding with unusual weather patterns, i.e. the strong wind event coinciding with the Shady Beach fire. Riparian areas are not as deeply incised, decreasing the incidence of "chimney" burns in riparian areas.

Habitat Type: Vegetation is dominated by low elevation species such as Douglas-fir and western hemlock, and there are fewer non-forested special habitats in this area than are located in the upper stratum.

Habitat Patterns: Fire patterns in this stratum created a landscape characterized by large, unbroken blocks of multi-aged forest.

Lower

Location and Land Allocations: Comprised of the steep terrain in the lower third of the watershed. Approximately 70% is in matrix; all scenic allocations are in this stratum. Elevation range is from 1,600 to 5,000; the majority of the stratum is below 4000 feet.

Geology, soils and Landform: Pyroclastic bedrock (tuffs and breccias) with fine grained soil. Dissected terrain. Mass wasting regime characterized by combination of mechanisms described for Upper and Middle strata.

Riparian Reserves, Storm Response and Channel Type: Riparian Reserves cover 17% of this stratum, the least of any of the strata. Storm response is primarily high, but with a region of low and a region of moderate in the area southeast of Hills Creek. The channel network has roughly equal portions of source and transport reaches. Most of the mainstem of Hills Creek is a response reach in this stratum. Class III and IV Riparian Reserves are subject to stand replacement fires.

Fire Response: Fire patterns strongly resemble those in the upper stratum.

Habitat Type: This stratum is dominated by low elevation plant communities. There are also a large number of special habitats present, a large proportion of them being shallow-soiled, rocky types.

Habitat Patterns: The variety of fire intensities and habitat types caused fire processes which created mosaic landscape patterns.

Table 3. Hills Creek Strata Summary

	Lower	Middle	Upper
Total Acres	12597	6589	19179
High Elevation Species Acres	0	19	5604
Low Elevation Species Acres	11573	6149	12210
Landscape pattern	Mosaic	Large Block	Mosaic
% Reserve Allocations (incl. Riparian)	23%	37%	79%
Riparian Reserves Acres*	2029	1376	3490
Roads in Riparian Reserve (in acres)	135	115	214
Private	748	0	0
Roads	758	530	1048
Special Habitats (acres)	119	50	566

Note: not all riparian reserves have been identified.

General Assumptions for Analysis

Disturbance Processes

This analysis focuses on the effects of disturbance processes through time and on the landscape characteristics of the Hills Creek watershed. Some processes, such as large storms, have not changed significantly through time. Other processes, such as fire, have been affected by human management for several decades. Additional processes, such as road building and timber harvest, have been introduced and maintained by human management for several decades.

To simplify the analysis, upland disturbance by timber harvest is assumed to be roughly equivalent to stand replacing fire disturbance in the sense that both processes kill or remove the majority of the stand, alter soil characteristics, gradually destroy root strength and alter habitat structure and function. However, it should be noted that there are some critical differences which will affect specific analyses:

- Patch size, distribution and edge abruptness plays a role in dispersal habitat connectivity and habitat functions.
- Presence and distribution of large remnant trees and snags affects habitat connectivity and species distribution of plants and animals. Current practices which leave some mature stand legacy will more resemble natural disturbance regimes than did previous harvest practices.
- A full stand of dead trees provides some level of sheltering for seedling establishment, nutrient recycling, and to some extent reduces the period of hydrologic impact by ameliorating snow accumulation and melt rates.
- Mechanical compaction reduces soil infiltration and is generally not associated with disturbance by fire. It is associated with disturbance by ground-based heavy equipment.
- Lack of wood affects the character of sediment delivered to streams by landslides. Riparian reserves will provide some material for this purpose.

ISSUES AND KEY QUESTIONS

The main purpose of this Watershed Analysis is to facilitate management activities and decisions by providing current resource information set within the context of applicable standards and guidelines. Therefore, the issues identified in this Watershed Analysis focus on areas where current or expected future condition have a direct tie with management goals and desired future condition. If the actual and desired conditions differ, the intent is to identify specific projects or management activities which might bring current and predicted conditions closer to desired conditions.

Issue: Aquatic Condition

The Forest Plan provides us with objectives and directives for aquatic ecosystem management. Recent research has provided increased understanding of linkages between upland, riparian and in-channel ecosystem components including cumulative effects.

Key Questions

Are the present aquatic conditions and trends meeting the Forest Plan objectives and directives?

AQ1: Is the development of upland vegetation condition likely to facilitate desired trends in peak flow disturbance patterns?

AQ2: Is the projected mass wasting frequency likely to lead to desired trends in sediment input and habitat condition?

AQ3: Are roads interacting with upland disturbance processes to affect stream channel conditions through input of sediment and water?

AQ4: Are riparian vegetation conditions and trends meeting desired stream temperatures, sediment and availability of large wood?

AQ5: Are current conditions and trends in stream temperatures, sediment and large wood meeting desired fish habitat?

AQ6: Are artificial barriers or culverts affecting connectivity of fish habitat?

Issue: Vegetation Pattern and Condition

The Forest Plan provides us with objectives and directives for ecosystem management, with emphasis on the context and relations within and between landscapes such as 5th field watersheds.

Key Questions

How do the present vegetation patterns, conditions and trends meet management objectives and directions?

VE1: Given the historic disturbance regimes and current condition, what landscape patterns such as patch size, seral stage distribution, and habitat community types could be projected with current management direction?

VE2: How do those projected patterns affect ecological functions such as LWD, species distribution and dispersal within this 5th field watershed?

VE3: Are road locations and densities meeting management objectives for elk emphasis areas, special habitats and noxious weed management?

Issue: Timber Harvest

The Organic Administrative Act of 1897 and the National Forest Management Act of 1976 set the basis for Timber Management on National Forest Service lands. The Forest Plan designates that allocations for programmed harvest are expected to contribute to the Forest's timber yield while being compatible with other resource needs.

Key Question

TH1 What opportunities are there in the Hills Creek watershed to manage timber harvest in accordance with aquatic and terrestrial objectives?

REFERENCE, CURRENT AND TREND

Key Question AQ1: Is the trajectory of upland vegetation condition likely to facilitate desired trends in peak flow disturbance patterns?

Trajectory of Upland Vegetation Condition

The percentage of total area in young forest is the most relevant factor for hydrologic processes. "Young forest" is defined in this analysis as combined stand initiation (SI) and early stem exclusion (ESE) size classes. Research indicates runoff from stands of these sizes can be increased, though to varying degrees (citation). This variation in hydrologic effect within size classes is not accounted for due to limitations of the historic data. Thus the "young forest" condition encompasses degrees of effect from minimum to maximum but allows direct comparison over time. Table 4 below compares the area of young forest over time by strata.

Table 4. Young Forest Over Time

	Upper		Middle		Lower		Total	
Time Period	*acres*	*%*	*acres*	*%*	*acres*	*%*	*acres*	*%*
1850's	2052	11.0	41	.6	889	7	2983	8.0
1900's	466	2.4	150	2.3	1347	11	1962	5.1
1997	6604	34.0	3605	55.0	6573	52	15538	40.0
2040	1000 - 3000	5 - 15	?	15 - 45?	?	15 - 45?	< 1997	< 1997

The change in upland vegetation from reference conditions to current has been an increase in the area of young forest. In the upper strata, young forest was approximately 2.4 to 11 percent historically compared to 34 percent in 1997. The lower strata ranges from 7 to 11 percent compared to 52 percent in 1997. The change is greatest in the middle strata which ranged from .6 to 2.3 percent historically and is currently 55 percent young forest. If increased runoff is occurring due to the change in vegetation conditions, the increase may be greatest on the south facing slopes of this strata in the high storm response zone.

The trajectory of upland vegetation condition into the future will be determined by a combination of natural and management disturbance mechanisms that produce young stands. The main factors that affect the trajectory include:

- the stability of the land allocations through time
- average rotation in harvest allocations
- trends in road construction or obliteration
- fire management (suppression / prescribed burning) activities
- weather patterns affecting fire severity

In general, the large reserve allocation in the upper strata (see Table 1) will tend to exert a moderating influence over time on the percentage of the entire watershed in young forest condition. Even if the current 1000 road acres remain, a catastrophic fire burns 1500 acres in the reserve, and 500 acres of harvest occurs in the harvest allocations, the resulting 3000 acres in young forest will be less than half the current total. With substantial road obliteration and fires similar to those of the past, the percentage of young forest in the upper strata could be much lower.

Trajectories of the lower and middle strata are more difficult to determine. The pattern of land management allocations concentrates future harvest-related disturbance in these strata. In general the trend is probably for the future percentage of young forest to be higher than in the past, especially in the middle strata, but lower than the current percentage.

Peak Flow Disturbance Patterns

Streamflow was measured near the watershed outlet by the USGS from 1958 - 1980. The period of record was extended back to 1936 by correlation with a downstream gage on the Middle Fork Willamette above Salt Creek prior to filling the reservoir. The record was extended forward to 1993 by correlation with the Middle Fork gage above Hills Creek reservoir. See the appendix for regression equation statistics. The combined data are presented below as a time series of annual maximum peaks.

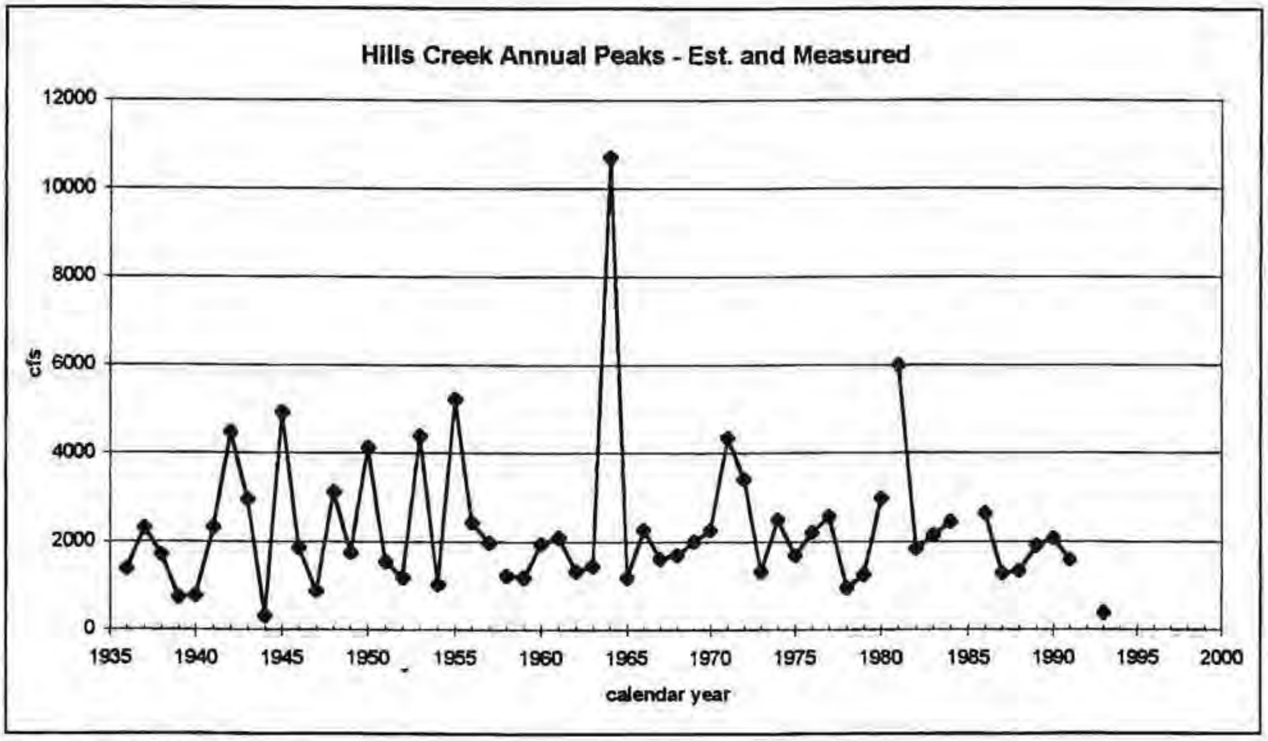


Figure 6. Peak Flow

The chart displays a 60 year flood history of Hills Creek which is useful for general information purposes. It does not exhibit a significant trend over time, due to the high year to year variability of peak flows which is often a factor of 2 to 5 in Hills Creek. An average increase over time due to a change in vegetative conditions would have to be greater than the "storm-caused" yearly variability to be detectable with this approach. This is unlikely to be the case. The fact that most of the data consists of estimates rather that measurements further reduces the chance of detecting a meaningful trend. An analysis which controlled for storm-related variability by comparing stream discharge for storms of the same precipitation intensity might be possible but is beyond the scope of this project.

Key Question AQ2: Is the projected mass wasting frequency likely to lead to desired trends in sediment input and habitat condition?

Management direction, research background, and conceptual model for AQ2 can be found in the appendix along with complete landslide inventory results.

Forest Mass Wasting Inventory

Landslides were inventoried on six sets of airphotos spanning a time period from 1940 - 1990. The land-use associated with the slide origin was assigned as Forest (F), Road (R), or Managed Clear-Cut (MCC). The number of slides divided by the area of each land-use divided by the period of record was then computed as the mass wasting frequency in terms of number per 1000 acres per decade for each land-use. For example, 20 slides in a 3000 acre area over 5 decades would produce a computed frequency of 1.33, (20 / 3 / 5 = 1.33). The different frequencies were then applied to the proportion of the watershed in each land-use (by strata) to obtain an overall mass wasting rate.

Mass wasting from roads is excluded from consideration since it is specifically addressed in the next question. The area occupied by roads is excluded from the total forested area in computing the mass wasting rate. Since the question above is focused on sediment input to streams, only those landslides with stream delivery were considered (Figure 7). These represented 37 out of 49 forest landslides or 76% of the total number.

To allow comparison with historic data, the land-use category of Managed Clear-Cut (MCC) is interpreted as equivalent to Young Forest condition created by natural disturbance. "Young forest" is defined in this analysis as combined stand initiation (SI) and early stem exclusion (ESE) size classes. An assumption is made that the timespan represented in the photo record contains sufficient climatic variability to yield an accurate average frequency for each land-use. Thus the factor controlling changes in the mass wasting rate over time is the area of each land-use.

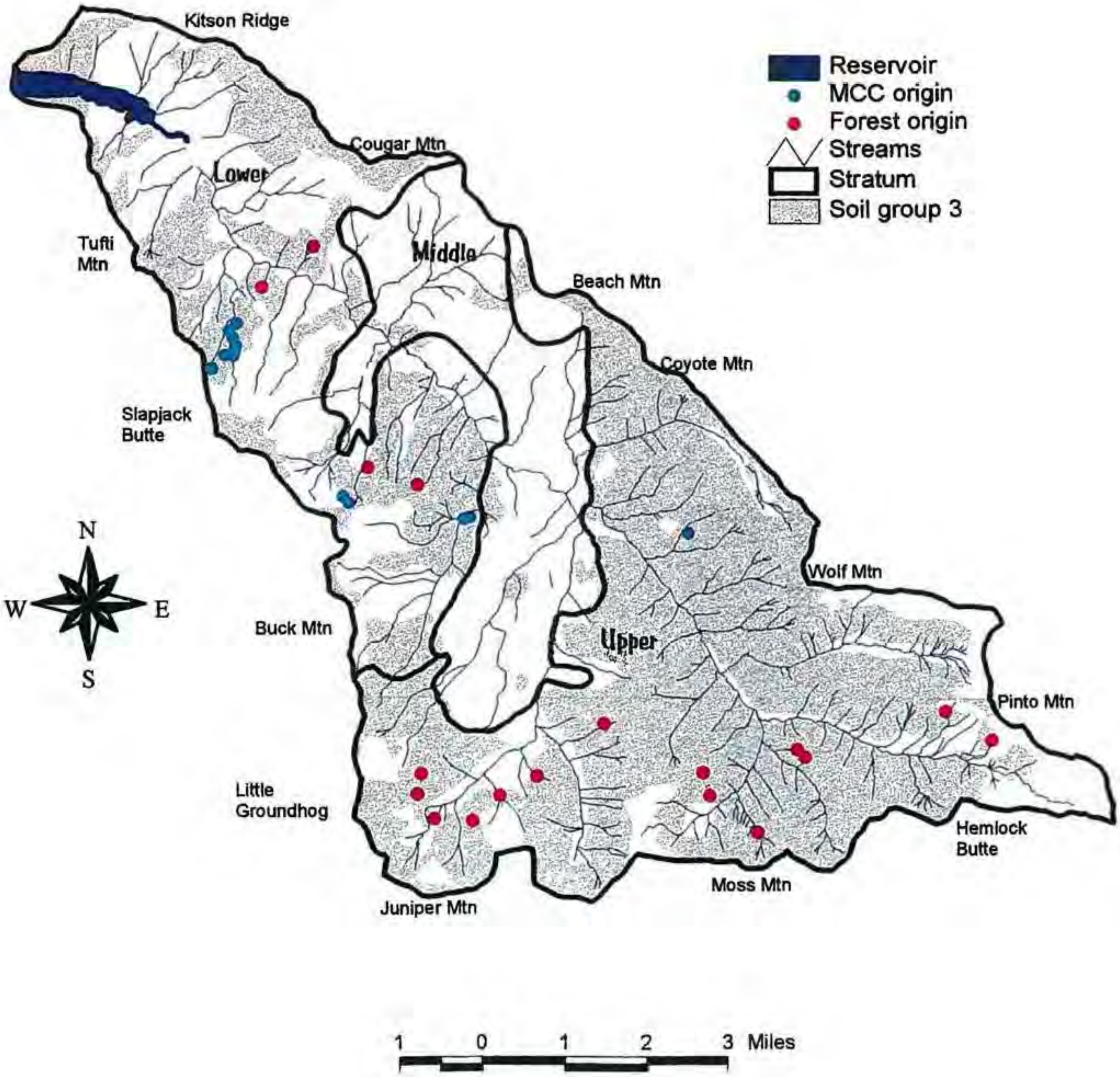
The inventory results revealed the majority (31 of 37 or 84%) of forest landslides with stream delivery occurred in steep terrain with shallow rocky soils. For this reason, the analysis of trends in mass wasting frequency and sediment input is limited to this landtype. This landtype is rare in the middle stratum and no slides were recorded from it over the period of record. Therefore, the middle stratum is not included in this part of the mass wasting analysis .

The map displays the location of forest slides with stream delivery observed on aerial photos.

Forest Slides with Stream Delivery 1946-1990

Hills Creek

FIGURE 7



Computed Frequency

Table 5 below presents the computed mass wasting frequencies.

Table 5. Current Mass Wasting Frequency

	Number of Forest Slides with Stream Delivery from High Risk Landtype					
	Lower		**Upper**		**WA total**	
Young	12		1		13	
Mature	4		14		18	
	Current Forested Area of High Risk Landtype					
	acres	**%**	**acres**	**%**	**acres**	**%**
Young	2516	47	3962	28	6679	34
Mature	2820	53	10079	72	13174	66
	Slide Frequency from High Risk Landtype (number per 1000 acres per decade)					
Young	1.192		0.063		0.487	
Mature	0.355		0.347		0.361	
	Current Proportional Landslide Rate from High Risk Landtype					
Young	.56		.02		.17	
Mature	.19		.25		.24	
Overall (Sum)	**.75**		**.27**		**.41**	

Results

The highest forest slide rate (.75) occurs in the lower stratum. Slides from young stands which occupy slightly less than half the forested area (47%), contribute approximately two thirds of this overall rate (.56 of the .75 total). In the upper stratum, slides from mature stands comprise over 90% of the overall calculated rate (.25 of the .27 total). The rate for the watershed as a whole reflects the rates of combined strata.

It is possible that the slide frequency from young stands is actually lower than from mature stands in the upper part of the watershed. It is also likely that the slide frequency for young stands in the upper stratum is artificially low due primarily to the sample size of 1 used in the calculation. Since little of the upper stratum had been harvested prior to the 1964 storm, the area of young forest in that stratum has not been subject to the full range of climatic variability, thus the calculated frequency is probably below the true average. Results of the inventory of slides from the 1996 storms should clarify this question.

Despite data limitations, the large difference between the upper and lower strata in calculated landslide rates from *young* forest suggests there may be important differences between these strata in response to disturbance. Specifically the importance of root strength in holding the soil on slopes may be greater in the lower part of the watershed. The frequency calculated for mature forest is very similar in both strata suggesting it is reasonably accurate.

Trends in Mass Wasting Rate

The trajectory is developed by comparing the combined landslide rate with stream delivery from young and mature forest stands for both current and historic conditions, and to the extent possible, for future conditions. The area of young and mature forest on high risk landtypes is multiplied by the corresponding slide frequency developed from the 50 year photo inventory to produce a comparable rate in terms of number per 1000 acres per decade. For example, 20 slides in a 3000 acre area over 5 decades would produce a computed frequency of 1.33, (20 / 3 / 5 = 1.33). The two large fire episodes of the 1850's and the early1900's provide an estimate of the historic area of young forest on high risk landtypes. Table 6 below presents estimated historic mass wasting rates.

Table 6. Estimated Historic Mass Wasting Frequency

	Historic Area in High Risk Landtype (fires of 1850's and 1900's)											
	Lower				**Upper**				**WA Total**			
	acres		**%**		**acres**		**%**		**acres**		**%**	
	1850	**1900**	**1850**	**1900**	**1850**	**1900**	**1850**	**1900**	**1850**	**1900**	**1850**	**1900**
Young	320	329	6		1553	351	11	2.5	1874	680	9	3
Mature	5016	5007	94		12488	13690	88	97.5	17979	19173	91	97
	Slide Frequency from High Risk Landtype (number per 1000 acres per decade)											
Young	1.192				.063				.487			
Mature	.355				.347				.361			
	Historic Proportional Landslide Rate											
	1850		**1900**		**1850**		**1900**		**1850**		**1900**	
Young	.07				.01		.00		.04		.01	
Mature	.33				.31		.34		.33		.35	
Overall	**.41**				**.32**		**.34**		**.37**		**.36**	

Results

Comparing the numbers in tables 5 and 6 indicates the greatest increase in overall landslide rate from historic to current conditions occurs in the lower stratum. The rate in the lower stratum has nearly doubled from .41 to .75. In the upper stratum the rate appears to have decreased by approximately 20% from about .33 to .27 compared to historic conditions. While this may be the case, it is likely due to the underestimated slide frequency from young forest in the upper stratum (see discussion above under Mass Wasting Frequency). Combining the large rate increase in the lower stratum with the apparent small decrease in the upper stratum yields a slight increase from about .36 to .41 (approximately 14%) in the mass wasting rate of the watershed as a whole. Again, this figure probably underestimates the true difference in rates between historic and current conditions.

If the present land management allocations remain intact, the increased rate observed in the lower stratum will likely persist in the future. The rate in the upper stratum will return to approximately the historic rate within about 30 years.

Key Question AQ3: Are roads interacting with upland disturbance processes to affect stream channel conditions through input of sediment and water?

Management direction and conceptual framework for this question can be found in the appendix along with complete inventory results.

Road Related Mass Wasting Inventory

A landslide frequency was computed for roads from the photo-based landslide inventory used in key question AQ2 above. Since the question above is focused on sediment input to streams, only road-initiated landslides with stream delivery were considered (Figure 8). These represented 32 out of 40 slides or 80% of the total number. Inventory results revealed a majority (21 of 32 or 66%) of road-initiated slides with stream delivery occurred in steep terrain with shallow rocky soils. The analysis of trends in road-related mass wasting is limited to this landtype. This landtype is rare in the middle stratum and no slides were recorded from it over the period of record. Therefore, the middle stratum is not included in this part of the mass wasting analysis .

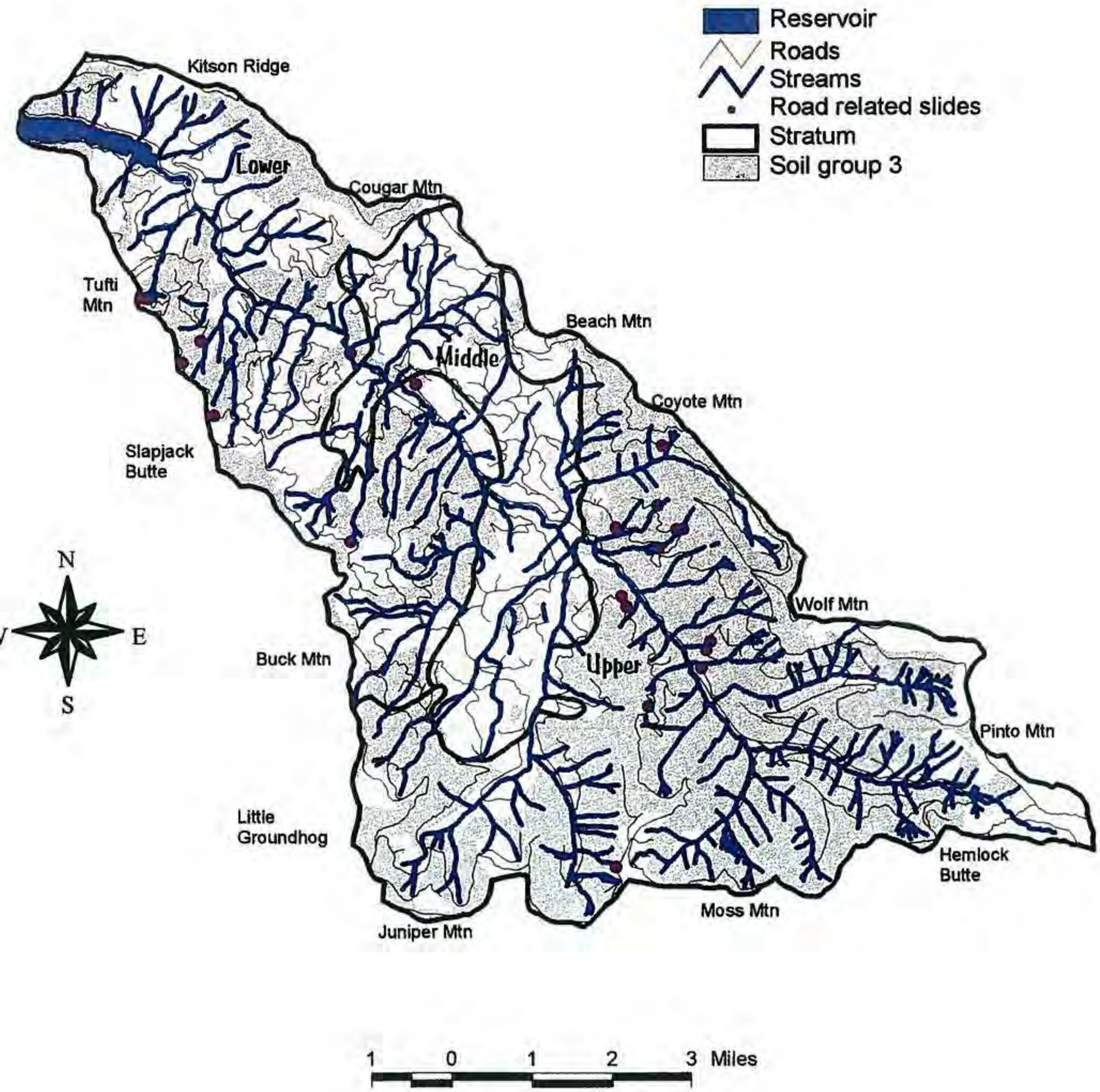
The recent slides which occurred in February and November of 1996 are not included in the analysis because their origin has not yet been determined.

The map displays the location of road-related slides with stream delivery observed on aerial photos.

Road-Related Slides with Stream Delivery 1946-1990

Hills Creek

FIGURE 8



As in question AQ2 above, the number of slides divided by the roaded area divided by the period of record was computed as the mass wasting frequency in terms of number per 1000 acres per decade. For example, 20 slides in a 3000 acre area over 5 decades would produce a computed frequency of 1.33, (20 / 3 / 5 = 1.33). This frequency is then applied to the proportion of the watershed that is roaded and combined with the remaining proportions in young and mature forested conditions to produce an overall landslide rate (by strata). The resulting rate is then compared to the rate without roads under both current and historic conditions to specifically address road-related effects. Table 7 below presents the mass wasting results.

Table 7. Mass Wasting Rate with Roads

	Number of Road-Initiated Slides with Stream Delivery from High Risk Landtype					
	Lower		Upper		WA total	
	8		13		21	
	Current Area in High Risk Landtype					
	acres	%	acres	%	acres	%
Roads	322	6	944	6	1311	6
Young Forest	2516	44	3962	26	6679	32
Mature Forest	2820	50	10079	67	13174	62
	Slide Frequency from High Risk Landtype (number per 1000 acres per decade)					
Roads	6.21		3.44		4.01	
Young Forest	1.19		0.06		0.49	
Mature Forest	0.36		0.35		0.36	
	Current Proportional Landslide Rate with Roads					
Road	0.35		0.22		0.25	
Young Forest	0.53		0.02		0.15	
Mature Forest	0.18		0.23		0.22	
Overall (sum)	**1.06**		**0.47**		**0.63**	
	Current Proportional Landslide Rate without Roads					
Overall (sum)	**0.75**		**0.27**		**0.41**	
	Historic Proportional Landslide Rate without Roads					
	1850	1900	1850	1900	1850	1900
Overall (sum)	**0.41**		**0.32**	**.034**	**0.37**	**0.36**

Results

In the lower stratum, roads contribute approximately one third to the total current landslide rate (.35 of the 1.06) but occupy only six percent of the land area. The current overall slide rate including roads is more than double the rate compared to historic conditions without roads (1.06 compared to .41). Roads alone increase the current overall slide rate by about one third (1.06 compared to.75).

In the upper stratum, roads contribute nearly one half the total current landslide rate yet occupy six percent of the land area (.22 out of .47), and the current overall rate is increased by about one third compared to the estimated historic rate without roads (.47 compared to .33). Roads alone increase the current overall slide rate by about 75 percent (.47 compared to .27). The proportional increase due to roads alone is probably overestimated in this stratum due to the likelihood that the computed young forest slide rate is below the true value.

In the watershed as a whole, roads increase the current overall slide rate by about 50% (.63 compared to .41). Many roadfill failures occurred from older roads constructed with sidecast methods. Given declining road maintenance, a high rate of road-initiated slides, especially from drainage failures, is expected to continue.

Fine Sediment from Roads

Sources of fine sediment associated with roads include, cutbanks, ditches, and gullies below relief culverts as well as the road surface itself. No measurements of this type of sediment input are available for this watershed. The most likely area of concern would be the middle and lower strata where soils are fine grained. A planned survey of North and South Groundhog Creeks should provide some information on this question.

Water Input From Roads

Road may increase water delivery to streams by extending the surface drainage network via ditches and gullies below culverts. The road density in the watershed as a whole is 3.8 miles per square mile and the stream density is 3.1 miles per square mile. Research indicates approximately one half of the total road network may be directly connected to streams thus increasing the effective drainage density to approximately 5 miles per square mile. The effects of this potential increase of water delivery to channels have not been measured.

Key Question AQ4: Are riparian vegetation conditions and trends meeting desired stream temperatures, sediment, and availability of large wood for fish habitat?

Native cutthroat and hatchery rainbow are the primary fish species found in the Hills Creek watershed. Historically the watershed supported a limited number of Spring Chinook and Bull Trout. The habitat needs of resident trout are the focus of the analysis for this question.

Trends in Riparian Seral Stage

Selected data on riparian vegetation is excerpted from a table presented in the Terrestrial section of the document (page 43). For purposes of answering this question, the comparison focuses on the trends in the smallest (SI plus ESE) and largest (MOG) seral classes only.

Percent of Riparian Reserve Area in Selected Seral Classes								
	Upper		Middle		Lower		Watershed	
	Historic	Current	Historic	Current	Historic	Current	Historic	Current
SI + ESE	1.0	37	0.0	46	2.8	49	1.3	39
ROADS	0	7	0	8	0	6	0	6
MOG	90.6	53	98.7	26	88.2	35	91.4	38

The data indicates riparian vegetation conditions have changed considerably in each stratum. The greatest relative change in terms of seral class has occurred in the middle stratum. In each stratum, the percentage of the riparian reserve occupied by roads alone (equivalent to an early seral stage) is much greater than the historic percentage in an early seral stage as a result of natural disturbance.

Airphoto Analysis and Records of Riparian Salvage Logging

Additional information about trends in riparian vegetation conditions is provided by a time series of airphotos from 1944 to 1994 and district records of riparian salvage logging. The photos were examined for evidence of changes in riparian conditions caused by both natural and management disturbance. Flow records and salvage logging records provide additional insights into the type of disturbances that occurred between photo sets.

The analysis focuses on the riparian area of the mainstem of Hills Creek and the lower reaches of the main tributaries since these areas are the most important for fisheries. Table 8 presents a summary of the main observations by selected photo periods.

Table 8. Photo Interpreted Riparian Disturbance History

Period	Disturbance	Riparian Conditions
to 1946	2 floods. One ~ 10 yr. event in 1942. One ~ 15-20 yr. event in 1945. Road extends to Gate Cr. only.	Vegetation primarily large conifer, mixed with deciduous in less confined reaches. Hills Cr. surface partly visible with LWD in mostly single thread channel. A few sediment deposits visible near tribs and one large bank slide near Mike Cr.
to 1959	3 floods, all ~ 10-20 yr. events - 1950, 1953, 1955. Road 23 widened and extended to Wolf Cr. with 3 Hills Cr. crossings. Harvest units on Mike, Landes, and NF Groundhog Creeks. Obvious instream and riparian salvage along Hills Cr.	Patchy riparian vegetation removed around bridges and between rd. 23 and Hills Cr. up to Groundhog. Hills Cr. surface nearly continuously exposed, braided in sections, and large sediment deposits visible along banks to Groundhog. Patchy surface and sediment visibility to Pinto. Much LWD in Hills above Juniper Cr. Extensive bank erosion in units along Mike and NF Gndhog Creeks.
to 1967	1 flood ~ 100 yr. event in 1964. Removal of 11 log jams between Juniper and Wolf Creeks. Harvest units on Juniper Cr. and SF Groundhog. Multiple slides into Hills Cr. above Juniper.	Thinning of conifer along Hills below Gate and riparian removal (by flood or salvage) between Mike and Juniper. Extensive riparian destruction from Juniper to Pinto. Continuously visible water surface even above Pinto. Visible sediment along banks and channel braiding in sections to Juniper Cr. Single channel and no LWD from Juniper to Wolf (removed) but much LWD above. Much bank erosion from Mike, NF and SF Groundhog and Juniper Cr. units.
to 1974	1 flood ~ 10 yr. event in1971. Hills Cr. channel moved away from road and straightened near mp. 5 on rd. 23. Tractor logging and cleanout of Hills Cr. from Juniper to TNT Cr. Harvest units on Burro, Andy, Pinto & unnamed trib between Tumbledown and Pool Creeks.	Continued conifer removal along Hills Cr. below Mike Cr. Deciduous growth evident but channel surface remains visible throughout. Braiding, riparian removal and large sediment deposits persist between Mike and Groundhog Creeks. LWD present above Wolf. Bank erosion evident from old and new units on all tribs.
to 1981	No significant floods. Timber sale along both sides of rd. 23 to edge of Hills Cr. 14 new harvest units on slopes below Gate Cr. Bridge across Hills Cr. near Tufti Cr.	Evidence of continued conifer removal along Hills Cr. below Gate Cr. Deciduous growth continues along entire channel margins. Water surface is mostly visible and channel form is mostly single. Bank erosion from units on tribs is less visible as deciduous vegetation grows..

to 1986	1 flood ~ 25 year event in 1981. Three slides into Hills Cr. and salvage of resulting LWD from Burro to Tumbledown	Stripping of deciduous vegetation by floodwaters along Hills Cr. to Tumbledown. Water surface and some sediment deposits visible. No LWD. Renewed bank erosion in old Groundhog units.
to 1994	No significant floods. No new harvest units near creeks. LWD added to Hills Cr. below Juniper for habitat improvement.	Regrowth of deciduous veg along entire Hills Cr. Mostly visible single channel. LWD increased. Visible bank erosion in Groundhog, Burro, TNT, and Tumbledown units.

Effects on Stream Temperatures

Data of summer maximum stream temperatures is available for the mainstem of Hills Creek at the site of a USGS gauging station near the mouth. The period of record is from 1959 to 1997 with some gaps. The data is presented in Figure 9 below in reference to the current Oregon DEQ threshold of 64 degrees F for the seven day rolling average of the daily maximum temperature.

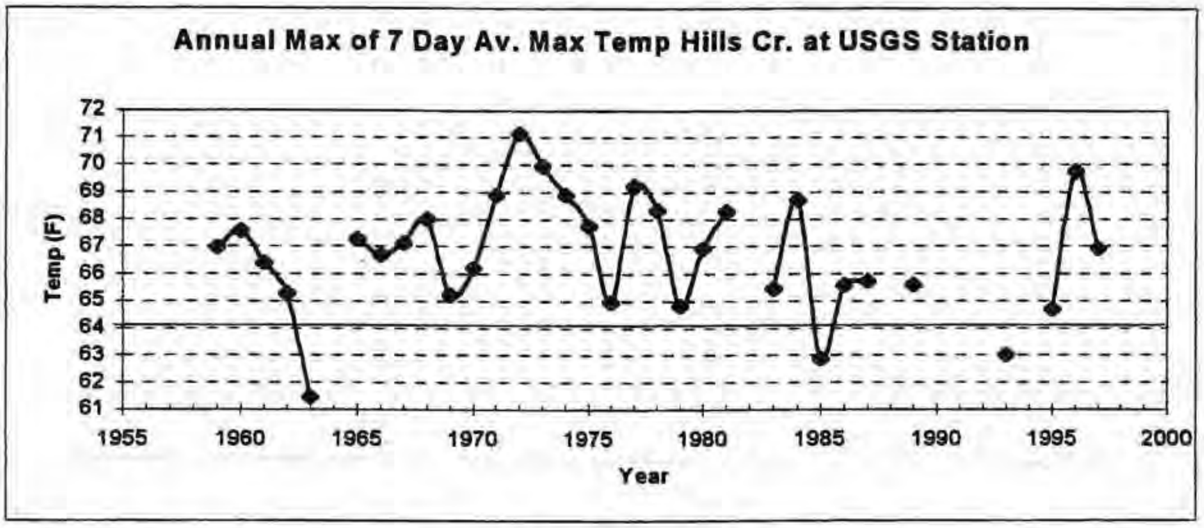


Figure 9. Stream Temperature in Hills Creek Mainstem

Stream temperatures in the mainstem of Hills Creek near the mouth have exceeded the state standard in most of the past 38 years. Note that the period of record begins after the extensive riparian changes discussed in the previous section. The only data available before this period is a single grab sample from 9/11/37 at 2:00 PM. With an air temperature of 76 degrees F, the water temperature at approximately the same location in Hills Creek as the data above was recorded at 57 degrees F. Subtracting max water temperature from max air temperature for the period of record charted above and comparing the resulting difference to the 19 degree difference between air and water temperature in 1937 would perhaps provide more insight, but is beyond the scope of this analysis.

Data collected from various tributaries over the years is presented in Table 9 below.

Table 9. Max Recorded Stream Temperatures in Tributaries and Upper Mainstem

Year	Hills near Juniper	Gate Mouth	Juniper Mouth	Mike	NF Gndhog	Pinto	SF Gndhog	Tufti Mouth	Warfield Mouth	Wolf Mouth
1977				74						
1978				70						
1979				70						
1981									63	
1982						60				
1989				68						
1990	67	64	62	66				69		
1992	66					63				
1993										58
1995			56		58	57	58	66	58	
1996	64				57	60	60			61
1997	65	62		73	54		60			

It appears warm temperatures in the mainstem of Hills Creek extend as far upstream as Juniper Creek. At least two tributaries, Mike and Tufti appear to be contributing to the high temperatures. Both of these tributaries are in the Shady Beach Fire area. Elevated stream temperatures appear to be persisting ten years after the fire. The other tributaries listed are within state standards and are likely having a moderating effect on mainstem temperatures.

The overall habitat quality in the lower half of Hills Creek is probably diminished by the current temperatures. Tributaries that could provide thermal refuge are all in the upper half of the creek (in the middle and upper strata). Unfortunately, the lower half is the most popular stretch for fishing and has some of the best habitat potential. The only two response reaches on the mainstem are in the lower half and previous restoration efforts have focused on these reaches.

Of the two main factors contributing to the warm temperatures, tributary input would seem to have a shorter recovery trajectory. Given the riparian trends discussed in the previous section, mainstem surface exposure and thus direct heating will likely persist considerably longer.

Effects on Sediment

The main sediment related processes addressed in this question are those affected by riparian vegetation: sediment input from bank erosion and bedload sediment transport and storage. Photo interpretation provides ample evidence of accelerated bank erosion from tributaries and portions of the mainstem after riparian removal. Increased sediment supply has resulted in episodes of bar growth in the main channel. Recent habitat surveys indicate accumulation per se of fine or coarse sediment is not a major concern in Hills Creek primarily due to its basic morphologic characteristics.

However, removal of the LWD structural elements, especially from response reaches, has probably reduced long term sediment storage and increased sediment transport which may be more of a concern. There is some anecdotal evidence that the dominant substrate size in these reaches has shifted from gravel to cobble or larger over the past several decades. The effects on fish habitat are primarily reduced spawning quality, both in terms of the availability of appropriate size material and the likelihood of redd scour in unprotected gravel deposits. The planned addition of LWD could help mitigate this effect.

Effects on the Availability of Large Wood

Riparian conditions along most of the mainstem currently are not meeting objectives for availability of large wood. This is also the case on the two tributaries surveyed to date, Pinto and Wolf (see Appendix for data summary). In addition to the sediment storage functions discussed above, the other important habitat functions of large wood in Hills Creek are for cover and macroinvertebrate substrate. These habitat qualities are currently diminished. Monitoring of recent additions of LWD showed increased numbers of juvenile and adult fish associated with the structures. The project was destroyed in the 1996 floods but is planned for replacement.

Key Question AQ5: Are artificial barriers or culverts affecting connectivity of fish habitat?

Results

Currently there are five known impassable culverts at the mouths of tributaries to Hills Creek. These occur at Shady, Crabapple, Landes, Warfield, and South Fork Groundhog Creeks.

Although listed as fish bearing, no fish were sighted in Shady, Crabapple, or Landes Creeks in 1997 biological surveys. These creeks have natural bedrock barriers at their mouths so the culverts alone are not disrupting connectivity.

Warfield and South Fork Groundhog are important fish bearing tributaries. Connectivity to a total of approximately 6 miles of additional habitat, roughly one third of the total available tributary habitat, is currently affected by impassable culverts.

Key Question VE1: Given the historic disturbance regimes and current conditions, what landscape patterns could be projected with current management direction?

Seral Stage Distribution

This watershed covers a range of elevations and site conditions. Due to variations in site conditions and varying growth rates between stands, stand age does not correlate evenly to tree size across the watershed. Therefore, tree size rather than stand age has been used in this analysis. Stands were classified as stand initiation (SI), stem exclusion (SE), understory reinitiation (UR), and mature/old growth (MOG) based on average stem size within the stand. For the issues identified in this analysis, mature and old growth stands function similarly (Harris, 1984) and are therefore lumped into a single category (MOG). The four categories used in this analysis are fully described below:

Reference

Reference conditions were established using the Lane County Forest Type mapping of 1949, and provides approximately 100 years of fire history between the mid-1800's and mid-1900's. According to the mapping, mature and old growth forests were the dominate habitat, covering approximately 84% of the landscape (Figure 10, Figure 11, Table 10).

- Fire caused 5%-15% of the watershed to be in young seral stages (SI and ESE) at any given time.
- Compared with the upper and lower strata, the middle stratum had the greatest proportion of old growth (96%).

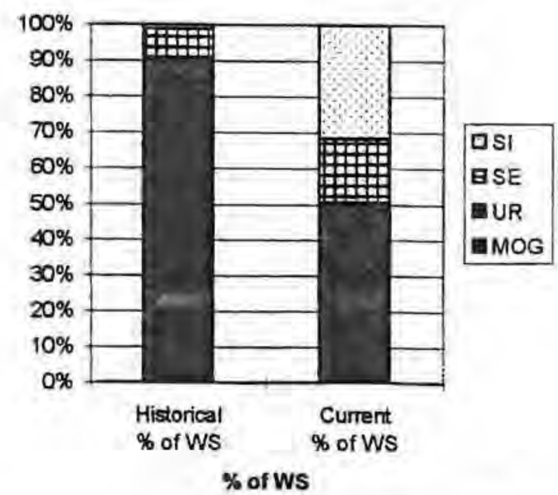


Figure 10. Reference and Current Distribution of Seral Stages

Table 10. Reference and Current Distribution of Seral Stages

Seral Stage	Reference % of WS	Current % of WS
Stand Initiation	1	30
Stem Exclusion	8	15
Understory Reinitiation	6	17
Mature/Old Growth	84	26
Special Habitats	2	2
Unknown	--	5

Current and Trend

Current conditions were established using Rigdon Ranger District's current vegetation layer. Only vegetated habitats were considered, so road matrix and water was excluded. The greatest change from historical condition has been the conversion of some MOG stands to SI and SE (Table 10 and Figure 10).

- MOG habitat in the middle stratum has decreased from 96% to 19%, and is the lowest proportion of MOG habitat in the watershed.

Non-matrix Allocations

- Approximately 7,750 acres in non-matrix allocations are MOG (20% of the watershed).
- There are 7,675 acres of stem exclusion and stem initiation stands in non-matrix allocations (37% of non-harvest allocations).
- SI and SE stands will mature into LSE and UR while fires will convert some areas to young stands.

Matrix Allocations

Discussed in 'Quantity of Size Classes', pages 64-65.

Fire and Landscape Patterns

Although a number of ecological processes interact to determine landscape patterns within the watershed, fire has historically been dominant in shaping vegetation patterns and habitat structure. Since these items are intrinsically linked, they are discussed together here.

Reference

A diversity of fire behavior, landform and habitat type (described in Characterization, pages 10, 15 and 16) is reflected in the historical fire regime which contributed to the landscape patterns described in Table 10. The upper and lower stratum are very similar in these patterns, so are discussed together. In the middle stratum, there are some notable differences between north-facing and south-facing slopes, so these are discussed separately.

The historical data for this watershed is based on the Lane County Forest Type mapping of 1949 which was largely an interpretation of aerial photos. This is a somewhat course-scale analysis and limits conclusions which may be drawn, both spatially and temporally.

- The data does not include information on smaller gaps. Canopy gaps less than approximately 10-15 acres are not recorded. In addition, canopy gaps less than 1 acre in size are often not visible. Thus, information about historic wind-throw, insect and disease damage is not available.
- Fire data reflects only stand-replacing events.
- The historic data is a "snap-shot" in time, able to provide information for roughly a 100 to 150 year period. Therefore, some information on fire return interval is based on information applicable to a broader land base than just the watershed.

Table 11. Reference vegetation conditions by fragmentation and connectivity pattern

Stratum	Fire Regime	Resulting Habitat Characteristics
Middle	<u>North of Hills Creek</u>: *Severity*: Mostly low to moderate, burning downed fuels and understory trees. Typical fires killed some fire-susceptible overstory trees and produced small patches (<150 acres) of total mortality. However, occasional catastrophic, stand-replacing events occurred when fire events corresponded with unusual strong east-wind events as in the Shady Beach fire. *Size*: Underburns covered large areas (1,000+ acres); stand-replacing burns were typically small and infrequent, < 100 acres except for large-scale events in which full mortality could be well in excess of 1,000 acres. *Frequency*: Underburns occurred frequently, with a fire return interval less than 100 years. Catastrophic events were very infrequent, occurring on a temporal scale beyond the scope of the data for this analysis.	*Stand Characteristics*: Typically, this area maintained an open forest habitat, with an overstory of large-diameter tree; Douglas-fir was often dominant. Between fire occurrences, multi-level canopies of mixed conifer and hardwood species developed. *Fragmentation pattern*: There was low natural levels of fragmentation; this stratum typically functioned as almost a single large block of interior forest.
	<u>South of Hills Creek</u> The fire regime was similar to the north half of the stratum, but due to higher moisture levels, there are subtle differences leading to a corresponding difference in stand conditions. *Severity*: Fires were often lower severity, so less down wood was consumed *Frequency*: The fire return interval was longer, allowing more understory species to become established.	*Stand Characteristics*: There was a higher percentage of multi-layer canopy structure and higher concentration of large woody debris (LWD) in all decay classes.

Table 11 Reference vegetation conditions by fragmentation and connectivity pattern (continued)

Stratum	Fire Regime	Resulting Habitat Characteristics
Upper and Lower	*Severity:* Moderate to high. Fires were typically large and mosaic; numerous patches of stand-replacing burns with intervening underburn. *Size:* Stand-replacing burns were relatively frequent, but typically 50-150 acres. Occasional large stand-replacing fires occurred ranging in size from 500 to 1000 acres or occasionally more.	*Stand Characteristics*: Stands in these strata typically initiated as even-aged stands resulting from stand-replacing fires, and became structurally diverse at about age 150. *Fragmentation pattern:* The landscape pattern was a mosaic of young and old stands, with the majority of stands of mature and old growth characteristics. Most early-seral stands were 50-150 acres, with occasional large-scale burns (Table 2).

Current Condition

Differences between reference conditions and current conditions are linked to changes in the disturbance regime during the 20th century described in the characterization chapter, page 10. These changes were largely a shift from natural fire events to anthropogenic events and have contributed to current conditions which differ from reference conditions in the following ways:

Fire

Fire suppression has resulted in increased fuel loading across the landscape, a condition once associated with protected refugia such as gently sloped canyon bottoms, some north slopes and small pockets enclosed by cool, most forest types (Agee, 1993). This widespread increase in fuels has increased the risk of high intensity fires. The watershed is now approximately evenly split between fuel model 8 predicting low flame lengths with occasional flare-ups, and fuel model 10 which predicts a greater fire intensity with more frequent, larger flare-ups. Many fuel model 8 locations are rapidly transitioning to fuel model 10.

- Fuel loading and ladder fuels have changed most the south-aspect upslope areas of the middle stratum which were not burned in the Shady Beach fire. In these areas, fuel models 8 and greater are well above historical levels.
- Although fuel management has kept fuel loading of dead and down materials lighter within managed stands, the dense, small-diameter stands provide contiguous ladder and canopy fuels, and are highly susceptible to wind-driven stand-replacing burns, particularly in steep topography. This effect was readily evident during both the Shady Beach and South Zone fires.
- Dense young stands in steep class III and IV streams may amplify the frequency and magnitude of the 'chimney' effect.

Stand Characteristics

Current stand characteristics in mature stands have changed from historical conditions largely due to the exclusion of fire. Characteristics in young stands are different from historical conditions largely due to differences in disturbance mechanism; most young stands in the landscape today are due to harvest activities followed by silvicultural reforestation.

The exclusion of fire has most altered stand characteristics in the open forests of the middle stratum north of Hills Creek. The understories are uncharacteristically dense as fire-intolerant and shade-tolerant species have increased, both in number and in size. In addition, the quantity of dead and down material has also increased.

Timber management activities have varied over the decades, and there are a number of effects:

- There was a period when reforestation and stand improvement practices emphasized valued wood products; stands replanted during those periods are uncharacteristically high in commercially valuable conifer species, and lower in species diversity.
- In general, stocking densities lead to stands which are uncharacteristically dense, particularly on south-facing slopes and at low elevations.
- Most managed stands are without residual overstory structure

Fragmentation

During the past five decades, the forest habitat in the watershed has become fragmented due principally to timber harvest. Dispersed harvest units, smaller on average than naturally occurring fire stands, have created an uncharacteristically fragmented landscape resulting in reduced interior habitat and habitat blocks too small to support some of the larger species home range requirements.

- There are two large blocks of minimally fragmented forest habitat in the watershed: 1) the southern end of the watershed, predominantly in the LSR, and 2) a block in Matrix along Kitson Ridge at the north end of the watershed.
- The middle stratum is highly fragmented, both in comparison to the other two strata and in comparison with reference conditions.

Riparian Reserve Vegetation Condition and Connectivity

Reference

Lands now allocated to Riparian Reserves were historically characterized by a relatively stable seral distribution. Mature and Old Growth (MOG) stands dominated and provided shade and a source of large woody material (Figure 11).

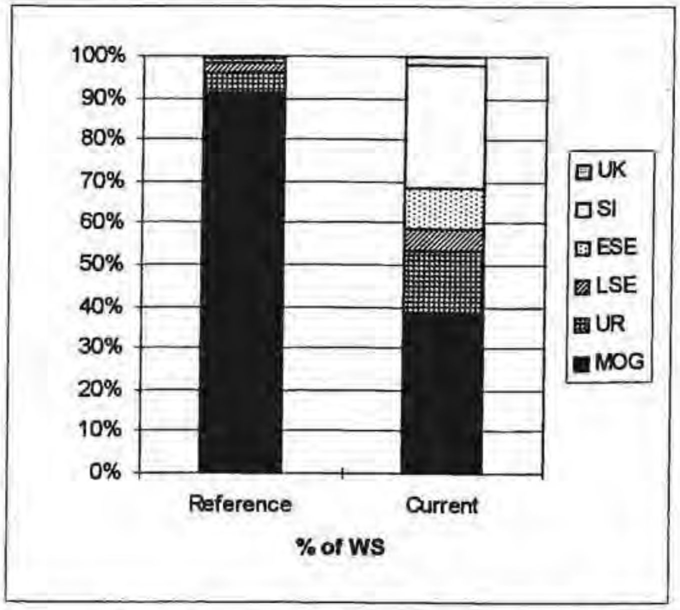


Figure 11. Reference and Current Riparian Condition

Distribution of seral stage by stream class supports the observation that Class III and IV streams are more likely to burn that Class I or II (Table 12). Class IV streams support the greatest amount of SI and SE stands: while Class I and II streams support the greatest amount of MOG and UR stands.

Table 12. Historic Seral Stage Distribution by Stream Class

	Class I		Class II		Class III		Class IV		Total WS	
	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of WS
SI	0	0.0%	0	0.0%	9	0.4%	15	0.5%	24	0.3%
ESE	2	0.5%	0	0.0%	5	0.2%	66	2.2%	73	1.0%
LSE	4	1.1%	16	1.1%	38	1.7%	139	4.6%	197	2.7%
UR	0	0.0%	33	2.1%	89	4.0%	203	6.7%	325	4.5%
MOG	390	98.4%	1490	96.8%	2102	93.7%	2613	86.1%	6595	91.4%
Total	396		1540		2243		3035		7214	

Examining distribution of seral stage distribution by strata supports the observation that fires burned riparian areas on gentle slopes less frequently. The riparian areas of the middle stratum supports almost exclusively mature habitat, while the upper and lower strata support greater amounts of young forest attributable to fire.

Table 13. Historic Seral Stage Distribution by Strata

	Upper		Middle		Lower		Total WS	
	Acres	% of Stratum	Acres	% of Stratum	Acres	% of Stratum	Acres	% of WS
SI	11	0.3%	0	0.0%	13	0.6%	24	0.3%
ESE	24	0.7%	0	0.0%	49	2.2%	73	1.0%
LSE	75	2.1%	19	1.3%	103	4.7%	197	2.7%
UR	230	6.4%	0	0.0%	95	4.3%	325	4.5%
MOG	3258	90.6%	1397	98.7%	1940	88.2%	6595	91.4%
Total	3598		1416		2200		7214	

__Current__

The greatest change in Riparian vegetation has been an increased percentage of SI and SE, largely connected with past timber harvest activities but also due to fire (Figure 12). SI and ESE generally provide little to no late successional habitat characteristics, such as LWD, large trees and deep multi-layered canopies; in addition, these stands fragment the Riparian Reserves. These conditions have reduced function in attaining desired aquatic and terrestrial conditions in Riparian Reserves. MOG covers 38% of riparian reserves.

Table 14. Current Seral Distribution by Stream Class

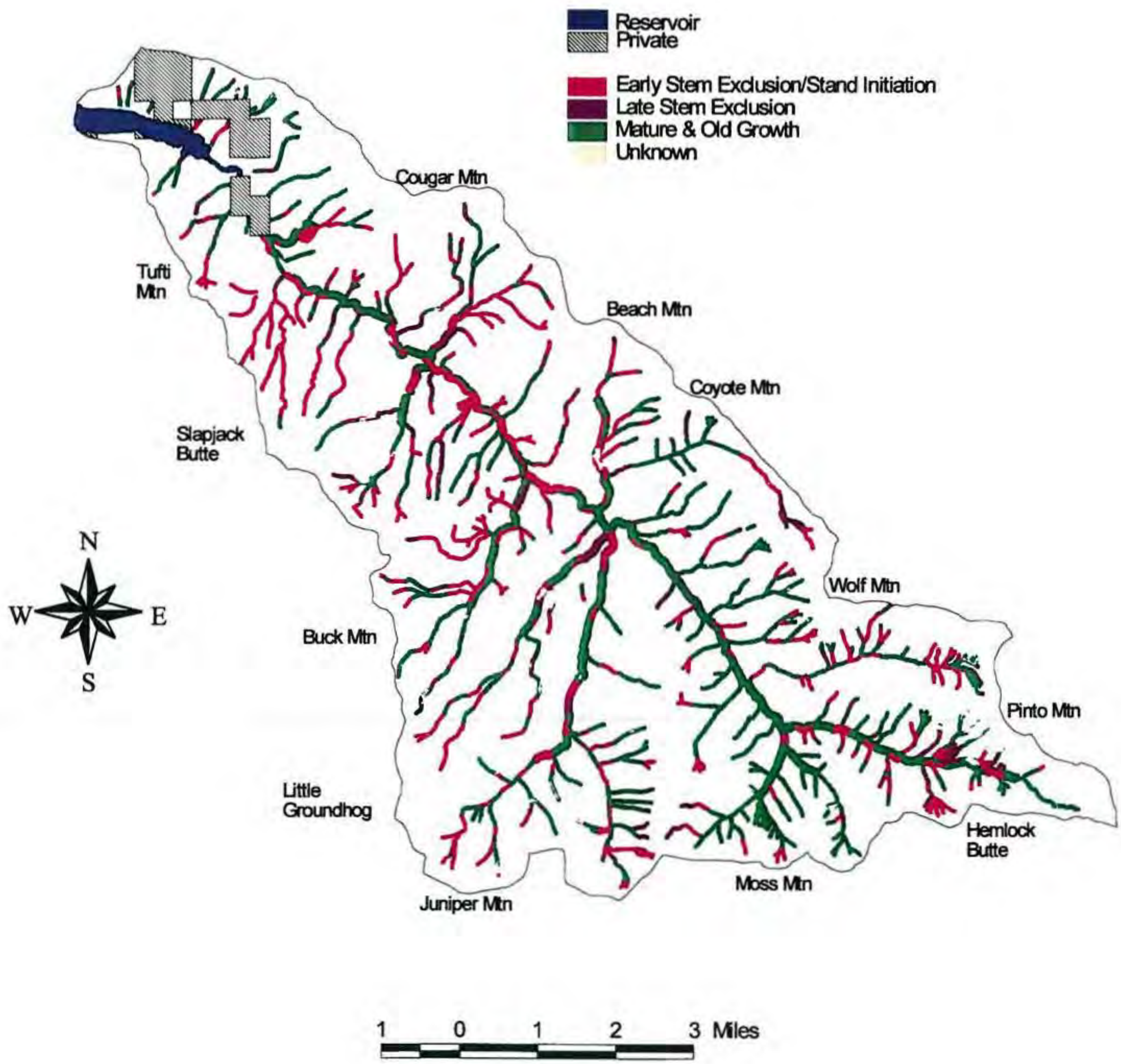
	Class I		Class II		Class III		Class IV		Total WS	
	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class	Acres	% of Class
SI	140	43.8%	336	22.5%	612	30.4%	940	30.6%	2028	29.4%
ESE	9	2.8%	76	5.1%	241	12.0%	366	11.9%	692	10.0%
LSE	4	1.3%	132	8.8%	70	3.5%	160	5.2%	366	5.3%
UR	14	4.4%	227	15.2%	395	19.6%	399	13.0%	1035	15.0%
MOG	143	44.7%	691	46.2%	647	32.2%	1140	37.2%	2621	38.0%
UK	10	3.1%	34	2.3%	46	2.3%	63	2.1%	152	2.2%
Total	320		1496		2011		3068		6894	
Roads	74	19%	135	8%	115	5%	140	4%	464	6%
Total RR	394		1631		2126		3208		7358	

Young stands have increased the most from historical conditions in the middle stratum and in the Shady Beach burn area.

Riparian Reserves Vegetation Condition

Hills Creek

FIGURE 12



Interdrainage Connectivity

Hills Creek

FIGURE 13

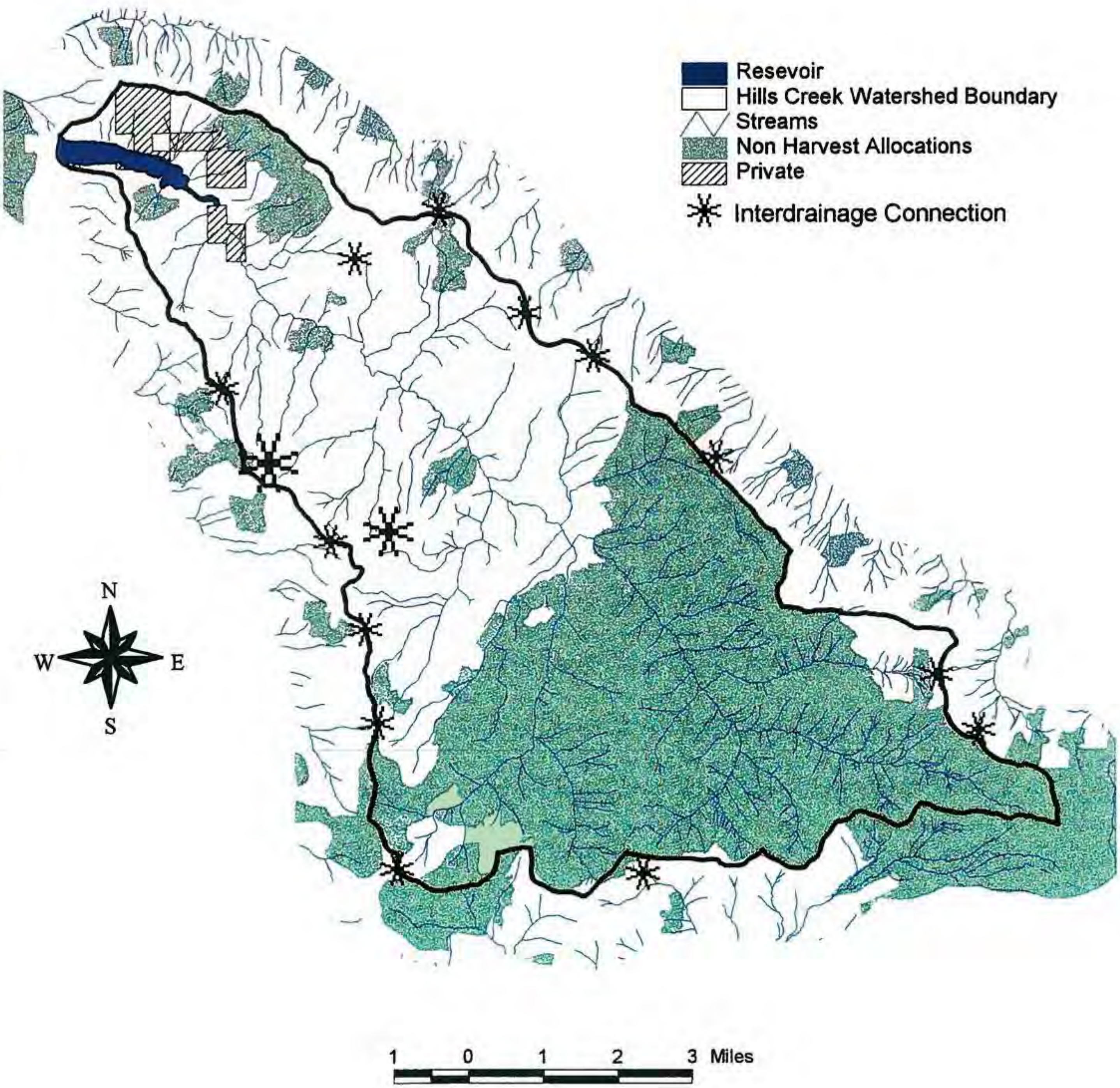


Table 15. Current Seral Distribution by Stratum

	Upper		Middle		Lower		Watershed	
	Acres	% of RR	Acres	% of RR	Acres	% of RR	Acres	% of WS
SI	851	29%	480	35%	698	34%	2028	29%
ESE	242	8%	148	11%	302	15%	692	10%
LSE	153	5%	139	10%	74	4%	366	5%
UR	61	2%	204	15%	219	11%	1035	15%
MOG	1554	53%	359	26%	708	35%	2621	38%
UK	79	3%	45	3%	28	1%	152	2%
	2940		1375		2029		6894	
Roads	214	7%	115	8%	135	6%	464	6%
Total RR	3154		1490		2164		7358	

Trend

Overstocked young managed stands which are not silviculturally treated could result in:

- stands which lack vertical and horizontal structural diversity.
- trees which decrease in crown to height ratio as they mature, leading to a thin canopy less effective in shading streams.
- Understories that appear as dense thickets, which impede wildlife dispersal and do not provide habitat useable to a wide variety of wildlife.
- Trees which are uncharacteristically slow in gaining diameter, slowing the development of late seral characteristics.
- High height to diameter ratios creating unstable stands prone to windthrow.

Key Question VE2: How do those projected patterns affect ecological functions such as LWD, dispersal and species distribution within this 5th field watershed?

Large Woody Debris

Reference

Valid records aren't available to know how large woody debris (LWD) was distributed across the landscape, and periodic fires and wind-throw events would have caused the quantities to fluctuate. This analysis is based largely on observations during the past 13 years by the Wildlife Biologist Ken Kestner, supplemented by anecdotal records for the Cascades. These two sources suggest that Large Woody Debris (LWD) patterns varied; some areas supported high LWD quantities, while other areas relatively sparse in LWD quantity.

The southerly aspects north of Hills Creek supported relatively sparse amounts of LWD, with occasional high points due to specific events. Old LWD in the fire replacement stands on Kitson Ridge and Coyote Mountain is sparse and small in diameter, suggesting repeated stand replacement fires.

In many other areas on the south aspects north of Hills Creek, the natural forest habitats (UR and MOG) are characterized by large old growth overstory and younger (~100 years) understory, suggesting underburn fire scenarios. Much of the LWD in these habitat stands are of Decay Class I and II, some III but very little class IV and V. This scenario suggests that LWD existing today is of a current period, not of historic occurrence.

In UR and MOG stands along the northerly aspects south of Hills Creek, there are much higher quantities and frequency of Class IV and V, along with Classes I, II and III. This suggests a higher and more persistent quantity of LWD.

Current and Trend

SI and ESE stands with no MOG legacy are often low in LWD and are often without near-term (35-40 years) recruitment of LWD. These stands are very high compared to historic and are predominantly harvest units, mostly occurring during the past three decades when management philosophy encouraged clean harvest units and full utilization of merchantable products.

Some areas on the south aspects north of Hills Creek have more LWD than historically. This increase is largely due to windthrow associated with fragmentation and reduced underburn frequency.

The current standard and guide is to leave 240 lineal feet of LWD per acre. This standard may not be representative of historic distribution and quantities across the watershed. It may over-represent historical levels on the south facing aspects north of Hills Creek, and may under-represent historic average in some areas on north aspects south of Hills Creek.

Dispersal

The Forest Plan relies heavily on Riparian Reserves and reserve allocations embedded in matrix for future dispersal across matrix lands. This analysis evaluates the condition of dispersal habitat both for dispersal within the drainage and between drainages.

Historic

In the mosaic landscapes of the upper and lower strata, dispersal habitat was provided by unburned class I and II riparian areas and old growth around the periphery of fire stands. Connectivity of habitat in these strata was somewhat variable temporally as the landscape fluctuated through time due to the fire regime.

In the large-block landscape of the middle stratum, the overstory mature and old growth habitat is assumed to have functioned as a relative stable refugia for old growth species as the forested habitat in the steeper terrains of the other strata fluctuated, and provided connectivity with other drainages. The MOG habitat extended into Salt Creek drainage, as depicted by the historic seral stage map in the Salt Creek Watershed Analysis (1997). This open forest sustained nearly contiguous canopy between large-diameter trees, facilitating dispersal of forested species having low mobility (i.e. red tree voles, bryophyte and lichen propagules).

Movement of terrestrial species between drainages, such as between Hills Creek and Salt Creek, and to the Middle Fork of the Willamette River, general occurred overland through ridgeline saddles (Figure 13). Historic distribution of vegetation (Figure 14) and fire history (Figure 4) shows that dispersal routes were not static over time, but were consistently available and effective at the landscape scale. Dispersal routes are occasionally affected by stand replacement fires, while some stands are denuded due to fire and other stands usually remained intact due to the mosiac burn pattern inherent with fire.

Current

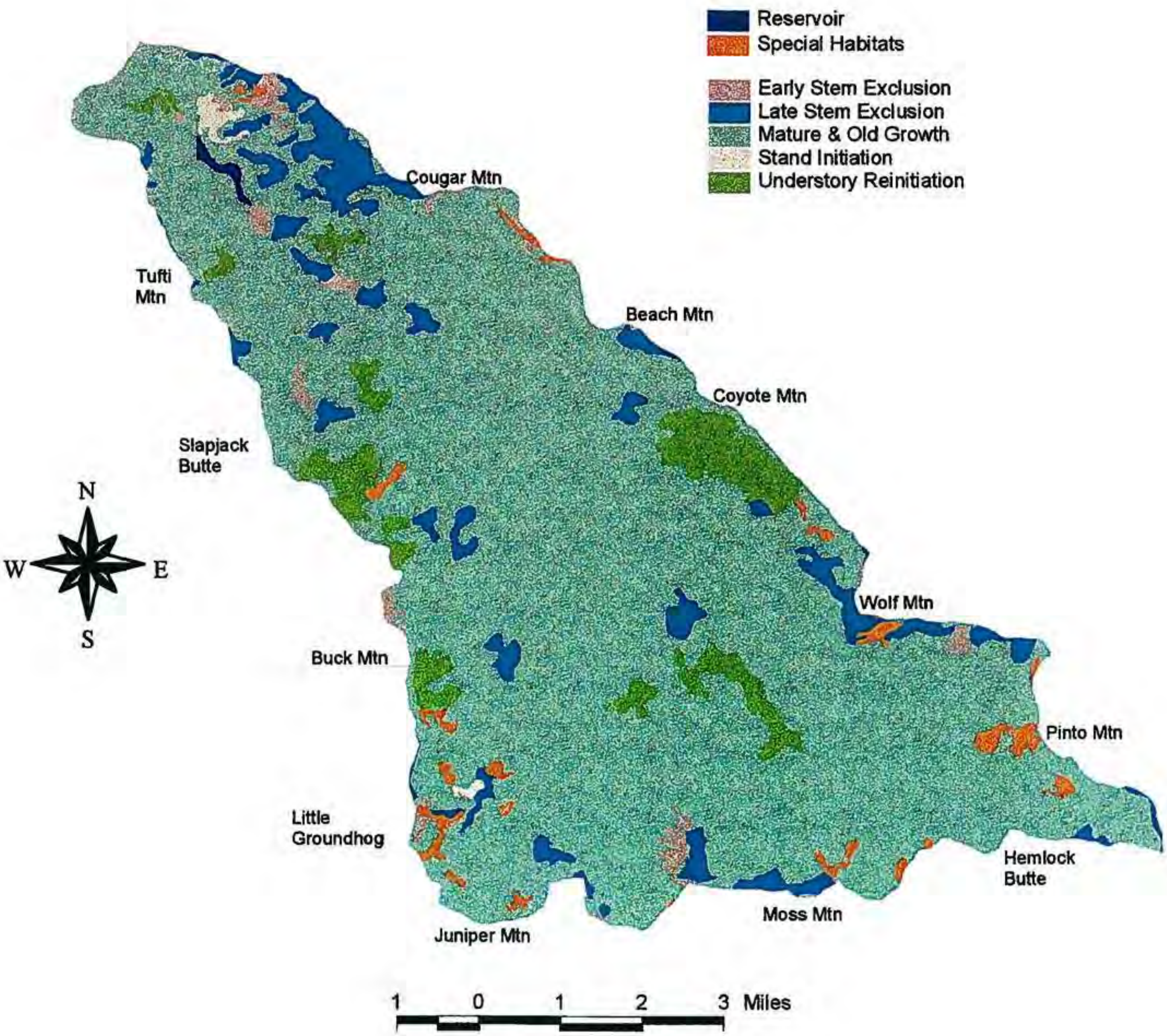
Increased fragmentation across the watershed (Figure 15) has substantially reduced connectivity of habitat, and therefore affected dispersal capabilities.

- The fragmentation of the middle stratum impedes the dispersal effectiveness.
- Shady Beach burn, in conjunction with the Hills Creek Reservoir, serves as a north/south dispersal barrier for many MOG-related species. While Shady Beach may be a temporary barrier, the Reservoir is a more permanent barrier for connectivity to the northwest section of the watershed.
- In the Shady Beach Fire area, most of the Riparian Reserves are stand initiation. This condition limits the effectiveness of Riparian Reserves as dispersal habitat for MOG-related species across this area.
- Due to the effect of Shady Beach, two pileated/pine marten areas in the watershed have been retained to help provide a dispersal corridor across the matrix.

Historic Vegetation (Based on 1946 aerial interpretation)

Hills Creek

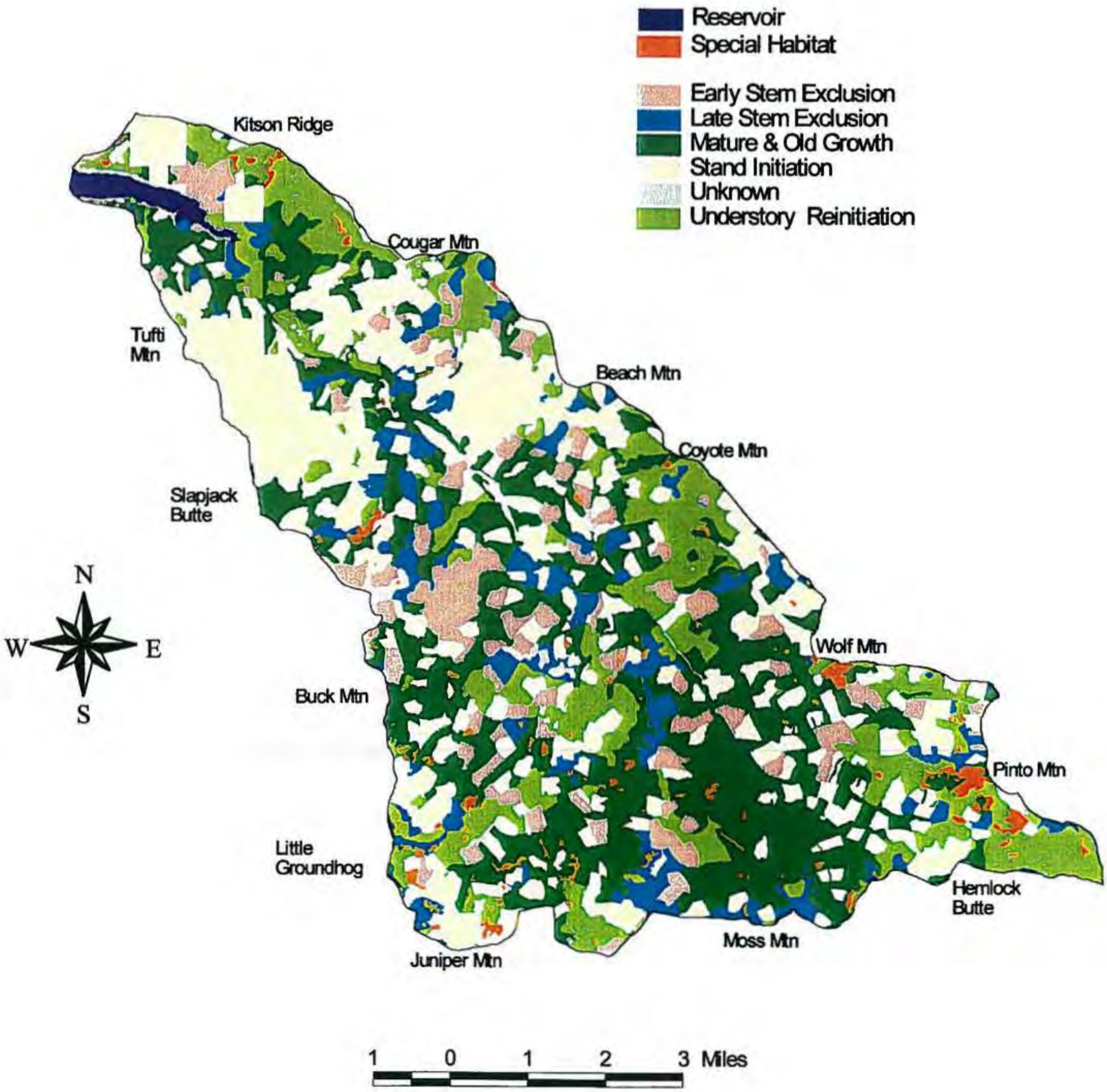
FIGURE 14



Current Vegetation

Hills Creek

FIGURE 15



On a larger landscape perspective taking into account adjoining watersheds, there is a complex of features which form a large block of poor dispersal habitat. This complex is formed by the combination of the reservoir, the block of private lands, the City of Oakridge and the Shady Beach fire area. The connectivity ineffectiveness of Shady Beach area and the private lands is temporary, but the reservoir and city of Oakridge are more permanent in nature.

Within this complex of unsuited dispersal habitats, a narrow corridor remains at the base of Hills Creek that can serve as a connector between LSR 222 in Larison Ridge on the west and the Hills Creek and Salt Creek drainages on the east. Providing a large block of suitable habitat on each end of this corridor as a dispersal corridor is desirable to provide effective travel through the narrow corridor, that acts as a connectivity link between LSR's and other reserve areas. LSR 222-Larison Ridge, provides a large block on the west, and Scenic allocations provide a large block on the east.

Trends

Dispersal connectivity with other LSR's (north of Salt Creek) are good due to short distance; connected to wilderness. Across to Buck Creek/Youngs Creek area will improve as young stands at head of Groundhog mature.

- Large blocks of young stands (i.e. Shady Beach, clusters of harvest units) will serve as future dispersal habitat (Figure 16).
- The design and placement of future harvest activities will determine the extent of that dispersal is impeded until the older managed stands mature.
- Retention of overstory in middle stratum can hedge against catastrophic loss of connectivity in the Hills Creek LSR (0221).

Wildlife Communities and Species

TE & S and Management Indicator Species

Several species that are now listed as either threatened or endangered inhabited this watershed. They include:

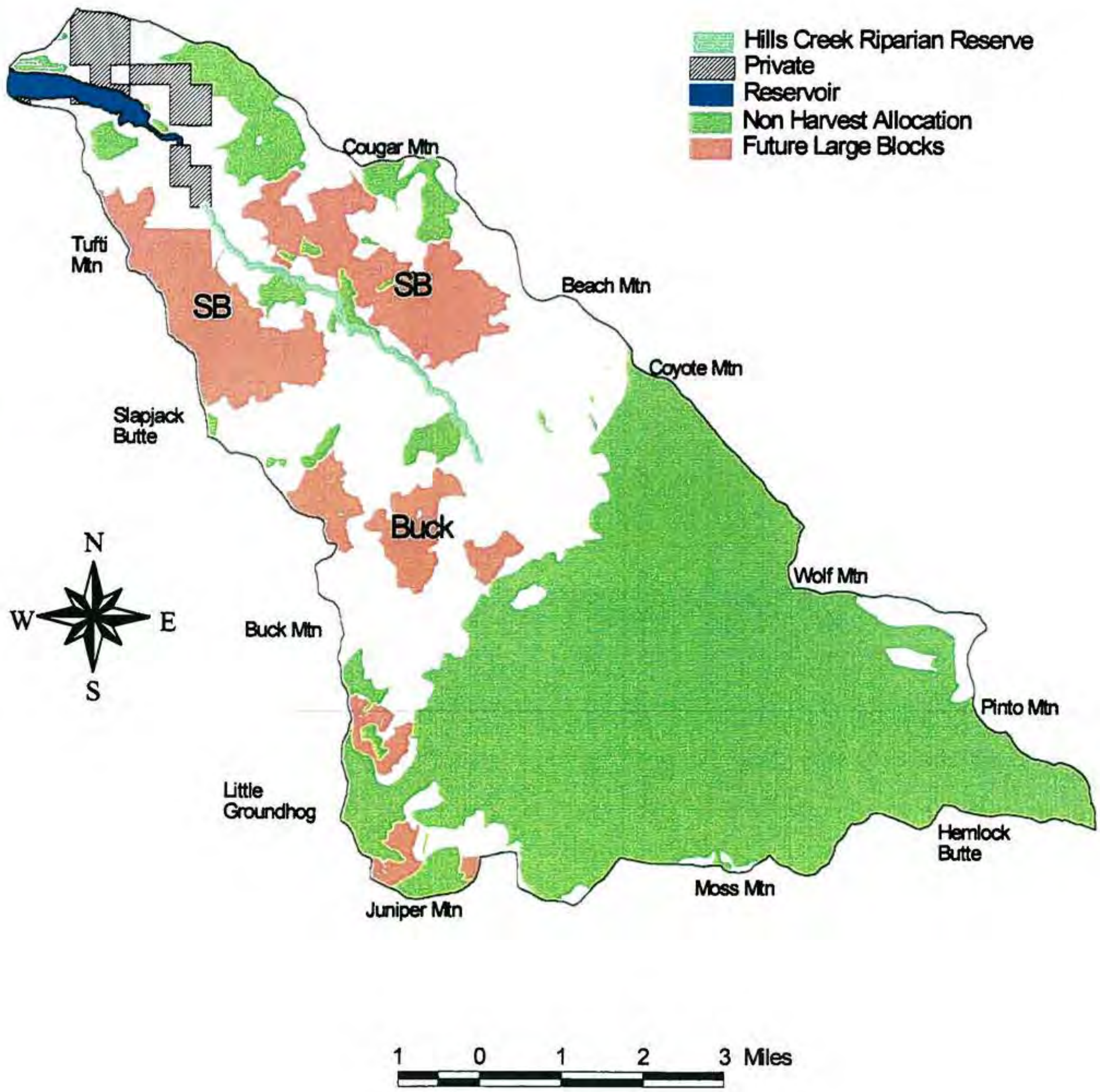
- Grizzly bear historically inhabited a variety of habitats within this area. This species was extirpated from the Oregon Cascades in the late 1930's or early 1940's, and no efforts have been made to reintroduce the species.
- The Gray wolf historically was known to inhabit this watershed. A federal eradication program during the late 1800's and 1900's is believed to have extirpated the wolf by the mid-1940's, and it is presumed still absent form the Cascades. However, wolf-like canines have been observed in this watershed during the past three to four decades, but no confirmations have been made as to species.
- Historically, Northern spotted owls inhabited mid to low elevation mature and old growth forests of conifer and mixed conifer-hardwood. Currently, there are 18 spotted owl activity centers known in the watershed: LSR: 12 activity centers, Matrix: 6 activity centers, five with 100-acre supplemental LSRs delineated and one recent discovery without a 100-acre LSR.

- Historically, Peregrine falcons were assumed to inhabit the watershed, though few in numbers. One peregrine falcon site (OR-14) is currently known to exist within the watershed. A portion of the tertiary zone for this site is located outside of the Hills Creek watershed. However, a portion of a tertiary zone on an adjacent site (OR-30) is included in this watershed. Foraging habitats included major riparian and the upland forests, which were predominately of mature and old growth habitats. A Management Plan is in preparation for this species, which will establish a three-tiered management zone. Compared to the historic conditions, foraging habitat surrounding the falcon site is altered to a higher percentage of SI and SE habitats.
- Bald eagles nest adjacent to this watershed and most likely frequent this area for foraging, as well as the river and early seral habitats which make locating carrion (carcasses of big game) much easier. One bald eagle nest site was recently discovered adjacent to this analysis area, this site has been recorded as successful (reproductively) for the past three years.
- Red tree voles are known to occur in late-seral habitat types; within this watershed a number of these habitat conditions occur. Interim guidance for this species was sent to Districts, via an Interagency memo dated 10/29/96. This memo stated that surveys needed to be completed if the 5th field watershed has less than 40% potential habitat, the Hills Creek watershed has approximately 55% potential habitat and is projected to maintain this throughout the end of the decade.

<u>Non-Native Wildlife Species</u>

The barred owl is the only non-native wildlife species of concern. The barred owl was absent in this area. Current fragmentation patterns favor barred owl utilization. One pair is known to be presently in the Hills Creek Watershed. The primary concern is the displacement and genetic dilution of spotted owl populations by the barred owl.

Large Blocks
Hills Creek
FIGURE 16



Botanical Communities and Species

T E & S

There are no known Threatened, Endangered or Sensitive botanical species in this watershed. Approximately 10-15% of Forest Service land in the watershed has been surveyed for sensitive plants, most in conjunction with proposed timber sales and other projects. No surveys for rare plants have been done on private lands in the watershed. Future surveys could result in locating other sensitive plant populations in this watershed. Most of these species are linked with non-forested special habitats, with the exception of Woodland milkvetch milkvetch (*Astragalus umbraticus)*, moonwarts (*botrychium* sp.) and tall bugbane (*Cimicifuga elata*).

The current distribution of sensitive and rare plant populations is assumed to be generally similar to that of the historical with the exception of Woodland milkvetch (*Astragalus umbraticus*) which is dependent on moderate intensity fires for germination. The recent South Zone fires, which were not widely seeded as were the Shady Beach fire, may have provided habitat for this species.

Survey and Manage Species (ROD appendix C-3)

The Northwest Forest Plan established survey and manage guidelines for a number of plants, bryophytes, lichens and. Habitat requirements for this group are diverse, but are typically linked with mature and old growth stand characteristics. Many of these species have limited dispersal capabilities.

Historic surveys for these species are limited to ecoplots and scenic locations. More comprehensive surveys for this species are to begin in 1998. The only Survey and Manage species known to occur in this watershed is Candystick (*Allotropa virgata*). Management direction has been amended for this species; the guideline at this time is to protect 30% of the known populations (cite the memo; include memo in appendix), spatially arranged to conserve genetic exchange pathways. At this time, there are two known populations in this watershed; one is a historical record which has not been relocated. Patterns in adjacent watersheds suggest this watershed has more populations which will likely be identified during botanical surveys; these new populations may affect spatial arrangement of timber harvest activities.

Non-Forested Special Habitats

The Willamette National Forest Plan, Management Area Standards and Guidelines describes Management Area 9d (special habitat areas) to include "...special or unique habitats for wildlife and botanical resources such as dry meadows, cliffs, caves, talus, mineral springs, mineral licks, wet meadows, marshes and bogs." In addition, FW-211 directs that special habitats in matrix shall be maintained.

Eighty-five percent of flowering plants in the central western Cascades are found in non-forested areas such as rock outcrops and meadows (Hickman, 1976). Many of the special habitats identified in the Special Habitat Management Guide (WNF 1992) are present within the watershed. However, inventory and mapping of special habitats is not complete.

<u>Reference</u>

Historic lightening fires played a key role in producing non-forested openings, particularly in drier mountain areas. In addition, it is suspected that prior to European settlement, Native

American populations used fire as a tool to create or perpetuate meadow habitat in order to maintain early seral conditions for longer periods than natural fire intervals. Forested areas were also probably underburned in places to provide more productive animal forage and to facilitate travel. Several non-forested meadows and prairies in the watershed have undergone past modifications to habitat diversity in the form of post-settlement use.

Past livestock grazing, logging history, and fire suppression have all contributed to changes in the diversity, composition and function of non-forested areas.

Current/Trend

The exclusion of fire during the past century has caused the surrounding forest to encroach on any dry and mesic fire-maintained special habitats. One result has been the reduction in meadow opening size and abundance in the watershed. Past harvest activities and associated road building has affected special habitats in several ways. Rock garden and rock outcrop communities have been used as landings, rock quarries and fuel breaks. Many species inhabiting these communities are slow growing (i.e. lichens), and thus particularly vulnerable to these activities. Soil disturbing activities in areas closely associated with dry and mesic type special habitats have allowed non-native species to invade. Loss of surrounding forest canopy has changed temperature and humidity regimes in some mesic and wet type special habitats. Road construction and other site disturbances may have altered the hydrological regime in some wet and mesic special habitat types.

The Forest Plan S&G FW 211 directs protection of special habitats and their ecotone which will substantially reduce future degradation. Current forest management practices will provide for re-establishment of some of the natural regimes important to maintaining a diversity of special habitats. However, the two following trends remain a concern.

- With current fire exclusion levels, forest habitat will continue to encroach on fire-maintained special habitat types.
- Noxious and non-native plant species will invade dry type special habitats. This process will be accelerated when soil disturbing activities occur in the vicinity of the following special habitat types.

Non-Native Botanical Species

Non-native plant species in this watershed have increased dramatically during the 20th century and are associated with ground-disturbing activities. Vectors included erosion control plantings, forage seeding, ground disturbance associated with timber harvest and road building, vehicle traffic, and use of domestic pack animals. In addition, many species invade as contaminants in pack animal feed, erosion control and road building materials.

Species classified as new invaders on the Willamette National Forest noxious weed list are given the highest priority for control. New invaders are those species which are in the early stages of invasion, occur at levels which can be eradicated, and have not naturalized to the point that resource damage is occurring.

New invader noxious weed species in this watershed are spotted, diffuse and meadow knapweeds, yellow and dalmation toadflax, giant knotweed, field bindweed, and climbing nightshade. Most known populations of the new noxious invaders are found along roadsides. Invasive exotic species in the watershed include non-native blackberries, yellow sweetclover, oxeye daisy, wild lettuce, wild carrot, and reed canarygrass. Areas most vulnerable to invasion are roadsides, previously harvested areas, trails and sensitive/special habitat areas (i.e. wet and dry meadows, rock gardens, riparian areas).

Several species occur at levels considered to be established infestations, having spread to the point that eradication is impossible. Established noxious and non-natives include the thistle species, tansy, scotch broom and common St. John's wort.

Many non-native species are commonly associated with ground-disturbing activities. Although noxious weeds can colonize harvested stands immediately after disturbance, conifers usually become established and displace the sun-dependent non-native species in managed stands. In addition, the lower levels of timber harvest and associated road building called for in the Forest Plan as amended by the ROD will likely decrease the spread of those non-native species that require disturbance and high levels of light.

Key Question VE3: Are road locations and densities meeting management objectives for elk emphasis areas, special habitats and noxious weed management?

Elk Emphasis Areas

The Forest Plan establishes that the Habitat Effectiveness guide for road density (HEr) should be within the range of 0.5 to 1.0 in High Elk Emphasis Areas (HEEA), and between 0.4 and 1.0 in Moderate Elk Emphasis Areas.

In Shady Gate HEEA, the current HEr value is 0.21, well below the objective. Of the road miles in this HEEA, 36 miles need to be closed to meet the Forest Plan objectives. For moderate Elk Emphasis areas in this watershed (Juniper Groundhog, Tufti and Wolf, Figure 17) to meet Forest plan HEr objectives, just over 30 miles of roads would need to be closed:

Special Habitats

There are approximately 70 locations where roads intersect special habitats, occurring primarily in the upper stratum. Depending on special habitat type, and on the placement, engineering and construction of these roads, these roads may be impacting key environmental factors which maintain the special habitat (Dimling & McCain, 1996).

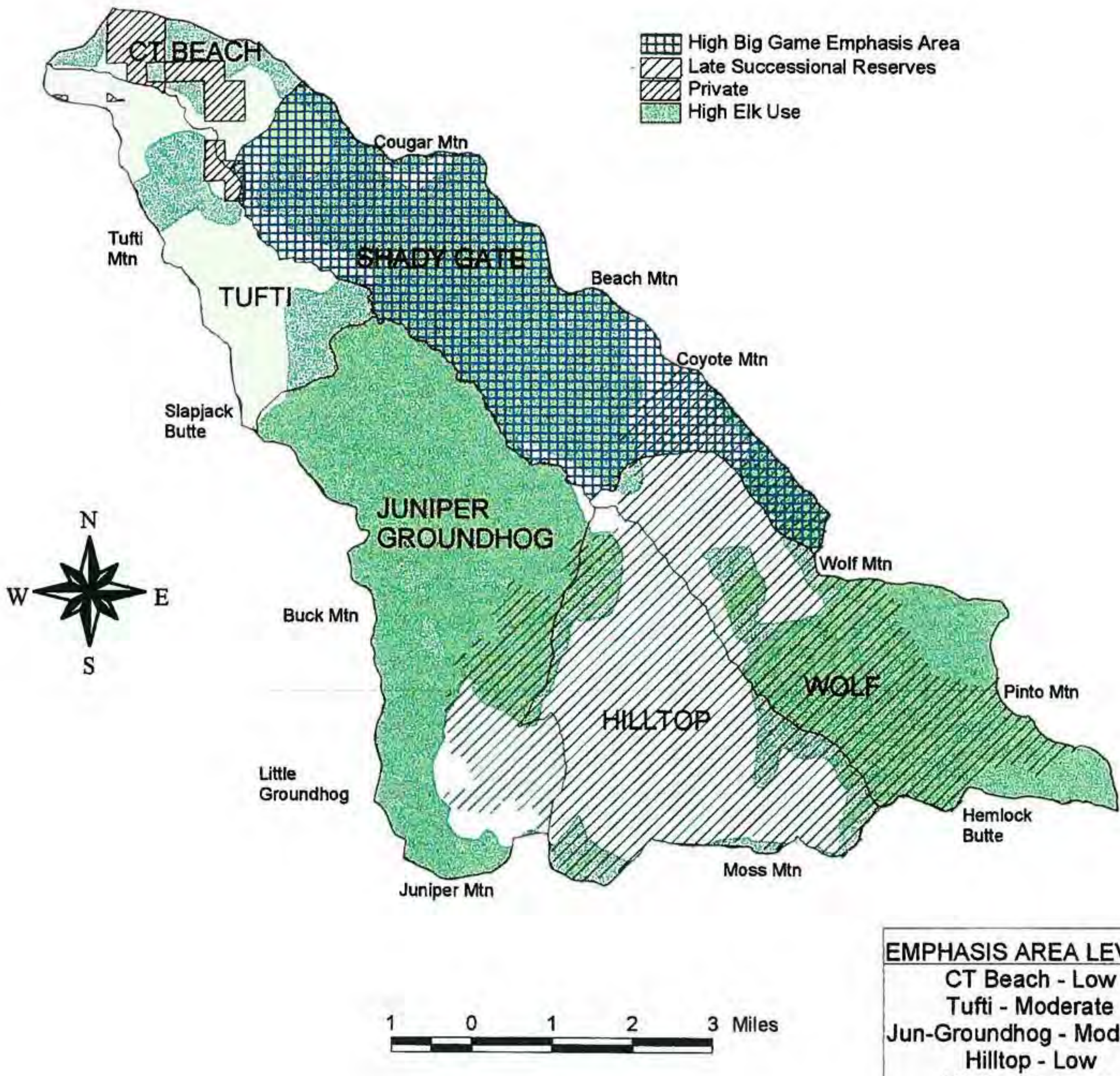
Noxious Weeds

Major forest roads and other corridors, such as power-line and railroad right-of-way clearances, serve as noxious weed dispersal pathways and establishment sites. The Hills Creek Road (FS road 23) is a well-used travel corridor. The only new invader population known in this watershed (spotted knapweed) is located near on this road.

Big Game Emphasis Areas

Hills Creek

FIGURE 17



EMPHASIS AREA LEVELS
CT Beach - Low
Tufti - Moderate
Jun-Groundhog - Moderate
Hilltop - Low
Wolf - Moderate

Key Question TH1: What opportunities are there in the Hills Creek watershed to manage timber harvest in accordance with aquatic and terrestrial objectives?

This analysis will first evaluate what is currently available for harvest management in matrix allocations, and then evaluate what, where and how much resource objectives may shift timber harvest activities in this watershed. Finally, general trends in the condition of suitable and available lands are presented.

Matrix

There are 14,818 acres in this watershed within matrix (40% of the watershed) (Figure 18). Acres which are suitable and available for timber harvest were calculated using GIS information available at the district.

Table 16. Acres Suitable and Available for Timber Harvest

	Total	Roads	Unsuited	15% for GTR	Special Habitats	Suitable & Available
General Forest	13,843	1,316	622	2,076	107	9,722
Scenic Modification Middleground	375	14	7	56	0	297
Scenic Partial Retention Middleground	189	16	3	28	0	142
Scenic Partial Retention Foreground	26	3	8	4	4	7
Scenic Retention Middleground	3	0	1	0	1	1
Scenic Retention Foreground	382	42	59	57	4	219
Total Matrix	14,818	1,391	700	2,223	117	10,388

Green Tree Retention (GTR) requirements and identification of currently unmapped class III and IV streams and special habitats may further reduce suitable and available acres.

Calculations at the forest level to determine quantities of suitable and available harvest land base calculations for this watershed on a total of 9,080 acres, approximately 1,000 acres difference from analysis here. Upon analysis and comparison, the following differences were noted:

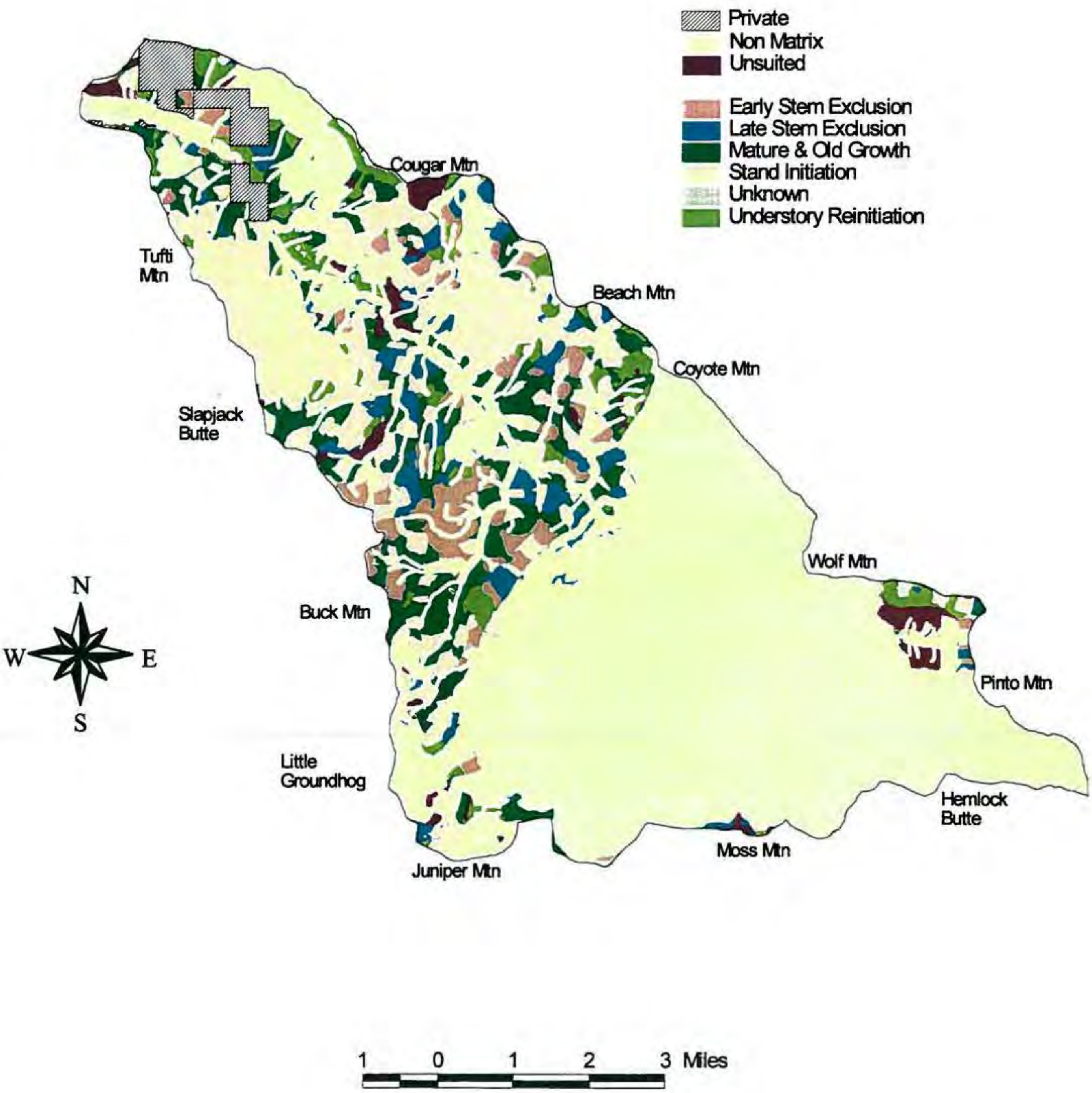
- The Peregrine allocation is not accurately located and is over-represented on the forest layer.
- The pileated/pine marten management area in the Juniper drainage has been vacated, but remains on the forest layer.
- One of the 100-acre LSRs adjacent to the reservoir is not valid. However, when the bald eagle habitat area is established and digitized, this land base will be part of that allotment.
- The district layer has more class-IV streams mapped than the forest layer.

This analysis is based on the suitable and available acres calculated from District GIS layer.

Seral Stage Condition of Matrix

Hills Creek

FIGURE 18



Quantity of Size classes in Matrix

See page for a complete description of each size class, along with assumed silvicultural treatments and growth rates.

Table 17. Size Class Distribution in Matrix

Size Class	Total Acres	General Forest	Scenic Allocations
SI	4719	4603	116
ESE	1191	1106	86
LSE	945	896	49
UR	1448	1190	258
MOG	2496	2311	185
UK	16	10	6

These are the current seral stages suitable and available for timber harvest in matrix allocations. However, some Forest Plan standards and guidelines may limit options for planning timber harvest based on current resource condition. Below is an analysis of the effect of standards and guides relating to hydrologic recovery, elk, soils, and retention of old growth on timber harvest.

Hydrologic Recovery:

Hydrologic recovery can be quantified by the Aggregate Recovery Percent (ARP) method. Calculated ARP values can be used as a measure of the risk of increased peak streamflow related to management activities. For a further discussion of ARP, see the Willamette National Forest Land and Resource Management Plan FEIS Chapter IV, Section: Water and Appendix.

For planning purposes, drainages have been assigned a midpoint ARP value as a reference point for sensitivity. These may be viewed as threshold value below which a more detailed assessment should be conducted to determine the potential for adverse effects associated with increases in peak flow.

The current ARP value for the watershed is 66%; the recommended mid-point is approximately 70% (based on previous planning sub-drainages). Over time, ARP will increase more than decrease due to set-aside allocations. Growth of approx. 5,000 acres young stands in Late Seral and Riparian Reserves will increase ARP value for the watershed. 3,000 acres of stand initiation will achieve significant hydrologic recovery within 20 years raising ARP to approximately 75% for the watershed as a whole, providing there is no catastrophic fire event. Fire will act as a confounding factor, converting mature stands to young.

Although the aggregate ARP value is below the recommended mid-point for the watershed as a whole, a few drainages in lands allocated for timber harvest have ARP values close to or greater than the mid-point and could be evaluated for timber management (Figure 19). The following drainages which could be evaluated for harvest activities have at least a portion in matrix:

Low ARP Streamsheds in Matrix

Hills Creek

FIGURE 19

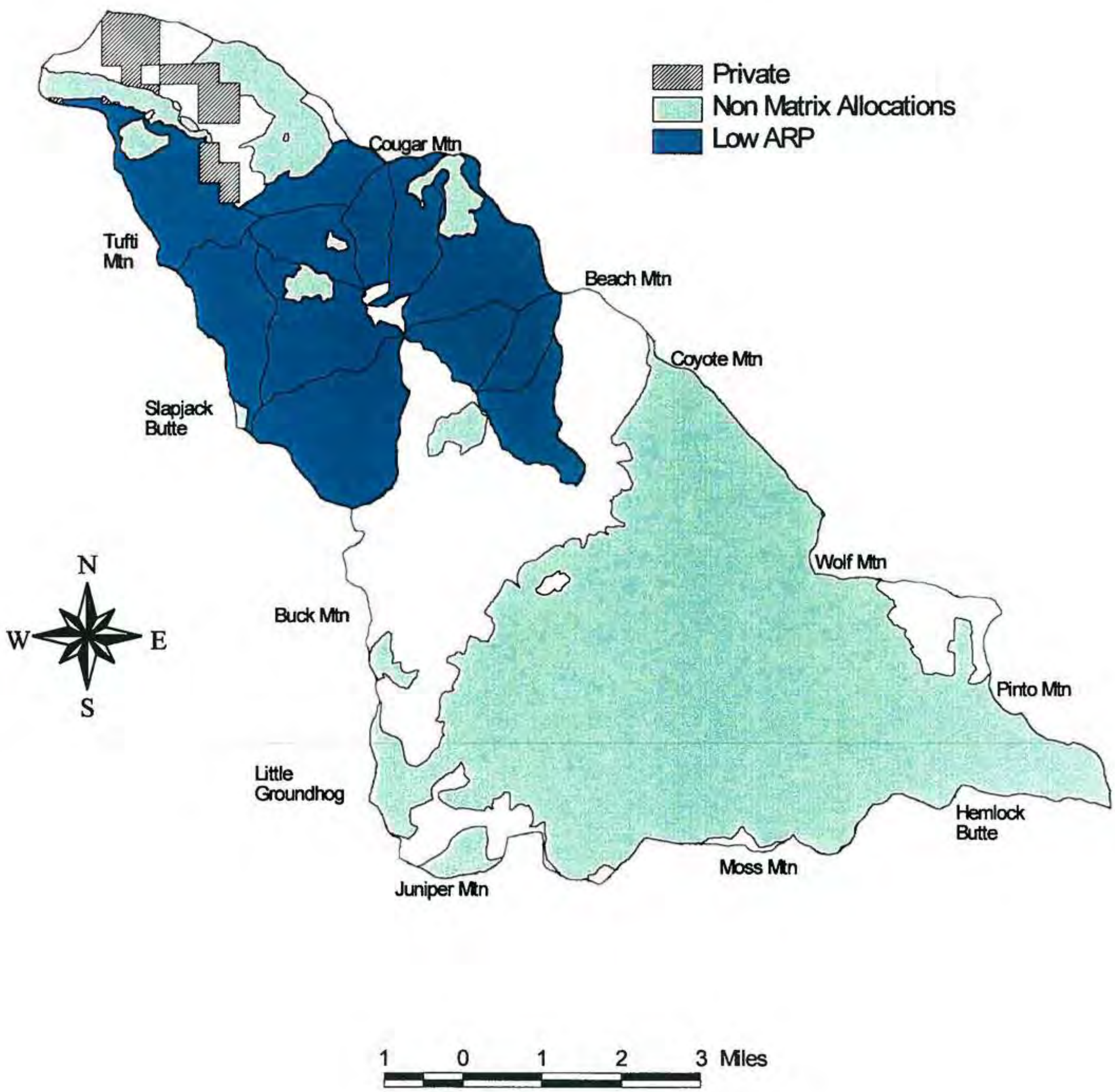


Table 18. ARP Value At/Above Mid-point

Watershed Division	ARP Value
Groundhog North	65
Warfield	71
Juniper	73
Apple Face	74
Groundhog South	79
Coyote Face	79
Gilligan's Face	80
Delta Face	96

Elk

In this area, there are three Forest Plan standards and guides which need management consideration to address habitat effectiveness and distribution. These standards apply to Shady Gate High Elk Emphasis which is the only High Emphasis Elk Area in the watershed (Figure 17). The other Elk Emphasis Areas are of low or moderate emphasis and do not present management concerns at this time.

1. *Habitat Effectiveness*: FW-149 designates that within High Elk Emphasis Areas (HEEA), the Habitat Effectiveness coefficient for cover (HEc) be at least 0.5 within winter range. FW-139 designates that trends Habitat Effectiveness be evaluated for a 10-15 year period.

   This FW-149 standard is measured by the Habitat Effectiveness for cover (HEc) coefficient; see Appendix XXX for a brief explanation of HEc and its components. The current available cover is predominantly thermal and optimum thermal, both of which are relatively high quality cover. The HEc is currently 0.63, well above the FW-149 designated value of 0.5. However, the trend projects a sharp decline to 0.41 HEc value in 10-15 years provided there is no further programmed harvest in the Shady Gate HEEA; harvest in the area would reduce the HEc to 0.40.

   The downward trend is attributable to approximately 3,500 acres of forage (SI) moving into hiding cover; this addition of a large amount of hiding cover lowers the overall HEc value. Removal of thermal cover, especially of optimum thermal cover, would further lowers the HEc value by widening the acreage percentages between hiding cover and thermal cover and optimum thermal covers.

2. *Distribution of Habitat*: FW-147 designates that high quality cover within the winter range be available throughout HEEA.

   The remaining acreage of winter range thermal cover and optimum cover is limited mostly to the Skipper Creek and west fork of Warfield Creek portions of the emphasis area.

Fisheries and Aquatics

The segment of Hills Creek between Mike and Juniper Creeks is the most sensitive response reach in the watershed. The lower gradient, less confined character of this reach and its position in the stream network makes it the primary depositional zone in the upper two thirds of the watershed (Middle and Upper strata). It is the one reach along the mainstem where the channel has extensive contact with its floodplain.

These characteristics produce a greater abundance of spawning gravel, side channel habitat, and general habitat diversity in this reach than elsewhere in the mainstem. Historically, this reach was known as the best spawning grounds for Spring Chinook in Hills Creek. It remains important for spawning and juvenile rearing of native cutthroat.

These same characteristics allow fine sediment to accumulate. A 1997 survey found up to 20% of the bottom substrate in this reach is fine particles less than 2 mm. This finding is a concern since it was noted after a recent large flood which also flushed fine sediment. Fine sediment input could be equal to or exceeding output, and increased input may cause undesirable changes in spawning habitat quality.

Cool water from North and South Groundhog and Juniper Creeks helps make the summer temperature more hospitable to fish in this reach than further downstream. In addition, this reach provides access to the above named tributaries which have high habitat values compared to other tributaries.

Retention of 15% Old Growth

Mature and old growth stands in upland non-harvest allocations in this watershed cover 13.4% of the watershed, and riparian reserve old growth provides another 6.8%, totaling 20.2% of the watershed which is currently in old growth stage and in non-harvest allocations. In the current condition, the 15% old growth requirement is met by old growth on non-harvest allocations. However, these stands are vulnerable to catastrophic events; if there were a 2,000 acre event, non-harvest allocations would no longer provide 15% old growth. As immature stands in non-harvest allocations grow, the 15% old growth requirement will be more stable over time.

SYNTHESIS

Key Question AQ1: Is the trajectory of upland vegetation condition likely to facilitate desired trends in peak flow disturbance patterns?

There is an observable increasing trend in the percentage of young forest in the watershed over time. The percentage has increased over the past 150 years and will likely remain above the amount created by either of the two historic fire episodes. This increase illustrates that harvest and road disturbance basically have added to rather than replaced fire disturbance in the watershed. Modern fires of stand replacement intensity have been suppressed with little success and have subsequently been harvested. In addition, planned harvest of unburned stands continues.

It is not known if fire disturbance prior to 1850 created as high a percentage of young forest as currently exists. If so, those fires would have to have been at least 5 times larger than the largest of the two known episodes. It is not likely that such a condition would have been a common state of the watershed. The management plan for the watershed implies that an elevated percentage of young forest will persist especially in the lower and middle strata.

No significant trend is observable in annual peak flow data over time. Additional data to define the trend is inconclusive or unavailable. Trends in upland vegetation condition Research suggests that increases in small peak flows (smaller than 2 year events)is likely occurring in first or second order drainages that have a high percentage of young forest. However, these results cannot be extrapolated to larger flows in the mainstem (Ziemer and Lisle 1997) (Jones and Grant 1996).

Key Question AQ2: Is the projected mass wasting frequency likely to lead to desired trends in sediment input and habitat condition?

Trends in the Character of Sediment Input

While differences in the <u>rate</u> of sediment input are more straightforward to measure, differences in the <u>character</u> of sediment may in fact be more important. Slides from young stands created by natural disturbance would presumably have delivered large inputs of LWD as well as inorganic sediment to streams. Slides from young stands created by management disturbance generally lack the same LWD component unless they pass through a mature stand before entering a stream.

Early airphotos reveal clearly defined debris flow tracks in nearly all the tributaries of Hills Creek in the upper stratum, indicating mass wasting from hillslopes was the primary mechanism of wood delivery to the upper mainstem. These tributaries, classified as source reaches, currently are less able to function as sources of LWD to the mainstem of Hills Creek. In a transport reach such as upper Hills Creek, LWD helps trap gravel size sediment (also supplied via mass wasting) which would otherwise be transported downstream. The function of LWD supply from tributaries will gradually recover over the next several decades as riparian reserves mature, and as natural disturbance replaces management disturbance in the upper stratum. (Refer to AQ3 for discussion of an important road-related consideration regarding this future projection).

In the lower stratum where management disturbance is projected to persist, mass wasting appears to have been a less important mechanism of LWD delivery to the mainstem of Hills Creek. Transport of LWD from the upper mainstem and input from the riparian zone of the lower mainstem were probably the main mechanisms. Only three of the inventoried slides in the lower stratum delivered directly to Hills Creek. The change in the character of sediment input from mass wasting is less significant for the mainstem in this stratum.

It may still be significant in fish bearing tributaries such as Juniper Creek, a transport reach where LWD would help sort sediment and retain gravel.

Desirability of Trends in Sediment Input

Desirability is defined by the Aquatic Conservation strategy and other Forest Plan objectives.

The long term trend in the upper stratum is generally desirable with both the rate and character of sediment input returning to conditions similar to the historic regime.

Trends in sediment input were not analyzed in the middle stratum due to the fact that landslides are not the primary input mechanism.

In the lower stratum, the long term trend of increased rate and altered character of sediment input from mass wasting is probably not detrimental to conditions in the mainstem. Much of the lower mainstem channel is incised in bedrock and is not over supplied with sediment. Long term LWD sources will improve over time and will help sort and retain some of the sediment.

Key Question AQ3: Are roads interacting with upland disturbance processes to affect stream channel conditions through input of sediment and water?

The high slide frequencies from roads result in an increased overall landslide rate compared to both current and historic conditions without roads.

From this analysis, roads appear to affect the mass wasting rate most in the lower stratum even on the same landtype. This is similar to a finding of the forest mass wasting analysis (see AQ2) and is further evidence of greater instability in the lower part of the watershed. In addition, localized slope failures not included in the aerial survey are numerous in the middle and lower strata.

Clearly roads are increasing coarse sediment input to streams, but the effects on channel conditions are variable. In the source reaches of the upper stratum, little detrimental effect persists. In the lower stratum, where the input rate from roads alone approaches the total historic input rate, the likelihood of long term sediment overload increases, especially since the road network will be a persistent feature in this part of the watershed. However, the fact that there are few depositional areas in either the tributaries or the mainstem of this stratum reduces the likelihood of severe impacts from increased sediment input alone.

Confounding the conclusion further is the fact that roads sometimes intercept the delivery of sediment from forest mass wasting to streams. Thus they can also subtract from the total sediment input rate. Roads also can change the character of sediment delivered to streams by intercepting the woody debris component of a landslide while passing the more mobile rock and soil. This effect is generally undesirable especially in the upper stratum where wood delivery from mass wasting via tributaries is an important process.

Key Question AQ4: Are riparian vegetation conditions and trends meeting desired stream temperatures, sediment, and availability of large wood for fish habitat?

Discussion of Riparian Conditions and Trends

The condensed history presented in the analysis section reveals that much of the riparian area along Hills Creek has been extensively altered from earlier conditions as a result of the combined disturbances which have occurred in the past 50 years. Perhaps the most significant change took place in the 1950's when floods, road building, and riparian logging together transformed the riparian zone below Groundhog from conifer dominated with a partly closed canopy to barren banks in many places with a completely exposed channel. A similar disturbance sequence occurred in the 1960's, but extending further up to Wolf Creek.

Before this transformation, the riparian zone seemed to accommodate floods of a 10 to 20 year recurrence interval with little visible effect. Afterward, a visible exposed water surface persists as young deciduous growth in the riparian zone is unable to withstand floods of a similar magnitude. It is also likely that mobile sediment supplied from eroding banks of nearby tributaries and from the mainstem, plus bedload destabilized by the removal of LWD from the channel, has contributed to riparian destruction during recent floods.

The future trajectory of disturbance in the riparian zone will include the continued presence of road 23 as well as floods of unpredictable timing and magnitude. It probably won't include salvage logging but probably will include LWD addition. The future sequence of floods will be the primary determinant on the length of time necessary for the riparian zone to return close to its former condition. The present condition will likely persist for many decades until large conifers are reestablished, especially in the inner riparian zone.

Integrated Aquatics Summary Key Questions AQ1 - AQ5

Results of the aquatics analysis indicate that riparian conditions and trends, especially along Hills Creek mainstem, is the component that diverges most from Forest Plan objectives. This situation also presents limited management opportunity. Thinning to increase growth rate in riparian plantations and passive restoration of conifer canopy where it is currently deciduous dominant are about the only options.

The road system is probably the next most important element in the aquatic condition picture due to their multiple effects. Roads are a main source of increased sediment input, yet are also a factor in decreased wood input from mass wasting. Roads contribute to the amount of riparian area permanently in a young seral stage. And stream crossing culverts are often problematic for fish passage.

An increasing trend in peak flows related to upland vegetation condition remains hypothetically possible and potentially important to aquatic ecological values. However, the minimal flow monitoring which has taken place during the past few decades is inadequate to determine the trend. At present, the flow gage on Hills Creek is inactive. Unless it is reactivated, there is no opportunity to monitor flow changes over time.

Key Question VE1: Given the historic disturbance regimes and current conditions, what landscape patterns could be projected with current management direction?

Seral Stage Distribution

Considering current management allocations and historical fire patterns, the amount of MOG in the watershed is likely to increase. The upper stratum is composed mostly of LSR, and will have the largest MOG component, covering up to approximately 55-70% of the landbase in the upper stratum. The middle and lower strata are composed of a mix of allocations which include matrix; there will be a mix of seral stages, with an old growth component in reserve allocations covering up to approximately 25-35% of the landbase in the middle stratum and 15-25% of the lower stratum.

Fire Processes

Fire severity risk has increased compared with detectable historical patterns. Average fuel loading will likely increase as understories become more dense and laden with woody debris. In addition, many areas of the watershed are within or approaching their expected fire interval.

Due to contiguous standing fuel, small fires can be expected within the Shady Beach area. These fires will provide structural and compositional diversity.

Stand Characteristics

- Without some recurring understory treatment in the middle stratum, understory density will continue to increase in the open-forest type.
- There will be a further reduction of overstory connectivity through programmed harvest in matrix.
- In areas of the middle stratum which were historically characterized by broad-scale understory fires, overstory density and fuels accumulation may be higher than historic levels.

Fragmentation

- In the LSR, overall fragmentation will decrease as managed stands mature; with fire and disease fragmentation patterns should begin to model historical patterns.
- In the matrix, fragmentation will depend on how we design and place future harvest activities.
- As the large blocks of young stands associated with the Shady Beach and Buck fires mature, they will offer large blocks of interior habitat.

Key Question VE2: How do those projected patterns affect ecological functions such as LWD, dispersal and species distribution within this 5th field watershed?

LWD

- Many stands harvested according to previous standards are low in LWD. This condition has the largest effect where it is prevalent on a large scale, such as in the Shady Beach burn area.
- Natural stands north of Hills Creek (south facing slopes) tend to be high in LWD compared to historical conditions. This is largely attributable to increased wind-throw and decreased underburning.
- The 240 linear feet per acre standard may be too high on south-facing slopes north of Hills Creek, particularly in the middle stratum which historically experienced frequent widescale understory burns. Conversely, this 240' standard may be too low on the moist, north-facing slopes south of Hills Creek.

Dispersal Habitat

Fragmentation has decreased the effectiveness of many interdrainage connections (Figure 22). Many of these are of SI and ESE which may impede MOG related species dispersal across ridgelines.

Wildlife Communities and Species

With the LSR (Hills Creek 0222) in the northern portion of Hills Creek watershed, owl, eagle and populations are currently stable or improving.

Peregrine falcons are currently using the falcon site (OR14). Fragmentation of peregrine habitat, and loss of prey species habitat present the largest risk to this species.

Botanical Communities and Species

Botanical species most likely to be affected by projected landscape patterns are those species with limited dispersal capabilities. Fragmentation, loss of large-diameter LWD, and loss of large individuals with well-developed lower branches could contributed to decreased dispersal pathways for a number of the Survey and Manage (C-3) species which are dependent on these characteristics and have limited dispersal characteristics.

Some communities dependent on specific environmental factors may be affected by projected landscape conditions. Without fire treatment to set back succession, fire-dependent plant communities such as meadows and open woods may decrease across the landscape. The effect may be either a shift in species or a loss in acreage.

Noxious weeds and non-native plants have the potential to invade special habitats. This process is accelerated when soil disturbing activities occur in the vicinity of non-forested special habitats.

Key Question VE3: Are road locations and densities meeting management objectives for elk emphasis areas, special habitats and noxious weed management?

Depending on the special habitat type, road placement, engineering and construction, the 70 locations where roads are intersecting non-forested special habitats may be affecting community structure and/or presence of noxious weeds in the special habitats. No analysis or survey has been done to determine the presence or extent of effect.

Roadside inventories on the Rigdon Ranger District conducted by the Oregon Department of Agriculture have shown an upward trend in quantity and distribution of road-associated noxious weeds. Of particular concern is the increase in quantity and distribution of new invader noxious weed species.

Key Question TH1: What opportunities are there in the Hills Creek watershed to manage timber harvest in accordance with aquatic and terrestrial objectives?

Summary of Conditions Affecting Timber Harvest Opportunities

Very low ARP values suggest that much of the northern portion of matrix (around the Shady Beach Burn) is insufficiently hydrologically recovered to plan programmed harvest in that area. The trends in HEc suggest that harvest in the Shady Gate HEEA should be limited to harvesting leave blocks of a size and shape to be ineffective in functioning as cover. With these conditions, the most likely areas for planning programmed timber harvest in the next decade are illustrated in Figure 20. Size classes within this area are presented in **Error! Reference source not found.**19.However, as noted on pages 64-65, some fish and aquatic issues may complicate project design in this area since this area contains some of the most sensitive stream reaches.

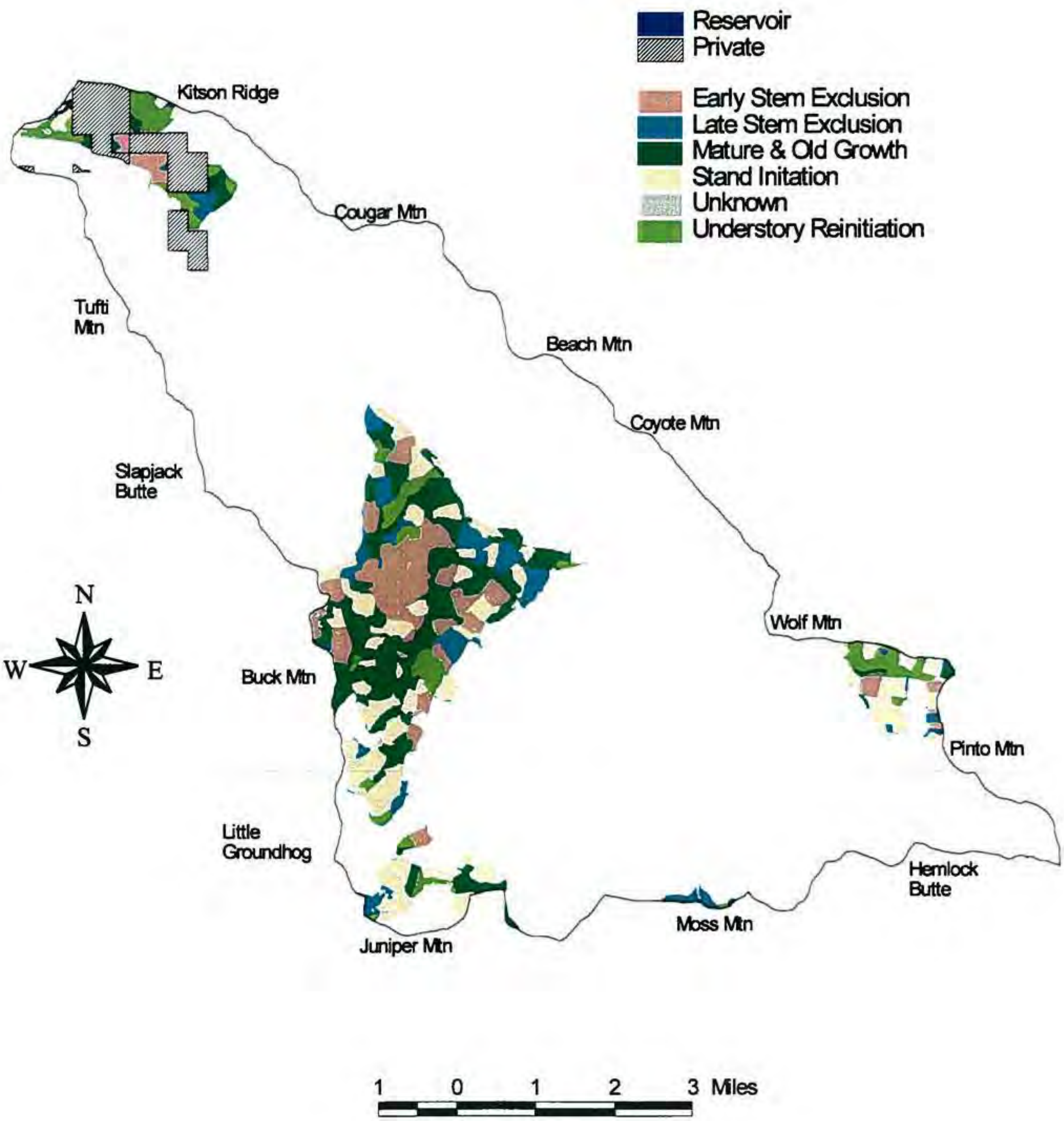
Table 19. Size Class Distribution in Potential Planning Area

	Acres	15% GTR	Suit & Avail
SI	1894	284	1610
ESE	1275	191	1084
LSE	701	105	595
MOG	1841	276	1565
UR	912	137	775
UK	104	16	89

Trends

Beginning on page 74 is presented an approximation of inventory based on the assumption that average stand rotation is 80 years with at least one pre-commercial and one commercial thinning; additionally, no allowance is made for other cultural treatments such as fertilization, improved genetic stock, etc. which would improve productivity.

Potential Planning Area
Hills Creek
FIGURE 20



Period 1: Current plus approximately 25 years

The stream sheds listed in the analysis above are the primary source of available harvest lands during this period. There are 2,750 acres of understory reinitiation and old growth stands which could be available for some sort of regeneration or selective harvest.

There are 1,200 acres of late stem exclusion in harvest allocations and another 950 acres in LSR lands which are likely ready for commercial thinning.

Period 2: Approximately 25-50 years

ARP recovery in previously young stands will be nearly complete at the beginning of this period, and fully complete by the mid-point. At this point, ARP should not be constraining unless harvest and natural disturbance combines during period to decrease it in the drainages entered in the first period. Elk habitat effectiveness will have to be re-evaluated.

The 1,200 acres of UR and MOG in drainages excluded from harvest in period one will be available. In addition, the 1,174 acres currently in late stem exclusion should be mature and ready for some type of large saw-log removal; net acres after GTR is 1,000. Stands which were in the early stem exclusion stage during Period 1 which will be in late stem exclusion and could be evaluated for commercial thinning, depending on growth patterns and market value; this includes 1,150 acres in matrix, 930 acres in non-harvest allocations, and 650 acres in Riparian Reserves.

Period 3: Approximately 50 years - 70 years

In addition to whatever large-diameter stands were not harvested during the first and second periods, the acres currently in early stem exclusion will be mature and should be evaluated for commercial thinning. There are 1,200 acres in this category.

RECOMMENDATIONS

In the reference, current and trend section of this document, a number of conditions have been identified where trends diverge from desired future conditions and/or the standards and guides established by the forest plan.

Some of these conditions can be mitigated for through careful placement and design of timber management and silvicultural activities.

Fire

For management of non-matrix habitats which evolved with fire, prescribed fire is an important tool which can simulate the ecological disturbance process of natural fires. For non-matrix allocations where prescribed fire is determined as beneficial to function, a Prescribed Natural Fire Plan (PNC) needs to be developed.

Condition and Effect	Design Options to Consider
Special habitats - acres decreasing of certain habitat types due to reduction in fire across the landscape. Plant communities changing.	Prescribe controlled burning to restore and retain fire-maintained special habitats and plant communities, and their zone of influence.
Stands where the understory and fuel loadings are uncharacteristically high, increasing the potential for catastrophic fire event. In addition, the understory is changing the habitat characteristics so that they are unsuitable for open forest MOG-related species.	Prescribed controlled burning in non-matrix to re-establish open stand characteristics where site-specific analysis determines an ecological need to maintain these conditions. Prime candidates for consideration would be Douglas Fir stands on the south facing slopes north of Hills Creek in the middle stratum.
Fuel loading and ladder fuels in riparian reserves may be exceeding historic levels, particularly in the middle stratum. This may increase the risk of catastrophic fire in riparian reserves which historically did not burn frequently.	With site analysis, prescribe underburning or thinning in riparian reserves to reduce excessive fuels.

Timber Management and Silvicultural Treatments

With thorough planning, design and implementation, timber management and silvicultural treatments are important tools to bring the current vegetation conditions toward desired future conditions. The vegetation conditions listed below pertains to a variety of resources, from falcons to large woody debris.

Condition and Effect	Design Options to Consider
Fragmentation has increased from historical condition. Many timber harvest units are smaller than historical patch sizes. In some areas, this condition impedes dispersal and decreases effective habitat for species needing large blocks of MOG habitat.	1. In matrix, design sales to decrease fragmentation by incorporating leave strips between previous harvest units to form large blocks. If these blocks are united, fragmentation is reduced, future interior habitat is created, and future dispersal connectivity is improved 2. In slopes less than approximately 60% in the middle stratum of the watershed, consider distributing GTR and wildlife trees in dispersed small clumps to provide some residual overstory continuity. In steeper terrain, clump GTR and wildlife trees to simulate natural residual overstory conditions. 3. Try to design harvest unit sizes to approximate the historical distribution of patch sizes where appropriate. 4. Maintain connectivity through corridors from ridgetops to riparian areas.
The Peregrine Falcon secondary zone has a large acreage of SI stands. As these SI acres grow into SE, habitat diversity would be low and provide for a lower diversity of bird species as prey for Peregrine Falcons.	When the large acreage of SI habitat within the falcon secondary foraging zone needs silvicultural treatments, consider prescriptions which would diversify the habitat to promote a diversity of prey species.
Some young managed stands are uncharacteristically densely stocked and low in diversity. This could delay progression to late successional forest function (i.e. dispersal, LWD recruitment)	1. In non-matrix allocations, consider thinning to a wider and varied spacing to promote habitat diversity. 2. In non-matrix allocations, also consider underplanting with diverse conifer and hardwood species in plant communities which are typically diverse.
Upland and riparian dispersal habitat for MOG related species has been fragmented, impeding its function.	1. During project analysis, identify and prioritize interdrainage connections. In functioning dispersal corridors, consider delayed timber harvest while blocking up the less functioning corridors for future development (figure 22). 2. In the matrix consider blocking up the highly fragmented areas to promote future large dispersal habitats. In the matrix, design projects to maintain existing mature forest habitat blocks, while blocking up the fragmented areas.

Condition and Effect	Design Options to Consider
In some class IV riparian reserves, the historical range of events included stand replacement events. Riparian reserve widths and standards may cause stand conditions which deviate from historical conditions.	Assess whether the current interim riparian reserve widths are appropriate, or need adjustments. Riparian Reserve Evaluation Techniques and Synthesis, Version 2.2, provides a good discussion in the paragraph under "Changing the Boundaries", Page RR-3.
Riparian Reserves are more fragmented that historically, with a larger component of SI and SE stands in areas which were historically MOG habitat. This impedes the Riparian functions, i.e. aquatic and terrestrial habitat and dispersal.	With site specific analysis consider stand treatments that would promote late successional forest characteristics in riparian areas of SI and SE stands, such as underburning or thinning.

Roads

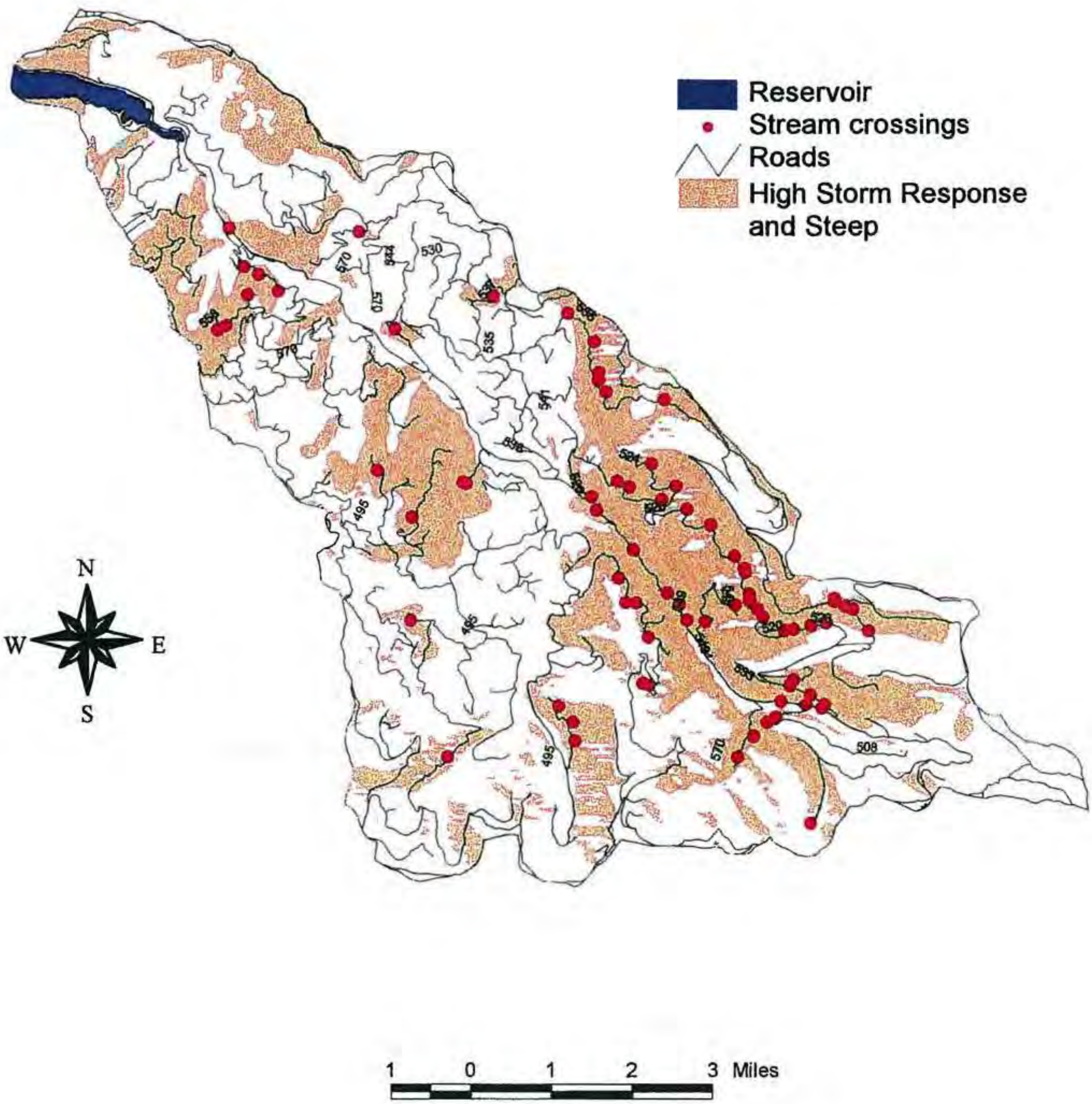
While serving the beneficial function of access for management and public use of the watershed, some roads and certain levels of road maintenance or miles can be conflicting with other resource objectives. A structured Access Travel Management Process is needed to incorporate the Conditions and Option below to identify road closure needs and reassess roads closed under earlier NEPA documents.

Condition and Effect	Design Options to Consider
Roads are functioning as dispersal means for non-native plant species.	When closing roads, evaluate the probability of infestation by Willamette NF new invader species; plan out-year surveys according to risk of infestation.
Roads in special habitats may disrupt conditions and processes (defined in the Special Habitat guide) which maintain the special habitats.	For roads located in special habitats, evaluate the degree to which the roads are affecting ecological functions and community structure. Consider all mitigating options such as road upgrade, closure, or obliteration.
Open road density exceed the Forest Plan guidelines in several Elk Emphasis Areas, affecting Habitat Effectiveness objectives.	Roads would need to be closed as follows: Elk Emphasis Area — Miles to Close Juniper/Groundhog — 13.5 Tufti — 9.0 Wolf — 8.0 Of the miles of roads in need of closure to meet S&G open road density objectives, consider closing those that are already identified in various NEPA documents. Many of these identified roads have been incomplete and/or ineffective. High priority roads would include 2316-530, 533, 534, 535, 537, 538, 2300-541, and 542, and 5875-544 and 549. If closed, approximately 7 miles of open roads density would be eliminated.
Roads with stream crossings in mass wasting and high runoff prone terrain have a high risk of problems in the future. See figure 21, Potential High Risk Stream Crossings.	Stream crossing removal or road obliteration of 2300-520. 508, and 570 in the LSR and 2308-495, 2303-558 and 563 in matrix. Vented ford installation at other LSR stream crossings.
Culverts that block fish passage	Replace culverts on Warfield and SF Groundhog creeks near the mouths
Roads with a history of mass wasting and maintenance problems.	Obliterate Road 2302 between 570 and 580 junctions

Potential High Risk Roads & Stream Crossings

Hills Creek

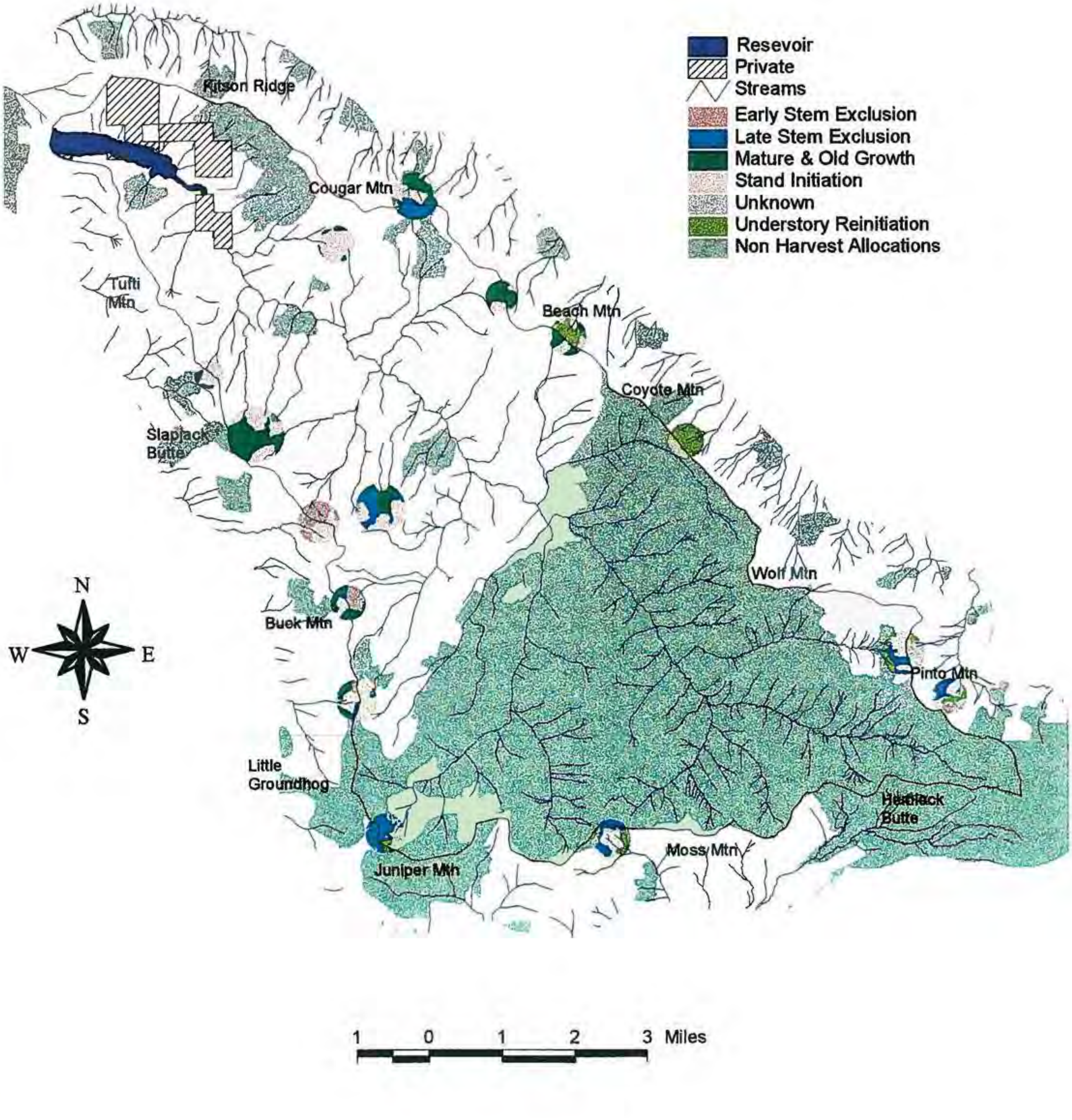
FIGURE 21



Current Condition of Interdrainage Connectivity

Hills Creek

FIGURE 22



Monitoring

- Reactivate the Hills Creek gage to monitor long term stream flow as a fundamental ecosystem process. Evaluate the suitability of the Hills Creek watershed for validation monitoring of the effects of large Late Successional Reserves on runoff.

- Monitor Hills Creek riparian and channel conditions with high quality airphotos at least every 5 years and after floods > 10 year event.

- Conduct a thorough landslide inventory every 5 years and after large storms.

APPENDICES

Appendix A: Seral Stage Descriptions and Distribution

Stand Initiation (SI)

Condition: seedling stands to sapling/pole mixes with sapling size dominant; diameter measurement from 0 to 4.9" dbh, some stands with a component of poles (5-8.9"). Canopy is open; down woody material is limited by standards and guides in place at time of harvest. Stream shading is inadequate to maintain natural temperature regimes. Competition between conifers is nonexistent or minimal.

Silvicultural treatments possibly applied: Stand density management (precommercial), release (brush cutting, hand pulling), fertilization of individual trees, pruning, animal management (i.e. BGR, garlic, tubes)

Commercial opportunities: none

Early Stem Exclusion (ESE)

Condition: pole stands, predominant five to nine inches. Canopy is closed, single-layered and not deep. Large woody material has not developed within the stand. Relative density is often greater than 35%, indicating competition between conifers, resulting in slowed growth. Streams receive inadequate shading due to thin canopy layer.

Silvicultural treatments possibly applied: Stand density management (precommercial), aerial fertilization, release (brush cutting), pruning

Commercial opportunities: poles if market is optimal; generally none.

Late Stem Exclusion (LSE)

Condition: Trees predominantly nine to twenty-one inches. Canopy is closed, single layered and moderately deep. Down woody material is minimal or not available. Relative densities are 45-55%, indication conditions of mortality and slowed growth. Provide adequate stream shading due to increased canopy depth.

Silvicultural treatments possibly applied: Stand density management (commercial), fertilization, pruning, underplanting (in LSR).

Commercial opportunities: may provide either commercial thinning opportunities or occasionally small-diameter regeneration harvest opportunities. Stands which are not beyond culmination provide commercial thinning opportunities which could improve stand health and allow an increased growth rate. In allocations not available for harvest, commercially thinning LSE stands is consistent with directions in the Forest Plan so long as the stand is younger than 90 years, the action would benefit the stand and the action would not interfere with Aquatic Conservation Strategy goals.

Understory Reinitiation (UR)

Condition: Trees predominantly over twenty-one inches. The onset of this stage is indicated by the development of the forest floor stratum, largely due to small-scale mortality (i.e. root-rot pockets, windthrow, snow damage, etc.). Canopy complexity and depth is developing. Down woody material and snags are increasing due to mortality. Provides adequate stream shading due to increased canopy depth.

Commercial opportunities: Thinning, regeneration harvest (seed trees, partial, final removal, shelterwood, group selection).

Old Growth (OG)

Condition: Trees predominantly over 25 inches. Old growth characteristics can vary somewhat across the landscape, depending on plant association and site conditions. However, some of the characteristics which can be found in old growth stands include (Oliver & Larson, 1990):

- Many large, old trees, often at a wide spacing.
- Understory is well developed
- Deep canopy, often with a relatively continuous vertical distribution of foliage
- Snags and large logs on the ground

Commercial opportunities: Regeneration harvest (seed trees, partial, final removal, shelterwood, group selection).

Appendix B: Storm Response Calculations

Conceptual Model

Storm Response = Soil Response + Snow Response

Storm Response = Water Yield Class + Snow Melt Rate

Data (soil resource inventory) (elevation & aspect)

Definitions:

Water Yield Class

I = low runoff rate and high detention

II = moderate runoff rate and moderate detention

III = high runoff rate and low detention

Snow Meltrate

Low = N. Aspect and > 4000'

Moderate. = N. Aspect and < 4000' **or** S. Aspect and > 4000'

High = S. Aspect and < 4000'

Storm Response Matrix	Soil Response (runoff)		
Snow Response	**low**	**moderate**	**high**
low	L	L	M
moderate	L	M	H
high	H	H	H

Appendix C: Flow Regression Statistics

To extend the flow record back in time, a two step regression proceedure was followed. Daily flows in Hills Creek were coorrelated with daily flows on the Middle Fork for the period 1958 - 1961 before Hills Creek dam became operational. The resulting equation was then used to generate a set of estimated daily flows for Hills Creek from 1936 to 1958 based on daily flows in the Middle Fork. Statistics for this equation are presented below (Hills Cr. daily flows - dependant variable, MF daily flows - independant variable).

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.97252393							
R Square	0.9458028							
Adjusted R Square	0.94572825							
Standard Error	36.8018998							
Observations	729							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	17182985.2	17182985.22	12686.977	0			
Residual	727	984634.134	1354.379826					
Total	728	18167619.4						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-9.5334107	2.08466672	-4.57311023	5.648E-06	-13.62609245	-5.440729	-13.626092	-5.440729
Mid. Fk. daily flows	0.13926292	0.00123639	112.6364801	0	0.136835594	0.14169024	0.13683559	0.14169024

A separate correllation was developed for peak vs. average daily flows in Hills Creek for the period 1958 - 1981 when the Hills Creek gage was operational. This equation was used to then generate the estimated annual peaks from 1936 - 1957 from the estimated average daily flows derived from the equation above. Statistics for the equation of Hills Creek annual peaks (dependant variable) with Hills Creek average daily flows (independant variable) are presented below.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.986968529							
R Square	0.974106878							
Adjusted R Square	0.973702298							
Standard Error	217.0547215							
Observations	66							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	113433320.3	113433320.3	2407.698876	1.67717E-52			
Residual	64	3015216.135	47112.75212					
Total	65	116448536.4						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-141.3469547	43.30288565	-3.264146315	0.001764549	-227.8543353	-54.83957401	-227.8543353	-54.83957401
Hills av. daily flow	1.477619181	0.030113514	49.06830826	1.67717E-52	1.417460576	1.537777786	1.417460576	1.537777786

Regression results of Hills Creek annual peaks (dependant variable) with Middle Fork Willamette above Hills Creek Reservoir (independant variable) to extend record from 1982 through 1993.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9439512
R Square	0.8910438
Adjusted R Square	0.8886226
Standard Error	507.47961
Observations	47

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	94775669.81	94775669.8	368.01004	2.7228E-23
Residual	45	11589100.02	257535.556		
Total	46	106364769.8			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-87.283677	121.9014402	-0.7160184	0.4776793	-332.80577	158.23842	-332.80577	158.23842
Mfpeak	0.2338341	0.012189277	19.1835877	2.723E-23	0.2092836	0.2583845	0.2092836	0.2583845

Appendix D: Fish Habitat Supplement

D.Hann, 10/1997

Pinto Creek - Riparian Condition

Reference conditions are not available for this drainage or other streams of similar size. However, current channel conditions and associated goals for Pinto Creek are summarized in Table E-1. The desired goals are established from both the Forest Plan and the recommendations outlined by the National Marine Fisheries Service for the High Cascades (1996).

Table E-1. Channel conditions and associated goals for Pinto Creek.

Parameter	Current Value	General Goal
W/D Ratio	18.0	< 12.0
% Primary Pool Habitat	25.1%	> 30 %
Pools/mile	49	102-170
% Quality Pools (Greater than 1 m)	12.5%	> 20 %
# Large/Med. Wood/mile	13.7	> 30 pieces/mi.
Substrate (Dom/Subdom)	CO/SA/GR/BD	Stable over time
% Embeddedness	23%	< 30 %
% Bank instability	2%	< 10 % total length
% Side channels (#)	2.8 % (8)	Maintain over time
% RR in late seral stage	43%	> 80 %
7 day max. water temp (max. water temp) (F)	59 (60)	<68
Miles rd/sq. mile	4.04	< 2 mi./sq. mile
Rate of debris slides	>100 %	+ or - 20 % historic rate

The inner riparian zone averages 23 feet and is dominated by the shrub/seedling age class, primarily willows. The outer riparian zone varies from sapling pole to large tree, primarily Douglas Fir. Presently, 43 percent of the riparian vegetation is in the late seral stage class. The trend is toward recovery, with a goal of 80 percent of the riparian vegetation in this age class to provide for large wood into the stream and riparian area in the future.

Pinto Creek is a Rosgen A channel, functioning as a transport reach. The stream serves as a conduit from the upper watershed to Hills Creek below. According to biological surveys completed in 1995, the larger cutthroat trout in the stream tended to reside in the areas with an intact riparian area and associated large woody debris. Juvenile cutthroat were distributed more evenly throughout the stream.

The areas with intact reserves were dominated by vine maple and conifers whose roots extended out over the stream creating undercut banks, covered channel margins and pocket pools. The channel was more open, but provided shade cover throughout the day. The LWD was more prevalent and influenced large pocket and scour pools and upstream gravel accumulation. Banks tended to be stabilized by extensive root systems (1996 Stream Survey). Areas without a mature riparian forest were dominated by thick, shrubs of willow and alder. The inner riparian growth extended into the channel margins and often covered the entire stream. The stream sinuosity was reduced with a lack of pools, substrate and habitat variation. A minimal amount of LWD was in the stream channel.

The riparian reserve condition is functioning to meet the desired goal for stream temperatures and bank stability for fisheries. It is not, however, meeting the desired goal for large woody debris recruitment. Stream restoration was completed in 1995, increasing large wood to 13.7 pieces per mile. However, the stream is still below the standard of 30 pieces of wood per mile.

The projected trend is for continued recovery of the riparian reserve and associated parameters as the forest continues to implement the Forest Plan. Thus, long term goals to return to the desired range of variation should be attained.

Presently, the predominant substrate in the channel is cobble, with sand, gravel and bedrock as the subdominant component. The stream embeddedness was 23 percent prior to the 1996 and 97 flood and debris events.

The width to depth ratio of Pinto Creek is higher than expected and may be a result of increased sediment loads in the stream as well as increased drainage density. Roads have been established in the drainage at a density of 4.04 miles per square mile. The trend is toward a reduction of road miles, with a goal of less than 2 miles per square mile to reduce sediment delivery into the streams.

Wolf Creek - Riparian Condition

Channel condition and Biological Response - Wolf Creek

Reference conditions are not available for this drainage or other streams of similar size. However, current channel conditions and associated goals for reach 1 of Wolf Creek are summarized in Table E-2. Reach 1 describes the only fish bearing reach in Wolf Creek. These channel conditions and goals are assumed to be similar for the other second order streams in the watershed. The desired goals are established from both the Forest Plan and the recommendations outlined by the National Marine Fisheries Service for the High Cascades (1996).

Table E-2. Channel conditions and associated goals for Wolf Creek.

Parameter	Current Value	General Goal
W/D Ratio	12.0	< 12.0
% Primary Pool Habitat	32%	> 30 %
Pools/mile	35	102-170
% Quality Pools (Greater than 1 m)	23%	> 20 %
% Bank instability	2%	< 10 % total length
% Side channels (#)	1 %	Maintain over time
% RR in late seral stage	36%	> 80 %
7 day max. water temp (max. water temp) (F)	(47)	<68
Miles rd/sq. mile	3.53	< 2 mi./sq. mile
Rate of debris slides	>100 %	+ or - 20 % historic rate

Wolf Creek is a Rosgen channel type A, 2nd order stream with small cutthroat trout and a few sculpin present from the confluence upstream for approximately 0.4 river miles. Wolf Creek functions as a transport reach. The stream serves as a conduit from the upper watershed to Hills Creek below.

The inner riparian zone averages 10 feet and is dominated by the shrub/seedling age classes of red alder, willow, and vine maple. The outer riparian zone varies from sapling pole to large tree of Noble, Silver and other "true" firs, followed by Mountain hemlock and Incense Cedar. Presently, 36 percent of the riparian vegetation is in the late seral stage class. The trend is toward recovery, with a goal of 80 percent of the riparian vegetation in this age class to provide for large wood into the stream and riparian area in the future.

Similar to Pinto Creek, the riparian reserve condition is functioning to meet the desired goal for stream temperatures and bank stability for fisheries. It is not, however, meeting the desired goal for large woody debris recruitment. Presently, only 11 pieces of wood per mile are distributed throughout this reach. This amount is well below the standard of 30 pieces of wood per mile. No stream restoration has been completed in this size of stream.

The projected trend is for continued recovery of the riparian reserve and associated parameters as the forest continues to implement the Forest Plan. Thus, long term goals to return to the desired range of variation should be attained.

The width to depth ratio of the stream is at the general goal, with dominant and subdominant substrate of cobble, gravel and boulders. The percent embeddedness at 24 percent is below thethreshold of 30 percent. The function of Wolf Creek and other streams of similar size and gradientis to transport sediment through the system. These stream types are relatively resilient to disturbance.

The future trend of sediment loading into the stream system is toward decline. With implementation of the Forest Plan, high risk roads will be evaluated and changed as necessary over time.

Hills Creek - Riparian Condition

Channel condition and Biological Response - Hills Creek

Some historic conditions for Hills Creek were documented in surveys completed by the Bureau of Reclamation in 1937 and by the Oregon Game Commission in 1959 and 64. In 1937, only the first two miles of stream were surveyed. The data from the 1959 survey was very qualitative. Current channel and fish habitat conditions are provided in the 1992 Forest Service Stream Survey and preliminary results from a 1997 survey.. Historic and current conditions are summarized in three tables which follow. Associated goals for each parameter are the same as Pinto and Wolf Creeks (Table E-3).

Table E-3. Quantifiable current (1992) and historic (1964,1937) channel conditions in Hills Creek

Reach	River Mile	Grad %	Rosgen Type/ Entrenchment	Wetted Width (F) 1992/ 1964*/ 1937	W/D Ratio 1992
Res.	0-2.8	-	-	-/25/31	-
1	2.9-4.3	2%	B/Deep	31/25/-	8
2	4.3-6.7	2%	B/Deep	29/25/-	5
3**	6.7-7.6	1%	B/Shallow	29/25/-	10
4**	7.6-8.4	1%	B/Mod	36/15/-	5
5	8.4-8.8	1%	B/Mod	35/15/-	-
6	8.8-9.9	3%	B/Deep	35/15/-	-
7	9.9-10	3%	B/Mod	26/15/-	-
8	10-10.2	3%	B/Mod	30/15/-	-
9	10.2-10.6	7%	B/Mod	25/15/-	6
10	10.6-11.4	3%	B/Shallow	24/15/-	8
11	11.4-12.2	6%	B/Mod	23/10/-	8
12	12.2-12.6	10%	B/Mod	27/10/-	5
13	12.6-13.1	7%	B/Mod	19/10/-	-
14	13.1-13.9	3%	B/Deep	16/10/-	-
15	13.9-14.2	7%	B/Mod	9/10/-	-
16	14.2-14.9	8%	B/Mod	9/10/-	8
17	14.9-15.6	12%	. B/Mod	8/10/-	-

* Wetted width in 1964 was averaged over several miles.

** Reach 3,4 habitat restoration sites.

The historic vegetation was described as medium sized conifers and underbrush, with dense vine maple. Very little erosion was evident. In the upper reaches the valley flattened and widened considerably and was "filled with a virgin growth of timber". Based on the 1992 stream survey, the age class of the riparian reserve along Hills Creek is predominantly seedling/shrub and sapling trees. Only 6 of the 17 reaches are bordered by old growth trees. Only reaches 11,16 and 17 meet the desired goal of 80 percent of the riparian reserve bordered by old growth. The low values are a result of harvest along the streambanks and of the bedrock nature of the channel. As a result the stream temperatures are relatively high in Hills Creek, with recorded temperatures between 53 and 60 degrees F. As a result of the flood, stream cleanout and harvest the large wood debris in Hills Creek is very low. Most of the wood that was added to the channel after the Shady Beach Fire did not stay in place. Similarly approximately 80 percent of the wood placed in Reach 3 and 4 for habitat enhancement was also lost after the two flood events. A quick survey of inchannel wood in 1996, prior to the flood, revealed an average of 7.5 pieces of large wood per mile. The wood was generally associated with falls and side channels. As a result the percent of pool habitat (5-25) and pools per mile are below the established goals (>30 percent pool habitat).

Old time residents reported a "heavy run" of spring chinook before the construction of the dam. Numbers of small trout were fair, with scarce numbers of suckers and whitefish. Trout fingerlings were stocked every year. Trout were relatively scarce in the lower six miles as a result of fishing pressure. Trout were more abundant and larger further upstream in areas of limited access. The potential for salmon and steelhead production in Hills Creek is limited to the first 1.9 miles below a 7 foot cascading falls. The present scenario of the fishery is generally the same. Oregon Department of Fish and Wildlife continues to stock the lower 6 miles of the river. As a result of the stocking it is difficult to assess the selection of habitat use by the cutthroat and rainbow. The 1995 monitoring efforts did however, show adult cutthroat and rainbow trout preferred complex habitat conditions, were deep pools and food were readily available. They also tended to reside in stretches with intake riparian reserves (similar to Pinto Creek).

The condition of the riparian reserve is not functioning to meet desired recruitment of large woody debris into the stream channel and to maintain shade over the channel. It is functioning for the most part to provide bank stability. Bank stability however is also provided by the bedrock and boulder substrate. The trend is toward recovery of the riparian reserve as the Forest Plan is implemented

Table E-4 . Quantifiable current (1997), transitional (1992) and historic (1964) fish habitat conditions in Hills Creek

Reach	River Mile	Grad %	Rosgen Type/ Entrenchment	# CT or RB Juv/Adu 1997/ 1992	% Primary Pool Habitat 1997/1992/ 1964	Pools/ Mile 1992/ 1964	% Quality Pools	# Large/Med Wood/ mile 1997/1992	Substrate (Dom/ Subdom) 1997-1992-1964	Spawning Gravel 1997/ 1964	# Site Failures 1997/ 1992	% Embedded 1997/ 1992	% Side channels 1996/ 1992	% RR in late seral stage 1992	Max. water temp (F) 1997/ 1992/ 1964
1	2.9-4.3	2%	B/Deep	24/23 4/12	Fair/ 25%/ 20%	14.6/ 10	95%	Poor/LWD structures were placed in this reach after the fire. None held.	BO/CO-CO/BR-BO/CO	17%/-	Low/ 3	16% 20-40%	Fair/ 6%	0%	-/55/56
2	4.3-6.7	2%	B/Deep	21/14 29/104	Good/ 15%/ 20%	11/ 10	88%	Poor/LWD was recruited into this area from Shady beach fire (1992)	CO/BO CO/SB BO/CO	18%/-	Low bedrock sideslopes	8.5%/ 20-45%	-/ 2%	68%	60/55/56
2.5 (1997)		5%	A/Deep	-	Good/ - -	-	-	Poor/ -	BO/CO	17%/-	Low bedrock walls	16%/ -	One significant dry side channel	-	-
3	6.7-7.6	1%	B/Shallow	28/16 1 spring chinook 5/13	Fair/ 9%/ 20%	7/ 10	100%	Fair, assoc. w/ falls & side channel/7.5	BO/GR CO/GR BO/ CO	25%/ 880 sq./yds	Low	14.5%/ 20-30%	Good/ 10%	24%	55/56
4	7.6-8.4	1%	B/Mod	7/10 16/4	Fair/ 11%/ 20%	8/ 20	49%	Fair, wood present was active in shaping morphology/7.5	BO/GR CO/SB CO/ BO	23%/ 415 sq./yds	Some associated with road	6%/ 30-40%	Good/ 2%	0%	53/60
5	8.4-8.8	1%	B/Mod	12/13 2/0	Good 12.3%/ 20%	13/20	80%	Fair, cabled log failures/7.5	CO/SB CO/BO		2 large slides have deposited wood & sediment	-/ 45%	Good/ 0%	0%	-/60

Table E-4 (continued). Quantifiable current (1997), transitional (1992) and historic (1964) fish habitat conditions in Hills Creek

Reach	River Mile	Grad %	Rosgen Type/ Entrenchment	# CT or RB Juv/Adu 1997/ 1992	% Primary Pool Habitat 1997/1992/ 1964	Pools/ Mile 1992/ 1964	% Quality Pools	# Large/Med Wood/ mile 1997/1992	Substrate (Dom/ Subdom) 1997, '92 '64	Spawning Gravel 1997/ 1964	# Site Failures 1997/ 1992	% Embedded 1997/ 1992	% Side channel 1996/ 1992	% RR in late seral stage 1992	Max. water temp (F) 1997, '92 '64
6	8.8-9.9	3%	B/Deep	5/14 17/0	7%/ 20%	6/20	100%	7.5	CO/LB CO/BO	-	-	-/ 30-50%	-/2%	0%	-/60
7	9.9-10	3%	B/Mod	4/0	2%/ 20%	10/20	100%	7.5	LB/SB CO/BO	-	-	-/ 20%	-/0%	0%	-/60
8	10-10.2	3%	B/Mod	- 0/0	12%/ 20%	5/20	100%	7.5	CO/LB CO/BO	-	-	ND	-/1%	0%	-/60
9	10.2-10.6	7%	B/Mod	36/16 13/0	13%/ 20%	20/20	75%	7.5	CO/SB CO/BO	-	-	-/ 30-35%	-/4%	0%	-/60
10	10.6-11.4	3%	B/Shallow	37/9 14/0	12%/ 20%	23/20	65%	7.5	CO/SB CO/BO	-	-	-/ 15-50%	-/6%	12%	/60
11	11.4-12.2	6%	B/Mod	17/19 18/0	8%/ 10%	11/25	-	7.5	CO/GR BO/CO	65 sq./yds	-	-/ 10-40	-	82%	-
12	12.2-12.6	10%	B/Mod	10/4 25/0	21%/ 10%	13/25	-	7.5	CO/SB BO/CO	-	-	-/ 20-40	-	0%	-
13	12.6-13.1	7%	B/Mod	7/7 9/0	7%/ 10%	14/25	-	7.5	CO/GR BO/CO	-	-	-/ 25	-	0%	-
14	13.1-13.9	3%	B/Deep	14/2 4/0	3%/ 10%	6/25	-	7.5	CO/SB BO/CO	-	-	-/ 20	-	0%	-
15	13.9-14.2	7%	B/Mod	-	7%/ 10%	20/25	-	7.5	CO/SB BO/CO	-	-	-/ 40	-	0%	-
16	14.2-14.9	8%	B/Mod	8/6	10%/ 10%	34/25	-	7.5	GR/CO BO/CO	-	-	-/ 30-50	-	90%	-
17	14.9-15.6	12%	B/Mod		5%/ 10%	14/25	-	-	GR/CO BO/CO	-	-	-/ 30-35	-	100%	-

* Wetted width in 1964 was averaged over several miles. 1997 Survey ended at Reach 8. ** Original wood entries were inaccurate. Wood was recounted for the entire stretch in the fall of 1996 and average for the whole stream section. Reach 3,4 habitat restoration sites.

Reaches 3,4 and 5 are the highest priority for recovery and short-term placement of large woody debris. Historically this area was described as "accessible only by trail at that time, Hills Creek flattened out and contained excellent spawning grounds. The gradient was moderate, pools numerous, banks flat, and substrate primarily gravels." Today the reaches are described as low in gradient (1%), Rosgen B channel types, with a predominance of boulder, cobble and gravel substrates. The influence of large wood in the channel is most evident in these channels. The 1997 survey noted that the wood present in the reach 4 is active in shaping the channel morphology. Placed wood would increase habitat complexity and the average number of pools per mile.

Hills Creek Debris Slides

The debris slides that have been recorded in Hills Creek have actively recruited wood and fine and coarse sediment into the channel. The amount of wood in the stream, however, is still below the desired condition (7.5 pieces per mile versus 30). Similarly, , the percent embeddedness of the channel has decreased from a range between 20 to 40 percent to a range between 6 and 16 percent, based on 1992 and 1996 data. Before the large floods in 1996, however, the embeddedness values in Hills Creek did exceed the goal of less than 30 percent in a majority of the stream reaches. It is assumed that the increased number of roads and associated effective drainage density in the watershed and the increased rate of debris slides contributed to the high percentages of stream embeddedness. It is difficult to evaluate if the dominate and subdominant substrate types and proportions have changed over time.

The trend for this parameter is for the number of slides to decrease over time. As roads are improved and harvest in the riparian reserves limited, the number of debris slides entering the streams will re reduced, thus reducing fine sediment contribution.

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Glossary

Bankfull - Height of the floodplain surface, generally occurring at a 1.5 year frequency.

Commercial Thinning - Any type of tree thinning that produces merchantable material at least equal in value to the direct costs of harvesting.

Ecosystem - An interacting system of organisms considered together with their environment.

Even-aged management - The application of a combination of actions that results in the creation of stands in which trees of essentially the same age grow together.

Forested Land - Land at least 10 percent occupied by forest trees or formerly having had such tree cover and not currently developed for nonforest use.

Fuels - Combustible wildland vegetative materials.

Geomorphic - Of, or pertaining to, the figure of the earth or the form of its surface; resembling the earth.

Green Tree Retention (GTR) - A stand management practice in which live trees as well as snags and large down wood are left as biological legacies within harvest units to provide habitat components over the next management cycle.

Habitat - The area where a plant or animal lives and grows under natural conditions. Habitat consists of living and non-living attributes, and provides all requirements for food and shelter.

Habitat Diversity - The number of different types of habitat found within a given area.

Land Use Allocation - The commitment of a given area of land or a resource to one or more specific uses.

Large Woody Material - Portion of a tree that has fallen or been cut and left in the woods. Usually refers to pieces at least 20 inches in diameter.

Management Area - An area with a similar management objective and a common management prescription.

Mature Forest - In the WNF, areas containing trees whose average age is 120 - 200 years old. There is significantly less diversity of plant species and structure than in an old-growth forest.

Morphology - The observation of the form of lands.

Non-forested Land - Lands that never have had or that are incapable of having 10 percent or more of the area occupied by forest trees; or lands previously having such cover and currently developed for non-forest use.

Old-Growth - A forest comprised of many large trees, large snags, and numerous large down logs; having a multi-layered canopy composed of several species of trees; the last stage in forest succession. In the WNF, forests begin to show some old-growth characteristics at 175-200 years.

Overstory - That portion of the trees forming the upper or uppermost canopy.

Precommerical Thinning - Removal of some trees in a stand before they attain merchantable size so the remaining trees will grow more quickly.

Reforestation - The natural or artificial restocking of an area with forest trees.

Regeneration - The renewal of a tree crop, whether by natural or artificial means. Also, the young crop itself.

Riparian - Pertaining to areas of land directly influenced by water or influencing water. Riparian areas usually have visible vegetative or physical characteristics reflecting this water influence. Stream sides, lake borders, or marshes are typical riparian areas.

Salvage - The cutting of trees that are dead, dying, or deteriorating (before they are "overmature", or materially damaged by fire, wind, insects, fungi or other injurious agencies) before they lose their commercial timber value.

Seral - A biotic community which is a developmental, transitory stage in an ecological succession.

Snag - A standing dead tree usually greater that 5 feet high and 6 inches diameter at breast height. Its interior may be sound or rotted.

Stand - An aggregation of trees or other vegetation occupying a specific area and sufficiently uniform in species composition, age arrangement, and condition as to be distinguishable from the forest or other vegetation or land cover on adjoining areas.

Structure - The configuration of elements, parts, or constituents of a habitat, plant, or animal community.

Succession - The progressive development of vegetation from bare ground towards its highest ecological expression, the climax community; the replacement of one plant community by another.

Water yield Class - Classification based on the water retention properties of soil types. It is an indication of the rate and amount of water yield expected from each soil based on various factors.